

# FINAL TECHNICAL REPORT / RAPPORT TECHNIQUE FINAL SCIENTIFIC WRITING REPORT

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**Hawassa University  
College of Agriculture**



**University of Saskatchewan**

# **Workshop on Scientific Paper Writing**

**Canadian International  
Food Security Research  
Fund (CIFSRF)**

**December 11-16  
2017**

## **Preface**

The Canadian International Food Security Research Fund (CIFSRF) Project at College of Agriculture of Hawassa University has been supporting graduate students who conduct researches on problems areas directly linked to its objectives. Besides covering the cost to undertake the proposed researches, grantees got trainings on different scientific activities to build their scholastic career and future undertakings. These activities has helped the students and their professors to publish many articles in reputable journals and positively contributed to the outcome of the project.

The participants of the current scientific paper writing workshop were earlier trainees on a workshop how to write proposals with the objective to shape their draft proposals in to viable MSc research projects. The current scientific paper writing workshop was organized for six days (December 11-16). The main objective was to introduce students to scientific papers and help them write standard scientific papers starting with their MSc research findings. The interactive training had theoretical and practical sessions where by the two trainers, Dr. Ferdu Azerefege and Dr. Tewodros Tefera, and fellow students continually gave comments and critics on the student draft papers. The students learnt the structure of scientific papers and how to write each section, the language of scientific papers, dos and don'ts. Besides the mechanics of writing, trainees were introduced to the processes publishing articles, including selection of journals, sending articles, and communicating with the editors.

This report contains thirteen manuscripts which were prepared under the guidance of the trainers. The trainers witnessed very good progress in the development of the manuscripts and are of the opinion that most of them will eventually be accepted for publication in good journals.

The trainers appreciated very much the support by CIFSRF project to students on proposal and scientific writing. Supports by similar projects are mostly limited to the research work and converting the hard earned data in to valuable scientific papers has often been overlooked. The excellent setup of the training, organization and support from the project leader and his team made the training very convenient and enjoyable to the trainers and the participants.

Ferdu Azerefege, Hawassa University  
Tewodros Tefera, Hawassa University  
December, 2017

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## **1. Agribusiness and Value Chain Management Graduate Program**

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# **Determinants of Chickpea (*Cicer arietinum* L.) Marketed Surplus among Smallholder Farmers in Humbo and Damot Gale Woredas, Southern Ethiopia**

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## **Abstract**

This research was aimed to study the chickpea (*Cicer arietinum* L.) marketed surplus among smallholder farmers in the Humbo and Damot Gale Woredas. A multi-stage sampling technique was used in order to determine the sample respondents. By using simple random sampling technique four sample Kebeles were selected. Cross sectional data were collected from 182 farm households who produced chickpea in 201x production season. Primary data were collected from sample households using structured questionnaire. Descriptive statistics and econometric model were employed to analyze the data. To identify determinants of marketed surplus of chickpea, Ordinary Least Square (OLS) model was employed. The finding revealed that cultivated area, seed variety and distance to nearest market, access to credit and livestock holding (TLU) were significantly influence marketed surplus of chickpea. The study suggest interventions such as intensification strategies which increase yields through proper management and use of inputs, rural infrastructure improvement increases the likelihood of market orientation and marketed surplus of chickpea.

**Key words:** Chickpea, Marketed surplus, Household, South Ethiopia

## **1. Introduction**

Pulses are important components of crop production and cash crop in Ethiopia and contribute considerably to attain food and nutritional security (Tewodros, 2013). Pulse crops occupy about 13% of croplands in Ethiopia and are the second most important elements in the national diet (CSA, 2015). In Ethiopia, Chickpea is a less labor-intensive, widely grown, important food crop and source of cash (Shiferaw et al., 2007). The Southern Nation, Nationalities and Peoples Region (SNNPR) production of chickpea accounts 3% the total chickpea production in the country (Rashid et al., 2010). Chickpea productions of Humbo and Damot Gale *Woredas* in 2015/16 production season were 1,984,000 kg and 282,600 kg respectively, among this legally marketed amount of chickpea crops were 767,000 kg and 150,000 kg respectively (Humbo WoANR, 2017; Damot Gale WoANR, 2017).

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The study *Woredas* have sufficient potential and environmental settings for production of chickpea. Some studies investigated the major constraints of chickpea crop production in the study sites. Tewodros (2013) reported that land shortage, low soil fertility and disease on chickpea crop were the major constraint limiting chickpea production in Damot Gale *Woreda*. On the other hand, the chickpea market of the study areas had grown substantially in recent years, although the current market is still under developed (Rashid et al., 2010). A study in the Rift Valley of Ethiopia including Humbo and Damot Gale *Woredas* found that limited access to credit, poor market linkage and price volatility were also problems of chickpea crop producers (Frehiwot, 2010). However, in the aforementioned study the chickpea crop marketing is not well explored.

The available literature on pulses dwell on the performance of the existing cultivars and biofortification of chickpea cultivars (Legesse et al., 2017; Gemechu et al., 2011; Lemma et al., 2013); wilt/root rot diseases in major chickpea growing areas (Tebkew and Chris, 2016); analysis of chickpea value chain in Southern Ethiopia (Tewodros, 2013). The available information on determinants of marketed surplus of chickpea is not sufficient. Moreover, the recent expansion of chickpea in SNNPR also deserve new studies. Hence, this study designed to address the research gap to provide valuable information for practitioners, researchers, policy makers and producers. The study analyzed the determinants of chickpea marketed surplus in the Humbo and Damot Gale *Woredas* of SNNPR.

## **2. Methodology**

### **2.1. Description of the Study Area**

The study was conducted in Southern Nation, Nationalities and Peoples Region (SNNPR), Humbo and Damot Gale *Woredas* of Wolayta Zone. Humbo is one of the *Woredas* in Wolayta zone. The administrative center of Humbo is Tebela. The *Woreda* is located in 6°43' N latitudes and 37°45' E longitudes and 1100 to 2300 m.a.s.l. The agro-climate zone of the area comprises *Woina-dega* (30%) and *kola* (70%) (HumboWoANR, 2017). Based on the 2007 census conducted by the CSA, this *Woreda* has a total population of 125,441, of whom 63,017 are men and 62,424 women; about 6,247 or 4.98% of its population are urban dwellers.



Damot Gale is located in  $7^{\circ} 58' \text{ N}$  latitudes and  $37^{\circ} 52' \text{ E}$  longitudes and altitude of 2050 m.a.s.l. The administrative center of Damot Gale is Boditi. The *Woreda* agro-climate zone of the area is characterized by *Woina-dega* (Damot Gale WoANR, 2017). Based on the 2007 Census conducted by the CSA, the Woreda has a total population of 151,079, of whom 74,227 are men and 76,852 women; and about 24,133 or 15.97% of its population are urban dwellers.

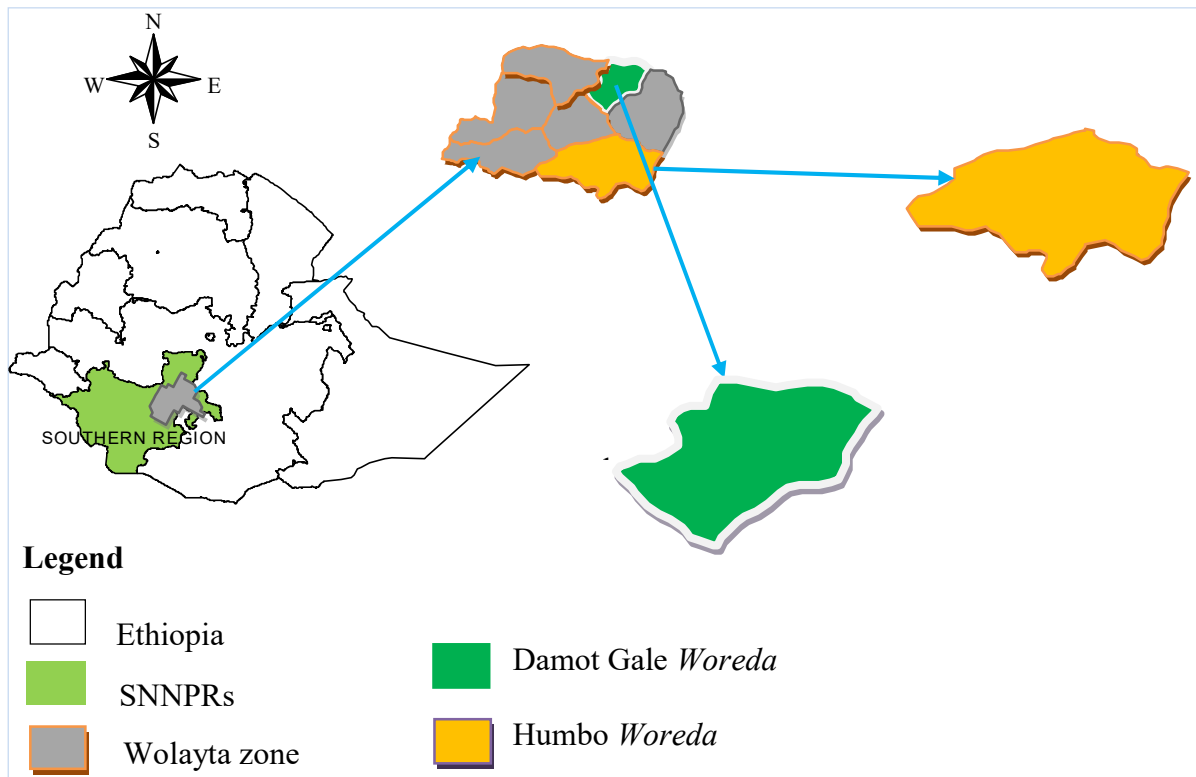


Figure 2: Geographical map of the study areas

## 2. Research Design

### 2.1.1. Data Types, Sources and Methods of data Collection

The study used both primary and secondary sources of data, which is qualitative and quantitative in nature. The primary data were collected using questionnaire. Secondary data were obtained from various sources such as reports of Bureau of Agriculture and Natural Resources at different levels, CSA, NGOs, previous research findings, journal articles, e-books and other published and unpublished materials which are found to be relevant to the study.

To generate the necessary data from the primary sources, different procedural approaches such as face to face interview with sample respondent households were used. Most of research data were

collected through questionnaires by means of household survey. The farm household survey data collected by using enumerators since most of farm households was not able to read and write. A total of 6 enumerators from *Woreda* office of agriculture and natural resources who speak the local language were selected and trained on the method of administering the interview schedule in general and on the content of the questionnaire in particular. The enumerators had a qualification of a minimum of college diploma. Before administering the survey, questionnaire pretesting was conducted by enumerators to test the contents of the questionnaire, to measure how long it takes to fill a questionnaire and validate interviewing approaches. The pretesting was conducted in a Gacheno Kebele administrative. Then, the questionnaire was revised and content, which was unclear, was modified and removed. The field data collection took 15 days, and all efforts were exerted to supervise on field level to check and correct gaps.

### **2.1.2. Sampling Technique and Sample Size Determination**

#### **Sampling Technique**

In this study, multi-stage sampling technique was used. In the first stage, all *Kebeles* of the two *Woredas* (Damot Gale and Humbo *Woredas*) were stratified into chickpea producers and non-producers. From the 65 *Kebeles* about 40 *Kebeles* were found to be chickpea producers. Secondly, by using simple random sampling techniques, 4 sample *Kebeles* out of 40 pulse crops producer *Kebeles* were selected. Following the kebele selection, households were stratified in to producers and non-producers of chickpea crops. Finally, chickpea producing sample households were selected from chickpea producing stratum using systematic random sampling technique.

#### **Sample Size Determination**

An important decision to be taken while adopting a sampling technique is about the size of the sample. Hence, the sample size of the study was determined based on the scientific formula that designed to find out the appropriate size of the survey research. In the study, the Khotari (2004), sample size determination formula used in order to decide the size of sample population:

$$n = \frac{Z^2 * N * p * q}{e^2 (N - 1) + Z^2 * p * q}$$

Therefore, by using the formula using  $Z = 1.96$  to 95%,  $p = 0.5$ ,  $q = 1 - p$  and  $e^2 = 0.07$ ,  $N = 2,616$  values and the sample size calculated  $n = 182$  (165 male and 17 female) which is the necessary sample size of the study.

Where: N= total households, n = size of the sample, Z= standard variation at a given confidence level, P= proportion of successes, q = proportion of failures,  $e^2$ = acceptable error.

Table1. Sample Size and Sample Distribution by Kebeles

Sample Kebeles	Chickpea Crops Producing households	Selected Size of ample
<b>Gututo Larena</b>	550	39
<b>Abala Sipa</b>	823	59
<b>Taba</b>	776	48
<b>Gacheno</b>	467	36
<b>Total</b>	2,616	182

Source: Own computation based on data from WoANR (2017).

## 2.2. Methods of Data Analysis

### 2.4.1. Ordinary Least Square Model (OLS)

OLS regression model was used to analyze determinants of marketed surplus of chickpea in Humbo and Damot Gale Woredas. The reason for using this model was that all sample farmers who produced chickpea were suppliers to the market in 2015/2016 production season. The OLS regression model was specified as  $Y=f$  (Farm size, Age of household head, Sex of household head, Education status, Households size, Farming experience, Access to credit, Market price of output, Livestock holding, Membership to cooperatives, Extension contact, Distance to the market, Off- farm income activities, Access to market information, Input used). The estimated coefficients indicate the amount of change in the dependent variable due to a unit change in the independent variable keeping other factors constant.

In matrix form, the supply function can be specified as:

$$Y = \beta X + U$$

Where: Y = the volume of chickpea supplied to the market in Kilogram

$\beta$  = a vector of estimated coefficient of the explanatory variables

X = a vector of explanatory variables, U = Disturbance term

Before fitting the independent variables in the OLS regression model, multicollinearity, heteroscedasticity and omitted variables test were performed. Multicollinearity was tested using

variance inflation factor (VIF). To address heteroscedasticity and omitted variables, Breusch-Pagan and ovtest were conducted using STATA software version 12.

### 3. Results and Discussion

#### 3.1. Socio-Economic and Demographic Characteristics of Respondents

The average age and family size of the sample households were 40.1 years and 6 persons, respectively. The household respondents' average experience in farming was 11.4 years. On average chickpea producer households own about 0.29 hectares of land for chickpea production and owned 4.24 livestock measured in TLU. The sample households located 5.9 kilometer away from the nearest market place (Table 2).

The households on average obtained an annual gross off-farm income of 1080.5 Birr. The lagged price of chickpea per quintal was 2063.20 (Table 2). The majority of the respondent households were applied improved variety (93%), access to credit (79%), and member of cooperative (77%). Overwhelming majority (91%) of respondents attained formal education (Table 2).

Table 2. Socio-economic and demographic characteristics of chickpea marketed surplus

Variables	Variable Description	Mean	Std.dev.
Age	Number of Years	40.1	7.7
Household size	Number of individuals of family	6	1.7
Farm experience	Number of years	11.4	9.6
Cultivated area	Measured in Hectares	0.29	0.07
Distance nearest market	Measured in Kilometer	5.8	3.0
Lagged Market price	Measured in Birr	2063.2	584.6
Off-farm activity income	Measured in Birr	1080.5	2045.04
Livestock holding	Measured in Tropical livestock unit	4.2	2.4
		%	
Sex (male, %)	1=male,0=female	84.07	
Improved Seed variety (%)	1= yes, 0= No	92.86	
Access to credit (%)	1=yes, 0=No	78.57	
Cooperative membership (%)	1= yes, 0=No	76.92	
Education status (%)	1= formal education, 0=No	91.21	

Note: \*\*\*, \*\* and \* represents significance at 1%, 5% and 10% probability levels, respectively.

Source: Own computation of survey data, 2016/17

## **2.1. Determinants of Chickpea Marketed Surplus**

The overall goodness of fit of the regression model measured by the coefficient of determination ( $R^2$ ) and F value was statistically significant at 1%. The  $R^2$  value of 0.7178 indicate that the independent variables included in the regression explain 71.8% of the variations determine the chickpea marketed surplus. The OLS regression model used to identify determinant factors influencing the marketed surplus of chickpea indicate that out of 13 explanatory variables five were found to affect the marketed surplus of chickpea significantly. These were cultivated area, seed variety and distance to nearest market, access to credit and livestock holding (TLU).

### **Cultivated area**

The chickpea cultivated area was found to influence marketed surplus of chickpea positively at 1% significance level. The finding implies that the larger the cultivated land allocated to chickpea production the larger the amount produce and thereby raising the amount produce available for sale. Thus, a hectare increases in cultivated area under chickpea production increase the amount of chickpea sold by 170 kilograms. The result is consistent with the findings of Shewaye et al., (2016) it was found that the larger the cultivated land size allocated to haricot bean production the larger the quantity produce and thereby increasing the quantity produce available for sale in Misrak Badawacho District of Southern Ethiopia.

### **Improved Seed variety**

As expected improved seed variety was found to affect marketed surplus of chickpea positively and significantly at 1% significance level. This implies that, households who have access to improved seed of chickpea was more likely to supply large amount of chickpea to the market. The result is consistent with the findings of Yaynabeba and Tewodros (2013). They reported that the haricot bean producers who had ease of access to input supply like improved seed varieties participated in the market more by increasing amount of haricot bean marketable surplus compared to those who did not have access to improved variety.

### **Distance to the nearest market**

Distance to the market negatively and significantly influences the marketed surplus of chickpea. This means that as chickpea producers residence home distance to the market increases, the amount of chickpea sold by smallholder farmers' decrease. It was significant and negatively

affects the level of marketed surplus at 10 %. The possible explanation for this is that as distance from the market increases, transport costs also increase and this discourages resource constrained smallholder farmers from selling high volumes to the market. The result showed that a kilometer increases in distance to the nearest market decrease the marketed surplus of chickpea by 5 kilograms, keeping other factors held constant. The result is consistent with the findings of Byron et al., (2012) it was found that farmers located in villages with large distance to market and poor road quality between the village and the market place sold fewer potatoes.

### **Access to credit**

It was found that credit access positively and significantly influences amount of chickpea marketed at 5% probability level. This means that credit services are the most important sources to solve financial constraints that hold back agricultural marketing related to marketing and transaction costs. Thus, households who had access and use credit sell 64 more kilograms of chickpea than non-users keeping another factors constant. This outcome is reliable with the findings of Tewodros (2013).

### **Livestock holding**

This variable affected chickpea marketed surplus significantly and positively at 5% level. Livestock holding (TLU) is a proxy for wealth under Ethiopian farmers' condition and sometimes it considered as an asset. The feasible explanation is that resource endowed households have more TLU which they can use for traction and transportation, a development which reduces production and market related transaction costs. The resource-endowed households are likely to have finances from which they are able to hire labor, purchase inoculants, and buy improved seed varieties and thus can produce chickpea on larger portions of land compared to the resource constrained smallholder farmers. The result indicated that a unit increase in number of livestock (TLU) owned by the households increases marketed surplus of chickpea by 9kilogram per year. Study by Nuri et al., (2016) on kocho market participation suggests that an increase in the value of livestock owned leads to an increase in enset sale.

Table 3. OLS results for determinants of marketed surplus of chickpea

<b>Variables</b>	<b>Coefficient</b>	<b>Robust Std. error</b>	<b>t value</b>
<b>Cons.</b>	0.3091503	1.901721	0.16
<b>Age</b>	-.0128045	0.0086798	-1.48
<b>Sex of HH</b>	0.1690853	0.3383849	0.50
<b>Education status</b>	0.0070496	0.0220231	0.32
<b>Family size</b>	-0.00818	0.0503656	-0.16
<b>Farm experience</b>	-0.004414	0.0063852	-0.69
<b>Cultivated area</b>	1.66301***	0.4658451	3.57
<b>Seed variety</b>	0.56219***	0.1356124	4.15
<b>Lagged Market price</b>	0.2736551	0.2308479	1.19
<b>Distance nearest market</b>	-0.0532744*	-0.0288756	1.84
<b>Access to credit</b>	0.6375506**	0.2600976	2.45
<b>Cooperative membership</b>	-0.0052607	0.1759857	-0.03
<b>Off-farm activity income</b>	-0.0087883	-0.0098338	0.89
<b>Livestock holding (TLU)</b>	0.0867891**	0.0313724	2.77
<b>Number of obs=182, F (13, 168) =6.92, Prob. &gt;F=0.000 ,R-squared=0.7185, Root MSE = 0 .9812</b>			

Note: The dependent variable is the amount of chickpea marketed/sold.

\*, \*\* and \*\*\* represents significance at 10%, 5% and 1% probability levels, respectively.

#### 4. Conclusions

Resource endowment of households such as landholding size and livestock holding, access to seed variety and credit and proximity to market were found influencing marketed surplus of chickpea in the study area. Increasing the cultivated area was not best option as land is scarce resources and limited supply. Rather intensification strategies which increase productivity per unit area are an important pathway. Moreover, yield improving strategies such as proper management land and efficient application of inputs increases productivity and thereby the likelihood of market orientation. Enhancing access to credit through formal financial institutions increases investment in agricultural inputs and the supply of chickpea grain to the market. Improving rural infrastructure in the form of establishing all weather road would assist farmers to

supply more amount of chickpea in to the market because it reduces transportation cost and it supports the integration of markets.

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# **Chickpea Market Participation and Market Surplus: The Case of Meskan District, Southern Ethiopia**

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## **Abstract**

Chickpea is an important pulse crop, particularly in the rain-fed ecology and for resource poor farmers. The research objective was to analyze the level of chickpea commercialization and determinant factors in Meskan and Sodo woreda, southern Ethiopia with the specific objective of the level of chickpea commercialization, factors that affect commercialization of chickpea and explore opportunities and constraints of chickpea commercialization. The study was employed three stage sampling technique to collect related primary data from smallholder farmers. A total 193 sampling households were selected from chickpea producer using probability proportional sample random techniques. Mixed, sequential and concurred research strategy was applying and qualitative and quantitative data used to collect primary data source. The household commercialization index model and Tobit estimation model were used. The model result showed that the average land size of the household was 0.75 hectare and the average land allocated for chickpea production was 0.38 hectare. In addition to that the household produce 5.8 quintal of chickpea but they sold in chickpea market only 3.5 quintal on average. The overall chickpea sold was 61.4 % of production. 80 % of smallholder households above formal education these were better off the chickpea market participation and commercialization of chickpea. The average family size indicates that 4.79 person per households. The result shows that family size positive influence in participation of chickpea market and sold in the chickpea market in contrary negative influence in commercialization of chickpea. The positive result may the opportunity cost and supply of labour, thus it could be the result of commercialization. The negative result also shows that the household consumption increases the result to decrease commercialization.

**Key words:** Commercialization, smallholder, household, market participation, Tobit model

## **1. INTRODUCTION**

Currently Ethiopian economy has shown a sign of transition from subsistence to commercial agriculture (Gebremedhin and Jaleta, 2012). To increase agricultural productivity and help drive subsistence agriculture towards market-oriented and income-generating pathway agriculture is the major focus. The country is following Agricultural Lead Industrialization Policy for the last two and half decades.

Ethiopia's foreign exchange earnings are led by the services sector, followed by exports of several commodities. While coffee remains the largest foreign exchange earner, Ethiopia is

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diversifying exports, and commodities such as gold, sesame, khat, livestock, pulse crops and horticulture products are becoming increasingly important.

In Ethiopia, chickpea is widely grown across the country and serves as a multi-purpose crop; it fixes atmospheric nitrogen to the soils and thus improves soil fertility and saves fertilizer costs in subsequent crops, it improves more intensive and productive use of land through double cropping, it reduces malnutrition and improves human health, it contribute to increases livestock productivity through feed. Moreover, chickpea is a less labor-intensive and its production demands low external inputs compared to cereals (Shiferaw et al., 2007; Menale et al., 2009).

In terms of production, Chickpea is one of the major pulse crops in Ethiopia, which is the second most important legume crop next to faba beans. Ethiopia accounts for more than 60% of Africa's global chickpea market share and 4.5% of the global chickpea market share (Sheleme, 2014). During 2015/16 the average amount of production of chickpea in Ethiopia was estimated to be about 473 thousand tones. In 2016/17 of meher season, the *SNNPR* covered 11.7 thousand hectares in chickpea, produced 214 thousand quintals of chickpea and attained 18.14 quintal per hectares yield (CSA, 2016).

However, low productivity and use of poor productive and low quality local varieties, inadequate market-orientation and lack of competitiveness hinder its potential (Menale et al., 2009). The current reality shows that commercialization of smallholder farming is not yet high enough to benefit farmers from increased income and the farmers are not fully released out of the subsistence-oriented agriculture (Mahelet, 2007). Bernard et al., (2007) stated that it is not possible for the smallholder farmers in Ethiopia to integrate with the market and enjoy the benefits of commercialization unless the already existing hurdles are removed and better environment is created. However, commodity oriented commercialization is emerged in Ethiopia and understanding the commercialization pathways are critical for organizing the support system and strengthen market oriented smallholders' agriculture. In line with this discussion, it is essential to understand the level of chickpea commercialization, factors that influence the participation of chickpea market and marketed surplus.

## **2. METHODS**

### **2.1 Description of the study area**

The study was conducted in South Nations, Nationalities & Peoples Region (SNNPR) in Meskan Wereda. The study area is located in Gurage administrative zone of the region. Geographically, it lies between the coordinates of 07°12'30.1" N latitude and 37°47'04" E longitude. It is bordered with Muhur Aklil, Kokir Gedebano, Sodo and Mareqo Weredas; Siltie Zone in the South; Oromia Regional state in the North & South. It covers a total area of 446.71 square km. The wereda capital (Butajira) is situated in at about 163 km Northwest of Hawassa and 130 km southwest of Addis Ababa through the asphalt road that passes via Addis Ababa, Almgena, and Hosanna of SNNPR.

According to the CSA (2012), the total population of the Meskan Woreda is 180,239.00, of which female account for 50.9% of the population and male 49.1 %.

The altitude of Meskan wereda ranges from 1500 to 3500 meters above sea level (masl). The mean annual rainfall is 1200mm. The mean annual temperature varies from 14 °C in the highlands to around 26°C in the lowlands. Yemerwacho 1 and Yemerwacho 2 *kebeles* are specific study area.

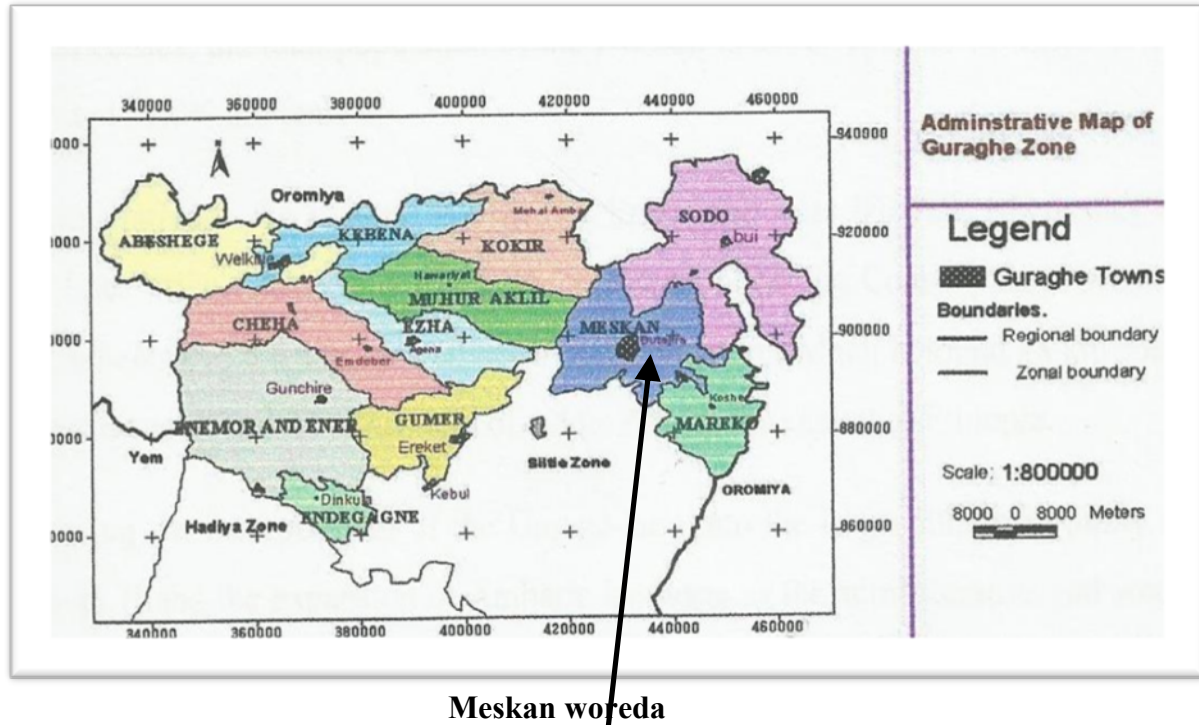


Figure 1: Location of the Study Areas (Source: Wubeyed, 2010)

## 2.2 Research Design

The research design employed is mixed & sequential approach employed both qualitative and quantitative methods which concurred with the aim of identifying the level of chickpea commercialization, the determinants & influencing factors of market orientation; and opportunities and constraints of chickpea commercialization in the study area.

## 2.3 Sampling Procedures

In this study a three - stage sampling procedures were employed. In the first stage Meskan woreda was purposively selected based on area coverage of chickpea production and the access of road and proximity to the central market. In the second stage, the potential chickpea producing kebeles Yemerwacho-1 and Yemerwacho-2 was selected in consultation with the Woreda Office of Agriculture and natural resources expertise. In the third stage a total of 193 sample households were selected using simple random sampling technique.

## 2.4 Methods of Data Collection

The data were collected through structured and semi-structured questionnaires, focus group

discussion (FGD) and key informant interview. The survey questionnaires were administered by researcher and qualified enumerators after they trained the content of the questionnaire and survey administration. While the quantitative data were collected through personal interview the qualitative data were collected using interviews, discussion and observation techniques.

## **2.5 Methods of data processing and analysis**

Two types of data analysis, namely descriptive statistics and econometric analysis was used to analyze the degree of chickpea commercialization and identify factors influencing marketed surplus. For data analysis softwares SPSS version 20 and STATA version 12 was used. Ratios, percentages, means and variances and standard deviations describe the data by using descriptive statistics analysis. Household commercialization index (HCI) used for econometric analysis:

$$HCI = \frac{\text{gross value of Chickpea crop sales hh i,year j}}{\text{gross value of total Chickpea production hh i,year j}} \times 100$$

To identify factors influencing chickpea market participation and level of marketed surplus, Heckman two stage selection models were employed. The first stage of Heckman involves a probit model which is used to estimate the determinants of market participation decision while the second part of the model is OLS, measures the intensity of marketed surplus of chickpea.

## **3. RESULTS AND DISCUSSION**

This section consists of the overall analysis and interpretation of major findings of the study on the analysis of chickpea market participation and marketed surplus of chickpea in Meskan worda.. The first part dealt with households' personal & demographic, and socio-economic characteristics. The second part identify factors influencing market participation and marketed surplus of chickpea whereas the third part presented opportunities and constraints of chickpea market participation and marketed surplus in the study area.

### **3.1. Demographic and Socio-Economic Characteristics**

A total of 193 household heads were interviewed for this study. Out of this, 169 (80.8%) were male and 24 (19.2%) were female (Table 1). About to 20 and 24 % of the respondents were

illiterate and able to read and write while the majority (56%) were attending formal education at primary and secondary level of education.

Genene, Legesse and Wagayehu, (2009) stated that educated farmers tend to use modern agricultural technologies, use improved variety seeds, agricultural extension services and diversify their source of income than the illiterates. Education is important instruments in boosting production, which makes farmers better off. Thus, educational status of the households was hypothesized to have a positive impact on Agricultural commercialization & productivity.

Table 1. Household heads sex and Education level

Characteristics of HH	Variables	Number	Percent
<b>Sex</b>	Female	24	12.4%
	Male	169	87.6%
	Total	193	100%
<b>Education level</b>	Household heads has no formal education (Illiterates)	38	19.7%
	With adult education (Write & read only)	47	24.4%
	Primary ed.1st cycle (Grade 1-4)	46	23.8%
	Primary ed. 2nd cycle (Grade 5-8)	54	28.0%
	Secondary education (Grade 9-10)	8	4.1%
	Total	193	100%

*Source: Survey, 2017*

Based on their age distribution, 125 (94.8%) were in the age group of 27 years to 45 years, 55 (28.5 %) were in the age group of 46 years to 64 years, and the remaining 13 (6.7 %) were above 64 years. This indicates that about 93.3% of sample respondents were in productive age group (i.e. 27-64). Most of sample household heads had experience in chickpea production. Minimum and maximum ages of the respondents were 27 and 75 respectively and the mean age was 45.42 years (Table 2).

The family size is a proxy indicator for availability of labor provided that there are more people within the age range of active labor force. Availability of labor in the household is one of the important requirements for the market participation and market surplus (cite source??). The household size influences the decision of farmers to adopt labour intensive agricultural technologies and the amount of production for commercialization. The household labor is the major supplier of the required labor for undertaking the farming. This was supported by Geoffer

(2004), who found that household size was associated positively with adoption of conservation practice. Wagayehu and Lars (2003) indicated that in the large families with greater number of mouth to feed, immediate food need is given priority and labor is diverted to off-farm activities that generate food. Hence, even during slack season, opportunity cost of labor for the household with greater size was higher (Wagayehu and Lars, 2003).

Regarding the household size, Sample households had total family member of 1054 persons, out of which 537 (50.9%) were females and 517 (49.1%) were males. The average family size was 5.46 persons per households. But there was wide variation in family numbers among households. Minimum and Maximum family sizes of households were 2 and 11 respectively. The majority of the households (81.8%) have four to eight family members.

Farming experience is one of the most important factors influencing market participation and marketed surplus. It helps farmers to compare different attributes of varieties such as yield, cooking quality, market demand, maturity date and the like. The mean chickpea farming experience in year was 18.02. The overall maximum and minimum farming experience of respondents were 5 and 46 years respectively (Table 2). The older household may have acquired better experience on chickpea growing and market interactions, that help farmers to produced and participate in the chickpea market.

### **3.2. Resource endowment of respondent Households**

#### **3.2.1. Land holding size**

Landholding size is one of the major determinant factors in agricultural productions and for market participation and marketed surplus. This is basically true as it is a base for any economic activity especially in rural and agricultural sectors. Farm size influences households' decision to allocate it for different land uses. Thus, increase in size of land is expected to have positive influence of commercialization of chickpea.

As the survey result indicated that (Table 2), the land holding size varies between 0.25 and 2.75 hectares. The Majority of sample households (87%) cultivate less than 1.00 hectare of land.



Households cultivating more than 1.00 hectare accounted for only 13 %. The overall minimum and maximum land holding size 0.25 and 2.75 respectively with the mean land holding size of sample households was 0.75 hectare. The mean land holding size of the respondents in Meskan woreda was 0.737.

**Table 2: Household family size, age, farm experience and size of land holding**

<b>Variables</b>	<b>N</b>	<b>Min</b>	<b>Max</b>	<b>Mean</b>	<b>Std. Deviation</b>
<b>Family size of household</b>	193	2	11	5.46	1.885
<b>The age of the household heads in years</b>	193	27	75	45.42	11.35
<b>The size of land holding in hectare</b>	193	.250	2.750	.750	.403
<b>Farming experience of household heads</b>	193	5	46	18.02	7.960

*Source: Survey, 2017*

### **3.2.2 Chickpea market participation and degree of commercialization**

The study area of household economy was mainly subsistence farming. The practices of the study area were mixed farming and livestock rearing. The statistical result shown in the Table 3 indicate that, 4.1 % of the smallholder farmers were not participate in chickpea output market, while the other extreme only 0.52 % (1 farmer) of fully commercialized sample household. About 32 % of sample households fall under the category of low commercialized farmers where they supplied less than 50% of their product in the chickpea market. The rest 34.3 % of households were medium commercialized implying they supplied from 51% up to 70% of their production while 29.5 % represented high commercialized farmers, these sample smallholder's farmer were participating in the chickpea market by supplying of more than 71% of their chickpea produce.

Table 3. Degree of smallholder's commercialization

<b>Level of commercialization</b>	<b>%</b>
<b>No participate in chickpea market</b>	4.1
<b>Supplied less than 50 % (low commercialized)</b>	32.1
<b>Supplied between 51-70%( medium commercialized)</b>	34.3
<b>Supplied more than 71% (High commercialized)</b>	29.5
<b>Total</b>	100
<b>100 % market oriented</b>	0.52 %

Source: survey (2017)

### **3.3. Econometric Model Analysis**

#### **3.31. Chickpea market participation**

In econometric analysis a smallholder demographic and socioeconomic factors are hypothesized to explain the difference in chickpea market participation and amount of marketed surplus of chickpea included. These explanatory variables include sex, family size, age, education, land size, quantity produce, fertilizer use, income from off farm, distance to market, chickpea variety, access to credit and extension service.

The Heckman two stage selection model, the first probit estimation result shows that sex of household, age of household, family size, distance to the nearest market, quantity produced, intensity of fertilizer, used of chickpea variety, access of credit and extension service are positive and statistically significant factors influencing chickpea market participation.

**Household Sex:** This variable was expected to have indeterminate effect on participation of chickpea market. Being a male increased the market participation by 7.6 %. Sex of household heads positive and significant effect on chickpea market participation at 1% significance level.

**Age of the household heads:** The household heads age positively and significantly influenced the amount of chickpea sold at 1% significance level. The household head year increase 1 year, the market participation increased by 0.25 percent.

**Family size:** The quantity of chickpea sold decision by households positive and significantly influenced at 10% at significant level. When the family size increases by one person the chickpea market participation increased by 1.1 %.

**Distance to the nearest Market:** Distance to the nearest Market variable has positive and

significant influence on participation of chickpea market per household. The positive and significant relationship between the two variables indicates that road access to household is a very important variable affecting household's participation of chickpea market at 1% significant level. A better road access to the nearest to market result increased by 1 k/m, 3.8 % of market participation in the chickpea market. The quantity of chickpea output production increased by 1 quintal, 1.1% increase the market participation on chickpea. A better road access to the nearest to market result increased by 1 k/m, 3.8 % of market participation in the chickpea market.

**Quantity produced of chickpea:** The quantity of chickpea output production increased by 1 quintal, 1.1% increase the market participation on chickpea. The participation of chickpea and quantity of chickpea produced a significance and positive effect at 5% significance level.

**Access to extension service:** Farmer's access to extension service increased the ability of farmers to acquire important market information as well as other related agricultural information which in turn increases farmer's ability to participate the chickpea market by 12.6 percent.

This is related to; Mamo and Degnet (2012) who found agricultural extension services in the form of visit of farmers by extension officers tended to increase the probability of selling directly to consumers in livestock market channel choice of farmers in Ethiopia. The variable was positive and significantly associated with participation of chickpea market at 1% level of significant.

**Intensity of Fertilizers: Fertilizer used** was one of the most important agricultural practices that are used by chickpea growers in the study area. The household used an additional fertilizer increased by the participation chickpea output market increased by 4.5 percent. The used of fertilizer and participation of chickpea market a positive and significance factor at 5% level of significance.

**Access to credit:** The participation of chickpea and access to credit has a significant and positive relation at 1% significance level. This implies; the chickpea producer had access to credit the chickpea output market participation increased by 9.3 percent.

**Chickpea variety:** The household heads used a new chickpea variety has significant and positive relation to the participation of chickpea output market. This is a result of use of improved seeds yields higher production keeping other factors constant. Besides, the case that improved seeds are perceived to be of high quality crops results in high demand and possibly higher selling price for the crop. The household used improved chickpea variety the participation of chickpea output market increased by 5.9 percent.

### **3.4. Amount of chickpea sold**

The smallholder demographic and socioeconomic factors are hypothesized to explain the variation in amount of chickpea sold. These include family size, age, education, land size, income from off farm, distance to market, income from other crop, access to credit and extension service. The Heckman selection model - two-step estimates that the land size is positive and statistically significant factor for total chickpea sold. But, income from other crop has a negative and statistically significant factor for quantity chickpea sold.

**Income from other crops:** The household's income from other crops is a negative related to the quantity of chickpea sold. This implies that as the household's income from other sources increased the amount of chickpea sold decreased. The income from other source has affected a quantity of chickpea sold at 10 % significance level.

**Land Size:** The respondent household's land size had positive and significant influence on the amount of chickpea sold at 5% significance level. A farmers could be hold large land size the entire This could be due to the role of land size in increase total production of crops and thus sales of surplus produce. Furthermore, the household participate in the output market because of the decision to allocate the land to consumption crop production and marketable crops. Other factors are constant the household head land size increased by 1 hectare the amount of chickpea sold increased 6.03 quintals.

#### **4. CONCLUSION**

Chickpea is one of the major pulse crops, which is the second most legume crop next to faba bean in Ethiopia. The study provides recent evidence on Chickpea market participation and marketed surplus and what factors affect the market participation and amount sold among smallholder farmers in Meskan woredas. The findings in this study showed that 80% of the households above informal education, thus, educated households had a better off to chickpea market participate. The 93.3% of age group of sample household was in productive age (i.e. 15-64) and experience in chickpea production. The productive age and experience of the households create to chickpea market participation. The average family size indicates that 5.46 person per households opportunity cost of labour, thus it could be the result of market surplus. The econometric model results showed that twelve explanatory variables, nine variables explained the probability of chickpea market participation. These are household sex, age, family size, education, quantity produced, fertilizer used, distance to market, chickpea variety, access to credit and extension service.

The land size increased, it was the source of chickpea market surplus. It indicates that, market surplus as well the basis of raise chickpea market participation of the households. In contrary income from other crops affect the chickpea output market negatively. These also decrease the chickpea market participation of the households.

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## Appendix

Appendix Table 1: Results of Heckman two stage estimation results and their marginal effect

Heckman selection model—two-step estimation  
(Regression model with sample selection)

Number of obs = 193  
censored obs = 8  
Uncensored obs = 185

Wald chi<sup>2</sup> (12) = 15497.16  
Prob > chi<sup>2</sup> = 0.0000

Variables	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]		dy/dx
<b>PARTCICKMARKET</b>							
<b>SEXHH</b>	.078	.024	3.19	0.001***	.030	.126	.084
<b>Family size</b>	.011	.004	2.47	0.014 **	.002	.020	.011
<b>AGEHH</b>	.002	.000	3.04	0.002**	.000	.004	.002
<b>EDUHH</b>	.007	.007	1.08	0.282	-.006	.021	.007
<b>QUNPRO</b>	.009	.005	1.74	0.081*	-.001	.019	.009
<b>LANDSIZE</b>	.038	.041	0.94	0.349	-.042	.120	.038
<b>INTFERTZER</b>	.051	.022	2.28	0.022**	.007	.095	.051
<b>Income Of farm</b>	3.92	2.66	1.48	0.140	-1.29	9.12	.000
<b>Dist Market</b>	.037	.002	13.43	0.000***	.032	.043	.037
<b>CHICKVARIETY</b>	.042	.018	2.33	0.020**	.006	.078	.042
<b>ACSCRT</b>	.096	.023	4.16	0.000***	.050	.141	.096
<b>EXTSER</b>	.128	.023	5.40	0.000***	.081	.174	.128
<b>CHICKPSOLD</b>							
<b>Family size</b>	.287	.211	1.36	0.173	-.126	.701	
<b>AGEHH</b>	.079	.061	1.29	0.198	-.041	.200	
<b>EDUHH</b>	-.117	.234	-0.50	0.617	-.576	.342	
<b>Income Of farm</b>	-.000	.000	-0.30	0.764	-.000	.000	
<b>Dist Market</b>	.151	.236	0.64	0.522	-.312	.615	
<b>INCOMEOCROP</b>	-.000	.000	-1.80	0.071*	-.000	.778	
<b>ACSCRT</b>	.379	1.24	0.31	0.760	-2.05	2.81	
<b>LANDSIZE</b>	5.99	2.94	2.04	0.042**	.221	11.7	
<b>EXTSER</b>	1.65	1.28	1.28	0.199	-.871	4.17	
<b>mills</b>							
<b>lambda</b>	.2523	.0585	4.31	0.000	.1375	.3671	
<b>rho</b>	1.000						
<b>sigma</b>	.1099						

Note: \*\*\*, \*\* and \* are significance at 1%, 5% and 10% respectively

(\*) dy/dx is for discrete change of dummy variable from 0 to 1

Appendix Table 2. Heckman two steps estimation results

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Heckman selection model -- two-step estimates      Number of obs      =      193
(regression model with sample selection)          Censored obs       =       8
                                                  Uncensored obs     =      185

                                                  Wald chi2(12)      =    15497.16
                                                  Prob > chi2        =     0.0000

```

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
PARTCICKMARKET						
SEXHH	.0784279	.0245691	3.19	0.001	.0302735	.1265824
Familysize	.0117867	.0045254	2.60	0.009	.002917	.0206563
AGEHH	.0025638	.0008508	3.01	0.003	.0008964	.0042313
EDUHH	.0081311	.006725	1.21	0.227	-.0050497	.021312
QUNPRO	.0110165	.005015	2.20	0.028	.0011873	.0208457
LANDSIZE	.0290405	.0391429	0.74	0.458	-.0476781	.1057591
INTFERTZER	.0450708	.0216007	2.09	0.037	.0027341	.0874075
IncomeOffarm	3.31e-06	2.54e-06	1.30	0.193	-1.67e-06	8.29e-06
DistMarket	.0388545	.0026568	14.62	0.000	.0336473	.0440617
CHICKVARIETY	.0598492	.0176766	3.39	0.001	.0252037	.0944947
ACSCRT	.0936086	.0221285	4.23	0.000	.0502375	.1369798
EXTSER	.1260541	.0226327	5.57	0.000	.081695	.1704133
CHICKPSOLD						
Familysize	.4926211	.268233	1.84	0.066	-.0331059	1.018348
AGEHH	.0627163	.0620645	1.01	0.312	-.058928	.1843606
EDUHH	-.245722	.2700069	-0.91	0.363	-.7749258	.2834817
IncomeOffarm	-.0000146	.0001383	-0.11	0.916	-.0002856	.0002564
DistMarket	.3187007	.3175228	1.00	0.316	-.3036324	.9410339
INCOMEOCROP	-.0001109	.000063	-1.76	0.079	-.0002344	.0000126
CHICKVARIETY	1.342565	.798038	1.68	0.093	-.2215605	2.906691
ACSCRT	.5070362	1.325903	0.38	0.702	-2.091686	3.105758
LANDSIZE	6.039077	3.011825	2.01	0.045	.1360088	11.94215
EXTSER	2.479091	1.454829	1.70	0.088	-.3723215	5.330504
_cons	-7.676617	5.671965	-1.35	0.176	-18.79347	3.440231
mills						
lambda	.2218047	.0505602	4.39	0.000	.1227086	.3209008
rho	1.00000					
sigma	.10489656					



# Gender Differential in Productivity and Income of Haricot Bean in Misrak Badawacho District of Southern Ethiopia

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## Abstract

This study investigated gender differential in agricultural productivity, highlights its key determinants, and estimated the gap in income generated from the production of haricot bean. The study was conducted based on data generated from 122 male headed and 39 female headed households from Misrak Badawacho district of southern Ethiopia. Descriptive and inferential statistics as well as econometric models were employed to analyze the data. The models used were Cobb-Douglas production function, and output decomposition model. The estimates of Cobb-Douglas production function showed that fertilizer, improved seed, pesticide, labor, total land size, project participation, number of extension contact, tropical livestock unit and distance from development agent center were significantly affect productivity of haricot bean. The estimate of decomposition model found that farm income differences between male and female headed household was 311 Birr. Based on the result of the study it can be recommended that enhancing resource endowment and institutional support is critical in increasing the productivity and income of female headed households in the study area.

**Key words:** Differential, Gender, productivity, household.

## 1. Introduction

The low growth rate of productivity in the African agricultural sector has been widely seen as one of the significant causes for the current high poverty rates and food insecurity. Despite the substantial progress made during the last two decades, Africa is still lagging behind in terms of production and yield levels, modern input uses, technology adoption, and access to credit or insurance markets which are often failing or incomplete (FAO, 2015).

Gender disparities in agriculture have been identified as another important hindering factor in African Agricultural transformation (Kilic *et al*, 2015). In sub Saharan Africa, women account for almost 50% of the agricultural labor force but suffer from low access to credit and other financial markets (Croppenstedt *et al*, 2013; Aguilar *et al*, 2014).

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In spite of the significant and growing role of pulse production for the economy at micro and macro levels, production of pulses in different regions of Ethiopia is severely constrained by lack of access and control over key resources and opportunities (Hailelassie *et al.*, 2007; MoARD, 2008). Recent studies suggested that women farmers have lower returns to inputs than men farmers, further contributing to the existing gap in agricultural productivity and women lag behind men in access to land, credit, and a broad range of technologies and training opportunities (Aguilar *et al.*, 2015; Gete *et al.*, 2015; Kilic *et al.*, 2015; Oseni *et al.*, 2015; Slavchevska, 2015).

Female-headed households and female farmers in male-headed households represent a large production resource in the agricultural sector, particularly in pulse cropping system. Yet many studies consider men as key players in crop and livestock production and are the principal beneficiaries in terms of control over income generated from the sale of produce (ILRI, 2010; Yenealem *et al.*, 2014; Gete *et al.*, 2015). Tewodros (2014) in his study in selected woredas of southern Ethiopia indicated that being female head of households reduced the likelihood of pulse market orientation by 0.331 compared to their male counter parts.

In the study area productivity of haricot bean and income generated from the crop is poor due to factors such as natural, socioeconomic and cultural factors of which gender differential is one and perhaps significant. The differential distribution of resources (financial, social, human and physical capital) between men and women affect the capacity of female headed households to generate more income (District Agricultural and Natural Resources Office, 2017). Therefore, Empirical analysis on the gender productivity differentials and their drivers is crucial to understand the ongoing changes in the area. Such analyses are important to design of sound and empirically-driven interventions.

The objectives of the study were, to investigate gender differentials in productivity, to identify factors contributing to gender disparity in productivity and to analyze gender differential on income from haricot bean.

## 2. Methodology

### 2.1. Description of the Study Area

#### Location and topography

Misrak Badawacho district is located in the East Rift Valley, 345 km of south of the national city Addis Ababa and is 121 km west of Hawassa, the capital city of the SNNPRS. The district lies between 7°05' N latitude and 37°-38°46' E longitude. Agro-ecologically: most of the *kebeles* (30) represents *weinadega* type (mid altitude) and the rest of the *kebeles* (9) represents *kola* type of agro ecology. The altitude of Misrak Badawacho is ranging from 1580 to 2050 m.a.s.l. The mean annual temperature of the district is 20.1°C and the annual rain fall ranges between 800 mm to 1500 mm, and it is bimodal. According to CSA (2013) report, the total human population of the district was about 171,524 out of which 85,210 were males and 86,314 were females, out of the total population about 143,267 live in rural *kebeles* and 28,257 live in town.

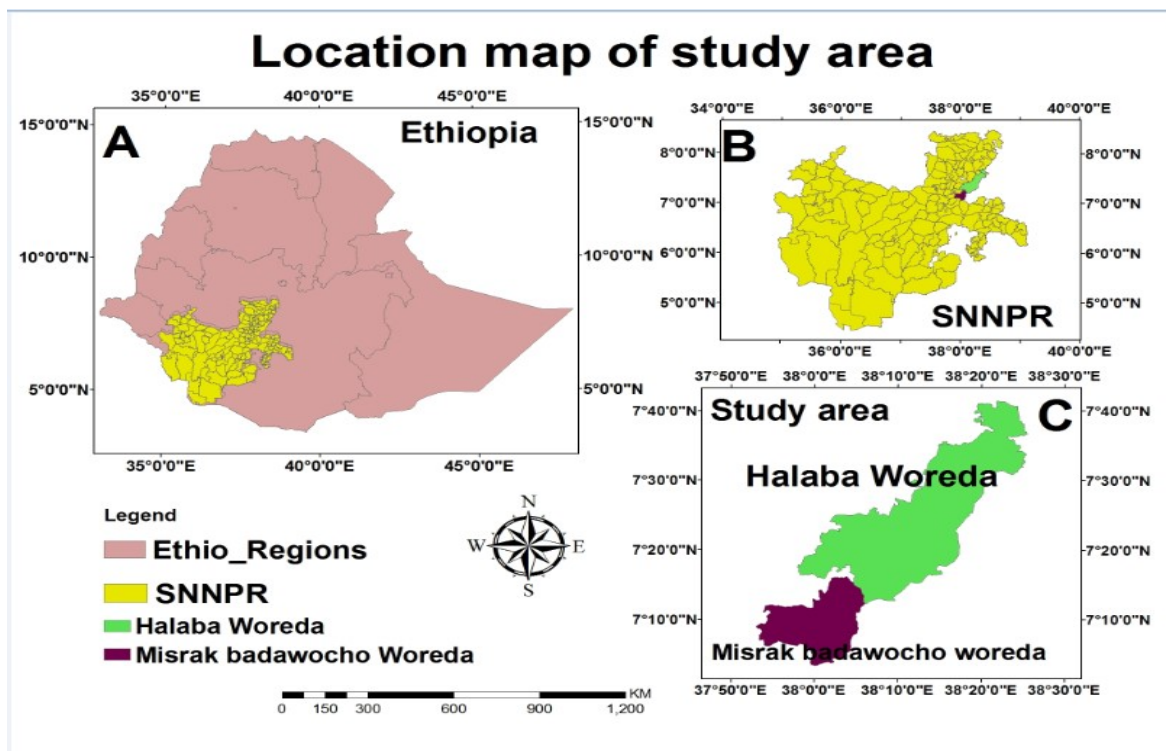


Figure 1 Location map of the study area

## 2.2. Research Design

### 2.2.1. Data Type, Sources and Methods of Data Collection

Mixed research design where qualitative and quantitative data were collected from primary and secondary sources. Primary data were collected directly from farmers through interview and focus group discussion. The major instrument for collecting the primary data was semi-structured questionnaire and focus group discussion checklist. Semi-structured questionnaire was prepared and pre-tested on 15 farmers to evaluate the appropriateness of the content, clarity and relevance of the questions. Hence, appropriate modifications and corrections were undertaken and then it was collected under supervision of the researcher. Secondary data were gathered from documented sources such as journal articles, books, thesis, dissertation, CSA, CIFISRF project. Moreover, data were also collected from Agriculture offices of selected districts.

### 2.2.2. Sample Size and Sampling Technique

#### Sampling Technique

A two stage sampling procedure was employed to reach at unit of analysis. In the first stage, two kebeles producing haricot bean were selected purposively based on their potential of pulse production. In the second stage, the sample farmers were selected using simple random sampling technique, and then stratified based on the sex of household head. Finally, 161 haricot bean producers from the two kebeles were selected for the study. Out of the total sample size 122 were male headed and 39 were female headed households. The number of female headed households is lower because their number in the study area is limited.

#### Sample Size

By using sampling design, the sample size was determined using sample size formula given by Yamane (1967).

$$n = \frac{N}{1+N(e^2)} = \frac{865}{1+865(0.07^2)} = 161 \text{ Households}$$

Where, n is sample size, N is total population producing haricot bean and chickpea, and e is the level of precision.

### 2.3. Methods of Data Analysis

Descriptive and inferential statistics as well as econometric models was employed to analyze the data. Specifically for analyzing gender disparity in pulse production and marketing, descriptive statistics such as frequency, percentage, means, and inferential statistics such as chi-square and t-test was used. Besides, econometric model was used to identify economic relationships. For this study, Cobb-Douglas production function was employed to find out factors affecting the gross male and female headed households' productivity in value term. To clearly distinguish corresponding implication on income level of both households (male and female headed) a decomposition model was in use. Both the models used in the study are described here under.

#### 2.3.1. Cobb-Douglas Production Function

This function is one of the most widely used functions in the economic analysis of problems to empirical estimation in agriculture. This power function was used in this specific study to investigate the agricultural productivity and income difference between male and female headed households. According to Gujarati (2003) Cobb–Douglas (CD) production function, in its stochastic form can be expressed as follows:

$$Y = AX_1^{b_1} X_2^{b_2} X_3^{b_3} \dots X_n^{b_n} e^{ui}$$

where, Y is the amount of farm output per hectare, Xi's are explanatory variables such as land size (ha), fertilizers (kg), plant protection chemicals (lit), livestock holding (TLU), male and female labor (man days), household head education level, number of extension contact, amount of credit used, project participation, and number of oxen. While A is an intercept and represents level of technology, beta represents elasticities of output for the respective inputs and u is error term.

Cobb-Douglas production function is not linear in parameter. So, one can't use Ordinary Least Square (OLS) estimation directly. But, as per Gujarati (2003) OLS is used extensively in regression analysis primarily because it is intuitively appealing and mathematically much simpler than the method of Maximum Likelihood (ML). Therefore, to apply OLS for estimating the parameters of Cobb Douglas, the power functions was transformed to logarithm form, which is linear in parameter.

The production function was estimated separately for male headed households and female headed households to find out their respective yield per hectare, due to heterogeneous nature and difficulty of aggregation in measuring of output physically hardly possible. In addition analysis was carried out for pooled data.

$\ln Y_{mi} = \ln A + \alpha_1 \ln X_{1m} + \alpha_2 \ln X_{2m} + \dots + \alpha_n \ln X_{nm} + U_i$  m stands for male headed households

$\ln Y_{fi} = \ln B + b_1 \ln X_{1f} + b_2 \ln X_{2f} + \dots + b_n \ln X_{nf} + U_i$  f stands female headed households

$\ln Y_{pi} = \ln C + c_1 \ln X_{1p} + c_2 \ln X_{2p} + \dots + c_n \ln X_{np} + U_i$  p stands for pooled data set

### 2.3.2. Output Decomposition Model

Blinder-Oaxaca decomposition (Oaxaca, 1973) is widely used to study mean outcome differences between groups. They initially used the technique to analyze the wage differential between two groups. The author divided the wage differential into a part that is “explained” by group differences in productivity characteristics such as education or work experience and a residual part that cannot be accounted for by such differences in wage determinants. The “unexplained” part is often used as a measure for discrimination, but it also includes the effects of group differences in unobserved predictors. Later researchers employed this technique to study group differences in any (continuous and unbounded) outcome variable. For example, O’Donnell et al. (2008) used it to analyze health inequalities by poverty status.

The rationale behind the Blinder-Oaxaca (OB) decomposition approach is therefore to show how much of the mean income difference  $G = E(Y_m) - E(Y_f)$ , with  $E(Y_m)$  and  $E(Y_f)$  denoting the expected values of income by male and female managers respectively, is accounted for by gender differences in the levels and returns of covariates X. Following Daymont and Andrisani (1984), the income difference, G can be written as:

$$G = E(Y_m) - E(Y_f) = [E(Y_m) - E(Y_f)] \beta_f + E(X_f)(\beta_m - \beta_f) + [E(X_m) - E(X_f)](\beta_m - \beta_f)$$

It follows the above equation that gender income difference can be explained by three factors:

- a) Differences between male and female managers in the levels of observable covariates X. In the above equation the first component in the right hand side gives the proportion of the estimated income gap explained by male and female differences in the levels of those covariates and is called the endowment effect.
- b) Differences in the returns of the covariates X. The second term, called the structural or coefficient effect, measures the part of the income differential attributable to differences in the returns of covariates (including the estimated coefficient of the intercept).
- c) Finally, the last component, the interaction effect, captures the portion of income gap coming from simultaneous differences in both the predictors and their estimated coefficients. A negative value of the first two components will imply that male managers have a structural advantage over female managers in regards to the specific covariate.

Accordingly, in this study the model was used to decompose source of difference in income of male and female headed household.

### **3. Results and Discussion**

#### **3.1 Socioeconomic and Demographic characteristics of the sample Respondents**

There was a significant difference between male and female headed households in education, family size, landholding and land use allocation, livestock holding, access to credit, extension service and agricultural inputs (Table 1). The finding signifies there are gender differential in access and control over resources.

Table 1. Socioeconomic and Demographic characteristics of the sample Respondents

Category	Description	Male headed households	female headed households	t –value
		Mean	Mean	
<b>Age</b>	Number of years	45.69	45.4	0.29
<b>Education</b>	Year of schooling	4.12	2.1	5.6102***
<b>Family size</b>	Measured in number	7.3	5.75	4.73***
<b>Total land size</b>	Measured in hectare	1.01	0.72	2.29**
<b>Total cultivated land</b>	Measured in hectare	0.81	0.52	2.36**
<b>Grazing land</b>	Measured in hectare	0.04	0.025	2.105**
<b>Home garden</b>	Measured in hectare	0.125	0.16	1.08**
<b>TLU</b>	Tropical livestock unit	3.15	2.14	2.44**
<b>Credit</b>	Amount of credit received	527	222	3.57***
<b>Number of extension contact</b>	Measured in number of contact made per month	24	14	5.26***
<b>Improved seed</b>	Measured in kilogram per hectare	66.15	43.4	2.69***
<b>Fertilizer</b>	Measured in kilogram per hectare	88	60	2.46***
<b>Labor</b>	Measured in man days per hectare	43	27	3.79***
<b>Pesticide</b>	Measured in litter per hectare	0.5	0.3	2.125**

Significant at \*\*\* (1%), \*\* (5%), and \*(10%)

### 3.2. Productivity Difference between the Male and Female Headed Households

Various studies revealed that women often achieve lower yields than men in agriculture. In Ghana for instance, Goldstein and Udry (2008) found that women had far lower yields, resulting in far lower profits per hectare, than their husbands who farmed the same crops. These studies



provide stark evidence of male and female yield differentials. Even in Ethiopia, Tiruneh *et al.* (2001) found that female-headed households had 35 percent lower value of farm yield per hectare than males. Below are the averages of areas allocated for haricot bean measured in hectare, amount produced measured in quintal, amount sold in quintal, and income obtained from the sale of the haricot bean measured in birr. The finding revealed a significant difference between male and female managers in area allocation, productivity, quantity sold and income generated from haricot bean (Table 2).

Table 2. Haricot Bean Production Difference by Sex of Household Head

<b>Haricot bean</b>	<b>Female headed households</b>	<b>Male headed households</b>	<b>t- value</b>
<b>Average area</b>	0.19	0.28	1.29***
<b>yield/hectare</b>	13.99	17.84	3.3213**
<b>Average amount sold in quintal/</b>	1.3	2.1	3.014***
<b>HB value</b>	1320.313	1632.042	3.7316***

Significant at \*\*\* (1%), \*\* (5%), and \*(10%)

### 3.3. Results of Econometric Models

In this section the identified explanatory variables were analyzed with the help of CD production function. Before fitting the data to CD production function, multicollinearity test for explanatory variables was done using VIF (variance inflation factor). The result of VIF test indicated that the VIF values of all continuous explanatory variables were below 10, hence the variables were included in the model for further analysis.

#### 3.3.1. Cobb Douglas Analysis Results

The output elasticity of fertilizer used by male and female headed households in the study area was positive and significant at less than 1% level of probability for male headed households, at

5% level of probability, for female headed households. The finding implying that increasing the amount of fertilizer used by 1% increases farm productivity by 22.3% and 9% for both male and female headed households respectively. The production elasticity of fertilizer was higher for male headed households than female headed households. The results are consistent as hypothesized and also in agreement with the findings presented by (Tchale, 2009) in Malawi where fertilizer was a key factor in production of major crops grown by smallholder farmers. Reardon *et al.* (1997) also found a positive effect of fertilizer on productivity in case studies from Burkina Faso, Senegal, Rwanda and Zimbabwe.

Labor contributed positively and significantly to the output elasticity at less than 1% level of probability for both male headed and female headed households. The result of the survey showed that increasing labor by 1% increases productivity by 31% and 14% for male headed households and female headed households respectively. The labor elasticity was higher for male headed households implying labor was more efficiently utilized in farm production in this household. This result is consistent with the finding reported by (Shambel, 2013).

Improved seed had positive and significant effect on households' farm productivity at less than 1% probability level for both male headed and female headed households. A 1% increase in improved seed increases farm productivity level by 4% and 8.8% for male and female headed households, respectively. Looking at elasticity of production with respect to improved seed measured in Kilogram, it was higher for female headed households than the male headed households. Tewodros (2013) also found that increasing agricultural inputs increases productivity of haricot bean in the case study from southern Ethiopia.

Pesticide has positive and significant effect on household's farm productivity. A 1% increase in pesticide measured in litter increases output level by 12% and 23% for male and female headed households, respectively. The elasticity is higher for female headed households. This result is consistent with the finding reported by Mukasa and Salami (2013).

Participation or being a member of projects increases household farm productivity in the study area. It had positive and significant impact on output elasticity. A status change from non-

participant to project participant, increases productivity by 305% for male headed households. It is significant at less than 1% probability level. Distance from DA center decreases household productivity by 3.5% and joint control of crop income in the household increases household productivity by 7.6% for male headed households.

Age of household head and total land size in male headed households significantly affect output elasticity. As the age of household head increases by 1%, productivity decreases by 1.03%. As the total land size of male headed households increases by 1%, productivity also decreases by 33%. This result might suggest that female managers would have an advantage over male managers since they cultivate on average smaller farms. However, since productivity differences between male and female managers still persist, other factors might be at play to explain the level of agricultural productivity. This result is consistent with the finding reported by (Mukasa and Salami, 2013).

An increase in family size was statistically significant in affecting output elasticity of female headed households. A 1% increase in family size of female headed households decreases farm productivity by 46%. Number of extension contact increases farm productivity for female headed households. As the number of extension contact increases by 1% in female headed households, productivity increases by 48%.

Table 3 Cobb Douglas Analysis Result for the Respondents

	<b>Female Headed Households</b>		<b>Male headed households</b>		<b>Pooled</b>	
<b>Variables</b>	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
<b>Fertilizer</b>	0.099**	0.03	0.223***	0.029	0.196***	0.024
<b>Improved seed</b>	0.088***	0.013	0.039***	0.01	0.062***	0.009
<b>Pesticide</b>	0.238 **	0.119	0.012**	0.003	0.009**	0.003
<b>Labor</b>	0.14 ***	0.039	0.31***	0.029	0.422***	0.025
<b>Age</b>	-0.013	0.029	-0.04**	0.02	-0.01	0.0186
<b>Total land size</b>	-0.25	1.14	-0.33**	0.458	-0.91**	0.405
<b>Family size</b>	-0.46**	0.153	-0.013	0.109	-0.128	0.087

<b>Education</b>	0.172	0.142	0.0523	0.062	0.0015	0.54
<b>Project participation</b>	0.643	0.806	0.588 ***	0.618	2.79***	0.537
<b>TLU</b>	0.23	0.002	0.025	0.134	0.029	0.115
<b>Credit</b>	0.594	0.642	0.447	0.445	0.0127	0.039
<b>Extension contact</b>	0.48***	0.115	0.0119	0.089	0.146**	0.061
<b>Distance from DA center</b>	-0.429	0.2914	-0.328**	0.155	-0.202*	0.017*
<b>Joint income control</b>			0.82**	0.465		0.118
<b><math>R^2</math></b>	0.770		0.869		0.823	
<b>Adjusted <math>R^2</math></b>	0.701		0.852		0.804	
<b>F-value</b>	41.42		46.21		71.6	

Significant at \*\*\* (1%), \*\* (5%), and \*(10%)

### 3.3.2. Decomposition of output differences

#### Source of income difference

The key source of income in the study area is agricultural outputs. Farmers get their income from sale crops, livestock and livestock products. There is a difference in income between the two households, where the total annual gross farm income of the female headed households was lower than that of male headed households by 311ETB due to lower agricultural productivity mainly due to lower use of farm inputs (Table 4).

Table 4. Income variability between male and female headed households

<b>1. Mean Income Differential</b>			
<b>Mean Income of male headed households</b>		1632	
<b>Mean Income of female headed households</b>		1320	
<b>Total Gap in Income</b>		311.7	
<b>2. Aggregate Decomposition</b>	<b>Endowment Effect</b>	<b>Structural Effects</b>	<b>Interaction Effect</b>
<b>Total</b>	554.4	253.1	495.8
<b>Share of total Gap</b>	177.8%	81.2%	159%

<b>3. Detailed</b>	Coefficient	Std. error
<b>Decomposition</b>		
<b>Education</b>	8.92**	0.804
<b>Tropical livestock unit</b>	26.8**	0.501
<b>Number of extension contact</b>	157***	0.85
<b>Improved seed Amount</b>	28.9***	0.1
<b>Fertilize(DAP)</b>	100.9***	0.74

Significant at \*\*\* (1%), \*\* (5%), and \*(10%)

The Oaxaca-Blinder decomposition model was used by previous studies to carryout income differential, (Duomontet et.al, 2012), and also used in other studies to compute productivity differential ((Mukasa and Salami, 2013). In this study, the Model result interpreted the income differential findings in three portions. The first portion is the endowment effect, i.e. the proportion of the income gap due to differences in the levels of observable variables between male and female managers, accounts for negative 554.4 Birr, while the second portion explains the structural effect, i.e. the portion of the gender differential attributable to the returns of the same variables, explains -253.1 birr of the gap magnitude. This implies that the income from farm could be increased by 554.4 birr if the female headed households could adjust their inputs to the same level of male headed households through increasing agricultural productivity and production. The third portion explains the interaction of the first two portions. Based on the result, female headed households could increase income from farm if they can be able to improve technological efficiency to the level of male headed households. The main cause for the difference in farm income of male and female headed households were differences in productive inputs access and use differential. Hence, from the model computed, it was observed the variables mentioned significantly contributed for the gap differently. Among the variables included in the model education, tropical livestock unit, number of extension contact, improved seed and fertilizer use differential was immense in explaining the difference in income obtained from production of haricot bean.

#### **4. Conclusions**

This study investigated gender differential in haricot bean productivity. It highlighted the key drivers of productivity and income differential from haricot bean between male and female headed households. As the estimates of Cobb Douglas production function indicates, use of pesticide, improved seed, fertilizer and labor use significantly affected the productivity of haricot bean for farmers in the study area. Therefore; increasing both male and female headed households' access to these key agricultural inputs is very important means to increase farm income by increasing farm productivity and production

The study revealed that male headed households owned more number of livestock (especially oxen), have more average cultivated land, and use more agricultural inputs than the female headed households, they generate more income from production of haricot bean than female headed households.

Education, livestock holding, extension contact, and input use were contributing factors for income differential in the production of haricot bean. Thus, enhancing the resource endowments such as livestock holding, and institutional support such as extension service, input supply, and education are critical to bridge the income gap between male and female headed households.

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# Community-based Haricot Bean (*Phaseolus vulgaris* L.) Seed Value Chain Analysis in Abeshge and Sodo Districts, Southern Ethiopia

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## ABSTRACT

The study was conducted to analyse community-based haricot bean seed value chain in Abeshge and Sodo Districts of Southern Ethiopia. The objectives of the study were four folds: identifying community-based haricot bean seed value chain actors and defining their roles; analyzing the cost and market margin of actors; analysing determinant factors of seed supply; and identifying constraints in the seed value chain. A multi-stage sampling technique was implemented for this study. The data were collected from both primary and secondary sources. Descriptive statistics, Value chain and econometric analysis were employed to analyse the data. Primary actors in the study are input suppliers, seed producers, collectors, South Seed Enterprise (SSE), Cooperatives and seed clients. Accordingly, the value chain activities are, input supply, production, value addition, marketing and final-use. The producer's share is highest in channel-III, which is 62.3% when producers sell their seed to SSE. The result of the multiple linear regression model indicates that market supply of haricot bean seed is significantly affected by farming experience in seed production, quantity of seed produced, frequency of extension contact and location (district). Late delivering of seed, shortage of improved seed, weak extension contact are main constraints in seed production in the study areas. The major seed marketing constraints include weak market linkage, low price at harvesting time, insufficient handling, poor quality seed and lack of storage centers in the production area. Hence, relevant seed value chain actors should join hands to upgrade the seed value chain to improve its performance and governance structure so as to overcome the prevailing constraints and seizing the opportunities.

**Keywords:** Value chain, Community-based, Seed, Actors, Market Margins

## 1. Introduction

Following cereal crops, pulses are important crops grown in most part of Ethiopia and in 2016 they covered 12.33% ha of cultivated land (CSA, 2017). From pulses, haricot bean provides an economic advantage to smallholders as source of protein, food security, and cash income; plays great role in soil fertility management; generate foreign currency; and create employment opportunity, , (Ferris and Kaganzi, 2008). Despite its importance, the national average yield is 16.94 Qts/ha for red bean which is low compared to its genetic potential (CSA, 2017). Seed is one of the most important yield-enhancing inputs in crop production; without seed farmers

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cannot be in production (FAO, 2006). The prevailing seed system in Ethiopia classified in to formal, community-based (semi-formal) and informal system. The formal seed sector covers only 15% of the national demand in Ethiopia (Dawit, 2010). The participation of the private sector in the pulse seed business is negligible; serving less than 7% of seed demand (Asnake et al., 2014). On the other hand, the informal seed system is incapable of producing improved seed with the required quality and quantity (Dawit, 2010; Kiros et al., 2009). Seed supply system and marketing in Ethiopia in general and the study areas in particular are weak and inefficient. For example, the supplies of certified grain legume crops seeds are less than 5% in Ethiopia (Zewdie et al., 2008)

Improved varieties of haricot bean in Ethiopia were not adopted by many farmers (Bekele et al., 2007). The main reasons are insufficient seed production (multiplication) and marketing systems that limit the availability of quality improved seeds, lack of credit, late delivery, low performance of extension services, poor linkage between different actors involved in seed supply system, and farmers' socio-economic situation (Ferris and Kaganzi, 2008; Zewdie et al., 2009).

Community-based seed supply is an intermediate between the formal and informal seed system and not well developed in Ethiopia (Abebe and Lijalem, 2011; Zewdie et al., 2008). The community based seed multiplication is owned and managed by farmers and supported by Non-Governmental Organizations (NGOs) and research centres. NGOs provide the financial assistance and capacity building (Thijssen et al., 2008) whereas the research system supplies early generation seeds. This system improves the access to high quality seeds and makes it available to farmers at affordable price. Thus, seed value chain study on community based seed system provide insightful feedback for possibility of value chain governance and upgrading. Successful value chains depend on, linkage between actors and their interactions. Abeshge and Sodo Districts there is insufficient seed production and lack of appropriate marketing systems of quality improved haricot bean seed. In addition, there are also poor linkages among actors. Improving input supply system, production, value addition, and marketing and strengthening farmers' participation in seed supply are key elements for proper functioning of community-

based seed value chain. In response of this fact, this study has been undertaken to narrow the research gap.

## **2. Methods**

### **2.1. Description of the Study Areas**

#### **Abeshge District**

Abeshge is one of the Districts of Southern Nations, Nationalities and People's Region State (SNNPRS), in Guraghe zone. It is located about 158 km southwest of Addis Ababa and 258.5 km northeast of Hawassa town, the capital of SNNPRS. The district is bordered on the south by the Wabe River which separates it from Cheha District, on the west and north by the Oromia Region and on the east by Kebena District. The District has 26 rural and 3 urban kebeles and has total population of 61,424 people, of which 32,450 (52.8%) are men and 28,974 (47.2%) women (CSA, 2007). The altitude of the District is varies between 1001 and 2000 m.a.s.l. The District has two agro climatic zones, *Woina-dega* (10%) and *Kola* (90%). Its annual rainfall varies between 801-1400 mm. The economy of the District is based on crop-livestock mixed farming system. The major crops produced in the District include maize, teff, sorghum, haricot bean.

#### **Sodo District**

Sodo is one of the Districts of SNNPRS in Guraghe zone and located at 100km to the southwest of Addis Ababa. The District bordered on the south by Meskan and on the west, north and east by the Oromia Region. Based on the 2007 Census conducted by CSA, the District has a total population of 134,683, of these 67,130(49.8%) were men and 67,553(50.2%) were women (CSA, 2007). The altitude of Sodo District is 1800-3400 m.a.s.l. The Agro-ecology classified into Woina-dega (65%) and Dega (35%) agro climatic zones and annual rainfall varies from 801 to 1200 mm. The economy of the District is dominated by mixed farming. The major crops of include wheat, sorghum, barley, haricot bean, pea and chickpea.

### **2.2. Data type and Sources of data**

The study employed both qualitative and quantitative approaches and the sources of data were primary and secondary sources. The qualitative approach used Focused Group Discussion, key

informant interview and observation whereas the quantitative approach employed questionnaire survey. The primary data were collected from seed producers, collectors, SSE and cooperative union. The survey was conducted through personal interview with randomly seed value chain actors by using questionnaire. The Key Informant Interviews and focused group discussion was carried-out after survey data collection completed. Secondary data were collected from Districts Agriculture and Natural Resources office, SNNPRS Bureau of Agriculture and Natural Resources, Hawassa University Canadian International Food Security Research Fund (CIFSRF) project. Relevant literature and documents were reviewed to provide theoretical background.

### **2.3. Sampling Procedure and Sample Size**

Multi-stage sampling technique was implemented to select community-based haricot bean seed producer kebeles and sample households. In the first stage, out of total kebeles of Abeshge and Sodo Districts' community-based haricot bean producer kebeles were purposively identified. In the second stage, from the identified community-based producing kebeles, four sample kebeles from Abeshge and three sample kebeles from Sodo District were selected randomly. In the third stage, out of the sampled kebeles community-based haricot bean seed producers farmers were separated from none producers. In the fourth stage, out of the identified community-based haricot bean seed producers 68 community-based haricot bean seed producer farmers were selected randomly. The numbers of respondents were determined by using a formula developed by Yamane (1967).

To determine the required sample size at 5% level of precision the following formula was applied:

$$n = \frac{N}{1 + N(e^2)}$$

Where: n = is the sample size, N = is total number of seed producers farmers in the selected Kebele and e = is the level of precision (0.05)

**Note:** Sample Kebeles are Hudad-7, Boketa, Tewul-gefersa and Fenta from Abeshge and Gogetie-2, Kela-zuria and Negassa from Sodo District. In addition to, 7 local seed collectors, SSE and Damot cooperative union were interviewed.

Table 5. Sample Distribution

Actors	Number of producers in sample kebeles		Sample size		Total Sample size
	Abeshge	Sodo	Abeshge	Sodo	
<b>Producers</b>	54	30	44	24	68
<b>Collectors</b>			<b>4</b>	<b>3</b>	<b>7</b>

Source: Own computation based on data from Abeshge and Sodo district offices

#### 2.4. Methods of Data collection

Development agents in each of study kebeles were trained for data collection. The questionnaire was pre-tested in two seed producer households in each kebeles.. Data were collected under intensive supervision and follow up of the researcher. Key informant interview was employed to get the supplemental information that shows current community-based seed value chain in the study areas. Focus group discussion was conducted to collect important data on constraints in value chain. The discussions were conducted in each selected kebeles with 6-8 participants per discussion group.

#### 2.5. Methods of Data Analysis

Descriptive statistics, inferential statistics and econometric analysis were employed to analyse the data. Thus; descriptive statistics, used percentages, means, so as to describing seed value chain actors, marketing function and household characteristics in the value chain. Whereas econometric analysis was used to analyse the determinates of seed supply in the study areas.

##### 2.5.1. Analysis of cost and marketing margins

As products move successively through the various stages, transactions take place between multiple chain actors, money and information are exchanged along product flow. (Kaplinsky and Morris, 2001 cited in Bezabih and Mengistu, 2011). The four steps of value chain analysis were applied in this study:

1. Mapping the value chain to understand the characteristics of the actors and their relationships.
2. Analyse the distribution of benefits in the chain or cost and market margin. This involves analysing the margins within the chain; who benefits from the chain and who would need support to improve performance and gains.

3. Defining upgrading needed within the chain. By assessing profitability within the chain and identifying chain constraints, upgrading solutions can be defined.
4. Emphasizing the governance role. Governance defines the structure of relationships and coordination mechanisms that exist among chain actors.

Estimates of the marketing margins are the best tools to analyse performance of market. Marketing margin was calculated by taking the difference between producers and consumer prices. Mathematically, produces' share can be expressed as:

$$PS = \frac{P_p}{C_p} = 1 - \frac{MM}{C_p} \quad (1)$$

Where: PS= Producer's share, P<sub>p</sub>= Producer's price, C<sub>p</sub> = Consumer price, GMM = Gross market margin and Total Gross Marketing Margin (TGMM) is always related to the final price paid by the end buyer and is expressed as a percentage (Mendoza, 1995)

$$TGMM = \frac{\text{Consumer Price} - \text{Producer Price}}{\text{Consumer Price}} \times 100 \quad (2)$$

Net Marketing Margin (NMM) is the percentage over the final price earned by the intermediary as his net income; once his marketing costs are deducted. The higher marketing margin diminishes the producer's share. An efficient marketing system is where the net margin is near to reasonable profit.

$$NMM = \frac{\text{Gross marketing margin} - \text{Marketing costs}}{\text{Consumer Price}} \times 100 \quad (3)$$

Gross Marketing Margin (GMM) is the difference between producer's price and consumer's price (price paid by final user). Mathematically computed as:

$$GMM = \frac{\text{Consumer price} - \text{Marketing gross margin}}{\text{Consumer price}} \times 100 \quad (4)$$

Where, GMM = Gross market margin.

### 2.5.2. Econometric analysis of Market supply model

This part of the analysis dealt with analysis of understanding determining variable for volume of seed supplied to market. Multiple linear regression was used to analyze factors affecting community-based haricot bean seed supply to the market in the study areas. This model is also

selected for its simplicity and practical applicability (Green, 2003). The multiple linear regression model was specified as  $Y_i = F(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11})$ , or

$$Y = X'\beta + U \quad (5)$$

Where  $Y_i$  = Amount of seed supplied to the market,  $X'$  = a vector of explanatory variables,  $\beta$  = a vector of parameters to be estimated and  $U$  = disturbance term and  $X_1$  = Age of HHH,  $X_2$  = Sex of HHH,  $X_3$  = Distance to market,  $X_4$  = Credit access,  $X_5$  = Number of extension contact,  $X_6$  = Educational level of HHH,  $X_7$  = Seed Farming Experience,  $X_8$  = Size of land holding,  $X_9$  = Quantity of seed Produced,  $X_{10}$  = Family size and  $X_{11}$  = District Dummy.

### Dependent and Independent variables Variable

Table 6 Summary of dependent and independent variables used in the model

Variable used	Explanation	Category	Code and unit of Measurements	Expected sign of the variables
<b>Dependent variable</b>				
<b>VSSM</b>	Volume of seed supply	Continuous	Quintal	
<b>Independent variables</b>				
<b>Age</b>	Age of Household Head	Continuous	Year	-/+
<b>Sex</b>	Sex of the Household Head	Dummy	0=Female 1=Male	
<b>DMkt</b>	Distance to Market	Continuous	Kilometre	-
<b>Credit</b>	Credit Access	Dummy	1=take credit 0=Otherwise	+
<b>FoEC</b>	Frequency of Extension Contact	Categorical	Number of contact	+
<b>LEdu</b>	Level of Education	Categorical	Number of year of schooling	+
<b>Land</b>	Land Size	Continuous	Total area of land in hectare	+
<b>SFExp</b>	Seed Farming Experience	Continuous	Year	+
<b>QSPro</b>	Quantity of Seed Produced	Continuous	Quintal	+
<b>Family</b>	Family Size	Continuous	Number	+/-
<b>District</b>	District of Household Head	Dummy	0=if Abeshge, 1= Sodo	

## 3. Results and Discussion

### 3.1. Demographic characteristics of sample households

The gender representation of the respondents indicates 88% male and 12% female. With regards to level of education; 14.6 %, 51.4 and 34 were attend non formal education, primary and secondary school, respectively. The average age of the respondents was 40 years and average

years of farming experience in seed production were 2 years. The average family and land size of household is 5.5 and 2.2 ha, respectively (Table 3).

Table 3. Demographic and socioeconomic characteristics of samples

Variables	Items	Total(N= 68)	
		N	%
Sex	Male	60	88.2
	Female	8	11.8
	Illiterate	10	14.6
Education	Primary	35	51.4
	Secondary	23	34
		<b>Mean</b>	<b>SD</b>
Age		40.	9.2
Experience		2	0.43
Family Size		5.5	2.1
Land size		2.2	0.9

Note: N is number of respondent, \*\*\* is statistically significant at 1% level.

Source: Own survey result (2017)

### 3.2. Value Chain Analysis

#### 3.2.1. Mapping actors and identifying their role in the haricot bean seed value chain.

According to UNIDO (2009), value chain mapping helps to identify the different actors involved in the value chain and understand the existing roles and responsibilities. Mapping seed value chain used qualitative and quantitative terms identified actors and map their roles and responsibilities. Hence, three major actor categories primary actors, chain supporter and chain influencer were identified. Four major roles and function was identified: input supply, production, and marketing and consumption. The value chain map of community-based haricot bean seed in Abeshge and Sodo woredas is shown in Figure1.

#### 3.2.2. Primary actors

##### Input Suppliers

Hawassa University Canadian International Food Security Research Fund (CIFSRF) Project is the only input supplier and financial source for seed producers. The project cover input expenses of community-based haricot bean seed in the Abeshge and Sodo Districts. Farmers repay seed in kind during harvesting season without interest.

##### Producers

All community-based haricot bean seed producers in Abeshge and Sodo Districts are small-scale seed farmers. Producers are the major actors who perform most of production functions from farm preparation to post-harvest handling and marketing of seed.

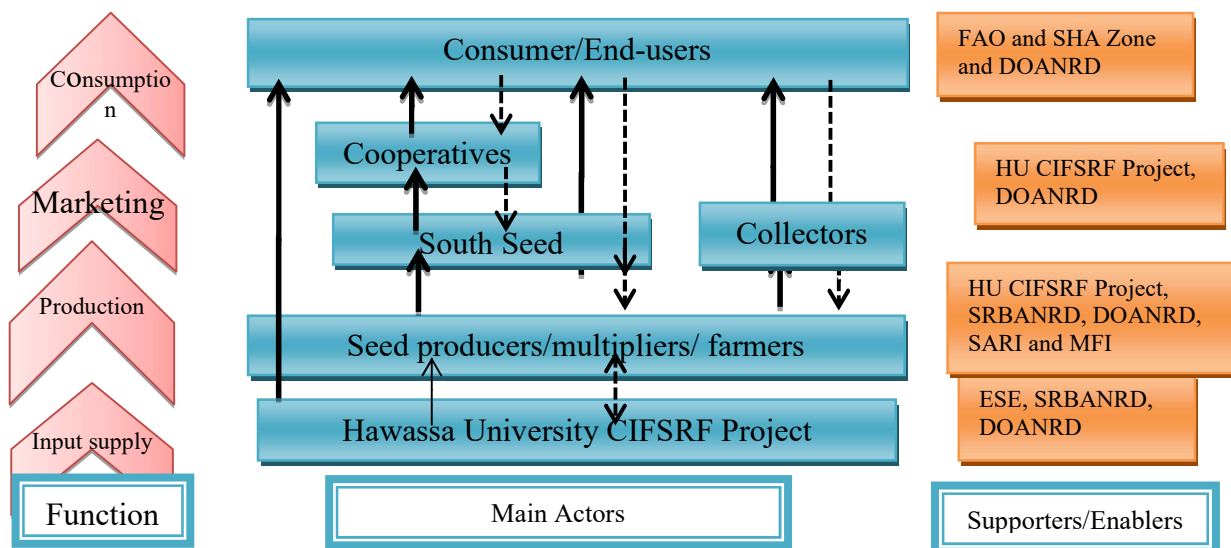


Figure 1 Value chain maps of community-based haricot bean seed

———→ Represents physical flow of inputs  
 ———→ Represent flow of products  
 - - - - -> One way flow of information  
 < - - - - -> Two ways flow of information and technology

### Local Seed Collectors

Seed collectors collect haricot bean seed from producers for the purpose of re-selling it to final-users. The activities of collectors include purchasing and collecting and selling seed to grain producers.

### South Seed Enterprise

South Seed Enterprise (SSE) purchase seed from producer farmers who can supply quality seed. Farmers submit seed to SSE with in specified day and the Enterprise purchase seed by premium price, 15% above grain price. The SSE purchase unclean seed and then transport, clean, and package, store and sell of clean and package at amount 25 kg and finally sold to grain producers.

### Cooperatives



The Cooperatives and Unions mainly involved in purchasing seed from South Seed Enterprise and transport and store seed until marketing and distribution of seed for members and non-members farmers carried out.

#### **Seed Users /Grain producer Farmers/**

Consumers or final-users are those purchasing the certified seed for grain production. About three types of seed consumers were identified: grain producer farmers, investors and NGOs (FAO and Self Help Africa). Grain producer farmers purchase certified seed directly from producers, collectors or from South Seed Enterprise and Cooperatives through District Agriculture and Natural Resources office. In general final-users have their quality criteria to purchase seed.

#### **3.2.3. Chain Supporters**

Hawassa University CIFSRF Project provides training and capacity building for experts on production and marketing of seed. Districts Agriculture and Natural Resource office provides extension and market information. SNNPRS Bureau of Agriculture and Natural Resources and District office of Agriculture and Natural Resources are playing facilitation role during input distribution. ESE, South Research Institute and Melkasa Research Institute supplies early generation seeds to CIFSRF project.

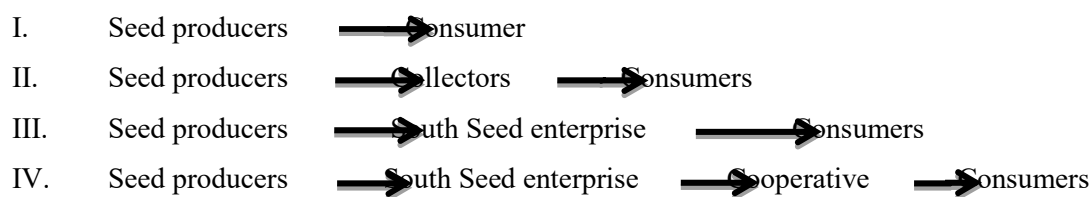
#### **3.2.4. Chain Influencers**

Field supervision, monitoring and quality controlling services were done by SNNPR Bureau of Agriculture and Natural Resources and in collaboration with Wolkite plant seed quality controlling centre. Decision on seed purchasing price by South Seed Enterprise was made by the committee established for buying price setting purpose. Federal and regional seed enterprises set price of certified seed selling prices. The smallholder farmers are not formally organized and due to low bargaining power they cannot governing the value chain, thus, farmers forced to sell their product at the price offered by collectors during harvesting time. There is weak linkage between producers and South Seed Enterprise. Most producers' seed were failed because of poor quality of seed; however, produce sold to the collectors were mostly sold in food grain market

with low prices. SSE was key value chain governor and seed market performance dependent on SSE, thus, the community-based seed value chains influenced by the South Seed Enterprise.

### 3.3. Haricot bean seed marketing channel

Four main alternative channels were identified for community-based haricot bean seed marketing. In 2016/17 total amount of production of haricot bean seed by sample respondents were 227.55 quintals and 161.85 quintals (71.12%) were supplied to the market.



### 3.4. Costs and Distribution of benefits among value chain Actors

Farmers incur costs during the production and marketing their produce. The marketing cost of the haricot bean seed mainly involves the cost of post-harvest activities. Table 4 indicates production and marketing cost related to the transaction of haricot bean seed by producers, collectors, South Seed Enterprise and Cooperatives.

Table 4 Costs of haricot bean seed value chain in birr per quintal

Items	Producers	Collectors	SSE	Cooperative
<b>Purchased price</b>	–	750	1190	<b>1913</b>
<b>Production costs</b>	650	–	–	–
<b>Total marketing costs</b>	44.5	60	340	<b>11</b>
<b>Total cost</b>	<b>694.5</b>	<b>810</b>	<b>1530</b>	<b>1924</b>

Source: Own survey result (2017)

Table 5 Marketing margin of haricot bean seed value chain

Actors	Items birr/quintal	Marketing channels			
		I	II	III	IV
<b>Producers</b>	Selling price	740	750	1190	1190
	Marketing costs	10	15	44.5	45.5
	Value added	80	85	495.5	495.5
	TGMM	0	39.3	37.8	38.3
	GMMp	100	61.2	62.3	61.7
<b>Collectors</b>	Purchasing price		750		
	Selling price		1220		
	Value added		405		
	GMMcl		38.5		

	NMMcl	33.2		
<b>SSE</b>	Purchasing price		1190	1190
	Selling price		1913	1913
	Value added		383	383
	GMMe		37.8	37.5
<b>Coop</b>	NMMe		20	19.8
	Purchasing price			1913
	Selling price			1930
	Value added			6
	GMMcp			1.0
	NMMcp			0.88

Source: Own survey result (2017)

Marketing margin can be used to measure the share (benefit) of the final selling price that is taken by a particular actor in the value chain. Gross Marketing Margin (GMM) is the percentage over the price earned by the producer/seller once his selling price is deducted. The TGMM was highest in channel-II which is 39.3%. Without considering channel-I (producers sell directly to final-users), the producers share was found to be the highest in channel-III which is 62.3%. This indicates that channel-III provides producers with better share of value created. In terms of profit made (value added), producer's profit was 80, 85, 495.5 and 495.5 birr per quintal for channel-I, II, III, IV, respectively. NMM was highest in channel-II, which 33.3% this is because collector directly purchases seed by low price from producers and sale to grain producers (Table 5).

### 3.5. Econometric Model Outputs

#### Determinants of Volume of Seed Supply to seed Market

Analysis of determinants of volume of market supply of seed was found to be important to identify seed supply to market by using multiple linear regression model. In this regard, eleven explanatory variables were hypothesized to determine the volume marketable supply of community-based haricot bean seed. The numbers of significant variables are four, which are Districts significant at 10%, seed farm experience at 5% significant level, amount of seed produced at 1% significance level and frequency of extension contact at 1% significance level (Table 6).

Table 6. Determinants of volume of seed supplied to the market

Variables	Coef.	std. Err	p-value
<b>District (Sodo)</b>	-.784	.404	0.058*
<b>Age</b>	.019	.018	0.287

<b>Sex</b>	-.097	.439	0.825
<b>Leduc</b>	.161	.269	0.553
<b>DMarket</b>	-.048	.157	0.763
<b>SFExp</b>	.939	.365	0.013**
<b>FSize</b>	-.046	.067	0.491
<b>LSize</b>	.097	.229	0.675
<b>ASProdu</b>	.328	.116	0.006***
<b>ACredit</b>	.124	.393	0.754
<b>FExt</b>	.734	.146	0.000***
<b>_cons</b>	-1.99	1.15	0.087
<b>N = 68    F/Ch<sup>2</sup> = 40.44***    R<sup>2</sup> = 0.88    Adj. R<sup>2</sup> = 0.86</b>			

Note: \*\*\*, \*\* and \* are statistically significant at 1%, 5% and 10%, respectively.  
Source: Own survey result (2017)

**District:** As the District is significantly at 10% significance level. Sodo District as compared to Abeshge District, the volume of haricot bean seed supply less than by 0.78 quintals, keeping other variables held constant. This is in line with Abraham (2013) who illustrated as Districts have effect on the volume of market supply of tomato in Habro and Kombolcha Districts in Oromiya Region attributed to agricultural protentional.

**Seed Farming Experience (SFExp):** Experience affects haricot bean seed market supply positively and significantly at less than 1% significance level. Thus, as farmer's experience increased by a year, seed supplied to market increased by 0.94 quintals. This is similarly Tadele and Ashalatha (2016) increase in volume of teff and wheat supplied to the market.

**Amount Seed Produced (ASProdu):** Amount of seed produced significantly and positively affected volume of seed supplied to the market at 1% significance level. Thus, a quintal increase in the amount seed production has caused an increase of 0.33 quintals of market supply of haricot bean seed. This is similar with Abraham (2013) an increase fruits and vegetables production has increased market supply of the commodities significantly in Habro and Kombolcha Districts.

**Frequency of extension Contact (FoEC):** It was positively and significantly associated with haricot bean seed volume of supply at 1% significant level. This indicates that as the number of contacts of farmer with Development Agent increases by a time, the quantity of supplied to the

market increased by 0.73 quintals of seed. The funding is in line with the study by Rehima (2006).

### **3.6. Constraints in the value chain**

#### **3.6.1. Production constraints**

During Focus Group Discussion farmers indicated that; the seed does not arrive on time and arrives after the farmers made alternative decisions on planting, this is in line with Zewdie et al. (2009). Productivity is below potential due to late delivery of seed. Amount of seed supplied to producers is inadequate and producers are not expanding production and supply of seed in the study areas. Accordingly, about 64.7% of the respondents responded that, as there is shortage of improved seed; the result has similar find as Dawit (2010) (Appendix Table 1). Due to involvement Agricultural development agents non-extension activities, the development agents not properly provide extension service for seed producers and some of development agents have no enough technical capability to support the seed producers; is similar as Zewdie et al. (2009).

#### **3.6.2. Marketing constraints**

Most of farmers need to sale early to cover their needs. However, purchase of seed by South seed enterprise is not conducted on time. Thus, marketing linkage between producers and South seed enterprise is weak. Due to this reason seed purchased by collectors at the price of grain during harvesting time. About 89.7% respondents mentioned the weak market linkage in the study area; the finding is in line with Zewdie et al. (2008; 2009). Poor farm management and post-harvest handling practice results poor quality seed, most of farmers produce poor quality seed and sold the product to by grain price. About 55.9% producers produced poor quality seed. The collection centers are vital for marketing and quality preservation; however, poor storage result in poor quality seed. About 52.2% of respondents have no proper storage place for the produced seed (Appendix Table 1).

## **4. Conclusion**

The major seed value chain actors in the study areas were input suppliers, seed producing farmers, collectors, South Seed Enterprise, Cooperatives Union and final users. Hawassa University CIFSRF Project supply inputs while community based seed producers members involved in seed production. Farmers are small-scale and formally unorganized; Efforts should

be made by government and CIFSRR Project to strengthen the yet infant seed producers to become organized seed producing and commercial seed producing Enterprise. Major actors such collectors, SSE, cooperative involved in seed and information flow from producers to final users. Hawassa University CIFSRR project, SNNPR Bureau of Agriculture and Natural Resources, Districts Offices are chain supporters. Seed regulatory authority, seed laboratory (Wolkite plant seed controlling centre) and research centres are chain influencers as they influence the quality and quantity of seed marketed.

The producer's share is highest in channel-III (producers-SSE-consumers), when they sale to SSE which is 62.3% and they get highest profit from channel-III which is 495.5 birr per quintal. The collectors purchase seed from the farmers at a lower price and sell at higher price. The main reasons farmers sell seed to collectors were due to late purchasing of seed by SSE and when rejected due to low quality of seed. The strong market linkages between producers and South Seed Enterprise needs to be enhanced by designing contract farming arrangements for mutually benefit and sustainability of production and marketing quality seed.

Market supply of haricot bean seed is significantly affected by district attributed to agricultural potential, seed production experience, quantity of haricot bean seed produced, and frequency of extension contact. Constraints of production are late (untimely) delivering of seed, shortage of improved seed, weak extension service. The major seed marketing constraints are weak market linkage, low price during harvesting time, insufficient handling and poor quality seed that cannot meet standard set by SSE and lack of storage facilities in the production areas and this reduce market supply of seed and profit of farmers. Seed should deliver at the right time to enhance productivity, and sustain of seed the supply. Production of seed should be according to Agro-ecology of Districts. Increasing the use of improved seed and farm management practices could increase productivity and amount of market supply. To maintain quality access to improved storage facilities should be enhanced at farm gate level and educating producers on post harvest handling activities of seed is the right pathway. Strengthen of linkages among community-based seed value chain actors shall be done. Strengthening extension contact by providing continuous capacity building and separating extension providers from other administrative activities should be done by Districts Agricultural and Natural Resources office.

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## Appendix

Appendix Table 1. Major Constraints of community-based seed production and marketing

Production constraints	Responses			
	Yes	%	No	%
<b>Late delivering of seed</b>	68	100	-	-
<b>Shortage of seed</b>	43	63.2	25	36.8
<b>Pest</b>	21	31	47	69.1
<b>High rain-fall</b>	12	19.1	56	82.4
<b>Marketing constraints</b>				
<b>Low price at harvesting time</b>	44	64.7	24	35.3
<b>Lack of storage</b>	35	51.5	33	48.5
<b>Market Linkage Problem</b>	57	83.8	11	16.2
<b>Poor quality of seed</b>	38	56	30	44.1

Source: Own survey result (2017)



# Consumers' Preference and Willingness to Pay for Chickpea Enriched Snack Products in Shashamane and Hawassa Cities, Ethiopia

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## Abstract

This study investigated the consumer preference and willingness to pay (WTP) for chickpea enriched snack products traits. Using choice experiment, we generated 8,400 observations from a random sample of 700 households in Shashamane and Hawassa city administrations. The study employed both descriptive statistics and econometric models to analyze the data collected from individual respondents through structured survey. Taste parameters and heterogeneities were estimated using the generalized multinomial logit model (G-MNL) and its different versions. The preference heterogeneities were observed with respect to all attributes. The taste heterogeneities around the mean were partially explained by sex, family size and educational level of the respondent. The results from both preference space and willingness to pay (WTP) space of the full G-MNL model revealed that nutritional and health claim labeling, mango flavor, sorghum chickpea main ingredient and the product mixed shape are the traits that have a strong in order and positive significant effect on choice of chickpea enriched snack products.

**Key words:** Snack products, Choice experiment, Generalized Multinomial L, Preference heterogeneity, Willingness to pay

## 1. Introduction

Snack food products are becoming an important part of the human diet as their convenience and availability attract consumer attention (Nor *et al.* 2013). Many of these ready-to-eat food products are high in fat, calories, salt and low in starch, protein and fiber. Cereal and pulse grains are excellent sources of protein and starch. Pulses, in particular, provide around one-fourth of dietary protein in many countries and are a good source of the essential amino acid lysine (Brennan *et al.* 2016) and is a cost-effective source of protein that accounts for approximately 15% of protein intake (Boere *et al.*, 2015). Therefore, enrichment of cereal-based foods with pulse protein has received considerable attention. There has been a trend to incorporate bran from various sources into cereal products as a high protein-fiber source (Hegazy *et al.*, 2009). Snack foods have a large impact on agricultural production and marketing as well as on agrifood processing business operations.

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Ethiopia is a culturally rich and diverse nation having varied lifestyles, religions, art, culture, attire and food. Within the manufacturing sector, the agro food processing is the largest subsector accounting for 36% of the total gross value of production (CSA, 2014) and 33% of the national value added (Legesse, 2015) of large and medium scale manufacturing industry. The country has a lot of potential from the supply side but is poorly organized with respect to connectivity, reliable supply, technology level and knowledge. However there are various industries tackling this issue by setting up their own supply chain (Bore *et al.*, 2015). Just like in many other successful industries, there is also a severe competition in this industry (Mammadli, 2016). Dynamic business environment and growing competition among market players force snack food operators to sustain competitive advantage, utilize their resources and enhance their operation. One way to achieve that is to constantly strive for improvement, keep up with changing customer needs, perceptions, habits, and retain market share through a carefully built marketing strategy.

The ever increasing and complicating customer demands and expectations makes competition among market players even tougher. Furthermore, several studies (Enz, 2010; Parsa *et al.*, 2011 and Wood, 2015) claim that the food industry has the highest business failure rates among other industry sectors. Parsa *et al.* (2011) further notes that poor performance and business failures are the consequence of misconception of the growing customer demands, needs and expectations. Production and marketing strategies are determined by consumer beliefs, attitudes, preference and willingness to pay. In order to implement the appropriate marketing concept, marketers require information about the characteristic, needs, wants and desires of their target markets.

In the free market, consumers dictate the market and play a vital role in the healthy functioning of local, national or international economies. In such market to become a successful producer and marketer, food product/service industry should have to maximize their selling by implementing appropriate marketing strategy which leads to successful relationships of consumer value, satisfaction and retention. Therefore, it is necessary for food producers and supply chain members to know the consumers' preference and willingness to pay a premium for the product and the main attributes that consumer value more to produce the product with preferred traits.

Hence, the study analyzed the consumer preferences for chickpea enriched snack products and consumers' willingness to pay for each attribute of the products and assessed the socio-demographic factors that affect consumer choice in Shashamane and Hawassa cities. Data from a choice experiment respondents of 700 randomly selected consumer in Shashamane and Hawassa city administrations were utilized. The taste parameters, preference heterogeneities, and the implicit prices of preferred chickpea enriched snack product traits were estimated by generalized multinomial logit model (G-MNL) (Fiebig *et al.*, 2010).

## **2. Research Methodology**

### **2.1. Description of the study areas**

This study was conducted in two cities of southern Ethiopia Hawassa and Shashamane. Hawassa is located in the Southern Nation's Nationalities and Peoples Region (SNNPR) on the shores of Lake Hawassa in the Great African Rift Valley. It is located at about 273 km south of Addis Ababa along the Ethio - Kenya highway. It serves as the administrative center of the SNNPR and Sidama zone. Geographically, it lies between 7°3' latitude North and 38°28' longitude east. The average altitude of the city is 1697 m.a.s.l. The city administration has an area of 157.2 sq. Kms, divided in to 8 sub-cities and 32 *Kebeles*. The urban population of Hawassa city is 328,562 based on the 2007 census result projection for 2017. Shashamane city is located in Oromia National Regional State, West Arsi Zone, at a distance of 250 km from Addis Ababa. It is located at 7° 12' North Latitude and 38° 36' East Longitude. The city administration has eight sub cities and 12 *kebeles*. The total population of Shashamane city is 147,800 based on the 2007 census result projection for 2015.

### **2.2. Sampling procedures (sample size determination and sampling techniques)**

#### **2.2.1. Sample size determination**

For this study, the target population was all households and individual consumers belonging to different socio-economic group in Hawassa and Shashamane cities. According to Cattin and

Wittink (1982), the median sample size for studies that analyze consumer preference ranges between 100 and 1000 subjects, with 300 to 550 most typical range. Many consumer preference studies used non formula based (purposive) sample size determination and determines the size that they believed large enough for their analysis. For these study, like other similar study, a total of 700 (400 from Hawassa and 300 from Shashamane cities based on their population proportion) samples were selected to ensure the accuracy and reliability of the estimation.

### **2.2.2. Sampling techniques**

Multistage sampling technique was employed to select representative respondents for this study. In the first stage Shashamane and Hawassa cities were selected purposively based on their potential of urbanization, customer size and proximity to snack production plant and study site. In the second stage, four sub-cities were randomly selected from each cities. Thirdly, 400 representative respondents from selected sub-cities of Hawassa and 300 representative respondent from selected sub-cities of Shashamane were selected using Systematic random sampling technique.

## **2.3. Research design**

In this study, mixed research design with sequential strategy was applied. Because mixed method enables harnessing the strengths of both qualitative and quantitative approaches and tackle disadvantages of both designs. The qualitative data were obtained from participatory market appraisal and key informant interview with knowledgeable respondents during the product attributes determination. The quantitative data was collected through face-to-face interview by using structured questionnaire and choice experiment cards that depicted the alternatives respondents had to choose from.

### **2.3.1. The Selection of the product attributes and levels**

For this study, the process of selecting attributes included discussion with scientific experts and industry stakeholder, Participatory market appraisal and a review of relevant literature. Chickpea enriched snack food has been selected as the product to be examined in this study. The major attributes of this product were the main ingredients, flavor of the products, price per unit, if the products are labeled their health/nutritional claim or not and shape of the products. Main ingredient attribute has three levels: sweet maize, maize-chickpea and sorghum-chickpea while two levels are specified for shape attributes: spherical and mixed. The flavor has two levels; mango flavor and spicy tomato flavor. In this study, health/nutritional claim labeling attributes has two level: labeled and not labeled. According to observations for other snack food products prices from food super market and retail shop in Hawassa and Shashamane cities, four levels are selected for price attributes. These selected price levels are 2 Birr, 4 Birr, 6 Birr and 8 Birr for 20g package of pulse enriched snack food products.

### **2.3.2. Choice Experiment Design**

The full factorial design of five attributes: with one four-level factor, one three-level factor and three two-level factors contained 96 possible combinations of alternatives ( $2^3 \times 4 \times 3$ ) was assigned to NGENE Software and a fractional factorial efficient design consisting of 12 choice sets was derived using the Halton (50) sequence in NGENE (Choice Metrics, 2014) software. We include opt out option in each choice sets and the respondents were presented with these 12 choice sets each with three alternatives, two alternatives refer to product profiles with varying level of each attributes and the third option refers to an opt out alternative.

### **2.4. Methods of Data Collection**

The primary data was a collected through a face to face interview with the sample respondents. The profile cards were prepared for each choice set and every respondent was given 12 choice sets and asked to choose one out of the three alternatives that were presented on each choice set. This makes the total number of completed choice situations 8,400 ( $700 \times 12$ ) were elicited from 700 respondents who participated in the stated choice experiment.

### **2.5. Statistical and Econometric analyses**

Both descriptive statistics and econometric analyses have been used to analyze the data collected from individual respondents through the formal survey. Statistics such as simple measures of central tendency, table, frequency, percentages and Chi-square test were employed. NLOGIT 6 (Econometric Software, 2016) was used to fit a wide range of generalized multinomial logit (G-MNL) models. The model was estimated by simulated maximum likelihood using Halton draws with 50 replications.

### 2.5.1. Discrete choice model

The conditional logit (CL) is the most common model used to analyze data from choice experiments (McFadden, 1974). These model is based on the random utility theory. The random utility model split the total utility in to two parts: a deterministic component based on product attributes  $j$  ( $V_{ij}$ ) and a stochastic or random, unobserved error component ( $\varepsilon_{ij}$ ) (Louviere *et al.*, 2000; Heiss, 2002). The resulting utility equation is:

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \quad j = \text{alternative 1, 2, and 3}, \quad (1)$$

where,  $U_{ij}$  is the utility of the  $i^{th}$  consumer choosing the  $j^{th}$  alternative.

The conditional logit model assumes independent and identically distributed (iid) error terms with a Type I extreme value distribution. CL also assumes independence of irrelevant alternatives (IIA). IIA states that the inclusion or exclusion of an alternative from the choice set will not affect the probability of an alternative being chosen (Hensher *et al.*, 2005). The mixed logit model relaxes the IIA assumption by allowing heterogeneity of preferences for observed attributes. Hence, the utility weight ( $\beta_i$ ) for a given attribute will be given as;

$$\beta_i = \beta + \Gamma v_i \quad (2)$$

where  $\beta$  is the vector of mean attribute utility weights in the population,  $\Gamma$  is a diagonal matrix which contains  $\sigma$  (the standard deviation of the distribution of the individual taste parameters ( $\beta_i$ ) around the population mean taste parameter ( $\beta$ )) on its diagonal, and  $v$  is the individual and choice specific unobserved random disturbances with mean 0 and standard deviation 1 (Fiebig *et al.*, 2010).

Another improvement over the conditional logit model is the scaled multinomial logit (S-MNL) model. The S-MNL formulation allows the model to accommodate scale heterogeneity; i.e., variance in utility across individuals. The added advantage of S-MNL can easily be seen for the fact that in the simple multinomial (MNL) and mixed or random parameters (MIXL) logit specifications, there is a scale or variance that has been implicitly normalized (to that of the standard extreme value distribution) to achieve identification (Fiebig *et al.*, 2010). In S-MNL, the utility weights are given as;

$$\beta_i = \sigma_i \beta \quad 3$$

The scaling factor,  $\sigma_i$  differs across individuals, but not across choices. This also implies that the vector of utility weights  $\beta$  is scaled up or down proportionally across consumers by the scaling factor  $\sigma_i$ . Fiebig *et al.* (2010) and Greene (2012) have developed a generalized multinomial logit model (G-MNL) that nests MIXL and S-MNL to avoid the limitations observed in MIXL. In G-MNL, the utility weights are estimated as;

$$\beta_i = \beta \sigma_i + \gamma \Gamma v_i + (1 - \gamma) \sigma_i \Gamma v_i \quad 4$$

The generalized mixed logit model embodies several forms of heterogeneity in the random parameters and random scaling, as well as the distribution parameter  $\gamma$  which ranges between 0 and 1. The effect of scale on the individual idiosyncratic component of taste can be separated in two parts: unscaled idiosyncratic effect ( $\gamma \Gamma v_i$ ) and scaled by  $(1 - \gamma) \sigma_i \Gamma v_i$  where  $\gamma$  allocates the influence of the parameter heterogeneity and the scaling heterogeneity. The parameter  $\gamma$  also governs how the variance of residual taste heterogeneity varies with scale in a model that includes both (Fiebig *et al.*, 2010). Several interesting model forms are produced by different restrictions on the parameters. For example, if we set the scale parameter  $\sigma_i = \sigma = 1$ , the model becomes ordinary MIXL. If  $\gamma = 0$  and  $\Gamma = 0$ , we obtain the scaled MNL model. Two unique forms of G-MNL are also presented by Fiebig *et al.* (2010). By simply combining 2 (MIXL) and 3 (S-MNL), G-MNL-I is formed whereby the utility weight is given as;

$$\beta_i = \beta \sigma_i + \Gamma v_i \quad 5$$

The other form is called G-MNL-II developed based on MIXL and explicit specification of the scale parameter to yield

$$\beta_i = \sigma_i (\beta + \Gamma v_i) \quad 6$$

where  $\sigma_i$  captures the scale heterogeneity and  $\sigma_i \Gamma v_i$  captures residual taste heterogeneity. The difference between G-MNL-I and G-MNL-II is that in G-MNL-I, the standard deviation of  $\Gamma v_i$  is



independent of the scaling of  $\beta$ , whereas in G-MNL-II, it is proportional to the scale heterogeneity  $\sigma_i$ . G-MNL approaches G-MNL-I as  $\gamma$  approaches 1, and it approaches G-MNL-II as  $\gamma$  approaches 0. In the full G-MNL model,  $\gamma \in [0, 1]$  (Fiebig *et al.*, 2010).

Greene and Hensher (2010) proposed including the observable heterogeneity already in the mixed logit model and adding it to the scaling parameter as well. Also allowing the random parameters to be correlated (via the nonzero elements in  $\Gamma$ ), produces a multilayered form of the generalized mixed logit model;

$$\beta_i = \sigma_i [\beta + \Delta z_i] + [\gamma + \sigma_i(1 - \gamma)]\Gamma V_i \quad 7$$

Following Kassie *et al.*, (2017), some of the appealing modifications and extensions of the general framework presented by Greene (2012) have been taken into consideration. Greene's specification of the utility weight explicitly shows how heterogeneities are accommodated in the above equation 7.

Following the G-MNL model specification in green (2012), the probability that individual  $i$  chooses alternative  $j$  from set in choice task  $t$  is given by:

$$P(j, X_{it}, \beta_{ir}) = \frac{\exp(X'_{ijt} \beta_{ir})}{\sum_{j=1}^{J_{it}} \exp(X_{ijt} \beta_{ir})} \quad 9$$

Where  $\beta_{ir} = \sigma_i [\beta + \Delta z_i] + [\gamma + \sigma_i(1 - \gamma)]\Gamma V_i$ ,  $\sigma_{ir} = \exp\left(\frac{-\tau^2}{2} + \sigma' h_i + \tau w_i\right)$ ,  $v_{ir}$  and  $w_{ir}$  are the  $R$  simulated draws on  $v_i$  and  $w_i$ .

### Estimating willingness to pay for snack food products' traits and trait levels

This generalized mixed model also provides a straightforward method of re-parameterizing the model to estimate the taste parameters in willingness to pay (WTP) space, which has recently become a behaviorally appealing alternative way of directly obtaining an estimate of WTP (Fiebig *et al.*, 2010, Fosgerau, 2007, Greene, 2012, Scarpa *et al.*, 2008, Train and Weeks, 2005, Hensher and Greene, 2011). If  $\gamma = 0$ ,  $\Delta = 0$  and the element of  $\beta$  corresponding to the price or cost variable is normalized to 1.0 while a nonzero constant is moved outside the brackets, the following re-parameterized model emerges:

$$\beta_i = \sigma_i \beta_c \left[ \begin{pmatrix} 1 \\ \frac{1}{\beta_i} \end{pmatrix} (\beta + \Gamma V_i) \right] = \sigma_i \beta_c \left[ \theta_c + \Gamma V_i \right] \quad 10$$

This model produces generally much more reasonable estimates of willingness to pay for individuals in the sample than the model in the original form in which WTP is computed using ratios of parameters (Train and Weeks, 2005; Greene and Hensher, 2010; Hensher and Greene, 2011).

### 3. Results and Discussion

#### 3.1. Description of Demographic and Socioeconomic Characteristics of Respondents

##### 3.1.1. Age and family size of the respondents

The average age of the sample respondents was 27 years (in 14 to 53 age range), whereas it was 27.3 and 26.6 for Shashamane and Hawassa cities, respectively. The total sample had an average family size of about 3 persons with a range of 1 to 9 persons (Table 1).

**Table 1: Sample respondents' age and family size**

Variables	Cities								Total (n=700)			
	Hawassa (n=400)				Shashamane (n=300)							
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Age	26.64	7.319	14	53	27.27	7.208	16	53	26.91	7.0485	14	53
Family-size	2.90	1.826	1	9	2.56	1.944	1	9	2.75	1.0118	1	9

### 3.1.2. Gender and marital status of the respondents

Out of the total respondents interviewed 51.1% were males while the rest 48.9% were females. The result shows that the sample constituted males and females in comparable proportions. In Hawassa, 52% were female and 48% were male while in Shashamane 55.3% were male and 44.7% were female (Table 2). Chi-Square test indicates, no significant difference in sex of respondents among the cities at 95% level of confidence. About 59.5%, 40.0% 0.5% were married, single and divorced, respectively in Hawassa, whereas 53.3%, 44.7%, 2.0% were single, married and divorced, respectively in Shashamane city. For the entire sample, 53.1% were married, 45.7% were single and 1.1% were divorced (Table 2). These variation in marital status of respondent among the two study cities were statistically significant at less than 1% level of statistical error.

**Table 2: Sample Respondents' Sex, Marital Status and Educational Level**

Variables	City				Total		Chi-Square	Sig.
	Hawassa		Shashamane					
Sex	Freq	%	Freq	%	Freq	%	3.690	.055
Female	208	52%	134	44.7%	342	48.9%		
Male	192	48%	166	55.3%	358	51.1%		
Total	400	100.0%	300	100.0%	700	100.0%		
Marital status the Respondents							17.139	.000***
Single	160	40.0%	160	53.3%	320	45.7%		
Married	238	59.5%	134	44.7%	372	53.1%		
Divorced	2	0.5%	6	2.0%	8	1.1%		
Total	400	100.0%	300	100.0%	700	100.0%		
Education status of the respondents							64.664	.000***
Illiterate	1	0.2%	16	5.3%	17	2.4%		
Write & read	17	4.2%	34	11.3%	51	7.3%		
Elementary	87	21.8%	88	29.3%	175	25.0%		
High school	114	28.5%	95	31.7%	209	29.9%		
Technical college	47	11.8%	27	9.0%	74	10.6%		
Diploma	83	20.8%	21	7.0%	104	14.9%		
Degree holder	51	12.8%	19	6.3%	70	10.0%		

Note, \*\*\* Significant at 1% level.

### 3.1.3. Educational status of the respondents

About 2% of respondents were illiterate and 7% can only read and write whereas 25% were in elementary schools, 30% in high school, 11% attended technical college, 15% diploma level, 10% University Degree holder (Table 2). Illiteracy level of the respondent was high in Shashamane

than Hawassa. The result of Chi-Square test shows that the difference in the educational status of the respondent in the two cities was statistically significant at 1% level of statistical error.

### **3.2. Econometric Results**

The empirical results for discrete choice experiments data were estimated by a flexible generalized multinomial logit (G-MNL) modelling approach that can accommodate scale as well as preference heterogeneity (Fiebig *et al.*, 2010). Mean preference parameter estimates for all attributes had the expected signs and were statistically significant at 1% and 5% levels of statistical error in all formulations of the G-MNL model. The significant standard deviations for the random parameters in G-MNL models show the unobserved heterogeneity in preferences coefficient for the choice attributes. In order to prove the explanatory power of the models, the McFadden pseudo R-squared was used as a goodness-of-fit measure. According to Hensher *et al.* (2005), a McFadden pseudo- $R^2$  of at least 0.3 represents an appropriate model fit. This study shows the model has a McFadden pseudo R-squared range of 0.43 to 0.45 which implies the model fit well.

#### **3.2.1. Basic G-MNL model results**

The full G-MNL model (no restriction on  $\tau$  and  $\gamma$ ) indicated nutritional and health claim labeling, mango flavor, sorghum chickpea main ingredient and mixed shape of products are the traits that have a strong in order and positive significant effect on choice of chickpea enriched snack products compared to their respective reference level. Unobserved heterogeneities were also evident around mean taste parameters for shape, flavor, nutritional and health claim labeling and price of the products. All the formulations of the generalized multinomial logit (G-MNL) models generated comparable results by order and direction of influence on consumer decision and significance level. Significant unobserved heterogeneities were evident around mean taste parameters for mango flavor, nutritional and health claim labeling and price of chickpea enriched snack products in G-MNL-II. Compared to full G-MNL model, the unobserved heterogeneities coefficient for mango flavor and nutritional and health claim labeling were quite heavier and the unobserved heterogeneities coefficient for price was quite weaker (Table 3).

The coefficients for the mean taste parameters were quite higher in G-MNL-I model than full G-MNL and G-MNL-II except the coefficient of price which was quite smaller than the coefficient in G-MNL-II model. Unobserved heterogeneities were also evident around mean taste parameters for mixed shape, mango flavor, nutritional and health claim labeling and the coefficients of unobserved heterogeneities around the mean taste parameters were quite strong in this model than full G-MNL and quite weaker than G-MNL-II model. The fourth model with restriction on  $\tau$  (G-MNL ( $\tau = 1$ )) resulted in slightly different coefficients both for mean taste parameters and standard deviations of random taste parameters (unobserved heterogeneities) compared to the other three models. Coefficients are quite higher than other models except for shape which was less than the coefficients in the two model and higher than the coefficient in full G-MNL model. It shows the same mean taste parameters' order and their respective direction of influence on the product choice to other three generalized multinomial logit models. Unobserved heterogeneity was also evident around the mean of the taste parameters of all attributes except for price and sorghum chickpea main ingredient.

Based on the estimates obtained from all formulations of the generalized multinomial logit (G-MNL) model, nutritional and health claim labeling, was the most influential attributes of chickpea enriched snack products. This fact revealed that consumers prefer health claims and nutritional information to be present on food packages. Therefore, labeling the snack products with scientifically confirmed nutritional and health benefits of the products helps the producing industry to maintain sustainable growth and competitive advantage by satisfying their customers' desires and expectations. This result agrees with that of Zou (2011) which reported that consumers perceive a disease prevention claim as a drug claim and are cautious of this claim on a food label.

The second most important trait in snack products choice decision was the product's flavor. The consumers prefer purchasing mango flavored snack food products to purchasing spicy tomato flavored one. Other important trait in influencing consumer decision to purchase these product was sorghum chickpea main ingredient which indicates, consumers prefer this ingredient to snack food products with sweet maize main ingredients. It shows, consumers are more cautious about their health and hence they choose protein, fiber, and carbohydrate enriched snacks over carbohydrate enriched and protein deficient snacks. Shape of the snacks was also an important

attribute in influencing consumer decision to buy chickpea enriched snack products. The attribute is positive and significant across all formulations of the G-MNL model implying that consumers prefer buying snack food products with mixed shape to those with spherical shape. Price has negative coefficient as expected which implies that a higher price per package of the product would decrease consumer's utility; i.e., as the product price increases from its lowest level to highest level, the consumers' likelihood to purchase the products decreases other things being constant.

Table 3: Basic G-MNL model results of attributes choice model

	Full G-MNL		G-MNL-II ( $\gamma=0$ )		G-MNL-I ( $\gamma=1$ )		G-MNL ( $\tau=1$ )	
	$\beta$	St. err.	$\beta$	St. err.	$\beta$	St. err.	$\beta$	St. err.
Taste parameters in utility functions								
Ingredient1	.584***	.071	.493***	.078	.595***	.085	.796***	.073
Ingredient2	-.208**	.086	-.147	.096	-.197**	.087	-.397***	.079
Shape	.205***	.042	.328***	.048	.226***	.047	.213***	.045
Flavor	.681***	.038	.680***	.048	.751***	.056	.958***	.050
Labeling	1.216***	.049	1.024***	.048	1.227***	.072	1.316***	.066
Price	-.260***	.014	-.301***	.015	-.283***	.016	-.307***	.022
Constant	-4.76***	.123	-5.12***	.151	-4.78***	.141	-4.97***	.149
Heterogeneity in mean (Standard deviation)								
Ingredient1	.083	.108	.051	.077	.033	.089	.035	.058
Ingredient2	.005	.159	.057	.118	.057	.060	.158**	.065
Shape	.123***	.042	.111	.319	.161**	.066	.206***	.059
Flavor	.236***	.027	.415***	.069	.343***	.047	.403***	.050
Labeling	.345***	.038	.701***	.050	.432***	.071	.891***	.061
Price	.055***	.018	.027***	.010	.013	.039	.008	.017
Tau ( $\tau$ )	.735***	.034	.684***	.082	.708***	.055	1.0	Fixed
Gamma ( $\gamma$ )	1.487***	.146	0.0	Fixed	1.0	Fixed	.098	.071
Sigma ( $i$ )	.976	.765	.979	.707	.978	.734	.957	1.089
N	8,400		8,400		8,400		8,400	
LL Function	-5124.27		-5065.44		-5111.37		-5078.14	
McFadden	.444		.451		.446		.449	
Pseudo R <sup>2</sup>								
AIC/N	1.224		1.209		1.220		1.212	

Note, \*\*\*, \*\*, \* implies significance at 1%, 5%, 10% level, respectively.

### 3.2.2. Heterogeneities in chickpea enriched snack products traits

The estimated coefficients on the attributes are significant and their standard deviations reveal significant unobserved heterogeneity across individual choices for all attributes. In order to obtain information about the sources of individual heterogeneity, socio-demographic variables were interacted with the choice experiment attributes and sex, family size and educational level were

the only socio-demographic factors significantly explain the variation around the average of taste preference for the traits. All heterogeneity-in-mean model formulations [full G-MNL, G-MNL ( $\gamma=0$ ), G-MNL ( $\gamma = 1$ ) and G-MNL ( $\tau = 1$ )] generated comparable results. Here our discussion will therefore be on unrestricted model (full G-MNL). The respondents' educational status was found to be the only significant factor in explaining the variation in coefficient of preference in sorghum chickpea main ingredient trait. The group of respondents with elementary, high school and diploma educational level are less interested in sorghum chickpea main ingredient trait compared to illiterate respondents. The interest in shape of the products was positively influenced by the respondents' educational level. The respondents with only write/read and elementary educational level shown strong interest in the products' shape compared to illiterate respondents. The respondents with elementary school level of literacy, who are apparently teenage children are interested in shape of the product compared to respondents with other level of literacy.

The variation around the average level of taste preference for flavor was found to be the result of respondents' sex and educational level. Female respondents were found to be more interested than their male counterpart in flavor trait. Educational level of the consumers was also identified as another factor for the variation in preference coefficient of the products flavor. The respondents with only write/read educational level were less interested in the products flavor while those with high school and University degree holders were strongly interested in the trait compared to illiterate respondents. The unobserved heterogeneity in preference around the mean parameter estimate of nutritional and health claim trait was also caused by the variation in the respondents' family size and educational level. As the respondents' family size increases their interest in nutritional and health claim labeling trait of snack product will decrease, everything else the same. This is intuitive that the respondent with small family size would certainly be keen on the quality and health benefit of the product by reading labeling rather than quantity while respondents with large family size would be keen more on the products quantity and price rather than quality to buy sufficient products for their family.

The unobserved heterogeneity around the mean of the estimated parameter of the nutritional and health claim labeling attribute was also explained by the difference in educational level of the respondents. The respondents with high school and diploma educational level were negatively

related to the attribute implying that these respondents are less interested in this attribute while respondents with degree and above educational level have positively related to the attribute suggesting their strong interest in this attribute compared to illiterate respondents. This is interesting and expected simply showing more educated consumers are more sensitive to labeling of the product by reading the label on the package before buying the product.



**Table 4: Heterogeneity in mean taste parameters models**

	Full G-MNL		G-MNL-II ( $\gamma=0$ )		G-MNL-I ( $\gamma=1$ )		G-MNL ( $\tau=1$ )	
	$\beta$	St. err	$\beta$	St. err	$\beta$	St. err	$\beta$	St. err
Taste parameters								
Ingredient1	.477***	.110	.439***	.105	.466***	.106	.667***	.115
Ingredient2	.086	.122	.114	.120	.092	.102	-.262**	.111
Shape	.372***	.044	.367***	.043	.259***	.042	.075**	.038
Flavor	.473***	.060	.474***	.056	.483***	.065	.677***	.100
Labeling	1.16***	.084	1.139***	.077	1.192***	.100	1.244***	.107
Price	-.378***	.027	-.379***	.026	-.352***	.027	-.188***	.020
Constant	-5.16***	.136	-5.12***	.139	-5.05***	.147	-5.01***	.155
Observed heterogeneities								
Ingred1*Elementary	-.464***	.090	-.456***	.089	-.373***	.107	-.179*	.092
Ingred1*High school	-.186**	.079	-.178**	.076	-.164**	.081	-.047	.070
Ingred1*Diploma	-.666***	.101	-.631***	.096	-.684***	.118	-.136*	.078
Ingred2*Family size	-.031	.031	-.040	.030	-.026	.024	-.070**	.031
Ingred2:Elementary	.464***	.125	.464***	.122	.360***	.113	.163	.112
Shape*Write & read	.493***	.121	.506***	.111	.556***	.120	.173**	.083
Shape*Elementary	.337***	.056	.346***	.055	.316***	.061	.167***	.054
Flavor*Sex	-.218***	.045	-.217***	.043	-.238***	.050	.016	.059
Flavor*Family size	-.018	.013	-.016	.013	-.004	-.004	-.041**	.017
Flavor*Write & read	-.354***	.077	-.340***	.071	-.266***	.096	-.009	.077
Flavor*High school	.184***	.052	.186***	.048	.165***	.056	.101	.062
Flavor*Degree	.539***	.089	.480***	.077	.531***	.111	.264***	.088
Label*Sex	-.081	.054	-.089*	.051	-.048	.068	.064	.073
Label*Family size	-.055***	.018	-.046***	.017	-.073***	.020	-.071***	.025
Label*High school	-.142*	.073	-.157**	.069	-.167*	.088	-.148*	.089
Labeling*Diploma	-.942***	.083	-.909***	.074	-1.08***	.146	-.098	.110
Labeling*Degree	.244**	.113	.221**	.101	.193	.152	.011	.116
Price*Family size	.018***	.005	.019***	.005	.022***	.006	-.011**	.005
Price*Write & read	-.178***	.054	-.161***	.051	-.294***	.077	-.036	.033
Price*High school	.031	.025	.038	.023	.042*	.021	.691	.018
Price*Tec. college	-.132***	.039	-.129***	.036	-.017	.037	.063**	.030
Price*Diploma	-.049	.029	-.053**	.026	-.101***	.036	-.046	.035
Heterogeneity in mean (Standard deviation)								
Ingredient1	.129	.120	.040	.105	.089	.083	.033	.099
Ingredient2	.039	.202	.048	.156	.000	.060	.025	.056
Shape	.127**	.063	.130**	.055	.128**	.057	.156***	.050
Flavor	.331***	.029	.321***	.028	.293***	.039	.351***	.054
Labeling	.518***	.037	.510***	.037	.536***	.051	.455***	.114
Price	.084***	.020	.076***	.019	.078***	.020	.031**	.012
Tau ( $\tau$ )	.564***	.035	.558***	.033	.553***	.030	1.0	Fixed
Gamma ( $\gamma$ )	.621***	.119	0.0	Fixed	1.0	Fixed	.565***	.200
Sigma ( $\sigma$ )	.984*	.573	.985*	.566	.985*	.561	.957	1.089
N	8,400		8,400		8,400		8,400	
LL Function	-5236.95		-5243.05		-5229.90		-5139.53	
McFadden Pseudo R2	.432		.431		.433		.443	
AIC/N	1.256		1.258		1.255		1.233	

Note, \*\*\*, \*\*, \* implies significance at 1%, 5%, 10% level, respectively.

The unobserved heterogeneity around the mean of the estimated parameter of the price trait was caused by the variation in family size and educational level of the respondents. Family size have positive relation with the price. This indicates, as the consumers' family increase their interest in price trait increase to select the cheaper one in order to purchase sufficient product for their family other things being constant. These results match with the consumer behavior theory by Nicholson, (2008), which states "in consumption decisions, individuals maximize utility subject to their personal budget constraint". The respondent with only write/read and technical college educational level were negatively related to price trait implying that, this group of respondents are less price sensitive compared to illiterate respondents.

### **3.2.3. Willingness to pay for Chickpea enriched snack food products traits**

Based on the absolute figures of the WTP estimation, the sample respondents are willing to pay an extra price premium of 2.83 birr for snack food product with sorghum chickpea as a main ingredient over the one with sweet maize as a main ingredient. It shows that, the consumers are willing to pay an extra price premium of 0.56 birr for snack food products with the mixed shapes over spherical shaped one, 3.17 birr for mango flavored snack product compared to spicy tomato flavored one and 4.54 birr for nutritional and health claim labeled product over unlabeled snack products (Table 5). However, the absolute figures of the WTP are almost not suitable to interpret due to the unavoidable prices fluctuation over time (Kassie *et al.*, 2014). Therefore, the WTP estimates are most practically interpreted as relative measures of the WTP coefficient strength.

Based on the relative strength of the WTP coefficient the result indicates the sample consumers are willing to pay for nutritional and health claim labeled snack products 1.43 times what they are willing to pay for mango flavored snack food products. The consumers also willing to pay for nutritional and health claim labeling 1.6 times the amount they are willing to pay for the improvement in main ingredient to sorghum chickpea. Similarly, the sample consumer are willing to pay for nutritional and health claim labeling 8.03 times what they are willing to pay for the change in the product shape from spherical to mixed shapes. It shows, the relative importance of nutritional and health claim labeling trait over all other traits of chickpea enriched snack products.

The willingness to pay values computed for each attribute show that changing the product flavor from spicy tomato to mango is valued 1.12 times more than a comparable change in main ingredient from sweet maize to sorghum chickpea. The value respondents willing to pay for a mango flavored snack product is 5.61 times the value they willing to pay for a product with mixed shape. This implies that flavor of the product is relatively strong trait that influence the consumers choice for chickpea enriched snack products than main ingredients and shape of the products. Similarly, the sample consumers are willing to pay price premium for a change in main ingredient from sweet maize to sorghum chickpea that is 5 times the amount they are willing to pay for change in the product shape from spherical to mixed one. This illustrates that, main ingredient strongly influence consumer choices for chickpea enriched snack products than shape of the products. Generally, sample consumer are willing to pay highest premium for nutritional and health claim labeling of the product and least premium for shape of the product while flavor and main ingredient are the second and third attributes as perceived by consumers.

**Table 5: Willingness to pay for Chickpea enriched snack food products traits**

	WTP (full G-MNL model)	
	Coefficient	St. error
Taste parameters		
Ingredient1	2.835***	.2669
Ingredient2	-1.433***	.2574
Shape	.566***	.1252
Flavor	3.177***	.2174
Labeling	4.547***	.2895
Price	1.0	Fixed
Distns. of RPs. Std. Devs or limits of triangular		
Ingredient1	.204	.4247
Ingredient2	.046	.5044
Shape	.605***	.2114
Flavor	.633***	.1492
Labeling	3.157***	.2652
Price	0.0	Fixed
Tau Scale ( $\tau$ )	1.0	Fixed
Gamma ( $\gamma$ )	0.0	Fixed
$\beta$ WTP	.325***	.0211
S. $\beta$ WTP	.119***	.0166
Sigma (i)	.957	1.0890
N	8,400	
LL Function	-5084.81	
McFadden Pseudo R <sup>2</sup>	.448	

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Note, \*\*\*, \*\*, \* implies significance at 1%, 5%, 10% level, respectively.

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## 4. Conclusion

Due to raising consumers demand and growing success of the snack food operators there is a fierce competition in the industry. To adjust and align marketing strategies, snack food manufacturers need to know consumer preference and willingness to pay for the product. Therefore it is important to elicit the consumers' preferences for the product traits and estimate the implicit price they are willing to pay for the product traits. Using choice experiment and generalized multinomial logit model the study analyzed the preferences of snack product buyers in the two cities of Ethiopia.

All the formulations of basic G-MNL model both in preference space (preference coefficient estimation) and willingness to pay (WTP) space (willingness to pay estimation) and the formulations G-MNL-with-mean heterogeneity models consistently shown that nutritional and health claim labeling, the product flavor and sorghum chickpea main ingredient are the most important traits in determining a snack food products choice respectively, while maize chickpea main ingredient, the product shape and price are also important with changing order across the models. The respondents, sex, family size and educational level were found to be the only socio-demographic factors that significantly explain these variation around the average level of taste preference for the traits. Considering this the study make the conclusion that consumer in the study areas, prefer the chickpea enriched snack products with sorghum chickpea main ingredients, combination of different shape (mixed shape), mango flavor and nutritional and health claim labeled. Therefore, the snack food vendors need to focus on these attributes besides other product attributes to create snack food products with the best combination.

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# Determinants of Haricot Bean Production and Resource Use Efficiency of producers in Halaba Special District, Southern Ethiopia

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## Abstract

The study assessed determinants and resource use efficiency of haricot bean production in Halaba Special district in Southern Ethiopia. The study employed multistage sampling technique to collect relevant primary data from smallholder producers. A total of 173 sample households were selected from two administrative *kebeles* using probability proportional to size sampling technique. Both qualitative and quantitative data were collected from primary data sources through structured questionnaire, key informant interview, and focus group discussion. Complementary secondary data were collected through literature review. Descriptive statistics, estimation of production function, and resource use efficiency index were the analytical methods employed to achieve the objectives of the study. Accordingly, the result indicated haricot bean output was positively and significantly influenced by plot size, amount of fertilizer applied, labor input in man days, level of education of the household head, farming experience, frequency of extension contacts and types of haricot bean seed used. Resource utilization was found inefficient for the crop in the study area. The finding indicated, fertilizer, pesticide, labor and oxen power were over utilized resources in haricot bean production. Thus, concerned bodies should work on policy relevant significant variables to improve the productivity and resources use efficiency.

**Keywords:** Marginal factor cost, Marginal value product, Production function, Pulses

## 1 Introduction

Pulses, which occupy around 13.24 % of cultivated land and account for 10.38 % of grain production, are critical to smallholder livelihood and the economy of Ethiopia (CSA, 2016). Ethiopia is one of the top twelve producers of total pulses in the world, third largest producer of haricot bean in COMESA member countries and the leading exporter in Africa (Agete, 2014). Pulses are the major constituents of food crops for the majority of Ethiopians and also serve as a source of income at household level and significant contributor of foreign currency earnings (IFPRI, 2010). They play a significant role in improving smallholders' food security, as an affordable source of protein and other essential nutrients (IFPRI, 2010). For instance, haricot bean is high in starch, protein and dietary fiber and is an excellent source of minerals and vitamins including iron, potassium, selenium, molybdenum, thiamine, vitamin B6, and folic acid (Ferris and Kaganzi, 2008).

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Haricot bean is in second place following faba bean in terms of area coverage and grain volume among pulses in the country. It accounts 21.6% of area of pulse production and 19.5% of pulse grain production (CSA, 2016). However, the productivity of haricot bean is significantly below the demonstrated potential yield. The national average yield of haricot bean is 1.48 tons per hectare while the research has demonstrated a potential of 3.4 tons per hectare (Mulugeta *et al.*, 2015).

Most of the efforts to increase pulse productivity has been related with the use of high yielding varieties and improvement of agronomic practices. Socioeconomic studies such as determinants of the production and resource use efficiency of smallholders are limited. Hassen *et al.* (2015) studied technical efficiency of smallholder haricot bean producers in Misrak Badawacho district. The study assessed the technical efficiency of haricot bean producers using stochastic frontier analysis and found production of haricot bean is inefficient. However, the study considered only conventional inputs of production to identify determinants of the production, which might not have revealed the influence of non-conventional inputs. Besides, stochastic frontier analysis could not show which inputs was inefficiently allocated by the producers. This study examined both conventional and non-conventional factors of haricot bean production and assessed resource use efficiency of smallholder haricot bean producers so as to generate information which could contribute in narrowing the knowledge gap.

## **2 Research Methodology**

### **2.1 Study area**

Halaba Special District is located between the coordinates of 7° 14' 46.7" and 7° 18' 08.2" N Latitude and 38° 05' 35.5" and 38 ° 06' 16.5" E Longitudes. The district has 79 rural Administrative *Kebeles*. The district is called “special” because it has a special autonomy where the administration directly reports to the regional state (Genene, 2006; IPMS, 2005). The mean temperature of the district varies from 17<sup>0</sup>C and 20<sup>0</sup>C. Rainfall distribution has been a major limiting factor in agricultural production in the area. Annual rainfall of the district varies between 857 and 1,085 millimeters. The district receives a bimodal rainfall where short rains occur between March and April while long rains occur from July to September (IPMS, 2005; JICA, 2012).



## 2.2 Research design and sampling procedure

The study employed concurrent mixed (qualitative and quantitative) approach. The quantitative approach focused on obtaining numerical findings with the survey method. Key informant interview and focus group discussion on the other hand, used with the qualitative approach. The combined approach employed to overcome the limitations of both approaches when used individually.

The population for the study comprises all haricot bean producers in 2016/2017 production season in the study area. The study followed multistage sampling technique to select sample respondents. Major haricot bean producer *kebeles* were selected purposively in the first stage. In the second stage, two *kebeles* were selected randomly out of identified producer *kebeles*. In the third stage, households produced haricot bean were selected purposively with the help of *kebele* development agents. Finally, sample households were selected from purposively selected producers using simple random sampling to administer the survey. The total sample size was distributed to selected *kebeles* based on the probability proportional to size sampling technique. The total sample size of 173 haricot bean producer households were selected based on Yamane (1967) formula, which is presented as follows:

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

Where  $n$  is the sample size,  $N$  is the population size, and  $e$  is the level of precision (95% confidence level and  $P = 0.05$  are assumed).

## 2.3 Types, sources and methods of data collection

Both qualitative and quantitative data were collected for this study. The data sources were both primary and secondary ones. Primary data gathered from sample respondents, key informants and focus group discussions. The survey schedule was pre-tested in one *kebele* that was not included for the study. The primary data collection was undertaken through trained enumerators. The study employed key informant interviews and focus group discussion (one focus group) to collect additional information to cross check and supplement the primary data collected from households using interview schedule. Secondary data was gathered from journals, books, thesis researches, reports of bureau of agriculture and natural resources to supplement the results found from the primary data.

## **2.4 Method of data analysis**

The analytical methods used in achieving the objectives of the study include descriptive statistics, estimation of production function and resource use efficiency index (ratio of VMP to MFC). The study used STATA 12 to execute descriptive statistics and estimate the production function. Whereas Microsoft office excel 2007 was employed to compute the resource use efficiency index.

### **2.4.1 Estimation of production function**

Choice between alternative production functional forms is a matter of subjective judgment, guided by consideration of goodness of fit, a priori economic theory, ease of analysis, and judgment about the economic implications drawn from the production function estimates (Dillon and Hardaker, 1980). William and crown (1998) pointed out how well each of the models satisfies the assumptions underlying the regression model are important criteria. Generally, literatures pointed that the selected functional form must be computationally manageable for both estimation and testing.

For this study, four most common types of production functional forms (Linear, lin-log, log-lin and log-log) were tested whether they better fit and appropriate to the collected survey data. The collected data was checked for outliers and missing values and existence of multicollinearity before running regression. Then Linear, lin-log, log-lin and log-log types of production functional forms was computed to select the model that was appropriate for the data. Model specification test (ovtest), hetroskadasticity test, and normality of error distribution were undertaken for each alternative model. Multiple linear regression was selected as it has been found to fulfill important regression assumptions and most of prior expectations to analyze haricot bean survey data while the others fail to fulfill the assumptions. The result of variance inflation factor (VIF) for each variable was less than 10 and the mean VIF was 1.71, which shows there was no series multicollinearity among the explanatory variables. A test for heteroskedasticity was done using Breusch-pagan test and the test was not significant suggesting that the data has no heteroscedasticity problem. The normality of the error was checked using a kernel density plot and the plot indicated the distribution of the residual resembled normal pattern. The selected model did not have problem of misspecification. Linear regression model is specified following Gujarati, (2004) and Theresa *et al.*, (2015) as follow.

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_{10} X_{10i} + \beta_{11} D_1 + \beta_{12} D_2 + \mu_i \quad (2)$$

Where,

$Y_i$  = output of haricot bean in kilogram

$X_1 \dots X_{10}$  = continuous explanatory variables (plot size, seed, fertilizer, pesticide, human labor, oxen power, education, farming experience, extension contact and nonfarm income respectively)

$D_1$  = dummy variable for sex of household head (1 = male, 0 = female)

$D_2$  = dummy variable for type of seed used by household (1 = improved seed, 0 = local seed)

$\beta_0$  = the intercept of the relationship (constant)

$\beta_1 \dots \beta_{12}$  = Slopes with respect to each input used

$\mu_i$  = Stochastic error term

Table 1: Summary of explanatory variables and hypothesis

Variable name	Type of variables	Unit of Measurement	hypothesis
<b>Plot size</b>	Continuous	Hectare	
<b>Seed</b>	Continuous	Kilogram	
<b>Fertilizer</b>	Continuous	Kilogram	
<b>Pesticide</b>	Continuous	Liter	
<b>Labor</b>	Continuous	Man Days	
<b>Oxen Power</b>	Continuous	Oxen days	
<b>Education</b>	Continuous	Schooling years	
<b>Farming experience</b>	Continuous	Years of farming	
<b>Extension contact</b>	Continuous	Number of contact in a year	
<b>Nonfarm income</b>	Continuous	Ethiopian birr	
<b>Sex</b>	Dummy	Dummy variable (0=female, 1=male)	
<b>Type of seed</b>	Dummy	Dummy variable (0=local, 1=improved)	

## 2.4.2 Resource use efficiency

The basic approach to estimate resource use efficiency is through the marginal value of product where the marginal value of product was calculated from econometrically estimated production function. Resource use efficiency was determined by comparing the marginal value of

product(MVP) with the marginal factor cost (MFC). It was assumed that farmers are price takers in the input market, so that the price of  $i^{th}$  factor approximates MFC. Following Chukwujiet *al.* (2006) and Eze and Nwibo (2014) resource use efficiency index (RUEI) was derived from the production function of equation 2 as follows:

$$MP_{xi} = \frac{\partial (Y_i)}{\partial x_i} \quad (3)$$

From multiple linear regression model:

$$MP_{xi} = \frac{\partial (\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_{10} X_{10i} + \beta_{11} D_1 + \beta_{12} D_2 + \mu_i)}{\partial x_i} = \beta_i \quad (4)$$

$$RUEI_{xi} = \frac{MP_{xi} \cdot P_Y}{P_{xi}} = \frac{MVP_Y}{MFC_{xi}} \quad (5)$$

Where,

$RUEI_{xi}$  : is the resource use efficiency index of  $i^{th}$  input

$MP_{xi}$ : is the marginal product of  $i^{th}$  input

$\beta_i$ : slopes with respect to  $i^{th}$  regressor variable

$X_i$ :  $i^{th}$  input included in the production function

$P_Y$ : is selling price per unit of haricot bean output

$P_{xi}$ : is cost per unit of  $i^{th}$  input used

$MVP_Y$  : marginal value of product of haricot bean resulting from an additional unit of  $i^{th}$  input.

$MFC_{xi}$  : marginal factor cost of  $i^{th}$  input resulting from an additional unit of  $i^{th}$  input.

### 3 RESULTS AND DISCUSSION

#### 3.1 Demographic and socio-economic characteristics of the respondents

The average age of haricot bean producer sample household heads was 40 which imply that most of sample households were in their active working age (Table 2). Majority of respondents were married (84.4%) whereas 3.5%, 1.7%, and 10% were single, divorced and widowed respectively (Table 3). The finding indicated that respondents on average spent 3 years in school. The average

annual income of respondents was 15,373 Ethiopian birr in 2016/17 production season. The average livestock holding of respondents was 4.39 TLU with minimum and maximum of 0 and 19.75 TLU respectively (Table 2). On average, typical haricot bean producer household has 2.17 hectare of land. Out of the total respondents, 75.1% of them had access to credit from different sources (Table 3). About 75.1% of respondents were members of cooperative, but only 20.81% of them sold their haricot bean grain for their cooperatives (Table 3).

Table 2: Description of continuous demographic and socio-economic characteristics of respondents

Variables	Unit	Haricot bean producers (n=173)			
		Mean	Std.D	Min.	Max.
Age	Years	40	9.36	22	70
Family size	Number	6	2.05	1	14
Education	School years	3	3.06	0	16
Livestock holding	TLU	4.39	2.57	0	19.75
Total land owned	Ha	2.17	1.2	0.25	8
Total annual income	ETB	15,372	11,929	800	55,000

Source: Author's survey (2017)

Table 3: Marital an educational status, credit access and cooperative membership of sample household heads

Variables	Response	Haricot bean producers (n=173)	
		Number	%
<b>Marital status</b>	Single	6	3.5
	Married	146	84.4
	Divorced	3	1.7
	Widow	18	10.4
<b>Educational status</b>	Illiterate	65	37.79
	Literate	107	62.21
<b>Access to credit</b>	Yes	130	75.1
	No	43	24.9
<b>Cooperative membership</b>	Yes	130	75.1
	No	43	24.9

Source: Author's survey (2017)

### 3.2 Description of output and input variables

The average haricot bean productivity in the study area was found 1,146 kg per hectare; which was below the national average productivity (1,480 Kg per hectare). The maximum reported yield potential of haricot bean was 3200 kg while as low as 200kg yield also reported in the study area (Table 4). The average plot area allocated by producers for the crop was close to half hectare (0.47). The minimum and maximum plot area allocated for haricot bean was 0.13 and 1.5

hectare. DAP fertilizer was the major fertilizer type used in haricot bean production whereas, only few of the respondents used urea for haricot bean production. Amount of fertilizer applied on haricot bean per hectare by the sample households vary between 0 and 300 Kg with average of 92.46 Kg per hectare. Typical haricot bean producer used 66.67 Kg of seed per hectare. Labor is an important factor of production in subsistence agriculture. The average labor used per hectare by respondents was 92.42 man-days. Oxen power was mainly used for land preparation in the study area and producers on average used 15.03 oxen days per hectare for haricot bean production in the study area. Pesticides were most important chemicals used by the producers in the study area. On average respondents used 0.033 liter of pesticide per hectare for haricot bean production. Very few respondents also used fungicides. Participation in nonfarm activities believed to support producers in their farm activities through strengthening purchasing power so as to get new technologies and other inputs like fertilizer and improved seed that assist the production (Wogayehu and Tewodros, 2015). On average, sample households earned 3,795 Ethiopian birr from nonfarm activities in 2016/17 production season. The mean farming experience of respondents was 12 years. Producers on average had received an extension service of 34 times in that particular production season (Table 4). There were two categories (local and improved) of haricot bean seed in the study area. Majority (90.8%) of the respondents were user of improved seed variety (Table 5). *Nasir* and *Hawassa dume* varieties of haricot bean were grown in the district.

Table 4: Summary of output and continuous input variables used in the econometric model

Variables	Unit	Haricot bean producers (n=173)			
		Mean	Std.D	Min	Max
<b>Yield</b>	Kg/Ha	1,146.2	518.63	200	3,200
<b>Plot size</b>	Ha	0.47	0.27	0.13	1.5
<b>Fertilizer</b>	Kg/Ha	92.46	63.16	0	300
<b>Seed</b>	Kg/Ha	66.67	29.50	20.5	184
<b>Labor</b>	Man days/Ha	92.42	55.87	22.4	384
<b>Oxen Power</b>	Oxen days/Ha	15.03	8.77	4	64
<b>Pesticide</b>	Liter/Ha	0.033	0.147	0	1.07
<b>Nonfarm income</b>	ETB	3,795	4,739.6	0	30,000
<b>Farming experience</b>	Years	12	5.88	2	30
<b>Number of extension contact</b>	Frequency	34	13.26	3	52

Source: own computation (2017)

Table 5: Summary of dummy variables used in the econometric model

variables	Category	Haricot bean producers (n=173)	
		No	%
<b>Sex of the household head</b>	Female (0)	37	21.4
	Male (1)	136	78.6
<b>Type of seed used</b>	Local (0)	16	9.2
	Improved (1)	157	90.8

Source: own computation (2017)

### 3.3 Determinants of haricot bean production

Determinants of haricot bean production in the study area were identified by estimating multiple linear regression that appropriately fits to the survey data. Value of coefficient of determination ( $R^2$ ) for the regression is 0.739 indicating 73.9% of the variation in haricot bean output is explained by the model. F-statistic indicated that the overall regression is significant at 1% level of significance (Table 6). Haricot bean output was responsive to plot size, amount of fertilizer, number of man-days, education level of the household head, farming experience, extension contact and types of haricot bean seed used. Output of haricot bean was not significantly responsive to amount of seed, pesticide, oxen days, nonfarm income and sex of the household heads (Table 6).

**Plot size (PLOTS):** The estimated coefficient of plot size allocated for haricot bean was 538.54. The sign of the coefficient was positive as expected and significant at 1% level of significance, indicating the relevance of plot size on haricot bean production in the study area. This positive effect of plot size on haricot bean output implies that a hectare increase in plot size leads to an increase in output of haricot bean by 538.54 Kg keeping other factors constant. The result agrees with Mustefa (2014) and Hailemaraim (2015) who reported land allocated had positive and significant effect on output in their studies.

**Fertilizer (FRT):** The estimated coefficient (0.82) of fertilizer was positive and statistically significant at 10% level of significance. The coefficient implies as amount of fertilizer increases by a kilogram, yield of haricot bean increases by 0.82 Kg. This might be due to farmers in the study area uses DAP fertilizer which provides the crop with required minerals that translated to

increased output. The result is consistent with prior studies undertaken by Hassen *et al.* (2015), Wogayehu and Tewodros (2015) and Birachiet *al.* (2011).

**Labor (LAB):** The coefficient of labor measured in terms of man-days was positive and significant at 1% level of significance. The result implies that for one man-day increase in the use of labor will increase output of haricot bean by 4.02 Kg. The result fits with the finding of Wogayehu and Tewodros (2015) which also reported labor input has positive and significant influence on haricot bean output, but contrary to this, Hassen *et al.* (2015) reported a negative and significant relationship between labor and production volume in their research.

**Education (EDU):** Education of the household head was positively and significantly influenced the output of haricot bean at 1% level of significance. The result implies that an increase in schooling year by one results an increase of haricot bean output by 15.3 Kg. The result was consistent with the findings of Wongnaa (2013), and Wogayehu and Tewodros (2015).

**Farming experience (FXP):** This variable had positive coefficient of 3.89 and statistically significant at 10% level of significance, implying that respondents with higher farming experience tend to produce more haricot bean per hectare. This implies that an increase in farming experience of the crop by a year results an increase of haricot bean output by 3.89 Kg. Shalma (2014) and Wongnaa (2013) found opposite result in which farming experience influence the output of soybean and cashew negatively. This might be due to farmers in that study areas were not improved their production system or produce in obsolete traditional system.

**Extension contact (EX):** Extension contact of the household heads was positively and significantly influenced output of haricot bean at 5% level of significance. The sign of the coefficient was as per prior expectation. This implies that as frequency of extension contact of producers increase, amount of haricot bean output obtained tends to increase. Wongnaa (2013) found similar result in which dummy of extension contact positively and significantly influence output, whereas Wogayehu and Tewodros (2015) found negative coefficient for frequency of extension contact but insignificantly influenced volume of the output.



**Type of seed (TSEED):** Type of seed used was positively and significantly influenced output of haricot bean at 1% level of significance. The sign of the coefficient was as per prior expectation. The coefficient implies households that used improved seed of haricot bean could possibly increase his haricot bean output by 121.25 Kg than those used local type of seed indicating the importance of high yielding seed varieties in haricot bean production. During the FGDs, farmers told they preferred *Nasir* variety because of its high productivity, and better demand in the market.

Table 6: Multiple linear regression estimates for haricot bean production in Halaba special district

Variables	Coefficients	Std.D	t-ratio
Plot size (PLOTS)	538.5414***	77.6925	6.93
Seed (SEED)	1.1055	1.4395	0.77
Fertilizer (FRT)	0.8238*	0.4839	1.70
Pesticide (CHEM)	3.2546	218.5072	0.01
Labor (LAB)	4.0178***	1.0095	3.98
Oxen power (OXP)	1.1337	4.7119	0.24
Education (EDU)	15.3017***	4.3805	3.49
Farming experience (FXP)	3.8995*	2.2590	1.73
Extension contact (EX)	2.3882**	1.0254	2.33
Nonfarm income (NFI)	0.0005	0.0025	0.19
Sex (SEX)	16.2736	32.9212	0.49
Type of seed (TSEED)	121.2477***	46.2237	2.62
Constant	-254.0076***	70.1538	-3.62
Number of observations = 173			
$R^2 = 0.7398$			
Adj_ $R^2 = 0.7203$			
F-statistic = 37.92			
Prob. (F-statistic) = 0.0000			

\*\*\*, \*\* and \* shows significance at 1%, 5% and 10% probability level respectively

Source: Model output of authors' survey (2017)

### 3.4 Resource use efficiency in haricot bean production

Cost minimization or a point of profit maximization is the point where marginal factor cost equals value of marginal product (MFC=VMP). The deviations from this point causes inefficiency (Debertin, 2012). Therefore, resource use efficiency in haricot bean production was investigated based on this economic principle. Table 7 portrayed the resource use efficiency in haricot bean production. The ratios of MVP to MFC for haricot bean plot size (0.9), fertilizers

(0.4), pesticide (0.2), labor (0.5) and oxen power (0.0) were less than one. These ratios indicated that much of these inputs were used in relation to the prevailing market conditions. The factor prices for plot size, fertilizers, pesticide, labor and oxen power used exceeded their respective marginal value products. The expected return from an additional unit of these factor inputs is less than the marginal factor cost incurred by these additional units of inputs. Hence, the sample households were inefficient in the use of the available inputs except amount of seed used. This implies that there were opportunities for the producers to improve their resource use efficiency and profit by using less of these inputs.

The result showed that the marginal productivity of land was higher than that of the other factors used in the production of haricot bean in the study area. This led to higher marginal value product for land. This would not however imply that farmers are more efficient in land use than in other factors, because their unit of measurement is not the same. Rather the resource use efficiency index (RUEI) could show the relative efficiency of land allocation. As it could be understood from the result, plot size had highest resource use efficiency index very close to one among over utilized inputs revealed that very little deviation from efficient utilization.

Most family labor works on the farms are done with little or no supervision and this might have contributed to the overutilization of labor (RUEI = 0.5). The over utilization of labor is in agreement with the finding of Jirgiet *al.* (2010).

Some households use urea additional to DAP even if the recommendation was only 100 Kg of DAP (District agriculture office) for haricot bean production in the study area. This might lead to over utilization of fertilizer (RUEI = 0.4). Bolarin, *et al.* (2012) found similar result during his study of profitability of production and resource use efficiency among rice farmers in Southwest, Nigeria.

Over utilization of pesticide (RUEI = 0.2) might be due to frequent occurrence of haricot bean pests as producers identified this as one of production constraints in the study area.

Generally, MPP of over utilized inputs were not negative indicating that households still use these inputs in economical range of haricot bean production even if they did not utilize them optimally. Therefore, there is a possibility of improving the efficiency of haricot bean production by using less of over utilized resources in the study area. Additional income could be made from haricot bean production in the study area by allocating inputs efficiently.

Table 7: Resource use efficiency in haricot bean production

<b>Resources</b>	<b>Haricot Bean Production (n=173)</b>			
	<b>MPP</b>	<b>MVP</b>	<b>MFC</b>	<b>RUEI</b>
<b>Plot Size</b>	538.54	3607.37	3947.28	0.9
<b>Seed</b>	1.11	7.41	7.41	1.0
<b>Fertilizer</b>	0.82	5.52	14.64	0.4
<b>Pesticide</b>	3.25	21.80	137.03	0.2
<b>Labor</b>	4.02	26.91	57.05	0.5
<b>Oxen power</b>	1.13	7.59	174.83	0.0

Note: Values of resource use efficiency index (RUEI) is rounded to one decimal point

Source: own computation (2017)

## Conclusion and recommendations

The average haricot bean productivity of sample households in the study area was below the national average productivity. It could be noted that the productivity could be further improved as this also assured by some of the respondents that have produced above the average. Therefore, district office of agriculture has to do to improve the productivity of the crop focusing on the identified determinants of the production.

Fertilizer was found an important determinant that has positive and significant influence on the output of haricot bean. However, farmers blame the price was not affordable. Therefore, government should supply fertilizer on credit and work on how to reduce the price of fertilizer so that it could be affordable to the producers.

Enhancing education of the household head was found important in haricot bean production. Thus, government has to give due attention for farmers training through strengthening farmers' education, adult education and farmer training centers.

Frequency of extension contact was positively and significantly influenced output of haricot bean. Since an extension service is the main instrument used in the promotion of demand for modern technologies, appropriate agronomic management. Therefore, the concerned body has to ensure accessibility of appropriate extension services for the producers.

Using improved seed of haricot bean was found significant determinant that positively and significantly influences the output. Thus, continuous and adequate supply of improved seed has to be emphasized by government.

Analysis of RUEI indicated that factor prices for fertilizers, pesticide, labor and oxen power used were exceeded their respective marginal value products in haricot bean production. Thus, expected return from an additional unit of these factor inputs is less than the marginal factor cost incurred by additional unit of this input indicating inefficient allocation. Therefore, it is advisable to improve the efficiency and expand the profit in haricot bean production by optimizing the over utilized resources in the study area.

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## **2. Agronomy Graduate Program**

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# **Performance of Chickpea Varieties Grown under Double Crop Sequence at Damotgale District, Southern Ethiopia**

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## **Abstract**

Increase production and productivity of the existing arable land through intensive crop production system. The experiment was conducted in Damot-galle district southern Ethiopia during 2016/17 cropping season. The trial had factorial arrangement in split plot design with three replications consisting of two factors, chickpea cultivars and double cropping sequence. Consequently, three chickpea cultivars (mastewal, habru and local) and three double cropping sequences (fallow-chickpea, maize-chickpea and haricot-chickpea) were factorially combined. Main effect of double cropping system and chickpea cultivars significantly affected grain yield of chickpea. The highest grain yield (2.83 ton/ha) was obtained at after fallow cropping system and the lowest after haricot bean (1.75 ton/ha), over cropping system showing 62 % increase and the highest grain yield from mastewal(2.80 ton/ha) and lowest from local(1.68 ton/ha), over varieties showing 66.66% increase. Chickpea cultivars by cropping sequence interaction significantly influenced the grain yield. The lowest grain yield (0.99 ton/ha) gained when local planted after haricot bean cropping sequence compared to the highest grain yield from mastewal after fallow (3.16 ton/ha) which is increased by 219% from the lowest. Treatment that assigned for habru in combination with after maize gave the highest marginal rate of return of 2946% indicating that for every 1.00 birr invested for habru after fallow got additional 29.46 birr at these levels of combination. Therefore cultivars, the combined application of habru and mastewal cultivar with maize and after fallow cropping sequence can recommended for chickpea production in gacheno kebele since it is the most feasible for obtained higher yield and benefits with low cost of production.

**Key Words:-** Pulse, chickpea , cultivars , benefit, marginal rate

## **1. INTRODUCTION**

Suitable land area for food crops production in most parts of the world remains fixed and may even be decreasing due to urbanization. On the other hand, it has become more important to improve crop productivity in order to meet the increasing food requirements of an increasing population all over the world (Midmore, 1993). Most of the developing nations exist in the tropical regions where food production is low and food shortage is common because of low economic development that is unable to keep pace with higher rate of population growth

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(Palaniappan, 1985). Thus, increasing production and productivity on the existing arable land through intensive crop production system, i.e., by growing high yielding crop varieties with appropriate agronomic packages and using cropping systems that enable to produce multiple crops in a year is essential. Tamiru (2013) reported that intensification is the only way to increase agricultural production. One form of intensification is double cropping—the harvesting of two crops grown one after the other from the same field in a given year.

Grain legumes are a major source of proteins in human and animal nutrition and play a key role in crop rotations in most parts of the world. When grown in rotation with other crops, they can improve soil fertility and reduce the incidence of weeds, diseases and pests (Mwanamwenge *et al.*, 1998). Legumes grown in rotation with the cereals are the important source of N. Wheat and barley from rotation with legumes enhance soil fertility, increased water use efficiency and decreased yield and quality yield and quality loss from weeds and soil born diseases (Miller, 2002).

Ethiopia is the largest chickpea producer in Africa, with a share of about 39% of total production of the continent in 2011 (FAOSTAT 2012). Chickpea is cultivated in the mid to high altitude areas of Ethiopia with Vertisols during the post rainy season using residual soil moisture as sole or double crop following some other annual crops including *tef*, barley or wheat (CSA, 2013, Kassie *et al.*, 2009 and MoA, 2012).

In Southern Nations Nationality and Peoples Regional State (SNNPRS) Chickpea is produced mainly as a double crop immediately following the harvest of early planted crops like maize, *tef*, potato and (a pulse crop) haricot bean. Such cropping practice enables farmers to produce two grain crops under rain fed condition in a year that increases the productivity of their land and earns additional income. Minta *et al.* (2014) reported that double cropping of chickpea or grass pea with early maturing forage crops like oat or vetch could improve forage availability and productivity of labor and land. Ghosh *et al* (2014) also reported that the production of chickpea in post rainy season following rain fed cereal production can solve the problems of food and nutritional insecurities of the society.

In SNNPR more than 6000 ha of land were planted with chickpea in the year 2008. In Wolaita Zone, SNNPR, Chickpea is one of the most important grain legumes produced by small scale farmers which serve as a source of food and cash. Because of its ability to grow on residual moisture, chickpea plays an important role in the farming system as a rotation crop and allows farmers to get extra crop each year.

Rotation of cereal with cereal and pulse with pulse is not usually recommended because they have similar soil and biotic constraints (soil nutrient, weeds, insects and disease). However, many farmers in southern region, specifically in Damot-gale district, produce chickpea as double crop after harvesting haricot bean planted in early April. This scheme enables farmers to harvest haricot bean in late July and plant chickpea in early September. Other farmers in the district also produce chickpea after harvesting early planted maize. Farmers in other districts with Vertisol produce chickpea as fallow-chickpea sequence due to water logging problem in the rainy season. The objective of this study is to identify more productive double cropping sequence for chickpea varieties

## **2. MATERIALS AND METHODS**

### **2.1. Experimental site description**

The experiment was conducted at Gacheno kebele in Damot-galle district Wollayta zone during 2016 cropping season. The area was situated at 07° 00'N latitude, 37° 54'E longitude and lies 1900 masl. The district receives 1200–1300mm annual rainfall and its monthly mean minimum and maximum temperatures are 11 and 26°C, respectively (Bizuneh, 2015).

### **2.2. Treatments and Experimental Design**

The experiment was laid as split plot design with three replications. The main plot consisted of three cropping sequence; planting chickpea after fallow, after maize, and after haricot bean. The sub-plots were three chickpea varieties; Habru, Mastewal, and local. Three separate fields on one farmer's land. Three chickpea varieties Habru was kabuli type while Mastewal and local variety were desi type. Individual plots had a size of 9.6m<sup>2</sup> (4m x 2.4M) with 40 and 10cm inter and intra row spacing respectively. The pathway between blocks and between plots was 1 and

0.5 m. DAP was applied at the rate of 60 kg per hectare just before planting, and other field managements including pod worm control was done as required.

### **2.3. Land preparation and Sowing**

The land on which experiment conducted was carefully prepared. The fallow land cultivated by hand three times within 21 days interval and 3 meter far from the land which occupied by haricot bean to reduce soil contamination. Plantation process was done at 07/01/09 by using di-amonium phosphate (DAP) fertilizer at the rate of 60 kg per hectare that means 57.6 gm per each plot with 6 rows and 9.6 gm per each row was applied in rows just before planting, and seeds drop two one ratio at depth of 10 cm.

### **2.4. Field managements**

Hand weeding and cultivation was done after 20 days from sowing, the second hand weeding and cultivation was after a month from the first cultivation. Wilting and diseases score data were taken three times in growing period and pod borer worm infestation assessment was undertaken and controlled by spraying pesticide (karate) at the early and flowering stage three times for the interval of 10 days.

### **2.5. Observations and Data collection**

#### **2.5.1. Soil Data**

Composite soil sample was collected at five random spots of each field at a depth of 0-20cm before sowing and at three random spots of each plot per experiment after harvesting. Soil samples taken from the plots of each variety in each experiment was bulked and analyzed for each chickpea variety. Both composite samples taken before planting and after harvesting were analyzed for total Nitrogen using Kjeldhal method (Bremner and Mulvancy, 1982). The available phosphorous content was determined by ascorbic acid method (Olsen and Sommers, 1982), while the organic carbon content was determined following the weight digestion method (Walkely and Black, 1934).

**Data on crop phenology, plant growth, yield and yield components were collected on three experiments as follows:**

***Crop phenology:*** days to seedling emergence, days to flowering and maturity

***Plant growth:*** plant height, pod bearing branches per plant and nodulation

***Yield and yield components:*** pods per plant, seeds per plant, hundred seed weight, biomass yield, grain yield

$$\text{Adjusted plot yield} = \frac{\text{actual plot yield (kg)} \times (100 - \text{Standard moisture content of pulse})}{100 - \text{Actual moisture content of the grain}}$$

## **2.6. Data analysis**

Analysis of variance on grain and biological yields and yield related traits was executed using a split plot design where cropping sequence was applied to the main plot and the three chickpea varieties were applied to the subplots by using a mixed model in SAS program. Correlation of yield with yield related traits were also analyzed.

## **2.7. Economic analysis**

Economic analysis was conducted to investigate the economic feasibility of the treatments; partial budget, dominance and marginal rate of return was performed using approach (CIMMYT, 1988). The gross benefit was calculated as average adjusted grain yield (kg per ha) × field price that farmers receive for the sale of the crop. Total variable cost was calculated as the sum of all cost that was variable or specific to a treatment against the control. Net benefit was also calculated by subtracting total variable cost from the gross benefit. The marginal rate of return (MRR) was calculated as the ratio of difference between net benefits of successive treatments to the difference between total variable costs of successive treatments. Treatments with higher cost and with lower net benefit than the previous successive treatments were indicated as dominated (D). For a treatment to be considered a worthwhile option to farmers, the minimum acceptable rate of return (MARR) needs to be between 50% and 100% (CIMMYT, 1988). However, the MARR of 100% was suggested as realistic (Minale et al., 2004; Getachew et al., 2012). The economic analysis was done by the formula developed by CIMMYT (1988).

### 3. Result and Discussion

#### 3.1. Main effects of double cropping sequence type on nodulation, growth, pod production, total biomass and straw weight of three chickpea varieties.

The effect of different double cropping sequence (fallow, after maize, after haricot bean) was studied for all the variables investigated in this study. But, significant effects of cropping sequence type were only observed for six variables (Table 1.).

Chickpea varieties grown after fallow were significantly ( $P<0.0001$ ) taller (61.6 cm) than those both after maize (51 cm) and after haricot bean (48.7cm) which is increased by 26.5% from the lowest but varieties grown after maize were significantly ( $P<0.0001$ ) taller than which grown after haricot bean with increasing by 4.7% (Table 1.). Likewise, a significant ( $P=0.0344$ ) effect of double cropping sequence was observed for number of main branches per plant (NMBPP). A higher NMBPP was recorded for plants grown after maize (3.7) than both after fallow (3.5) and haricot bean (3.3) (Table 2.).

Significantly ( $p<.0001$ ) higher mean nodule number plant<sup>-1</sup> was produced by plants grown after fallow (43.9) and after maize (42.97) than plants grown after haricot bean (15.7) (Table 1). This is indirectly related with the amount of water in the soil profile under continuously cropped no-till usually is lower compared with crop-fallow systems (Campbell et al. 2007). Nodule number and dry weight of nodule may affected by the residual moisture in the soil. (Kurdali 1996; Lupwayi and Kennedy 2007) reported that low soil water content reduces nodulation in legumes. Similarly, dry weight of nodule plant<sup>-1</sup> in gram was highly significant ( $P<.0001$ ) higher for plants raised after fallow with mean value of (0.151) whereas mean DWNPP was (0.122) and (0.077) for plants grown after maize and after haricot bean respectively and also significantly ( $p<.0001$ ) more DWNPP was obtained from plants grown after maize (0.122) than after haricot bean (0.077). These may be due to haricot bean fixed more nitrogen during growing period and the fixed nitrogen in the soil may inhibited nodule development of the next legumes. Keyser H. H. and Li F. (1992), and Biederbeck *et al.* (1996) root infection, node initiation, and nodule development were inhibited by the presence nitrogen combination.

In addition, a significantly ( $P=0.0006$ ) higher mean number of pods plant<sup>-1</sup> (NPPP) was produced by plants sown after fallow (109.7 pods) compared with plants next to maize (90.22 pods) and haricot bean (75.667 pods). When the two were compared, chick pea varieties after maize produce significantly more pods than varieties next to haricot bean. The effect of double cropping sequence was also highly significant ( $P<.0001$ ) for total biomass in ton ha<sup>-1</sup> with plants grown after fallow (5.29) than varieties grown after maize (4.80) and haricot bean (3.81). The value after fallow increased the lowest value by 38.8%. Which is may be due to nitrogen released by mineralization process from soil organic matter that was easily available to the next crop. Hurisso T. T., Norton J. B. and Norton U. (2013), Campbell C. A. *et al* (2008) reported that during the summer fallow period nitrogen is released as mineral from soil organic matter and this N is then readily available to crops that are grown the next cropping season. Within similar way cultivars sown next to maize significantly higher than cultivars after haricot bean (Table 1).

**Table 1: Main effects of double cropping sequences on nodulation, growth, pod production, and biomass of three chickpea varieties.**

Treatment	NMBPP	Plant height(cm)	NNPP	DWNPP	NPPP	TBM t/h	NSPP
Fallow	3.5111 <sup>ab</sup>	61.600 <sup>a</sup>	43.922 <sup>a</sup>	0.151 <sup>a</sup>	109.7 <sup>a</sup>	5.29 <sup>a</sup>	1.68 <sup>a</sup>
After h.bean	3.2889 <sup>b</sup>	48.711 <sup>c</sup>	15.744 <sup>b</sup>	0.077 <sup>c</sup>	75.66 <sup>c</sup>	3.81 <sup>c</sup>	1.51 <sup>ba</sup>
After maize	3.6889 <sup>a</sup>	51.111 <sup>b</sup>	42.978 <sup>a</sup>	0.122 <sup>b</sup>	90.22 <sup>b</sup>	4.80 <sup>b</sup>	1.48 <sup>b</sup>
Cv	8.08	4.20	16.6	15.09	16.78	10.17	12.14
P	0.0344	<.0001	<.0001	<.0001	0.0006	<.0001	0.048
LSD	0.2905	2.5418	5.8427	0.0166	15.562	0.4844	0.1945

*Note:* NMBPP= number of main branch per plant, NNPP= number of nodule per plant, DWNPP = dry weight of nodule per plant, NPPP= number of pod per plant, TBM t/h= total biomass in ton per hector, straw W t/h= straw weight in ton per hector. Means followed by the same letter(s) with in a column are not significantly different at  $P = 0.05$  (Duncan's Multiple Range Test).

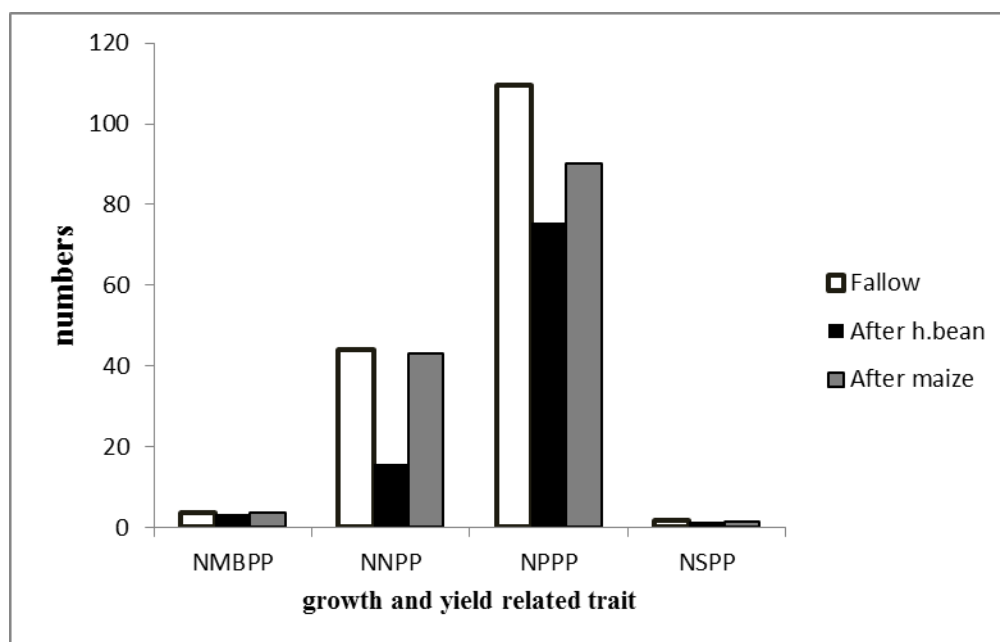


Figure 1: Effects of double cropping sequence on nodulation, growth, and pod production of three chickpea varieties. NMBPP= number of main branch per plant, NNPP= number of nodule per plant, and NPPP= number of pod per plant.

### 3.2. The phenological, nodulation and agronomic traits of the three chickpea variety (Number of main branch, plant height, nnpp, dwnpp)

The data revealed that cultivars differed significantly from one cultivar to another with respect to plant height. Previously similar results have been reported by Sundaram et al. (1999) and Kasole et al. (2005). Among three chickpea varieties' plant height one was significantly ( $P < 0.0001$ ) different than the two. Similarly the highest plant height (59.8) was recorded with habru chickpea cultivar than local and mastewal chickpea cultivars with the values (50.2 cm) and (51.2cm) respectively. However, non-significant differences in plant height between local and mastewal varieties were observed (Table 2).

The assessment of nodule number per plant (NNPP) was carried out at three different varieties of chickpea crop and only for NNPP of habru chickpea variety, a significantly ( $p = 0.0404$ ) higher number of nodule per plant (37.75) was observed.. However, when mastewal (34.870) and local (30.022) varieties of NNPP was compared, they were different but their difference was not significant (Table 2). The significant differences in total number of nodules for the desi chickpea and the kabuli chickpea (Stephen K.B. thesis 2000).



Dry weight of nodule per plant in gram significantly ( $P=0.0011$ ) different among the three chickpea varieties when they were compared each other. Significantly the highest DWNPP was weighted in gram (0.141 gram per plant) with habru chickpea variety than the two and the lowest DWNPP was weighted with local chickpea variety (0.088 gram per plant). Similarly from mastewal (0.121 gram per plant) chickpea variety significantly more DWNPP was obtained than local (0.088 gram per plant) (Table 2).

**Table 2: The growth and nodulation of the three chickpea varieties in Damot Galle, southern Ethiopia, 2016**

Variety	Plant height	NNPP	DWNPP
	(cm)		(g)
Local	50.26b	30.02b	0.09c
Habru	59.88a	37.75a	0.14a
Mastewal	51.29b	34.87ab	0.12b
cv	4.2	16.62	15.09
p	<.0001	0.0404	0.0011
LSD	2.5418	5.8427	0.0166

*Note:* NMBPP=number of main branch, NNPP= number of nodule per plant, DWNPP<sub>in gm</sub>=dry weight of nodule per plant, cv= coefficient of variance. Means followed by the same letter(s) with in a column are not significantly different at  $P = 0.05$  (Duncan's Multiple Range Test).

### 3.3. Yield and yield related traits of the three chickpea (*Cicer arietinum* L.) varieties

Significantly ( $p=0.0082$ ) different number of pods plant<sup>-1</sup> were counted when local chickpea variety was compared with mastewal and habru chickpea varieties. Accordingly, the lowest NPPP (77.48) was recorded in the mastewal treatment whereas the highest (104.7) NPPP was recorded for plants of local chickpea treatment followed by (88.64) NPPP for the habru chickpea treatment. Number of pods per plant of local chickpea was greater than pod number per plant of mastewal by 35% (Table 3.). The result is similar with Khourgami and Rafiees' (2009) report that there are significant differences between yield components of chickpea cultivars.

The chickpea cultivars exerted significant difference ( $P=0.0426$ ) on number of seed per plant. The number of seed per plant ranged from 1.41 by habru chickpea variety to 1.66 local chickpea

variety (Table 3.). Similar idea raised from Roz-Rokh et al. (2009) has indicated significant differences among chickpea genotypes in term of seed number per pod.

Analysis of variance indicated that total biomass of the three chickpea varieties was significantly ( $P=0.0006$ ) different. The use of improved varieties of chickpea varieties had significant effect on total biomass of chickpea as compared to the local. Consequently, the maximum mean total biomass (5.2 ton ha<sup>-1</sup>) resulted from mastewal chickpea treatment, which was followed by (4.71 ton ha<sup>-1</sup>) from the habru treatment. The lowest mean total biomass (3.99 ton ha<sup>-1</sup>) was recorded from the local variety and their difference is 30% (Table 3.). Consequently, there are variations among chickpea cultivars on yield components. This is supportive with the report of Khourgami and Rafiee (2009).

**Table 3: The result of yield related traits of the three chickpea varieties**

Treatment	NPPP	Total BM	NSPP
		ton/h	
Local	104.7a	3.99c	1.66a
Habru	88.64b	4.71b	1.6ba
Mastewal	77.5b	5.2a	1.41b
Cv	16.78	10.17	12.14
P	0.0082	0.0006	0.0426
LSD	15.562	0.4844	0.1945

*Note:* NPPP= number of pod per plant, total BM ton/h= total biomass in ton per hector, straw W t/h= straw weight in ton per hector, cv= coefficient of variance. Means followed by the same letter(s) with in a column are not significantly different at  $P = 0.05$  (Duncan's Multiple Range Test).

### 3.4. Interaction effects between cropping system treatments and variety types on growth and performance of chickpea

Interaction effects of type of double cropping system and chickpea varieties were studied for all the variables investigated. However, the analysis of variance showed that only six variables among all were significantly influenced by the interaction of the varieties treatment and cropping sequence types. Only these six variables (yield  $t/ha$ , HI, 100sw, S-Pw ratio, NSBPP, FWNPP in gm, NSPPt) (Table 4.).

The three cropping system and chickpea cultivars interaction exerted significant ( $p= 0.0039$ ) different number of seeds  $plant^{-1}$  were counted when local chickpea variety was compared with mastewal and habru chickpea varieties. Accordingly, the lowest NSPPt (99.5) was recorded in the mastewal treatments which grown after haricot bean whereas the highest (245.3) NSPPt was recorded from plants of local chickpea treatment after fallow (Table 4.). Roz-Rokh et al. (2009) has indicated significant differences among chickpea genotypes in term of seeds per plant.

There was a significant ( $P=0.0306$ ) effect exerted on yield by the interaction between the chickpea varieties (treatments) and the three double cropping sequence. There was large variation observed among various combinations of factors for this variable. The yield per hector ranged from (0.99)ton per hector in local chickpea variety (treatment) was sown after haricot bean to 3.16 ton per hector in mastewal chickpea variety (treatment) was sown after fallow (Table 4.). These results are in line with the findings of Minhas et al. (2007), Kumpawat et al. (2000), Verma (2004) and Vinay and Singh (2004) who stated that gram cultivars differed significantly in their genetic potential. In addition, (Ali 2004) and Lopez-Bellido *et al.* (2004a) reported that the average chickpea grain yield was higher for conventional tillage (fallow) than no-till in

wheat-chickpea rotation and Various researchers (Nezami and Bagheri 2005, Fallah 2008) have reported an existence significant difference between different genotypes of chickpea for seed yield.

The interaction between types of cropping sequence and the three chickpea varieties (treatments) had a significant ( $P= 0.0169$ ) effect on harvest index of chickpea varieties. With the three cropping sequence and the three chickpea varieties, habru and local chickpea varieties had a significant ( $P=0.0169$ ) difference in each of the three double cropping system. Accordingly, the minimum harvest index (0.287) was calculated when local chickpea variety was grown after haricot bean was harvested and the maximum harvest index (0.596) calculated mestawal chickpea variety was grown after maize (Table 4.).

The weight of hundred seeds of chickpea responded significantly ( $P=0.0082$ ) to the interaction of the three double cropping system and chickpea varieties. Appropriately, habru chickpea variety resulted significantly highest hundred seed weight (29.63 gram) which was grown after maize whereas the lowest hundred seed weight (11.37) recorded from local chickpea variety after haricot bean. Likewise, Khorgamy and Rafiee (2009) stated that 100- seed weight in chickpea cultivars were significantly different.

The results of analysis of variance indicated that chickpea varieties interacted with type of cropping sequence had highly significant ( $p<.0001$ ) different number of sub branches per plant at all level of interaction. Additionally at the same variety (local) the significantly highest (25.73) NSBPP was counted after fallow double cropping system than after haricot bean (15.4) and

maize (14.93) whereas after haricot bean (15.4) and maize (14.93) had not significant difference. Likewise, the exert of interaction on habru variety enhanced to gave highly significant difference on after fallow (22.6), maize (14.37) and haricot bean (18.47) field with the least significant difference 0.6047. Similarly, the maximum number of sub branches (19.93) of mastewal variety was recorded after fallow than the minimum (14.33) after maize and the medium (16.0) after haricot bean. Generally, the lowest (14.33) NSBPP was obtained from mastewal variety after maize cropping sequence although the highest (25.73) from local variety after fallow. Which is related with Tanaka D. L. and Aase J. K. (1987) stated that during fallowing period a proportion of the rainfall can be conserved in the soil profile, which is then available for crops grown the following cropping season (Sun, M. *et al.* (2013). Additionally, summer fallowing encourages the release of nitrogen (N) via the N mineralization of soil organic matter, thus increasing soil N availability (Campbell et al. 2007).

**Table 4: Interaction effects between cropping system treatments and variety types on growth and performance of chickpea**

Type of D cp	Varieties	yield t/ha	HI	HSW	NSBPP	SNPPT
Fallow	Local	2.49bc	0.55 ab	11.37d	25.73a	245.3a
	Habru	2.85ab	0.55ab	28.5a	22.60b	169.2b
	Mastewal	3.16a	0.52ab	26.07b	19.93c	142.4b
After maize	local	1.57e	0.41bc	12.1d	14.93fg	171.3b
	Habru	2.297c	0.39cb	29.63a	14.37g	103.87cd
	Mastewal	3.12a	0.59a	22.8c	14.33g	127.47cd
After H.bean	local	0.99f	0.29 c	11.37d	15.4ef	108.67cd
	Habru	2.14cd	0.593ab	28.9a	18.47d	109.80cd
	Mastewal	2.14cd	0.50ab	22.93c	16.0e	99.53d
	cv	11.26	18.49	4.32	3.27	12.949
	p	0.030	0.016	0.0082	<.0001	0.0039
	LSD	0.2671	0.093	0.9557	0.6047	18.881

*Note:* yield <sub>th</sub>= yield in ton per hectore, HI= harvest index, 100sw= hundred seed weight in gram, s-p w ratio= seed pod weight ratio, nsbpp= number of sub branch per plant, fwnpp <sub>in gm</sub>= fresh weight of nodule per plant in gram, cv= coefficient of variance. Means followed by the same letter(s) with in a column are not significantly different at  $P = 0.05$  (Duncan's Multiple Range Test).

### 3.5. Cost benefit analysis

The partial budget analysis indicate that most of the treatment were dominated and were eliminated from further consideration and some treatments were non dominated and those treatment were considered for further marginal rate of return analysis. Non dominated treatments are mastewal after fallow, habru after fallow system and habru after maize which were considered for further marginal rate of return analysis. The marginal analysis indicate that the treatment mastewal after fallowing system, habru after fallowing system and habru after maize were resulted in marginal rate of return (MRR) above the minimum acceptable value (100%). The three highest net incomes and give above MRR are obtained from habru interact with after maize double cropping sequence (93451 birr), habru interact with after fallow double cropping sequence (75060 birr), mastewal interact with after maize double cropping sequence (87941 birr) and mastewal interact with after fallow double cropping sequence(53760). Value of marginal rate of return(MRR) for treatments mastewal after maize, mastewal after fallowing cropping sequence, habru after fallow cropping sequence and habru after maize cropping sequence are 2946, 2055.9, 2130 and 551 respectively. There for, chickpea after maize and after fallow known to be economically feasible at *gacheno kebele*.

## 4. Conclusion

Cropping sequence and varieties had significant interaction which affected yield, harvest index, hundred seed weight, seed weight to pod weight ratio per plant, number branch per plant, fresh weight of nodule per plant and seed number per plant chickpea cultivars. Among cropping systems after fallow was found to be superior in improving the yield of chickpea and among cultivars, *mastewal* was found produced significantly higher yield compared with the two. Significantly, higher yield was obtained from combination of after fallow system and *mastewal* chickpea cultivar. Consequently economically optimum yield was obtained from treatment *mastewal* after fallow and habru after maize but habru after fallow gave economically highest marginal rate of return.

Thus, *habru* and *mastewal* chickpea cultivars after fallow and habru after maize can be recommended for enhanced production of chickpea in *gacheno kebele*. However, further verification and demonstration of the results on several farmers' field is recommended before large scale use of technology.

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# Response of Chickpea to Water Stress and Blended Fertilizers on Vertisols of Meskan, Southern Ethiopia

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## Abstract

A pot experiment was conducted to evaluate the response of chickpea to water stress and different blended fertilizer at Hawassa, College of Agriculture campus under green house from January to June, in 2017. Three water stress levels (Without stress (control), vegetative water stress & seed filling water stress) and five fertilizer type (0, DAP, NPS, NPSZnB & NPKSZnB) was laid in split-plot design with four replications. The results showed that water stress significantly affected all parameters studied in this experiment. The seed filling water stress resulted in reduced the value of all parameters studied compared to optimum watering and vegetative stress except number of primary branch and harvesting index, which were significantly lower under vegetative water stress. The NPKSZnB blended fertilizer applications resulted significantly (0.05) increase the value of all yield and yield attributes of chickpea. Similarly, the interaction effect of water stress and fertilizer showed significant effect (0.05) on number of primary branch, number of pods per plant, seed weight per plant, hundred seed weight, harvest index and number of nodules per plant. Seed filling stress with no fertilizer application was significantly reduced number of primary branch, number of pods per plant, seed weight per plant, hundred seed weight, straw yield and number of nodules per plant. The results of present investigation indicated that applications of NPKSZnB fertilizer with supplementary irrigation at vegetative and seed filling stage could increase chickpea productivity.

**Key words:** Chickpea, water deficit, blended fertilizer

## INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the second most important pulse crop in the world after dry bean (Akibode and Mywish, 2011). The protein, complex carbohydrates, fibre, vitamins and minerals constituents make this legume an important component of human diet in the developing world (FAO, 2004). Generally, the protein quality of chickpea is higher than that of many other legumes (Singh 'et al', 2005). Chickpea serves as a good rotational crop and significantly contributes to agricultural sustainability by fixing nitrogen (FAO, 2004). Its presence improves soil health by promoting microbial population and activity (Nishita and Joshi, 2010).

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In Ethiopia chickpea covers about 258,486 hectares of the land with production of 472,611 tones (CSA, 2016). The average national chickpea yield is 1.83 tones/ha (CSA, 2016), which is higher than countries including India and Pakistan (0.6-0.7 tones/ha) (FAO, 2013). However, yields on experimental plots in Ethiopia have produced 2.9 to 3.5 tones/ha (IFPRI, 2010) indicating a productivity gap of at least 1.07 tones/ha. Filling this gap would make Ethiopia among the major chickpea producing countries. The low productivity is mainly due to limited use of improved crop production technologies, beyond biotic and abiotic constraints (Menale et al., 2009; FAO, 2013). Therefore, it is essential to develop and disseminate yield-increasing technologies across agro ecology.

Chickpea is produced in a limited scale in Southern Ethiopia. Since 2010, chickpea production has expanded in SNNPR through introduction of improved production technologies and practices with the support of a joint project involving Hawassa University, Saskatchewan University (Canada), Bureau of Agriculture and Natural Resources and other partners. Production of chickpea in the region was limited to local low yielding Desi type landraces. High yielding improved desi and Kabuli varieties have been introduced in various districts through participatory variety selection. As a result of this joint effort, the area under chickpea production increased to 11,795 ha with yield of 21,400 tons and 82,083 households were involved (CSA, 2016). However, like other part of chickpea growing areas of the country the harvested yield is by far below from the potential yield.

Drought stress, absence of appropriate fertilizer type and limited application of other recommended crop production packages of chickpea are the main contributors for low yield. Therefore, introduction of appropriate and affordable technology practices that include appropriate fertilizer type, inoculation, planting high yielding varieties, appropriate water stress management will increase chickpea productivity per unit area.

Chickpea is usually grown on vertisols in Ethiopia. Although vertisols are highly productive relative to sandy soils, they exert a number of constraints on plant growth. Such as deficiency of major essential nutrients and their property of cracking affect root growth and plant survival. In the southern Ethiopia, chickpea is sown as a double crop in early September after harvesting the

principal crop. As a result, chickpea is essentially grown on residual soil water, which often exposes the crop to terminal drought and soil nutrient deficiency during its active growth period (Geletu and Yadeta, 2002). Water deficit during late vegetative and reproductive stages is one of the the limiting factors for production of this crop in the region. The severity of water stress varies from year to year, depending on the amount and distribution of rainfall. Supplementary irrigations at critical stages of crop growth and development can improve chickpea yield substantially (Soltani et al., 2001). However, this requires knowledge on the relative sensitivity and associated yield penalties on the crop when exposed to drought at different phases. Chickpea yields are low in the southern Ethiopia especially in Meskan districts. This study investigated the response of chickpea to water deficit at different growth stages when grown on vertisols of Meskan district applied with different blended fertilizers.

## **MATERIALS AND METHODS**

### **Description of Experimental Site**

A pot experiment was conducted at Hawassa University, College of Agriculture, SNNPRS, Ethiopia at 07°3'N and 038°28'E, and at 1708 masl. The soil was collected from Meskan district chickpea producing farms. Meskan is one of the Districts in Guraghe Zone and located at 8° 04'N latitude and 38° 22' E longitudes at an altitude of 1842 masl. The area receives annual rainfall of 1062.3 mm and has average annual temperatures of 17.4°C.

### **Treatments and Experimental Design**

The chickpea variety Habru (Kabuli type) released by Debrezeit Agricultural Research Center (DARC) in 2004 was used for the study. This was selected because of their high yield, and higher price in export markets. Moreover, this variety was identified to best performance in the study area through participatory variety selection (PACT, 2014). Treatments comprised of two factors: namely three water stress levels assign as main plots (without stress, stress at mid vegetative and stress at seed filling stage) and five fertilizer types assign as sub plots (0, DAP, NPS, NPSZnB, NPKSZnB).

The experiment was arranged in a split plot design with four replications. From these, one randomly selected replication was used for root and nodule data collection. The pots were

arranged with a distance of 20 cm between pots and 40 cm between blocks. Soil taken by auger from five randomly selected chickpea growing farms was composite for medium. Plastic pots having 24 cm diameter and 23 cm height with 10 liters capacity was used. Each pot was filled with 10 kg of soil. Five Seeds of chickpea which inoculated with cp17 *Rhizobium* strain from Holleta agricultural research center at the rate of 0.5 kg /ha was planting in each pot. After germination; seedlings was thinned out to three in each pot. Each fertilizer formula was applied at the rate of 100kg/ha. But plants grown in pots meet their nutrient requirement from confined soil mass only, while plants grown in fields draw nutrients from all sides and deeper layers (subsoils) without any barrier or hindrance. Therefore potted plants need almost double the dose of applied fertilizer nutrients (compared to those grown in fields) for normal growth (**Kundu ‘et al’. 1996**). Therefore, each pot was received 3.2gm fertilizer according to the treatments by calculating on plant basis.

Table 1. Treatment combinations

Water stress	Fertilizer types
Without stress (OPT)	0
	DAP
	NPS
	NPSZnB
	NPKSZnB
Vegetative water stress (VS)	0
	DAP
	NPS
	NPSZnB
	NPKSZnB
Seed filling water stress (SFS)	0
	DAP
	NPS
	NPSZnB
	NPKSZnB

Table 2. The percentage of each nutrient in different fertilizer formula

Fertilizer type	N (%)	P <sub>2</sub> O <sub>5</sub> (%)	K <sub>2</sub> O (%)	S (%)	Zn (%)	B (%)
DAP	18	46.0				
NPS	19	38.0		7.0		
NPSZnB	16.9	33.8		7.3	2.23	0.67
NPKSZnB	13	26.1	13.7	5.6	1.72	0.51

## Water Management procedure

All pots were well watered until the beginning of drought stress treatments. The water application was done by measuring the soil moisture content using Delta-T-Device, Model HH2, which was installed at 12cm depth inside of pots. The reading was displayed in volumetric water content. For control group soil water in each pot was maintained through around field capacity.

The amount of water to be applied was calculated based on water deficit (root zone depletion) as explained by FAO (2012) (Equation 1). Graduated cylinder was used to measure the amount of water applied.

$$Dr = Wr(fc) - Wr(t) \dots\dots\dots (1)$$

Where Dr=root zone depletion (mm), Wr(fc) =soil water content of the root zone at field capacity (mm), Wr(t)= soil water content of the root zone expressed as depth (mm)

$$TAW = fc - pwp \dots\dots\dots (2)$$

Where TAW = total available water (%), fc = field capacity (%) and pwp (%) = permanent wilting point

$$\begin{aligned} &= 39.16-19.35 = 19.81 \\ &= 19.81*0.25 = 4.9525 \\ &= 19.35+4.9525 = 24.3025\% \end{aligned}$$

One day before starting the treatments, soil moisture in each pot was maintained to field capacity so that the soil moisture amount at each pot was uniform. When the seedling reached first compound leaf stage, the irrigation was completely withhold for vegetative stress treatments until the moisture content of the soil arrived 25% of TAW (24.3025%). It took only 16 days to reach 25% of TAW. And then normal irrigation was applied. The same procedure was employed at seed filling crop stage for seed filling water stress treatments. However to arrive 25% of TAW (24.3025%) it took only 14 days.

## Data Collection

### Soil sampling and analysis

Before sowing, a composite sample was prepared from a bulk soil which collected at 0-30cm depth for physico-chemical analysis. Soils was oven dried for 24 hours at 105°C, grinded and

mixed thoroughly and passed through a 2 mm sieve. Then it was analyzed at the soil laboratory for soil texture, FC, PWP, pH, OC,CEC, K, P, N, S, B, Zn by following standard procedures for each parameter. And also moisture content at stress conditions was measured.

### **Measurements and statistical analysis**

Morphological and agronomic data (Plant height (PH), number of primary branches (NPB), number of secondary branches (NSB), dry mass (DM)), root and nodule parameters (number of nodules per plant (NNPP), nodule dry weight (NDW) and root dry weight (RDW)) were collected.

Also at harvest, plant yield and yield component data (number of pods per plant (NPPP), number of seeds per pod (NSPP), seed weight per plant (SWPP), hundred seed weight (HSW)) were collected. Harvest index (HI) was calculated as the ratio of seed dry weight to total crop dry weight.

The analysis of variance was carried out using statistical packages and procedures appropriate to RCBD design using SAS Computer Software. Mean separation was carried out by using least significance difference (LSD) at 5% probability level.

## Results and discussion

### physico-chemical characteristics of soil

Soil texture was determined by hydrometer method (Bouyoucos, 1962). The soil pH was measured using a glass combination electrode pH meter with the electrode inserted in the filtered supernatant solution of a 1:2.5 soil to water suspension, whereas soil organic carbon was determined by dry combustion method using a LECO CR-12 carbon determinator (LECO instruments Ltd, Mississauga, ON L5T 2H7). Total nitrogen of the soil was determined by wet acid Kjeldahl digestion method, and available P was determined using the standard Olsen extraction method (Olsen et al., 1954). the exchangeable base cations ( $K^+$ ,  $Ca^+$ ,  $Mg^+$  and  $Na^+$ ) were extracted with 1M ammonium acetate at soil pH 7.0 (Chapman, 1965). Cation exchange capacity of the soil was estimated by measuring the sum of exchangeable cations from the ammonium acetate extracted sample. Available Zn and B contents of the soil were extracted by diethylenetriaminepentaacetic acid (DTPA) method (Tan, 1996) and concentrations were determined by AAS.

Analytical results of the composite surface soil indicated that the soil was clayey in texture (66.41% clay) and had high field capacity (39.16) and permanent wilting point (19.35) (Table1).

It was neutral (pH 6.67) in reaction, low in total N and organic carbon and very low in C: N ratio (7.42:1), whereas the sulfate content was medium (5.6ppm) (Table1). The Netherlands commissioned by Ministry of Agriculture and Fisheries (1985) reported that soil total N (%) of > 0.300, 0.226-0.300, 0.126-0.225, 0.050-0.125 and < 0.050 as very high, high, medium, low and very low, respectively, and total C (%) of greater than 3.50, 2.51-3.5, 1.26-2.50, 0.60-1.25 and < 0.60 as very high, high, medium, low and very low, respectively. The report included C/N ratios of >25, 16-25, 11-15, 8-10 and < 8 as very high, high, medium, low and very low respectively. Tekalign et al. (1991) also classified soil N availability of < 0.05% as very low, 0.05-0.12% as poor, 0.12-0.25% as moderate and > 0.25% as high.

Accordingly, considering the respective limits set by the Netherlands commissioned by the Ministry of Agriculture (1985) and Tekalign et al. (1991), the total N and organic carbon contents



of the soil were low, while the C: N ratio of the soil in the study area was very low. The reason for the low level of total N and organic carbon contents of the soil might be due to continuous removal of the crop residues and organic matter oxidation, which is aggravated by tillage activities (Wakene, 2001).

The nutrient class range identified by Marx (1996) indicated that soils containing < 10 ppm, 10-20 ppm and 20 ppm were considered as low, medium and high respectively in available P. Thus, the experimental soil is low in available P, which indicating phosphorus application is needed for optimum plant growth. Such soil conditions may have apparently influence on the microbial activity since phosphorus plays important role in several energy requiring biochemical reactions including biological nitrogen fixation.

Calcium was the most dominant basic cation 30.38cmol (+)/kg followed by Mg, Na and K respectively (table1). Moreover, the soil exhibited high percent base saturation and very high cation exchange capacity showing that if it is supplemented with deficient nutrients the experimental soil is good for crop production. According to Landon (1991), topsoils having CEC > 40, 25-40, 15-25, 5-15 and < 5 cmol (+)/kg of soil are classified as very high, high medium, low, and very low respectively, in CEC. Accordingly, the soils of the study site have very high CEC, which is a reflection of the very high clay (66.41%) content.

The extractable Zn (1.35mg/kg) was bellow the critical level (1.5 ppm) suggested by Karlun 'et al' (2013), indicating the experimental soil is deficient and Zn fertilization is required for a better crop production. The deficiency of Zn could be due to high clay of the soil, which has capacity to fix Zn on colloidal surface. These results are in line with the findings of Alloway (2008) who reported that Zn generally has low mobility in soils and a tendency of adsorption on clay-sized particles. The other reason for the low level of Zn in the area might be due to continuous harvesting of crop, organic matter oxidation, removal of the topsoil by sheet erosion that is aggravated by tillage activities (Wakene, 2001).

Table 3. Selected physico-chemical properties of the experimental soil

Parameters		Value
Textural class		Clay
Bulk density		1.24
FC		39.16
PWP		19.35
pH(H <sub>2</sub> O)		6.67
Total N (%)		0.12
Available P(mg /kg soil)		8.6
S(mg/kg soil)		5.6
Zn(mg/kg soil)		1.35
B(mg/kg soil)		0.02
OC (%)		0.89
C/N ratio		7.42
Exchangeable cation (cmol(+)/kg soil)	Na	1.15
	K	0.80
	Ca	30.38
	Mg	9.97
CEC (cmol(+)/kg soil)		46.44

The extractable B (0.02 mg/kg) is also bellow the critical level (0.8 mg/kg soil) in accordance with Karlun et al. (2013). The major factors, which may cause B deficiency in soils, are low B content in the parent material, which decompose easily, soil type, pH and leaching (Tisdale et al., 2003). Low soil organic matter content, intensive cultivation and continuous nutrient uptake by crops without application to the soils as fertilizer, and the use of fertilizers poor in micronutrients are considered to be the major factors associated with the occurrence of B deficiency (Rashid ‘et al’., 2005, Niaz ‘et al’., 2007).

### Weather data

Daily maximum and minimum air temperatures ranged between 37.64°C and 14.75°C respectively (fig.1). During flowering stage average daily temperature was relatively high. As a result number of pods per plant was reduced due to flower abortion by high temperature.

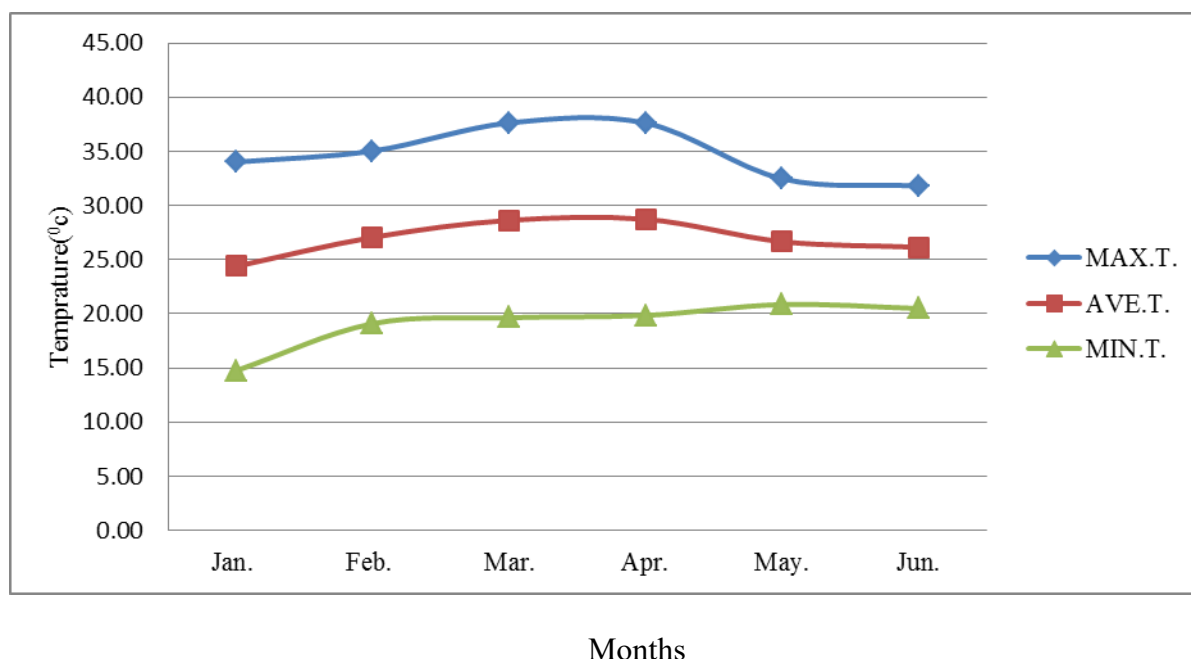


Figure 1. Monthly mean minimum and maximum temperature ( $^{\circ}\text{C}$ ) data of the greenhouse. MAX.T. = maximum temperature; MIN.T. = minimum temperature and AVE.T. = average temperature. The crop growth period was January to June 2017.

### Growth, yield and yield components

The tallest plant height and maximum number of primary branch were recorded from optimum watering. While the shortest height and minimum number of primary branch was recorded from vegetative water stress treatment (table 4). In agreement with this study Yunusa 'et al', (2014), Randhawa 'et al', (2014) who reported that moisture stress during vegetative stage is harmful and detrimental. This may be due to inhibited of cell elongation by interruption of water flow from xylem to the surrounding elongating cells. The highest performance in terms of dry mass, number of pod per plant, seed weight, hundred seed weight and number of seed per plant were obtained when chickpea was grown under optimum soil moisture condition (Table 4). While, the lowest values of those traits were obtained from chickpea when it was exposed for seed filling water stress except number of seed per plant which was minimum with vegetative water stress treatment. Alla 'et al', (2015) showed that number of pods and seed weight per plant and hundred seed weight decreased significantly ( $p \leq 0.001$ ) with the increase in water deficit. Morad 'et al', (2012) and Gwathmey and Hall (1992) reported similar results. The significant reduction in those

parameters under drought stress may be attributed to the abscission of the reproductive structures. The chickpea dry mass reduction in water stress pots could be attributed to lower CO<sub>2</sub> accumulation in biochemical reactions of photosynthesis and therefore to lower carbohydrates production (Hopkins and Hüner, 2004 ; Pots 'et al', 2008). Harvest index was significantly higher at seed filling and lowest at vegetative water stress conditions.

The fertilizer application of NPKSZnB followed by NPSZnB also gave the highest value of plant height, number of primary branch, pods per plant and seeds per pod, dry mass, seed weight per plant, hundred seed weight. In contrast stressed plants and non fertilized ones had the significantly lower. However the highest value of harvest index was obtained from control followed by NPKSZnB and the lowest was from NPS applications. Fertilization with DAP and NPS alone were gave significantly lower compared to applied with zinc, boron and potassium but higher compared to control in all growth, yield and yield components of chickpea parameter tested (Table 4). Potassium application increased the availability of nitrogen and phosphorus (Sahai, 2004) which resulted in better growth and yield performance of plant. Therefore poor performance of chickpea where no potassium was applied might have been due to less availability of N and P and stunted growth. The results are supported by Samiullah and Khan (2003).

Table 4. The main effects of water stress and fertilizer on selected growth, yield and yield components of chickpea

Treatments	PH (cm)	NPB	DM (gm)	NPPP	SWPP (gm)	HI	HSW (gm)	NSPP
<b>Stress</b>								
<b>OPT</b>	44.23a	5.43a	31.02a	43.73a	10.57a	0.342046b	20.37a	1.35a
<b>VS</b>	39.56b	3.96c	25.69b	39.10b	8.33b	0.327735c	16.90b	1.18b
<b>SFS</b>	39.80b	4.30b	20.00c	35.73c	7.06c	0.357616a	12.23c	1.26b
<b>LSD<sub>(0.05)</sub></b>	0.64	0.32	0.70	0.78	0.22	0.0093	0.33	0.10
<b>Fertilizer</b>								
<b>No</b>	37.83d	3.66d	20.71e	35.50d	7.53d	0.369a	14.77d	1.01d
<b>DAP</b>	39.83c	4.27bc	24.24d	36.88c	8.19c	0.344b	15.85c	1.14c
<b>NPS</b>	39.94c	3.94cd	25.24c	36.55c	8.14c	0.326c	15.93c	1.26bc
<b>NPSZnB</b>	42.44b	4.66b	27.44b	40.94b	8.93b	0.327c	17.09b	1.31b
<b>NPKSZnB</b>	45.94a	6.27a	30.21a	47.72a	10.47a	0.343b	18.85a	1.60a
<b>LSD<sub>(0.05)</sub></b>	0.83	0.41	0.91	1.01	0.28	0.012	0.43	0.13
<b>CV(%)</b>	2.98	13.44	5.27	3.81	4.89	5.20	3.89	15.62

Means with the same letters are not significantly different; LSD = Least significance difference; PH = plant height; NPB = number of primary branch; DM = dry mass; NPPP = number of pods per plant; SWPP = seed weight per plant; HI = harvest index; HSW = hundred seed weight; NSPP = number of seed per plant.

The interaction effect of water stress and fertilizer applications was significant (0.05) on plant height, dry mass, number of pods per plant, seed weight per plant and hundred seed weight. The tallest plant height and maximum number of pod per plant were obtained from NPKSZnB application followed by NPSZnB and the shortest plant height and minimum number of pod per plant was observed with no fertilization across all water stress treatments. In agreement with (Singh and Kuhad, 2005) who reported that water stress resulted in marked decrease in major yield and yield attributes of chickpea. This may be due to the presence of Potassium which helps in maintaining the water status of plants under water stress which in turn maintains various physiological processes and thereby increase the growth and yield For instance NPKSZnB applications under adequate watering gave 49.83cm height and 54.33 pods per plant. While no fertilization under vegetative water stress gave 35.66 height and 32.66 pods per plant (Table 5).

Table 5. The interaction effects of water stress and fertilizer on plant height, number of primary branch, number of pod per plant, harvest index, number of seed per plant, number nodule per

Treatments		Parameters							
Stress	Fertilizer	PH(cm)	NPB	NPPP	HI	NSPP	NNPP	DNW(mg)	DRW(gm)
OPT	No	39.66e	4.50	38.00ef	0.33bc	1.00	48.00	124.23	18.45
	DAP	43.16c	5.33	40.83cd	0.32c	1.23	48.66	141.58	18.75
	NPS	43.16c	4.83	39.66de	0.33bc	1.36	49.33	143.48	19.63
	NPSZnB	45.33b	5.50	45.83b	0.34b	1.50	51.66	132.00	19.03
	NPKSZnB	49.83a	7.00	54.33a	0.38a	1.66	59.50	176.58	19.38
VS	No	35.66g	3.00	32.66h	0.38a	1.00	13.00	33.91	17.76
	DAP	38.33f	4.00	32.66h	0.32c	1.06	19.66	54.71	18.11
	NPS	38.33f	3.50	32.83h	0.30d	1.13	20.00	55.53	18.36
	NPSZnB	41.50d	4.00	37.83ef	0.29d	1.20	22.33	62.28	18.55
	NPKSZnB	44.00c	5.33	42.66c	0.32c	1.53	28.66	83.78	19.01
SFS	No	38.16f	3.50	35.83g	0.39a	1.03	10.66	28.26	15.38
	DAP	38.00f	3.50	37.16fg	0.38a	1.13	11.83	30.66	16.30
	NPS	38.33f	3.50	37.16fg	0.34b	1.30	11.50	29.05	16.30

plant, dry nodule weight and dry root weight of chickpea.

	NPSZnB	40.50de	4.50	39.16de	0.34b	1.23	20.00	54.76	16.71
	NPKSZnB	44.00c	6.50	46.16b	0.33bc	1.60	23.50	66.86	17.56
LSD <sub>(0.05)</sub>		1.31	Ns	1.85	0.02	NS	NS	NS	NS
<hr/>									
CV		2.98	13.44	3.81	5.20	15.62	13.01	28.74	3.26
<hr/>									

Means with the same letters are not significantly different; LSD = Least significance difference; PH = plant height; NPB = number of primary branch; NSPP = number of seed per plant; HI = harvest index; NPPP = number of pods per plant; NNPP = number of nodules per plant; NDW = nodule dry weight; RDW = root dry weight

The presence of potassium, zinc and boron in blended fertilizer were increase the dry mass, seed weight per plant and hundred seed weight of chickpea across all water stress treatments. The current study in line with (Ahlawat et al., 2007) who reported that the main micronutrients that limit chickpea productivity are zinc (Zn) and Boron (B) may cause yield losses up to 100%. Potassium has an important role in different physiological and biochemical processes such as plant water relations, stomatal movement, osmoregulation, CO<sub>2</sub>-exchange, carbon and nitrogen metabolism, transpiration, protein synthesis, enzyme activation growth and yield of plant (Singh and Kuhad, 2005; Sharma et al., 2008).

Maximum dry mass, seed weight per plant and hundred seed weight were recorded with NPKSZnB under optimum watering. Whereas the lowest value of those parameters were recorded with control fertilizer treatments under chickpea grown seed filling water stress (fig.2).

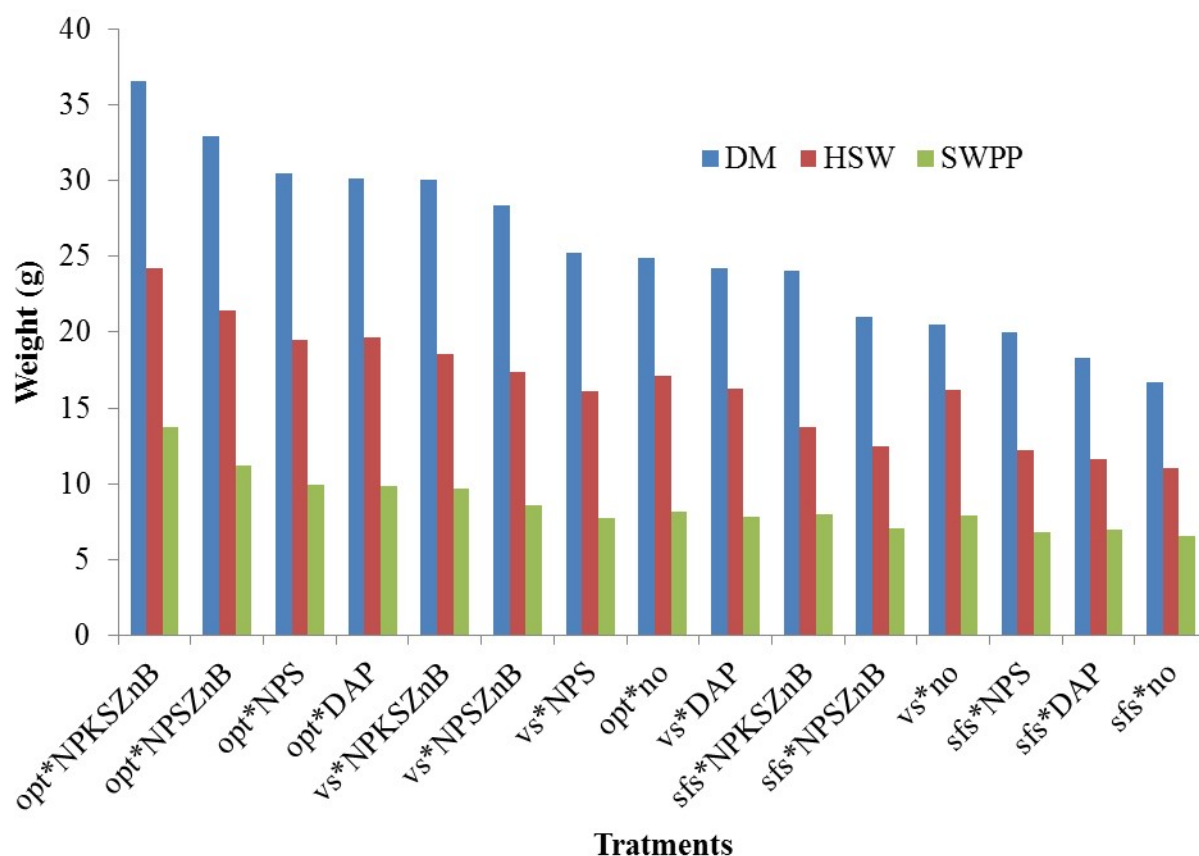


Figure 2. The interaction effects of water stress and fertilizer on dry mass, hundred seed weight, straw yield and seed weight per plant in gram.

### Root and nodule parameters

Number of nodule per plant, dry nodule and dry root weight were significantly reduced with seed filling water stress by 69.86%, 70.8% and 13.65% respectively compared to optimum watering (Table 6). In agreement with Kurdali 'et al', (2013) who indicated that water restriction during the post-flowering period in chickpea considerably affect number of nodules per plant. Adverse effect of water deficit on nodule parameters have been reported by number of workers (Asseng and Hsiao, 2000, Morteza 'et al', 2014. Structural alterations and reduced nodule number associated with moisture stress also causes a reduction in the amount of nitrogen fixed. This may be further aggravated by a reduction in the host photosynthetic capacity.

Randhawa 'et al', (2014) and Millan 'et al', (2006) supported the current study by reporting water stress significantly reduce dry weight of root on chickpea. This may be due to reduce portioning of biomass towards root Pimratch 'et al', (2008).



Those traits had significantly highest with NPKSZnB applications. While the lowest values of those parameters observed with no fertilization. This finding was also supported by Kurdali et al. (2002) in chickpea. However the interaction effect of water stress and fertilizer had not significant effect on tested nodule and root parameters.

Table 6. Main effects of water stress and fertilizer on root and nodule parameter.

Means with the same letters are not significantly different; LSD = Least significance difference; NNPP= number of nodules per plant; NDW=nodule dry weight; RDW = root dry weight

### Conclusions

Water stress at vegetative stage affects growth parameters. Whereas, yield and yield components, root and nodule parameters were highly affected when chickpea crop was water stressed during seed filling stage. Chickpea performed better due to applications of potassium, zinc and boron with NPS in blended form across water stress treatments. Therefore, supplementary irrigation at vegetative stage and seed filling stage with application of NPKSZnB increases the yield of chickpea which is usually growing after harvesting of cereal crop with residual moisture by majority of Ethiopian farmers.

Treatments	NNPP	NDW(g)	RDW(g)
<b>Stress</b>			
OPT	51.43a	143.57a	19.05a
VS	20.73b	57.84b	18.36b
SFS	15.50c	41.92c	16.45c
LSD <sub>(0.05)</sub>	1.98	12.13	0.34
<b>Fertilizer</b>			
No	23.88d	62.13c	17.20c
DAP	26.72c	75.65bc	17.72b
NPS	26.94c	76.02bc	18.10b
NPSZnB	31.33b	83.01b	18.10b
NPKSZnB	37.22a	108.74a	18.65a
LSD <sub>(0.05)</sub>	2.55	15.67	0.39
CV	13.01	28.74	3.26

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### **3. Applied Human Nutrition**

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# **Effectiveness of Women Development Team Leaders in Delivering Nutrition Education: The case of Women in Hawassa Zuria, Southern Ethiopia**

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## **Abstract**

The effectiveness of women development team and one-to-five network leaders in delivering nutrition education under the conditions of Hawassa Zuria (southern Ethiopia) was studied during the 2017. Quasi-experimental method was used. The experiment was conducted in three kebeles: the intervention kebele, positive control kebele and negative control kebele. In the intervention kebele the nutrition education was given to the health extension workers who taught women development team leaders; and then, these women development team leaders share their knowledge to one-to-five network leaders and team members; and finally, these one-to-five network leaders in turn transferred the knowledge to one-to-five network members. In the positive control kebele the nutrition education was given to the health extension workers who taught directly the one-to-five network members. In the negative control kebele no education was given during the study period, but after the end line data was collected. The data collected will be subjected to analysis of variance and significant means will be separated using Tukey multiple comparison test at 5% probability. The qualitative evaluation of data from focus group discussion and observation will also be narrated. The hypothesis is that nutrition education through the women development team leaders is more effective than through the health extension workers.

**Key words:** health extension worker; women development team; one-to-five network, knowledge transfer, sprout, KAP.

## **1. Introduction**

The government of Ethiopia introduced Health Extension Program (HEP) in 2003 (UNICEF, 2014), a free primary health care package with four components: disease prevention and control, family health, hygiene and environmental sanitation, and health education and communication (Kok *et al.*, 2015). The objectives of HEP were to deliver preventive and basic curative high-impact interventions to the Ethiopian population (Bilal *et al.*, 2011). The Health Development Team (HDT) was introduced in 2012, officially replacing other community-based workers such as health promoters and traditional birth attendants (TBAs). This is based on gradual training of model families by Health Extension Workers (HEWs). Model families become leaders of a group of five families known as the “one-to-five network”, who in turn form a “development group” of 25 to 30 households within a village (Kok *et al.*, 2015). The major health problems of

Ethiopia remain largely preventable communicable diseases and nutritional disorders (Mebratu, 2014).

Nutrition education can make a significant contribution to improved dietary practices. Carefully designed and effectively implemented nutrition education can motivate those participating to change dietary behaviors and provide them with the knowledge and skills to make healthy food choices in the context of their lifestyles and economic resources (FNS, 2010). Food-based strategies are key to addressing hunger and malnutrition, and the desired characteristics of foods include high nutrient density, low bulk property, as well as utilization of low cost and locally-available crops (Kebebu *et al.*, 2013).

Effective nutrition education helps consumers select and consume healthy and enjoyable foods by improving awareness, skills, and motivates to take action at home, school, and work (FNS, 2010). Applied food processing techniques like sprout and fermentation minimize anti nutritional factors and enhance nutrient intake and palatability (Kebebu *et al.*, 2013). Thus, this study assessed the effectiveness of WDT and one-to-five network leaders to transfer knowledge on the use of sprouted pulse through Health Belief Model in three *Kebeles* of Hawassa Zuria district, Southern Ethiopia.

## **2. Materials and Methods**

### **2.1 Description of the study area**

Hawassa Zuria district is one of the 19 districts of Sdama zone which found in the South Nation Nationalities and Peoples Region (SNNPR) (Fig. 1). It is bordered on the south by Shebedino and Boricha districts, on the west and north by the Oromia Region, and on the east by the Lake Hawassa (Encyclopdia, 2016). The main agricultural crops cultivated in the Woreda are maize, haricot bean peas and various types of root crops. The rainfall *ranges b/n 750 and 900 mmHg*. The climate of the area is semi-arid and arid receiving an average annual rainfall of 760 mm with an average temperature ranging from *Minimum 16<sup>0</sup>c Maximum 27<sup>0</sup>c. Altitude ranges from 1680 to 2090m*.



**Figure 1:** Map of the study area (Hawassa zuria district).

The district has a total population of 165,531 of whom 82,876 are men and 82,655 women and 85.8% of the inhabitants were Protestants, 6.67% Muslim, and 5.61% Catholic (CSA, 2007). The study was carried out from November 2013 to April 2014. Nutrition education was given for six months after completing the baseline survey.

## 2.2 Study design

The study used quasi-experimental design. The research was carried out from May to November 2017.

## 2.3. Study population and Study unit

The study populations were leaders of Women Development Team (WDT), one-to-five network and members of one-to-five network, purposively selected in the three selected kebeles, namely Jara Gelelcha, Lebu Korom, and Dore Bafana. Since WDT leaders were few in number, all of them in the selected *kebeles* were studied. Under each WDT four teams from each *kebele* were randomly selected for the nutrition education and their respective one-to-five network leaders and one-to-five network members were included. In the intervention kebele, Jara Gelelcha, the



HEWS trained WDT leaders who delivered the training to mothers. Lebu Koromo served as positive control where the nutrition education was delivered by HEW directly to mothers. Dore Bafana kebele was the negative control where nutrition education was not delivered.

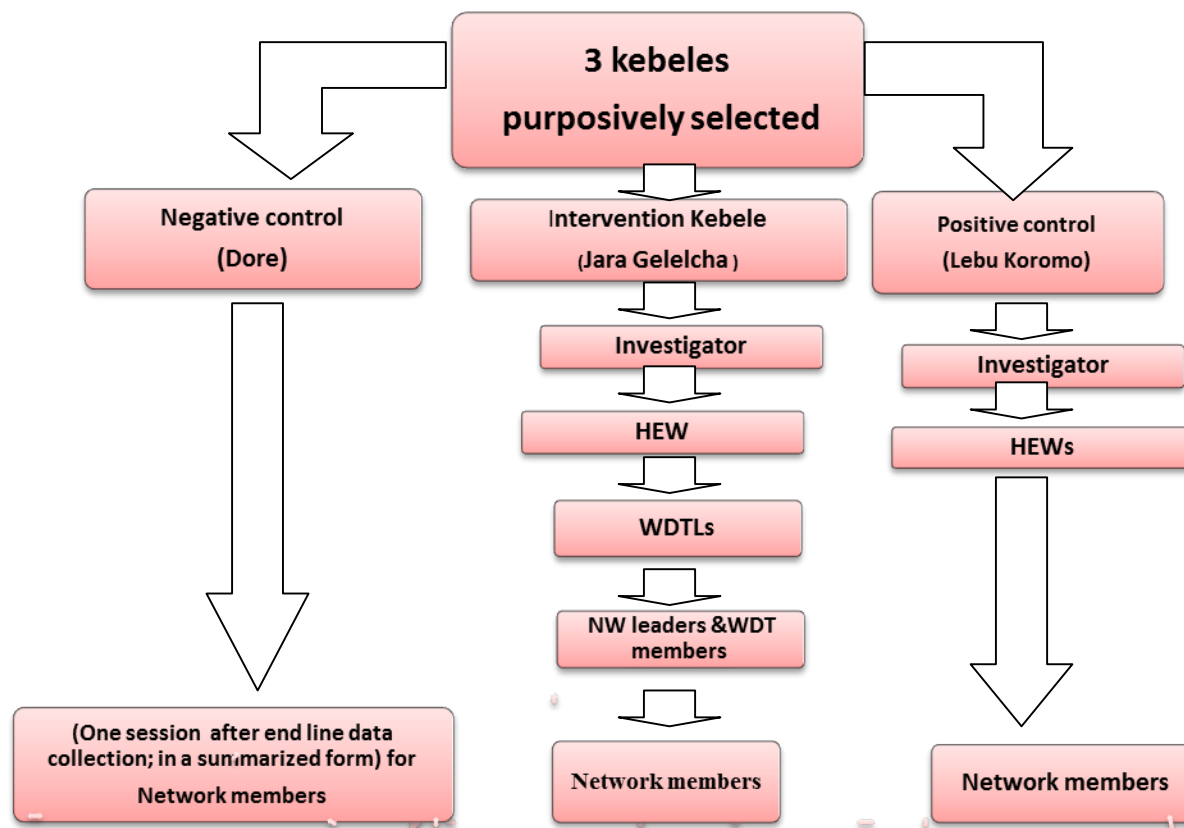
## **2.5. The health belief model (HBM)**

The nutrition education lessons were delivered by taking in to consideration on components of Health Believe Model concepts.

## **2.6. Nutrition education**

The nutrition education was on pulse sprout and its benefits. A total of thirteen sessions were held: six sessions for the intervention, six sessions positive control, and one summary session to the negative control kebele after data collection. The topics of the education included benefits of pulses, advantages of processing pulses, benefits of sprouting of pulse and description of pulse sprouting process, demonstration on pulse sprouting, and group discussions.

## The nutrition education flow



## 2.7. Data collected

In order to answer the research questions, the questionnaires were administered through face to face interview; in addition observations and focus group discussion were conducted. The data were collected by enumerators who were well trained and fluent in the local language; observations and focus group discussions were made by the investigator.

The FGD was conducted by two moderators and one assistant. The FGD was held in four groups; two from intervention kebele and the other two from positive control kebele. To keep homogeneity of the participants, one group was from leaders and the other group from members from each kebele which were enable us get more information in detail. Each group had 8 to 12 participants. About eight questions were used for FGDs. The discussions were recorded in both written form and in an audio by the assistant and note-taker. A discussion took from 45 to 90 minutes.

## **2.8. Data quality assurance**

A two days training with demonstration of data collection tools were prepared to all data collectors. Prior to actual data collection, 10% of the questionnaires was pretested in the nearby kebele to check the functionality and reliability of the tools and performance of data collectors. Then, based on the findings of the pre-test, modifications to the tools were made. The questionnaires were prepared in English and translated to Amharic and then were re-translated back to English to keep their consistencies. At the end of each data collection day the completeness and cleanliness of the data were checked with close supervision. Finally, at the completion of intervention but, before the post-intervention data collection, a one day refreshment training was given to the data collectors.

## **2.9. Data analysis**

The data collected through primary and secondary sources were processed and analyzed both quantitatively and qualitatively. Quantitative data were analyzed using SPSS version 20. All continuous data were checked for normality using the Kolmogorov-Smirnov test. Comparison of change within the group and between groups was done using analysis of variance (ANOVA) and significant means were separated using Tukey multiple comparison test at 5% probability. The qualitative evaluation of data from focus group discussion and observation were analyzed and interpreted using narration. Triangulations of information were further made to get reliable results.

## **2.10. Ethical issues**

The Institutional Review Board of Hawassa University, approved the study and the School of Nutrition, Food Sciences and Technology, Department of Applied Human Nutrition was asked for formal letter of cooperation to Hawassa Zuria woreda health department at the study area. Then, the woreda health office was asked for formal letter of cooperation to the selected Kebele administrative offices. Individual consent from the study subjects were obtained before the questionnaires were administered and nutrition education was started.

### 3. Research in Progress

The field work has been completed and both baseline and end line data have been collected. The data collected are in the process of being entered in to SPSS. Remaining works include further data analysis on the interaction effects and write up of the results.

### Acknowledgements

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# Gender Differences on Acceptance of Nutrition Education and its Effect on Household Pulse Consumption in Daramalo Woreda, Southern Ethiopia

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## Abstract

Pulses play a significant role in human nutrition since they are rich source of protein, calories, certain minerals and vitamins. The importance of pulses in Ethiopia in improving nutrition cannot be understated. Educating parents and guardians on nutrition is important since they are responsible for meal preparation at home. However, most such education activities mainly focus on female. Quasi experimental before-and-after without control study design was used in Daramalo Woreda, Southern Ethiopia. The kebeles were selected purposely and randomly assigned for men and women group and each of the groups had 129 study subjects. Descriptive summary was computed using frequencies and percentage, graphs and cross tabulations. In addition, Differences in socio-demographic characteristics between women and men groups was tested with ( $\chi^2$ ). Independent two samples t- test was used to compare the mean knowledge and practice score of household between the women and men groups. On the other hand, Paired sample t-test was used to compare the difference in mean knowledge and practice scores before and after the intervention within the same group. P-value of less than 0.05 was taken as significant. The outcome of the intervention is expected to show the gender differences on acceptance of nutrition education and its effect on knowledge and household pulse consumption.

**Key words:** nutrition education, pulse, Knowledge, consumption of pulse ,men and women.

## 1. Introduction

Pulses are edible seeds of members of Fabaceae (Leguminosae) family of legumes (plants with a pod), which include dry peas, dry beans, lentils and chickpeas (FAO, 2010). Pulses play a significant role in human nutrition since they are rich source of protein, calories, certain minerals and vitamins. In African diets, they are important contributor of protein and calories for economic and cultural reasons (El Maki *et al.*, 2007).Pulses are grown all over the world (Pulse Canada, 2015). Ethiopia is the 9th largest pulses producer in the world which produces 1,888 tons in 2010 (FAO, 2013).

The types of pulses which are grown in Southern Nation and Nationalities People region are chickpea, lentils, Faba beans, and field pea with expanded production of Haricot beans (CSA, 2008).

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Protein-energy malnutrition (PEM), especially among children in the developing countries is common, has both health and economic consequences. Moreover, children below five years, pregnant and lactating mothers are mostly affected by protein energy malnutrition. Protein-energy malnutrition in pregnant women will lead to children with low birth weight (Marino, *et al.*, 2011). The importance of pulses in Ethiopia in improving nutrition cannot be understated, since it contributes to smallholder livelihoods in many ways. Pulses can play a significant role in improving smallholders food security as an affordable source of protein. In addition, they bring income to smallholders, and help to diversify crop production which is important to avert risk of losses in the case of unreliable rainfall. And because they yield a higher gross margin than cereals. Besides, pulses improve soil health by fixing nitrogen (IFPRI, 2010). Efficient use of pulses and inclusion in the diets of the rural communities will help to reduce macro and micronutrient deficiencies (EDHS, 2011). Nutrition related knowledge, attitudes, and practices (KAP) of both parents and children are important determinants of nutritional status and are probable contributors to malnutrition. Educating parents and guardians on nutrition is important since they are responsible for meal preparation at home. Nutrition deficiency has impact on health of men, women and children. Therefore, pulse based nutrition education program need to include males and females to promote its consumption. However, most such education activities mainly focus on female. Although, women are often responsible for the majority of household care including food preparation, resources are mainly controlled by male. The current study assessed the gender differences on acceptance of nutrition education and its effect on household pulse consumption in Daramalo Woreda, Southern Ethiopia.

## **2. Materials and Methods**

### **2.1 Description of the study area**

The study was conducted in two kebeles of Daramalo Woreda found in Gamo Gofa zone, Southern Ethiopia. Daramalo Woreda is located at 265 kms south west of the regional capital, Hawassa. The Woreda is subdivided into 23 rural and 1 urban kebeles. The Woreda has a total population of 104,668; of these 53,783 are males and 50,885 are females in 2015.

The annual average rainfall ranges from 1401-1600mm with mean annual temperature of 10.1-25 °C (degree centigrade). The Woreda agro-climate is 19.2% tropical (*kola*), 39.9% sub-tropical (*Woinadega*), and 40.9% (*dega*). The major crops grown in the Woreda are garlic (400 ha), onion

(600 ha), maize (637 ha), cassava (658 ha), and yam (740 ha). Other crops grown on smaller area include beans (19 ha), peas (16 ha), haricot bean (16 ha), teff (16 ha) barley (16 ha) and , Sweet potato (91.8 ha). (Daramalo Woreda Socio Economic Profile, 2015).

## **2.2. Study Period**

The study was carried out from June to September 2017. Nutrition education was given for three months after completing the baseline survey.

## **2.3 Source population**

The study population included all men and women who have been living in Daramalo Woreda before the time of the study for at least 6 months and would not leave the area for at least 6 months from the start of the study.

## **2.4 Study Population**

Male and female headed or others male and female who are responsible for taking care of the households who are living in those selected Kebeles and willing to participate in this study.

## **2.5 Study Design**

Quasi experimental before-and-after without control study design was used with both descriptive and analytic elements to evaluate the effect of nutrition education intervention between men and women households. The study variables mainly focused on change in knowledge and practice of pulse consumption.

## **2.6 Sampling technique**

The study area was selected purposely because it is one of the target kebele of the Canadian International Food Security Research fund (CIFSRF) project with a potential for pulse production. Out of the 23 rural and 1 urban Kebeles, two Kebeles namely Menena abaya and Domia were selected purposely based on similar socio-economic status. Menena abaya Kebele was assigned randomly for male and Domia kebele for Female group, each of the groups had 129 study subjects. in both kebele, the list of household were used as a sampling frame to select the households using a systematic random sampling technique. In each selected households the head or responsible member for taking care of the household was selected and included in the study. But in the absence of study subject who fulfill the inclusion criteria in that selected household, the next household was included in the study.

## **2.7 Data Collection**

The data were collected at baseline and end line of the study from both Men and Women groups using structured and semi-structured questionnaire. The questionnaires were collected by trained Development Agents (DAs) and health Extension workers (HEWs), who can speak Amharic and the local language (*Gamogna*), and with regular supervision of the principal investigator. .

## **2.8 Data Collection Instruments**

Both pre-test and post- test data were collected using structured and semi-structured questionnaire. The questionnaire had four types of questions, a) men's and women's socio-demography, b) socio-economic status, c) knowledge and practice on household consumption of pulses and d) factors associated with pulse consumption.

## **2.9 Nutrition Education**

Starting two weeks after the baseline data collection period, nutrition education was given one hour/day every two weeks for a total of three months. The education lessons and group discussions were designed based on baseline data and health belief model (HBM). Trained government assigned Health Extension Workers (HEWs) and developmental agents (DAs) who can speak Amharic and the local language (*Gamogna*), delivered the nutrition education with regular supervision of the principal investigator.

## **2.10 Data analysis**

The data were analyzed using Statistics package for social sciences (SPSS), (SPSS inc. version 20, Chicago, Illinois). Descriptive summary was computed using frequencies and percentage, graphs and cross tabulations. In addition, Differences in socio-demographic characteristics between women and men groups was tested with Chi square ( $\chi^2$ ). Independent two samples t- test was used to compare the mean knowledge and practice score of household between the women and men groups. On the other hand, Paired sample t-test was used to compare the difference in mean knowledge and practice scores before and after the intervention within the same group.

Furthermore, the association of each independent variable with the outcome variable was assessed using bivariate analysis. Those variables having p-value less than 0.25 were entered into the multivariable logistic regression model to identify the effect of each independent variable with the outcome variables. A p-value of less than 0.05 was considered statistically significant. The



fitness and statistical assumptions of the logistic model, Hosmer and Lemeshow statistics and model summary table were checked.

### **2.11 Ethical Consideration**

The Institutional Review Board (IRB) of Hawassa University, College of Medicine and Health Sciences approved the study. Permission of Woreda administrative and the Kebele offices was asked with official letter from Hawassa University School of Nutrition, Food Sciences and Technology. In addition signed informed consent was obtained from each study participants.

## **3. Results**

### **3. 1 Socio demographic and socio-economic characteristics**

258 study participants was participated in this study with response rate of (100%) at baseline and (97%) at endline. Majority of the respondents were age 35-44 59(46%) for women and 45-54 38(29.4%) for men groups. Protestant religion, accounted for the larger majority of the respondents, 88(68.2%) and 99(76.7%) for the women and men groups respectively. Almost all of the participants, 123 (96%) and 129 (100%) were Gamo as well as married, 124(96.1%) and 119(92.2%) for the women and men groups respectively. Majority of the respondents in women group 85(65.9%) were illiterate and 41(31.8%) in men group were read and write. Regarding the family size majority 105(81%) and 120(93%) of the respondents have more than five total number of the family both in women and men group respectively.

When we compare the two groups there were no statistical differences ( $p > 0.05$ ) between the two groups with regard to their religion, ethnicity, family size and average monthly income. Majority of the participants in both groups (men and women) had similar socio-economic status. The main source of income for the family in both group was farming The average monthly income of most households who had less than 500 Ethiopian birr were 91(71%) and 105 (81.4%) in women and men groups respectively. None of the households in women group, and 10(8%) households in the men group had an average monthly income of greater than 1500 Ethiopian birr. Majority 76(58.9) and 59(45.7%) of the households in women and men group respectively used public tap as a source of drinking water. More than 96% of the study participants from both group own cultivated land and grown various types of crops, such as, maize 127(99%) and 119(92%), red or white haricot bean 65(50.4%) and 100(77.5%) bean 28(21.7%) and 25(19.4%),

sweet potato 41(31.8)and 64(49.6) in women and men groups respectively. The socioeconomic characteristics of household women and men are shown in Table 1.

Table 1: Socio-demographic and socio-economic characteristics of respondents, Daramalo Woreda, Gamogofa Zone, Southern Ethiopia, August, 2017

Variables	FG (n= 129		MG(n=129)	
	N	%	N	%
Age in years				
15-24	65	4	10	8
25-34	50	39	20	15
35-44	59	46	32	24.8
45-54	14	11	38	29.4
55-64	0	0	19	15
65	0	0	10	8
Religion				
Protestant	88	68.2	68.2	76.7
Others	41	31.8	31.8	23.3
Ethnicity				
Gamo	123	96	129	100
Others	6	4	0	0
Marital status	124	96.1	119	92.2
Ever Married	5	3.9	10	7.8
other				
Formal education				
No	52	40.3	30	23.3
Yes	77	59.7	99	76.7
Usual occupation				
House wife to women /Farmer to men group	91	70.5	115	89.1
Others	38	29.5	14	10.9
Average monthly income				
<500birr	94	72.9	105	<b>81.4</b>
500 to 999 birr	25	19.4	15	<b>11.6</b>
1000 and above	10	7.8	9	<b>7</b>
Source of drinking water				
Public tab/stand pipe	76			
protected well	36			
protected spring	-			
unprotected spring	17			
Own cultivated land and grow crops on land	119	92.2	125	96.9
Family size				
</= 5	21	16.3	24	18.6

>5	108	83.7	105	81.4
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## **4. Gender and Family studies**

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# **Effect of Improved Chickpea Production on Rural Women Economic Empowerment: The Case of Halaba, Southern Ethiopia**

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## **ABSTRACT**

The present study was conducted to evaluate the effect of chickpea production on rural women empowerment in Halaba special woreda southern Ethiopia. Simple random sampling techniques was used to select two study kebeles and 190 sample households. The data were analyzed with the help of SPSS software version 21. Statistical summary such as percentage, frequencies mean, and standard deviation was used to present the results. The findings revealed that women farmers worked long hours, significantly contribute labor in pulse production in land preparation, planting and harvesting. Female-headed households own meager resources, participating less in chickpea production and other strategic decision makings compared to in male-headed households. To benefit women farmers from pulse production requires robust women participation in decision making and economic benefit sharing, greater access and control over resources and the use of improved agricultural technology.

**Key words:** Women empowerment, Rural areas, Chickpea, Halaba

## **1. Introduction**

Empowerment is a multi-dimensional, transformative and relative concept. It is about access to and authority over resources and its absence influences both the types and the nature of target interventions. Empowerment has economic, political, social and personal dimensions. For example, women economic empowerment emphasizes two components of empowerment, namely resources (access related) and agency (control over). A woman is economically empowered when she has both the ability to succeed and the power to make and act on economic decisions. Empowerment is the process of enhancing the capacity of individuals or groups to make choices and transform those choices into desired actions and outcomes (Golla, et al. 2011; FAO, 2015).

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Women are part and parcel of society but mostly they have less authority and subordinate positions. Society cannot exist without women contribution; however, women have hindrances in every aspect of their life. For centuries, societies have tried to develop without giving women due rights. For the welfare of society, condition of women need to improve. A study by Hazel Jean L. Malapit, (2015) stated that women's empowerment is heavily dependent on many different variables that include educational status, social status (caste and class), and age.

Inequalities between men and women in their access to productive resources, services and opportunities are one of the causes of underperformance in rural development, and contribute to deficiencies in food and nutrition security, economic growth and overall development programs. According to FAO (2013), about 1.2 billion people living in poverty in the world, among which 70% are women. Although women do two-thirds of the world's work, they own less than 1 percent of the world's property. Women's poverty is directly related to the absence of economic opportunities, and resources such as, land ownership, access to credit, and inheritance, as well as minimal participation in the decision-making processes.

Gender equality and women's empowerment is an important development priority, as highlighted by its inclusion in the Millennium Development Goals (MDGs). The important role of gender equality in goals related to reducing poverty, eradicating hunger, and improving food security must acknowledge. Policy interventions that improve women's status and reduce gender inequalities are expected to improve women well-being (Sohail, 2014; Hazel Jean L., 2015).

The study conducted by Danjuma, et al., (2013) point out that women comprise more than 60% of the African population, which has caused more concern to the economy in the continent if they are left behind. International communities like World Bank, USAID, DFID, IMF, governments and others organizations have made several efforts in assisting women economically, but yet the level of poverty has been in the increase. Studies revealed that women potential labor force is still high in Africa and most of the poor are women (Danjuma, et al., 2013).

According to CSA, (2010) Ethiopian women make up to 70 % of the active population but; they have only 20 percent of agricultural rights. Despite representing 70 % of rural labor force, three out of four women are unpaid (Temesgen et al, 2015). Chickpea is important in Ethiopia's

smallholder agriculture although, there is unequal participation of women in decision- making and opportunity in providing an economic advantage (CSA, 2010). Despite several efforts made by governmental and non-governmental organizations to narrow gender inequality, in improved chickpea production and their access to necessary resources and technologies still the gender gap persisted (Nigatu and Gete ,2016 quoting Ferris & Kaganzi, 2008; IFPRI, 2011).

Chickpea in its economic significance, an important food and cash crop with high acceptability and wider use. In the economic term as an income source, chickpea contributes a significant portion of the total value of pulse exports. For example, chickpea constituted about 48% of the pulse export volumes in 2002. In this period of time, the exported volume accounts about 27% of the total quantity of chickpea production while the balance remains for household market (Shiferaw et al.,2007). Beyond economic importance, chickpea production has an advantage over field crops considered less labor intensive compared to other many field crops particularly for women farmers as its production is towards the end of the cropping season when there is less weed pressure and less soil water management problem that reduce farm management burden (Minale et al. 2009). Chickpea is essential commercial crop if used wisely in empowering women that hold more than 15% of Ethiopian legumes with about one million Household engaged .in its production (CSA 2010). Chickpea become among major pulses grown in Ethiopia, mainly in supporting subsistence farmers usually under rain fed conditions. Chickpea is used as the main annual crop in Ethiopia both in terms of its share of the total cropped pulse area and its role in direct human consumption and commercial. Regarding production areas it is produced in various zones, some special Districts s and pocket areas in the Southern Nations, Nationalities and Peoples Regional State (SNNPRS). In general, in this region chickpea occupies about 4,536.02 hectares of land annually with estimated production of 29,034.52 quintals (CSA, 2016 ). The national average yield of chickpea in Ethiopia is 12.69qt/ha and the regional average yield of 6.4 qt/ha, which is by far below the potential yield (CSA, 2016).

Thus far, many studies on women participation in pulse crop production value chain, marketing, seed, nutrition has been study findings by Tefera,( 2014 ) others indicates that market orientation chickpea is important pulse crop besides; chickpea produced by 26.8% of the households and about 69.5% of total chickpea produce was sold. This indicated that chickpea is even more



important cash crop in women economic empowerment compared to other pulses (Tefera, 2014, Nigatu and Gete ,2016 quoting Ferris & Kaganzi, 2008; IFPRI; Henry, et al, 2016). However, empowerment of women from chickpea production is not studied in the area. Hence, the present study is on effects of improved chickpea production on women economic empowerment in Halaba Special District in Sothern Ethiopia, because of inadequacy of information on women's economic empowerment to deliver the needed services for resource availability were not studied by other researchers.

Therefore, study was nesseciated to assess the gaps which is prohibited women from empowerment in producing improved chickpea for the reason that, chickpea field work requierment is very less, in using improved seed and new technology would bring better yield among rural women as highly burdend in the study area.

## **2. Methods**

### **2.1. Description of the study area**

Halaba special district is one of the districts of South Nation Nationality People Regional State of Ethiopia (SNNPRS). It is located about 315 kms south of Addis Ababa. Total area of District is 25,650 square kms. The geographic location of District is 6<sup>0</sup>9 to 5<sup>0</sup>4 Latitude and 33.5<sup>0</sup> to 35.3<sup>0</sup> Longitudes. *Halaba kulito* is the capital city and administrative center of District. The District has 81 rural kebeles and total population is 325,255 out of which 159,375 (48.9 %) are male and 165,880 (51.1 %) are female (DAO, 2008<sup>11</sup>). Women make up slightly over half of the total population. The great proportion of (93%) of the Districts population lives in rural areas.

The agro climatic condition of Halaba Districts is favorable for diversified crop production. The major food and cash crops grown includes Maize, pepper, teff, Irish potato and chat. In addition, pulses such as haricot bean and chickpea and fruit crops grown in the District.

### **2.2 Study Design**

A cross-sectional survey design with a mixed approach of data collection was employed. A mixed method was used since women's roles in farming is multifold and difficult to quantify.

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Moreover, capturing the effects of improved chickpea production on women empowerment in rural household work can be better understood with quantitative and qualitative information (Wudenesh, 2003).

### 2.3 Sampling procedure

The study Districts Halaba selected purposefully because of its potential for chickpea production from the Canadian International Food Security Research Fund's (CIFSRF) project site. Simple random sampling techniques was used to select two study kebeles, once the Kebeles were drawn up during the second stage of sampling, households per kebeles were randomly selected from the list of two selected Kebeles to arrive at a total sample size of 190. Key informant interviews were purposively selected and the discussion were held at district and village levels. At district level, experts from the Bureau of Agriculture and Natural Resource Development working on pulse management and monitoring, and Head of Women and children affairs office were interviewed on key issues related to chickpea and other pulse production and management. At the *kebel* /village level, key informants included extension workers, administrators and women representatives. Eight focus group discussions (two in district) were conducted separate focus group discussions.

### 2.4 Sample size determination and sample size

To determine the size for a planned sample, importance was given to the required precision, error of estimation, costs needed for the study and the financial resources as well as the time available for the survey. The number of sampled women farmers included for collecting data was determined by using the formula developed by Yamane (1967) considering six percent of level of precision. Accordingly, a total of 190 sample households were randomly selected for the study

$$n = \frac{N}{1 + N(e)^2}$$

Where:  $n$ =Sample size

$N$ =Total Population

$e$ =Sampling Error

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### 2.5 Type and Sources of data

Different types of data gathered that are relevant to the study from different sources. Both primary and secondary data comprising both quantitative and qualitative information gathered

from different sources through different data collection methods and tools. Hence, data was collect on issues related to the ranges of productive activities performed by women, access to and control over resources. The primary data gathered from female headed and female in male-headed household about the effects of improved chickpea production on women empowerment in rural household, key informants, and focus group discussions. The secondary data was extracted from books, theses, journals, official documents, unpublished materials and credible internet sources.

## 2.6 Method of Data Processing and Analysis

The data were analyzed using SPSS software version 21. Such as percentage, frequencies mean, and standard deviation was use descriptive statistics to provide a summary of variables. Data collected through interview and Focus Group Discussion (FGD) analyzed qualitatively using narrative for triangulation and strengthened the findings of the study.

## 3. Results

Males headed households comprises for 65.2 % while the remaining 34.8 % were female-headed (Table 1). It was observed that 85.8 % of the households were in polygamous marital relationship (where the husband had two or more wives) and the remaining 14.8 % were monogamy. The finding shows that there was very high rate of illiteracy among women farmer respondents (94.2 %) (Table 1).

Table: 1. Back ground Characteristics of the respondents (n=190)

Variables	Category	Frequency	Percentage
Level of Education	Illiterate	179	94.2
	Read & write	7	3.7
	Below grade 4	4	2.1
	Total	190	100.0
Head ship	Male	124	65.2
	Female	66	34.8
	Total	190	100.0
Marriage type	Poly gamy	163	85.8
	monogamy	27	14.2
	Total	190	100.0

**Source:** Household survey result, 2017

About 63% of respondents had an average landholding size of 0.5 to 1 hectare, whereas 34.2% of the households had land size of 1 to 2 hectares of land used for farming and grazing. Only 2.6% of respondents had land size of 2 to 3 hectares land used for farming and grazing (Table 2). The average landholding sizes of the respondents were 1 hectare that is by far lower than the national average (1.58) and regional average (1.77) (CSA, 2013).

Land tenure in Ethiopia has influenced the lives of rural women until recently. The study investigated land certificate ownership as a proxy of land tenure and found that 33.2% of the respondents had received certificate in husband name, 30% received land certificate in wife name and 30.5% of the respondents had joint land certificate (Table 2).

Table 2: Average land holding & land certification of the respondents (n=190)

<b>Variables</b>	<b>Category</b>	<b>Frequency</b>	<b>Percentage</b>
<b>Average land size</b>	0.5-1 hectare	120	63.2
	1-2 two hectares	65	34.2
	2-3 three hectares	5	2.6
	Total	190	100.0
<b>Land certification</b>	In husband name	63	33.2
	In wife name	57	30.0
	In joint	58	30.5
	Not registered	12	6.3
	Total	190	100.0

**Source:** Household survey result, 2017

The result of the study revealed that both women farmer in male headed households and women headed households in the study area are involved long hours work. The majority (80.5%) of the sampled respondents stayed up to 8 hours while, some 19.5 % of the sampled respondents work on average 10 hours a day in land preparation that is characterized by overburdened with heavy farm work.

In chickpea planting about 78.4% of the sampled respondents stayed on farm for 7 hours a day whereas; some 21.6% sampled respondents stayed up to 9 hours on average. In chickpea

harvesting, 58.4% of the respondents spent 8 hours whereas 41.6% of the respondents spent up to 10 hours (Table 3).

Table: 3. Time spend on chickpea farm management (n=190)

Variables	Category	Frequency	Percentage
<b>Land preparation</b>	8 hours	153	80.5
	10 hours	37	19.5
	Total	190	100.0
<b>Planting</b>	7 hours	149	78.4
	9 hours	41	21.6
	Total	190	100.0
<b>Harvesting</b>	8 hours	111	58.4
	10 hours	69	41.6
	Total	190	100.0

**Source:** Household survey result, 2017

Women participation in chickpea production has shown increasing trend (Table 4). In 2013, only 15.3% women farmers participated in chickpea production whereas in 2014 and 2015 31.6% and 53.1% women participated respectively. Out of the total sample about 21% engaged in grain production while the majority (79%) were took part in chickpea seed production through cluster arrangement. Based on the gathered three years data participation of women farmer increased year after years on improved chickpea production which was encouraged by yield and technical advice by extension worker on chickpea field management and technical training support from CIFSRF project.

Table: 4. Improved chickpea participation years of experience (n=190)

Variables	Category	Frequency	Percentage
<b>Participation years</b>	One year (2013)	29	15.3
	Two years (2014)	60	31.6
	Three years (2015)	101	53.1
	Total	190	100.0

**Source:** Household survey result, 2017

### Women participation in decision making

For the past several years women as a group enjoy less right and fewer advantages, usually they work longer hours than men do, and their work and opinions are under-valued in agricultural and

other sector of the economy. Although improvements observed recently still women earn less than men earn, do not assure fully land ownership, and face numerous obstacles. It is widely noted that increased gender equality within the household is a prerequisite for achieving improvements in all matters of development (Alemtsehay, 2014). The present study shows that women who has the right to decide individually in household decision-making issues were 34.8% while the majority (65.2%) of the respondents were decide jointly with their husband (Table 5). This indicated that women had extensively played important contribution in household's decision-making.

Table: 5. Decision making and utilization of Households asset (n=190)

Variables	Category	Frequency	Percentage
<b>Decision on assets</b>	Husband	125	65.2
	Wife	65	34.8
	Total	190	100.0

*Source:* Household survey result, 2017

The majority (65.2%) of women in male headed households before participation in the project were not decided jointly with husband on issues such as how much land to plant, what crops to plant, on share cropping & household income, fertilizer & other technologies use and whether and when to hire labor. Whereas, after participation in the project grater majority (73.7%) of them jointly participated in decision making with their husbands regarding how much land to plant, (73.2%) what crops to plant, (72.1%) on share cropping & household income, (80% ), on the use fertilizer & other technologies and (52.6%) (Table 6). This study finding was in agreement with the EDHS (2016) which show that the majority of currently married made key decision jointly with their wives. For example, when men were asking about who makes most decisions about the man's own health care, 70% reported that the decisions were made jointly with their wives. Similarly, more than three-fourths of men (77%) said that decisions about major household purchases are typically made jointly with their wives (DHS, 2016).

Table: 6. Women joint decision making on land and on crop growing before and after participation of the chickpea project (n=190)

Before	After
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Variables	Category	Frequency	Percentage	Category	Frequency	Percentage
<b>On how much land to plant</b>	Yes	43	22.6	Yes	140	73.7
	No	147	77.4	No	50	26.3
	Total	190	100.0	Total	190	100.0
<b>What crops to plant</b>	Yes	46	24.2	Yes	139	73.2
	No	144	75.8	No	51	26.8
	Total	190	100.0	Total	190	100.0
<b>To share crop the land &amp; household income</b>	Yes	48	25.3	Yes	137	72.1
	No	142	74.7	No	53	27.9
	Total	190	100.0	Total	190	100.0
<b>Whether to use fertilizer &amp; other technologies</b>	Yes	29	15.3	Yes	152	80.0
	No	161	84.7	No	38	20.0
	Total	190	100.0	Total	190	100.0
<b>Whether and when to hire labor</b>	Yes	143	75.3	Yes	99	52.6
	No	47	24.7	No	91	47.4
	Total	190	100.0	Total	190	100.0

*Source:* Household survey result, 2017

## 4. Discussion

The research analyses and consequent elaboration of women empowerment conceptual theory for chickpea production is based assessment of ongoing collaborative work between Hawassa University (HwU) and Halaba District Agriculture and Natural Resource Office. They were aimed at food gap and malnutrition in the area by promoting the adoption of improved chickpea technologies and nutrition interventions at household level, especially for young children and women.

The findings from the quantitative and qualitative data revealed that chickpea could produce in the area without difficulties. Both women headed and women in mal headed households cited confront constraints associated with the low productivity of chickpea. These included problems of selection of the right pest problems, high cost of artificial fertilizer and small land holding. Households also had certain preferences for producing one kind of chickpea than others due to different motives. In general, there was consensus that women's preference for some varieties of chickpea variety differed from that of men with the former usually preferring to produce crops, which mainly used for domestic consumption and the later opting for crop varieties that have high market demands and prices.

Rural households in the study area have limited Control over income, ownership of assets, relative contribution to family support, access to and control of family resources. Based on domains of women empowerment in agriculture, in relation to on major agricultural production after joined in the project respondents were decide jointly with husband over agriculture production. The study findings agreed with the (EDHS, 2016) majority of couple reported that key household issue decisions were made jointly. For example, when men asked about whom makes most decisions about the man own health care reported that the decisions made jointly. Similarly, more than three-fourths of men said that decisions about major household purchase typically made jointly with their wives (DHS, 2016).

Regarding access to and power over productive resources, almost all the respondents had unlimited right, ownership and management on access over resource utilization. Similarly concerning control over use of income, from different agriculture product; women were highly involved directly whereas; women in male headed household were participated indirectly in process of crops and livestock production in the study area, which was partaking of women in production roles. About autonomy in domestic chores, women work in their houses is fundamental to the survival of their families, given that unremunerated in many conventional activities such as for collecting firewood, for cooking food, for marketing women times were budgeted manage the above household task.

To generalize the overall findings of the study underlined the importance of women empowerment in on improved chickpea production jointly decision with husband over agriculture production and equal right of access over resource utilization and control over use of income from different agriculture product. Therefore, policy and empowerment interventions should give emphasis to improvement of women economy, which can address the rural households, more focuses should be given to scale up chickpea production to improve nutrition and further, enhanced women empowerment through allowing them to participate in decision-making in food production and chickpea marketing. This study agrees with findings of Nigatu and Gete, (2015) shows that women-headed households owned significantly small land and other important strategic resources compared to in male-headed households. Therefore, they are



substantially poorer in access to better income or resource as compared to men and wide women gap in terms of access and decision on assets (i.e. land, livestock, credit, and inputs) as well as sharing decision making in farm management and utilization. Before participation of the project, larger numbers of women in male headed households did not have sharing decision on access and control of assets whereas, after participation of the project majority of women in male headed households had experience of sharing decision with husband in farm management and utilization equally. Even on effective and equitable agricultural extension services women in male-headed households shared information on crucial issue in order to assure women socio-economic advantage from agriculture in the study area in particular.

Agricultural extension services were proved one of the most important effective instruments to reach empowering women farmer in male-headed households and women headed households in the rural areas. Similar study conducted on women empowerment (World Bank, 2008) shown the role played by both women farmer and women in male headed farmer in rural agricultural development program via extension service should equally be competitive and complementary.

## **5. Conclusion**

Gender equality and empowerment are critical to sustainable development efforts in Ethiopia and in most developing countries. The findings revealed that female-headed households own meager resources, participating less in chickpea production and important strategic decision making compared to in male-headed households. Addressing women empowerment requires robust women participation in economic activities, greater access and control over resources and the use of improved agricultural technology.

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## 4. MSc in Soil Sciences

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### Effect of Blended Fertilizers on Yield and Yield Components of Haricot bean (*Phaseolus vulgaris* L.) on Cambisol at Meskan, Southern Ethiopia

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#### Abstract

A pot experiment was conducted at Meskan District, in Southern Nations Nationalities and People's regional State (SNNPRS) to evaluate the effects of blended fertilizers on yield and components of haricot bean (*Phaseolus vulgaris* L.) in Completely Randomized Design with three replications. The treatments were control, NPS, NPSB+ sterilized soil and other four blended formulas. Data on plant height and number of primary branch; number of nodules, number of pods per plant, number of seeds per pod, 1000 seed weight, harvesting index, biomass and grain yield were recorded on the two replication. The effect of fertilizer was significant in growth parameters such as plant height and number of main branches plant<sup>-1</sup>. However, application was not significant in number of seeds pod<sup>-1</sup>, also its application had significantly increased grain yield. The grain yield ranged between 10.167g pot<sup>-1</sup> at 0 (control) and 22.64g pot<sup>-1</sup> at application NPSB+ST. Besides, total biomass was also significantly influenced by blend fertilizer application, and ranged between 27.23g pot<sup>-1</sup> at control to 45.51g pot<sup>-1</sup> at NPSB+ST. Similarly, application of NPKSZnB significantly increased grain yield and biomass yield in comparison with control and NPS; even though the highest yield is obtained by the application of NPSB+ST. This might due to sterilized soil this an indication of antagonistic effects of the inoculation. Therefore, application of NPKSZnB is recommended for better haricot bean production at *Meskan*.

**Key words:** fertilizer, Yield and Yield component, micro nutrient, soil Profile

#### 1. INTRODUCTION

Legumes are important components of farming systems in East African highlands because they are major protein sources for animals and humans, in addition to their role in the restoration of soil fertility (Amede and Kirkby 2004). Various types of legumes are grown in the different agro-ecologies of Ethiopia. Legumes rank second after cereals as agricultural staples and occupy 13.4% of the total cultivated area (CSA, 2016). Along with legumes the production of haricot bean (*Phaseolus vulgaris* L.) has increased because it is exportable and cash earning commodity (Girma et al., 2013). In Ethiopia, Haricot bean is grown predominantly by smallholders as food crop and source of cash. It is one of the fast expanding legume that provide

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an essential part of the daily diet and foreign earnings for most Ethiopians (Girma, 2009). The central, eastern and southern parts of the country are the major Haricot Bean producers (CSA, 2011).

The current national average yield of haricot bean is 14.85 quintals per hectare (CSA, 2016), which is below the yield recorded at research sites (2.5 – 3 tones ha<sup>-1</sup>) using improved varieties (EPPA, 2004). Getachew (1990) reported that lack of optimal fertilizer rate is one of the factors contributing to the low grain yield of the bean. Haricot bean productivity is greatly influenced by soil fertility especially phosphorous and nitrogen. The genetic potential of haricot bean is expressed under high nitrogen fertilization. Because bean has the ability to fix and use atmospheric nitrogen, phosphorus is considered as the first and nitrogen as the second limiting plant nutrients (CIAT. 1998). Graham (1984) reported that Haricot bean needs more inorganic phosphorus for nitrogen fixation than the same crop provided with mineral nitrogen. Phosphorus availability in soil is a major constraint to Haricot bean production in the tropics (Allen et al., 1997). Even though, N and P are the most limiting nutrients for haricot bean, deficiency of other nutrients like S, Zn, B, Fe, Cu and K- are common due to inherent soil fertility status and/or blanket fertilizer recommendations (Tegbaru, 2015). Although information on the impact of different types of fertilizers, except nitrogen and phosphorous, is low, mapping of soil fertility over 150 districts showed that most of the Ethiopian soil lack about seven nutrients (N, P, K, S, Cu, Zn and B) (EthioSIS, 2013). Continuous cultivation and biomass harvest without replenishment, and low or no application of fertilizer have been the major factors for the low yield and failure to express potential productivity of the crop. There for this study is conducted to determine the effects of blended fertilizer on yield and yield components of haricot bean on cambisols of *Meskan* district, southern Ethiopia.

## **2. Materials and methods**

### **Description of the Study Area**

The experiment was conducted at *Meskan* District of Southern Nations Nationalities and Peoples Region (SNNPR), during the 2016 production season. The site is located at a latitude and longitude of 08° 06' 0944"N and 38° 22' 341" E, with an elevation of 1842 meters above sea level (m.a.s.l). The soil of the study area was reported to be Cambisols. The mean annual rainfall is

1064 with a uni-modal pattern, which extends from June to September. The mean annual minimum and maximum temperatures are 10.3<sup>0</sup>C and 24<sup>0</sup>C, respectively. November and December are the coldest months, whereas February is the hottest.

## Treatments and the Experimental Design

The experiment was conducted in a Completely Random Design (CRD) with seven treatments and five replications. The description of treatments is given below.

Treatments	N	P <sub>2</sub> O <sub>5</sub>	K	S	Zn	B
1. Control	0	0	0	0	0	0
2. NPS	19	38.0	0	7.0	0	0
3. NPK						
4.NPSB	18.1	36.1	0	6.7	0	0.71
5.NPSZnB	16.9	33.8	0	7.3	2.23	0.67
6. NPKSZnB	13.0	26.0	13.7	5.6	1.72	0.51
7. NPSB+ST	18.1	36.1	0	6.7	0	0.71

## Agronomic Data Collection and Sampling

Number of main branches per plant, plant height, number of nodules, nodules fresh weight, nodules dry weight, number of pods per plant and number of seeds per pod were recorded. Six central rows were harvested for determination of grain yield and total biomass. Grain yield was adjusted to 10% moisture content. Finally, harvest index was calculated as the ratio of grain yield to total biomass, and 1000 seed weight was determined using sensitive electronic balance.

## Laboratory Analyses

Soil samples were collected before planting and after harvest. The before planting soil was a composite sample whereas the after harvesting were collected from each treatments to analyze

for selected physico-chemical properties mainly texture, bulk density, soil pH, cation exchange capacity (CEC), organic carbon, total N, available P, exchangeable K, available S, B, and Zn using standard laboratory. Additionally, samples were collected in each master horizon from the soil profile to characterize the soil type of the site.

Organic carbon was analyzed following the wet digestion method by Walkley and Black oxidation method as outlined by Sahlemedhin and Taye (2000). Total nitrogen was analyzed by Kjeldhal method (Bremner and Mulvaney, 1982). Cation exchange capacity was measured after saturating the soil with 1N ammonium acetate (NH<sub>4</sub>OAC) and displacing it with 1N NaOAC (Chapman, 1965). Available phosphorus was determined using the Olsen method (Olsen et al., 1954). Available S was determined using turbid metric method. Available B was determined using hot water method (Havlin et al., 1999). While available Zn was determined using DTPA extracting (Tan, 1996).

#### Statistical Analysis

Analysis of variance will be performed using SAS software and means was compared using LSD at a probability level of 5% to delineate significance difference between treatments. Correlation coefficients were computed to assess the relationships between yield and yield components of Haricot bean varieties across formula.

## 4. RESULTS AND DISCUSSION

### 4.1 Physico- chemical property of the experimental site

Before sowing, soil samples was taken from representative points within the block at 30 cm depth to make one composite surface soil sample analysis of soil texture, pH, organic carbon, available P, total N and cation exchange capacity analyzed in analytical laboratory. The results of soil analysis are indicated in Table-1.

Table 1. Selected physico-chemical properties of the experimental site before planting

pH (H <sub>2</sub> O) (1:2.5)	Bulk density( g/cm <sup>3</sup> )	OC (%)	TN (%)	Ava-P ppm	Exchangeable cations cmol/kg				CEC cmol/kg	Textural class
					Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>		
6.73	1.12	1.03	0.1 1	5.02	22.31	13.9	0.58	2.68	32.1	Clay loam

#### 4.2. Phenological and Growth Parameters of Common bean

Blended fertilizer application had significant effect on plant height (Table 2). The highest plant height (64.67cm) was observed at the application of NPSB+ST while the lowest plant height (37.88cm) was recorded in control. Similarly, NPKSZnB significantly increased plant height compared to control and NPS fertilizer. This could be the effects of Zn and K fertilizer; because application of K fertilizer increases the availability of NP fertilizer. This result was in line with Kumar, et al. (2014) in which plant height of mung bean was significantly affected by potassium rate and also Abay, et al. (2015) who reported that plant height of haricot increased significantly by fertilization with Zn .

Although blended fertilizer were significant for main branches, the highest number of main branches per plant (7.3) was recorded by the application of NPSB+ST and the lowest number of main branches per plant (4.6) was recorded at control (Table 2).

Similarly, analysis of variance showed that blended fertilizer had a significant effect on number of nodules (Table 2). The highest number of nodules (150.17) was recorded with the application of NPS while the lowest number of nodules (35.5) was recorded at the Control; (Table 2).

Table 2. Plant height, Number of main branch, and Number of nodule per plant for common bean were influenced by blended fertilizers

Treatment	Plant height (cm)	Number of Main Branches/ plant	Number of Nodules/ plant
0	52.17d	4.67d	35.5c
NPS	57c	5.83bc	150.17a
NPK	57.3c	5.33cd	88b
NPSB	60.17bc	5.83bc	111.5ab
NPSZnB	61.5b	6.5b	99.17b
NPKSZnB	62.17b	5.67c	110.83ab
NPSB+ST	65.83a	7.33a	105.33b
Significance	**	**	*
LSD (0.05)	3.17	0.68	43.35
CV (%)	4.5	9.7	36.5

Means in columns followed by the same latter are no significant different to each other at 5% level significant; \*= significant, \*\*= highly significant, PH = plant height, MBP = main branch per plant and NNP= number of nodules/plant,



#### 4.3. Yield Components and Yield of Common Bean

There was significant ( $P < 0.05$ ) effect of blended fertilizer on the number of pods per plant (Table 3). The highest number of total pods per plant (14.5) was recorded at NPSB+ST application whereas the lowest number of pods (8.5) was obtained from control. Similarly, NPKSZnB significantly increased number of pod per plant as compared to the control, NPS, NPK and NPSB (Table.3).

Unlike number pod per plant effects of blended fertilizer did not significantly affect the number of seeds per pod (Table 3). Thus, variations on the number of seeds per pod are highly affected by genetic factors than the treatments of this study. In conformity with this result, Fageria and Santos (2008) reported that the number of seeds per pod of different common bean genotypes varied in the range of 3.1 to 6 and attributed the difference due to the genetic variation of cultivars.

Blended fertilizer had a significant effect on thousand seed ( $P < 0.05$ ) (Table 3). The highest thousand seed weight (525.71 g) was recorded at the application of NPSB+ST whereas the lowest thousand seed weight (410.92 g) was recorded at the control. Effects of blended fertilizer on biomass yield of common bean was highly significant ( $P < 0.001$ ). The highest biomass yield (45.51 g pot<sup>-1</sup>) was produced at the application of NPSB+ST while the lowest (26.19 g pot<sup>-1</sup>) was produced at control (Table 3).

Although effects of blended fertilizers were highly significant ( $P < 0.001$ ) effect on grain yield. NPSB+ST gave the highest grain yield (22.64 g pot<sup>-1</sup>) while the lowest grain yield (9.67g pot<sup>-1</sup>) was observed at control (Table 3).

Similarly, the effects of blended fertilizer was significant at ( $P < 0.05$ ) on harvest index. NPSB+ST gave the highest harvest index (0.5) while the lowest harvest index (0.38) was from control (Table 3).

Table 3. Number of pod/plant, number of seed/pod, 1000 seed weight, Biomass yield (BMV), seed yield (SY), and harvest index (HI) of common bean as influenced by the main effect of blended fertilizer and inoculation.

Treatment	NPP	NSP	1000 SW	BMV (g pot -1)	GY (g pt-1)	HI
Control	8.5d	3.17b	410.92e	26.19e	9.67e	0.38d
NPS	10.17c	3.5ab	455.52d	30.88d	12.98d	0.42c
NPK	11.5cb	3.67ab	470.45cd	33.49cd	14.6c	0.43abc
NPSB	11.83b	3.83a	483.65bcd	35.48c	16.44c	0.47ab
NPSBZn	13.3a	3.83a	493.25bc	36.18bc	17.06c	0.47ab
NPKSZnB	13.5a	3.67ab	503.55ab	38.85b	19.15b	0.49a
NPSB+ST	14.5a	3.67ab	525.47a	45.51a	22.64a	0.5a
Significance L	*	Ns	*	*	*	*
LSD (0.05)	1.41	ns	28.46	3.27	1.63	0.06
CV (%)	10	13	5	7.8	8.5	11

Means within a column followed by the same letter(s) are not significantly different at 5% level of significance. \*= significant; \*\* = highly significant; ns = non- significant, NPP=number of pod/plant, NSP= number of seed/pod, 1000sw= seed weight, BMV= biomass yield, GY= grain yield and HI= harvesting index

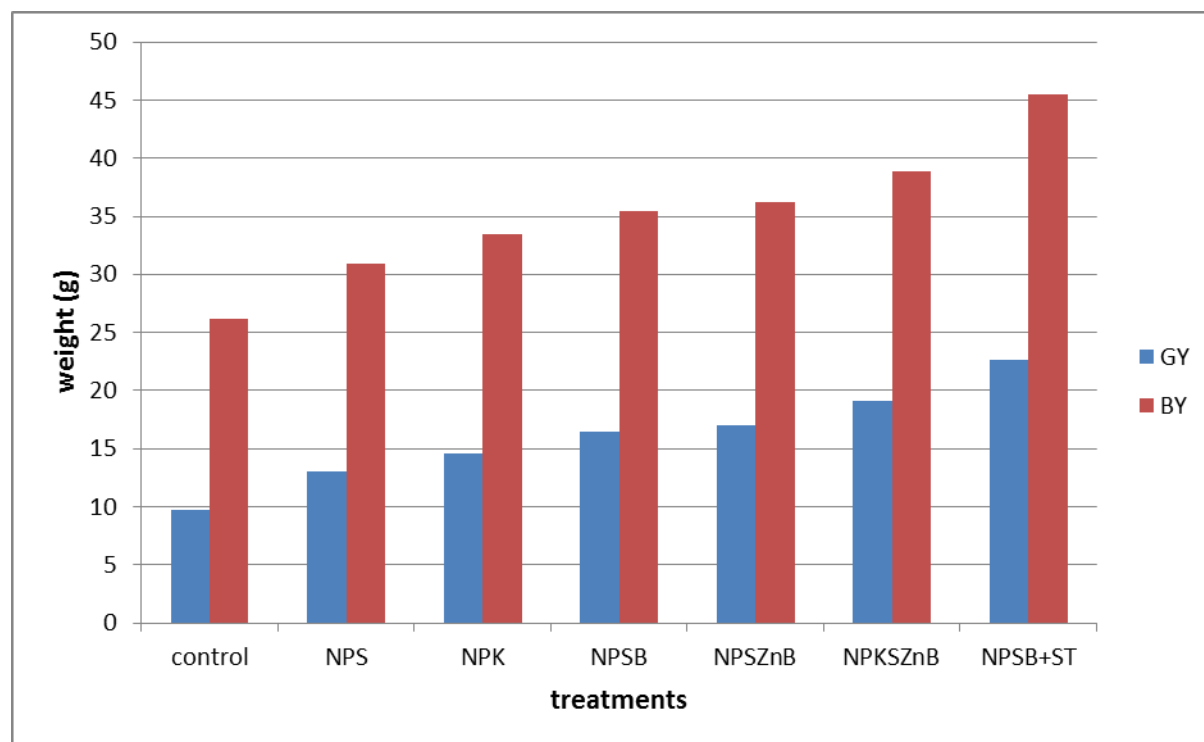


Figure 1. The effects of blended fertilizer on grain yield and biomass yield

## Conclusions

The application of blended fertilizer significantly improved grain yield and biomass over the control and the recommended fertilizer (NPS). Although other parameter like thousand seed weight plant height and number of main branches had highly significant by the application of blended fertilizer. The application NPSB with sterilized gave the highest value/yield this might be indication of the antagonistic effects of the former bacteria with externally added inoculants. The blended fertilizer NPKSZnB showed a significant difference in a parameter like grain yield, number of pod per plant, biomass yield and harvesting index compared to control and the recommended NPS fertilizer.

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# Characterization and Classification of Soils along a Catena in Borara Watershed, Southern Ethiopia.

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## Abstract

Information on soil properties and distribution is critical for making decisions with regard to crop production and mitigating land degradations. A field and laboratory study was conducted to Borara sub-watershed evaluate the relationship between topography and soil properties. Seven slope classes were considered and a total of seven pedons were opened and described at the sub- watershed. Soil samples collected from identified horizons and random surface composite of each pedon were analyzed for physicochemical properties. The field as well as laboratory textural class determinations revealed the dominance of clay fraction in the soils. The soils were characterized along toposequence and classified according to Soil Taxonomy and World Reference Based classification systems. The pedons sampled had mollic and umbric epipedons with argillic subsurface diagnostic horizon in the all pedons except bottom slope. The subsurface diagnostic horizons of the bottom pedons were Cambic. According to Soil Taxonomy all pedons except bottom are Vertisols, with suborder and great group of Usterts and Haplusterts respectively and the bottom slope was Cambisols with suborder and great group of Ustepts and Haplustepts respectively. The WRB equivalents of these Vertisols fall under Vertic Luvisols for the six pedon, and Cambisols for the bottom slope pedon. The result indicated that the distribution and properties of the soils vary along the toposequence in the watershed.

**Key words:** Soil characteristics, soil classification, Borara watershed, toposequence

## 1. Introduction

Agriculture is the most important sector of the Ethiopian economy (Shimeles, 2012), on which the livelihoods of the majority of the population depended for centuries (Amsalu *et al.*, 2007). The increase in human population led to the degradation of vital natural resources which has become a serious threat to sustainable agriculture (Gete and Hurni, 2001). Soil types and their characters vary across the regions of Ethiopia, because of the country's wide range of topographic, geologic and climatic features (Mesfin, 1998). Knowledge on the distribution and properties of soils is necessary to plan and implement sustainable land use and/or rehabilitation of degraded lands (Ali *et al.*, 2010). Knowledge about the properties of soils can be generated directly through field observation and laboratory analyses, though soil properties are extremely

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variable in space and time (Korres *et al.*, 2013). Various studies of soil properties at watershed level (Shimeles, 2006; Alemayehu, 2007; Ashenafi *et al.*, 2010; Sheleme, 2011) indicated that topographic position largely governs the change in types and characteristics of soils. A common denominator of all studies is a demonstrated strong relationship among topographic positions, soil properties and vegetation composition, such that the distribution of particular soil property may vary with topographic attributes and vegetation types (Dinku *et al.*, 2014).

Soils commonly occur in groups, each member of the group occupying a characteristic and different sequential topographical position from top to bottom of a slope, termed as toposequence. When the same sequence occurs as a mirror image on similar parent material, the two toposequences are called a catena (Buol *et al.*, 2003). The Ethiopian Mapping Authority (EMA, 1988) characterized the soils of siltie areas as Luvisols. But the Authority used a very small-scale survey that does not specifically describe the areas considered in this study. Agricultural production in the study area is severely constrained by the lack of adequate information on soil characteristics. In this study the soils Borara watershed along the catena were classified and characterized following the Soil Taxonomy (Soil Survey Staff, 1999) and the WRB Legend (FAO, 2014) systems and valuable data generated for proper land use.

## **2. Materials and Methods**

### **2.1. Description of the Study Site**

The Borara watershed is located in Siltie Zone of Southern Nations, Nationalities and Peoples' Regional State (SNNPRS). The watershed is located at the coordinates between 7°44'82" and 7°43'41" N latitude and 38°05'42" and 38° 12'63" E longitude with altitude ranging from 2064 to 2293 meters above sea level. The area has a humid climate with an average annual temperature of 17°C. The average annual precipitation is about 1013 mm. The major crops and grasses grown along the selected toposequences include cereals such as teff (*Eragrostis tef*), maize (*Zea mays*), wheat (*Triticum aestivum*), barley (*Hordem vulgare*), sorghum (*Sorghum bicolor*); pulses like bean (*Vicia faba*), field pea (*Pisum sativum*), haricot bean (*Phaseolus vulgaris*), chickpea (*Cicer arietinum*); and root crops like potato (*Solanum tuberosum*), sweet potato (*Ipomea batatas*) and Enset (*Ensete ventricosum*) and grass such as *Digitaria diagonalis*. Besides, plantations dominated by eucalyptus trees (*Eucalyptus camaldulensis*) are present. The soils of the study

area are developed on basaltic parent material and Vertic Luvisols and Cambisols are the dominant soil units (EMA, 1988).

## **2.2. Soil sampling and Sample Preparation**

Based on slope position and auger sample each toposequence was divided into topographic positions, namely upper slope, middle slope, lower slope and bottom at the center. Seven pedons, each having 2 x 2 x 2 m deep, were opened by hand digging on each slope positions. Description and soil sampling were completed within three days of opening the pedons. Thirty seven soil samples were collected from identified horizons making. In addition, twenty one surface random soil samples at 0-20 cm depth were collected from all directions around the pedons. The collected soil samples were air-dried and ground to pass through 2 and 0.5 mm sieve.

## **2.3. Laboratory analyses**

Analysis of the physico-chemical properties of the soil samples were carried out following standard laboratory procedures.

Particle size distribution was determined by the Bouyoucos hydrometer method (Bouyoucos, 1962) and Bulk density by core method (Xiao, 2009). Soil pH was determined using 1:2.5 soils to solution ratio using a combined glass electrode pH meter (Chopra and Kanwar, 1976). The organic carbon content of the soil was analyzed following the wet digestion method described by Walkley and Black (1934). Total N was determined by Kjeldahl wet digestion and distillation method (Bremner and Mulvaney, 1982), and available P by the modified Olsen method (Olsen and Sommers, 1982). The cation exchange capacity (CEC) and exchangeable bases were extracted by 1 M ammonium acetate (pH 7) method (Chapman, 1965). In the extract, exchangeable Ca and Mg were determined by atomic absorption spectrophotometer (AAS) and exchangeable K and Na by flame photometer. Available micronutrients (Fe, Mn, Zn and Cu) of the soil were extracted by diethylenetriaminepentaacetic acid (DTPA) method (Lindsay and Norvell, 1978) and determined using AAS.

## **3. Results and Discussion**

### **3.1. Morphological Features of the soils along the catena**

#### **3.1.1 Soil depth**

The depths of different surface horizons of the pedons varied from shallow to very deep (18-34 cm) (Table 1). Along the toposequence, the pedons at the both north west and south east facings of lower slope positions and that of the bottom topographic position had relatively deep surface horizons (24, 28 and 34 cm) followed by the middle topographic position pedon (20 and 22 cm), whereas the upper pedons had the shallowest (18 and 20 cm) surface layers. The surface shallow depth in pedons 1 and 7 sites may indicate soil instability due to active processes of soil erosion, whereas deep surface depth in pedons 2, 3, 4, 5 and 6 with more profile (soil) development in the other sites is an indication of relative soil stability. The A-horizons are formed because of a deposition and accumulation of humified organic matters from grasses (USEF) and agricultural crops (MSEF, LSEF, BOT, LNWF, MNWF and UNWF). The variation in soil depth is most likely attributed the topographic position that influenced soil formation and development through its effects on erosion, infiltration and the percolation of water deep into the soil. The running water, if the sites are unprotected, may erode soils on slopes and form thinner surface layer, A-horizon (Broderson, 1994) such that on slopping ground, especially on upper slopes, soils are often less deeply weathered because the surface soil is consistently removed by erosion. On the other hand, the increment in the thickness of A horizon down the slope can be attributed to soil deposition at the lower landscape and corroborates findings of previous studies (Mulugeta and Sheleme, 2010; Sheleme, 2011; Woods and Schuman, 1988).



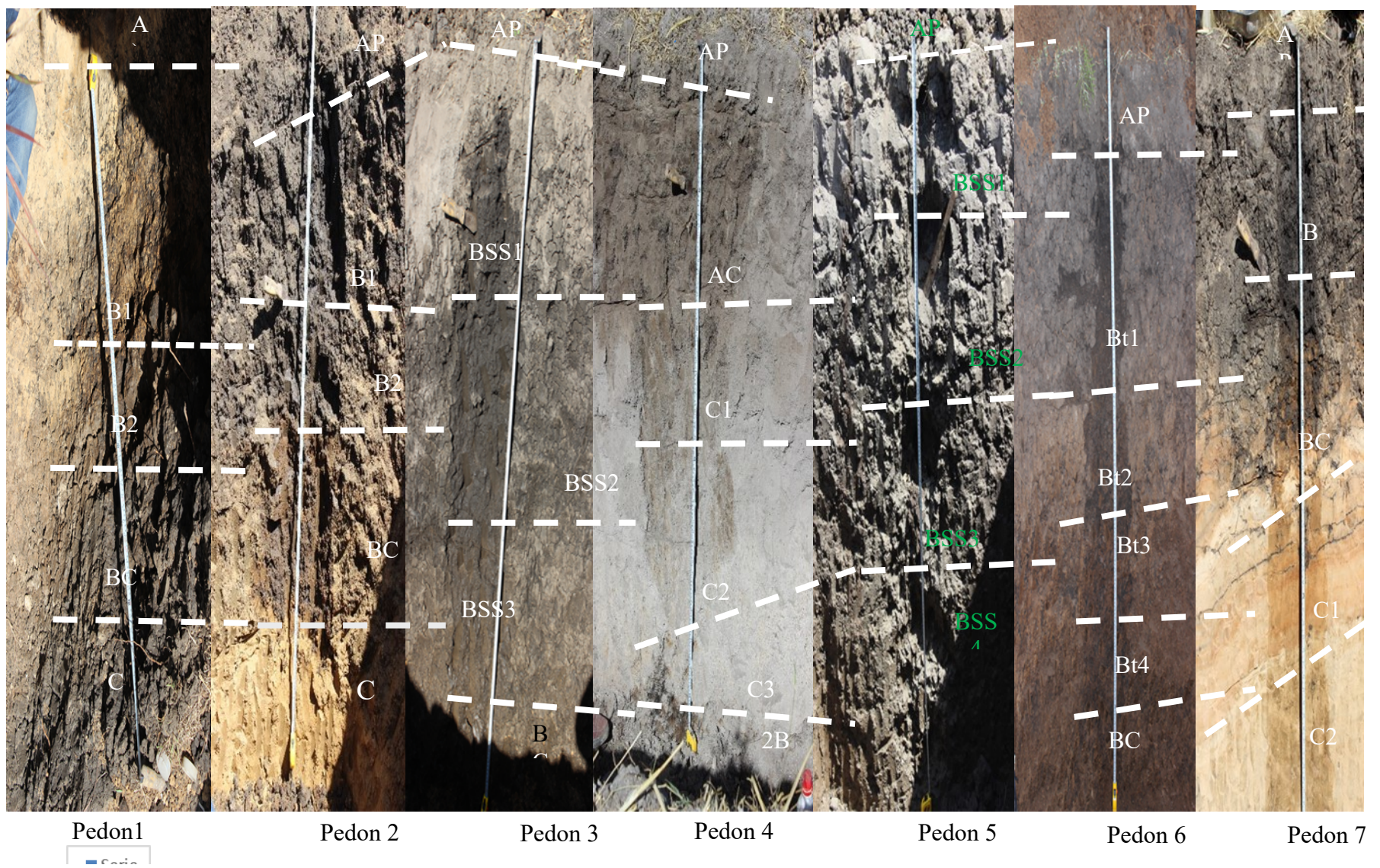


Figure 1. Profiles of representative pedons at borara sub-watershed



### **3.1.2. Soil color**

The surface soil color (dry) varied from very dark gray (2.5Y 3/1) in Pedon 1 and 6 to gray (10YR 5/1) in Pedon 3, while the subsurface color varied from black (2.5Y2.5/1) in Pedon 3 to yellowish brown (10YR 5/4 dry) in Pedon 5 (Table 2). Similarly, the surface soil color (moist) ranged from very dark gray (7.5YR 3/1) in pedon 7 to very dark gray (10YR 3/1) all pedon except for Pedon 2 and 5, whereas the color (moist) of the subsurface horizons varied from black (5Y2.5/1) in Pedon7 to brown (10YR 4/3) in Pedon 5(Table 2). The moist soil colors of the horizons in the Pedons 2 and 5 varied from black (10YR 2/1) to yellowish brown (10YR 5/6).

The variations in color observed within a pedon and among the seven pedons could probably be attributed to the differences in depth and topographic positions, clay and organic matter contents, parent material and drainage conditions that affect the redoximorphic reactions in the soil. Dengiz *et al.* (2012) also indicated that soil color could be related to organic matter, water logging, carbonate accumulation and redoximorphic features.

### **3.1.3. Soil structure**

There was a considerable variation in grade, size as well as shape of soil structure characteristics within the horizons of each pedon and among soil pedons (Table 1). The structure in the surface layers of the pedons varied from weak fine granular in Pedon 4 to strong fine granular in Pedon 5, whereas in the subsurface horizons it ranged from moderate fine prism in Pedon 6 to strong fine angular blocky in Pedon 1. The Sub-watershed is dominated by cultivated land, except for Pedon 1, and hence all the surface layers of the pedons were under the effect of management, specifically the stress of tillage. Consequently, the subsurface layers had better development of soil aggregates due to higher clay contents as compared to their surface layers counterparts. Ashenafi *et al.* (2010) who reported that higher clay content could be a reason for better development of soil structure.

## **3.2. Physical properties of the soils along the toposequence**

### **3.2.1. Particle size distribution and soil textural class**

The field as well as laboratory analyses indicated the textures of the pedons were dominated by clay, except for the south east facing upper and middle topographic positions (i.e., P-1 and 2), where sand was the dominant fraction in the A and C horizons (Table 1). The soil textural classes

varied from sandy clay loam in Pedon 1 to clay loam and clay in the surface horizons of all pedons. The texture became finer down the slope positions (from upper slopes to bottom) along the toposequences. The soils of the upper slope position of the Sub-watershed were predominantly sandy clay loam in texture, whereas clayey texture was observed in the lower part of the slope position. This might be also attributed to the removal of fine soil particles from steeper slope and their deposition at lower slope positions. Moore et al. (1993) also found that slope was one of the topographic factors, which was most highly correlated with soil properties. This is in agreement with the findings of Ellerbrock and Gerke (2013) who indicated that during erosion, clay sized particles can be transported along hill slopes from hilltop to foot slope areas forming colluvic soil at topographic depressions.

As a result of clay migration, silt: clay ratio decreased with increasing depth within the profiles and from the upper to middle slope positions along the toposequence indicated the susceptibility of silt fraction to water erosion and corroborating the findings of Dinku et al. (2014). A maximum value of silt/clay ratio (1.1) was recorded in surface layer of Pedon 5 while the minimum value of 0.08 was at the depth of 126 cm in Pedon 2 (Table 1). The presence of an appreciable amount of the silt fraction in the surface soils could increase the water-absorbing ability of the respective soils, and facilitate a longer period of soil-water retention for plant utilization.

### **3.2.2. Bulk Density**

The dry bulk densities of the soils in the Sub-watershed showed spatial variability among and within the soil pedons (Table 1). The highest bulk density of  $1.21 \text{ g/cm}^3$  was recorded in the surface horizons of the Pedons USEF, UNWF and BOT, while the lowest ( $0.9 \text{ g/cm}^3$ ) was in the MSE. The dry soil bulk density of subsurface horizons ranged from  $1.01 \text{ g/cm}^3$  in Pedon 2 to  $1.32 \text{ g/cm}^3$  in Pedon 6. The increment of bulk density with depth could be related to the reduced organic matter content, aggregation and root penetration compared to the surface layers. Subsurface layers are also subjected to the compaction by weight of the soil mass above them. The surface horizons have relatively higher OM content, which makes the soil loose and porous and thereby reducing its bulk density compared to the subsurface counterparts (Celik, 2005).



Table1.Selected physical characteristics of the soils under different topographic positions at Borara Watershed, 2017

Depth cm	Horizon	Sand%	Clay%	Silt%	Texture	Silt: clay	Bd (kg m <sup>-3</sup> )	FC%	PWP %	AWHC%
<b>Upper slope south east facing (USEF)pedon 1</b>										
0-18	A	64.76	29.6	5.64	SCL	0.19	1.21	31.6	19.2	12.4
18-42	B1	30.76	61.6	7.64	C	0.12	1.11	39.8	27.2	12.6
42-76	B2	18.76	65.6	15.64	C	0.24	1.26	40.4	27	13.4
76-127	BC	18.76	59.6	21.64	C	0.36	0.91	45.7	35	10.7
127-200 <sup>+</sup>	C	24.76	19.6	55.64	SiL	2.84	1.01	31	13.7	17.3
<b>Middle slope south east facing (MSEF)pedon 2</b>										
0-20	AP	84.76	9.6	5.64	LS	0.59	0.91	13.6	8	5.6
20-52	B1	22.76	65.6	11.64	C	0.18	1.01	42.1	29.7	12.4
52-80	B2	22.76	69.6	7.64	C	0.11	1.26	42.1	29.7	12.4
80-126	BC	22.76	71.6	5.64	C	0.08	1.16	42.1	29.7	12.4
126-200 <sup>+</sup>	C	52.76	19.6	27.64	SL	1.41	1.03	25.4	13.7	11.7
<b>Lower slope south east facing (LSEF)pedon 3</b>										
0-23	AP	26.76	37.6	35.64	CL	0.95	1.01	37.3	23.4	13.9
23-72	Bss1	12.76	75.6	11.64	C	0.15	1.06	32.5	11.5	21
72-97	Bss2	8.76	75.6	15.64	C	0.21	1.06	38.3	21.5	16.8
97-150	Bss3	8.76	73.6	17.64	C	0.24	1.16	39.6	24.1	15.5
150-200 <sup>+</sup>	BC	28.76	37.6	33.64	CL	0.89	1.96	37.1	23.4	13.7
<b>Bottom (BOT)pedon 4</b>										
0-14	AP	28.76	35.6	35.64	CL	1	1.21	36.3	2.3	14
14-53	AC	20.76	39.6	39.64	CL	1	1.26	38.6	24.3	14.3
53-87	C1	18.76	35.6	45.64	SiCL	1.28	1.06	31.4	22.2	9.2
87-113	C2	24.76	35.6	39.64	CL	1.11	1.16	36.8	22.3	14.5
113-152	C3	24.76	33.6	41.64	CL	1.24	1.42	36	21.2	14.8
152-200 <sup>+</sup>	2B	12.76	59.6	27.64	C	0.46	1.16	45.3	34.8	10.5
<b>Lower slope north west facing (LNWF)pedon 5</b>										
0-28	AP	24.76	35.6	39.64	CL	1.11	1.11	36.8	22.3	14.5
28-62	Bss1	22.76	59.6	17.64	C	0.3	1.16	45.9	35.1	10.8
62-102	Bss2	10.76	69.6	19.64	C	0.28	1.26	38.3	22.1	16.2
102-140	Bss3	10.76	61.6	27.64	C	0.45	1.32	45.2	34.7	10.5
140-200 <sup>+</sup>	Bss4	14.76	63.6	21.64	C	0.34	1.42	37.9	22.1	15.8
<b>Middle slope north west facing pedon 6</b>										
0-24	AP	30.76	47.6	21.64	C	0.45	1.16	41.1	28.9	12.2
24-49	Bt1	20.76	65.6	13.64	C	0.21	1.21	41.4	28.6	12.8
49-75	Bt2	18.76	61.6	19.64	C	0.32	1.26	41.5	28.6	12.9
75-105	Bt3	16.76	61.6	21.64	C	0.35	1.32	41.5	28.5	13
105-162	Bt4	16.76	57.6	25.64	C	0.45	1.32	44.9	33.8	11.1
162-200 <sup>+</sup>	BC	28.76	49.6	21.64	C	0.44	1.16	42	29.9	12.1
<b>Upper slope north west facing (UNWF)(pedon 7</b>										
0-20	AP	30.76	41.6	27.64	C	0.66	1.21	38.6	25.6	13
20-49	B	20.76	61.6	17.64	C	0.29	1.26	39.3	25.4	13.9
49-67	BC	24.76	51.6	23.64	C	0.46	1.06	42.8	30.9	11.9
67-102	C1	44.76	27.6	27.64	CL	1	0.81	30.7	18.1	12.6
102-200 <sup>+</sup>	C2	48.76	21.6	29.64	L	1.37	0.96	27.1	14.8	12.3

Texture; C=clay, L=Loam, SL=sandy loam, SCL=sandy clay loam, CL= clay Loam, SiCL= silty clay loam, SiL= silt loam, LS= loamy sand SiCR=Silt/clay ratio, BD= Bulk density, kg m<sup>-3</sup> = kilogram per cubic meter, .FC= field capacity, PWP= permanent wilting point, AWHC= available water holding capacity,

### 3.3. Chemical properties of the soils along the toposequence

#### 3.3.1. Soil pH

The pH-H<sub>2</sub>O values of the surface horizons of the soils ranged from 6.17 in Pedon 1 and 6 to 6.78 in Pedon 4, while in the subsurface it ranged from 6.26 in Pedon 7 to 7.30 in Pedon 4 (Table 2). The soil of the pedons opened in the lower area of the Sub-watershed had relatively higher pH-H<sub>2</sub>O values than those on the upper position pedons. This increase in soil pH down the slope position could be due to washing of bases from higher parts of the Sub-watershed and subsequent deposition at lower elevations, which is in agreement with the findings of Mohammed *et al.* (2005) and Shimeles *et al.* (2012).

#### 3.3.2. Organic carbon and total nitrogen

The organic carbon (OC) content in the surface horizons of the soils ranged from 2.18% in Pedon 6 to 4.02% in Pedon 4, while in the subsurface horizons it ranged from 1.09% in Pedon 3 to 3.12% in Pedon 2 (Table 2). The highest organic carbon value of 4.02% was recorded in the bottom position followed by USEF of grass land. The organic carbon (OC) contents of the soils decreased with depth in most pedons. The pedon at the bottom slope position had relatively higher OC and total N than the other pedons, except for total N in the pedon 1 and 2. Both OC and TN in the bottom pedon did not follow similar trend of decreasing with depth due to accumulation of contrasting material that add different materials through erosion in different years and water-logging, which might have affected decomposition and mineralization of OC (Wang *et al.*, 2000).

The carbon to nitrogen ration (C: N) of soils of the Sub-watershed also revealed differences with topographic position and soil depth (Table 2). The C: N values recorded in the surface horizons ranged from 8.94 in Pedon 1 to 17 in Pedon 7, while in the subsurface horizons it ranged from 10.2 in Pedon 4 to 19.2 in Pedon 2. The narrow carbon to nitrogen (C: N) ratio at the surface layers may be due to the effect of microbial activity that result in relatively fast decomposition of OM and the consequent CO<sub>2</sub> evolution than in the subsurface layers. Achalu *et al.* (2012) also reported narrow C: N ratio at the surface soils of cultivated land as a result of enhanced mineralization of OC due to better aeration during tillage and increased temperature.

Table2. Soil pH, EC, total N, OC, and Available P of the soils in the pedons from different topographic position at Borara watershed, 2017.

Depth	Horizon	pH(H <sub>2</sub> O)	EC dSm <sup>-1</sup>	OC %	TN %	C/N	Av.P mg kg <sup>-1</sup>
<b>Upper slope south east facing(USEF) (Pedon 1)</b>							
0-18	A	6.17	0.28	3.90	0.31	8.94	2.53
18-42	B1	6.69	0.33	2.15	0.19	11	1.81
42-76	B2	6.72	0.59	2.15	0.17	12.65	0.91
76-127	BC	6.85	0.29	1.68	0.15	11.2	0.90
127-200 <sup>+</sup>	C	6.60	0.12	1.83	0.13	14.1	0.19
<b>Middle slope South east facing(MSEF)(Pedon 2)</b>							
0-20	AP	6.30	0.90	3.12	0.26	12	3.60
20-52	B1	6.49	0.19	3.12	0.29	10.8	1.70
52-80	B2	6.45	0.18	2.11	0.11	19.2	1.47
80-126	BC	6.53	0.25	1.37	0.12	11.4	0.58
126-200 <sup>+</sup>	C	6.40	0.15	0.23	0.02	11.5	0.44
<b>Lower slope South east facing(LSEF)(Pedon 3)</b>							
0-23	AP	6.45	0.27	2.66	0.23	11.6	3.88
23-72	Bss1	6.46	0.38	2.11	0.18	11.7	1.47
72-97	Bss2	6.29	0.41	2.50	0.21	11.9	1.48
97-150	Bss3	6.54	0.19	1.09	0.11	9.9	0.33
150-200 <sup>+</sup>	BC	6.20	0.19	0.78	0.05	15.6	0.39
<b>Bottom slope (Pedon 4)</b>							
0-14	AP	6.78	0.11	4.02	0.25	16.1	6.01
14-53	AC	6.11	0.10	2.65	0.21	12.6	1.28
53-87	C1	7.19	0.10	2.61	0.18	14.5	2.09
87-113	C2	7.03	0.70	2.11	0.18	11.7	1.03
113-152	C3	7.50	0.90	0.27	0.04	6.8	1.61
152-200 <sup>+</sup>	2B	7.3	0.10	1.83	0.18	10.2	1.37
<b>Lower slope North west facing(LNWF)(Pedon 5)</b>							
0-28	AP	6.19	0.11	2.61	0.23	11.3	3.37
28-62	Bss1	6.43	0.22	2.31	0.19	12.2	1.48
62-102	Bss2	6.99	0.33	2.22	0.17	13	0.61
102-140	Bss3	6.33	0.24	2.20	0.21	10.5	0.98
140-200 <sup>+</sup>	Bss4	6.63	0.74	1.48	0.13	11.4	1.91
<b>Middle slope North west facing(MNWF)(Pedon 6)</b>							
0-24	AP	6.17	0.49	2.18	0.21	10.4	2.83
24-49	Bt1	6.32	0.52	2.34	0.20	11.7	1.52
49-75	Bt2	6.66	0.56	2.22	0.19	11.7	1.07
75-105	Bt3	6.40	0.44	2.11	0.19	11.1	1.84
105-162	Bt4	6.43	0.19	1.87	0.13	14.4	1.39
162-200 <sup>+</sup>	BC	6.40	0.10	1.95	0.09	21.7	01.37
<b>Upper slope North west facing(UNWF)(Pedon 7)</b>							
0-20	AP	6.18	0.15	2.22	0.13	17	2.74
20-49	B	6.26	0.20	2.03	0.11	18.5	0.89
49-67	BC	6.97	0.25	1.83	0.15	12.2	0.84
67-102	C1	6.30	0.29	1.44	0.01	144	0.74
102-200 <sup>+</sup>	C2	6.60	0.15	0.08	0.12	0.67	0.39

EC = electrical conductivity; OC = organic carbon; TN = total nitrogen; Av.P = available phosphorus.

### 3.3.3. Available Phosphorous

Available phosphorus (P) contents of the soils in the surface horizons was highest in the Bottom slope position ( $6.01 \text{ mg kg}^{-1}$ ) followed by LSEF (pedon3) ( $3.88 \text{ mg kg}^{-1}$ ) and pedon 7 ( $3.71 \text{ mg kg}^{-1}$ ) while the lowest was recorded in the pedons 6 and 1 ( $2.83$  and  $2.53 \text{ mg kg}^{-1}$ ) respectively (Table 3). The available P contents of the soils ranged from  $0.19 \text{ mg kg}^{-1}$  in pedon 1 to  $6.01 \text{ mg kg}^{-1}$  in pedon 4. Available P generally increased from the upper to the lower slope positions and with increasing soil depth in the pedons, except in BOT and MNWF pedons. The increase in available P down the slope might be due to the erosion processes that removes soil particles from upper slope position and accumulates in the lower slopes. The higher available contents in the surface layers compared to their subsurface counterparts could be due to the relatively higher OC in the surface layer that contributes to available P through decomposition. Girma and Endalkachew (2013) also reported relatively higher P in the surface layer and attributed the results to external phosphorus supply, and phosphorus carries over from fertilization.

### 3.3.4. Exchangeable cations

Exchangeable calcium (Ca) followed by exchangeable magnesium (Mg) were the dominant basic cations in the exchange complex of the colloidal material of the soils of the study area (Table 3). The concentrations of the basic exchangeable cations in the all slope positions were in the order of  $\text{Ca} > \text{Mg} > \text{K} > \text{Na}$  except Pedons 3, 5 and 6 where the order was  $\text{Ca} > \text{Mg} > \text{Na} > \text{K}$  in some horizons. The exchangeable Ca content of the surface soils ranged from  $15.03 \text{ cmol}(+) \text{ kg}^{-1}$  in Pedon 6 to  $21.27 \text{ cmol}(+) \text{ kg}^{-1}$  in Pedon 3, while exchangeable Mg ranged from  $5.17 \text{ cmol}(+) \text{ kg}^{-1}$  in Pedon 5 to  $13.71 \text{ cmol}(+) \text{ kg}^{-1}$  in Pedon 2. On the other hand, exchangeable Ca and Mg increased regularly with soil depth from A to B horizons in all pedons, except in the MSEF pedon. The variation with topographic position might be due to the removal of soil particles by soil erosion from the upper slope positions and subsequent accumulation in the lower topographic position. This is in agreement with the findings of Tadele *et al.* (2013) in Anjeni watershed, central highlands of Ethiopia and Shimeles *et al.* (2012) at Lake May bar watershed, northern highlands of Ethiopia, which indicated relatively higher accumulation of divalent cations in lower topographic position owing to washing away from the upper areas and accumulations in the lower areas. Similarly, the increments of the cations with depth could be attributed to their leaching down the soil profiles. Ashenafi *et al.*, (2010) also showed the increment of cations with depth due to leaching in soils of Delbo Wegene watershed, Ethiopia.



The exchangeable Na content of the surface soils ranged from 0.19 cmol(+) kg<sup>-1</sup> in Pedons 4 to 0.97 cmol(+) kg<sup>-1</sup> in Pedon 3, while exchangeable K content ranged from 0.73 cmol(+) kg<sup>-1</sup> in Pedon 3 to 2.27 cmol(+) kg<sup>-1</sup> in Pedon 6.

Exchangeable K content of the soils was relatively higher at the surface horizons in all pedons and it showed an increasing trend with soil depth, except in pedons 1 and 4 (Table 3). The increment of exchangeable K with depth could be attributed to the higher clay contents in the subsurface layer, which are holding the cation. On the other hand, higher exchangeable K in surface than in subsurface layers was reported by Jobbagy and Jackson (2001) who argued that nutrients strongly cycled by plants, such as K, were more concentrated in the top soil than nutrients usually less limiting for plants.

Table 3. Exchangeable bases, CEC, PBS and ESP of the soil under different topographic position at Borara watershed, 2017

Depth Cm	Horizon	Ca (cmol(+)/kg of soils)	Mg	K	Na	Sum	CEC	PBS%	ESP%
<b>Upper slope south east facing(USEF) (Pedon 1)</b>									
0-18	A	17.87	8.63	1.74	0.52	28.76	51.6	55.7	1
18-42	B1	21.72	10.88	1.31	0.47	38.02	49.6	76.6	0.9
42-76	B2	26.61	9.42	1.39	0.68	38.1	49.6	76.8	1.4
76-127	BC	18.18	9.98	1.85	1.17	31.18	43.6	71.5	2.2
127-200 <sup>+</sup>	C	14.02	8.89	2.82	1.74	27.47	37.6	73	4.6
<b>Middle slope South east facing(MSEF)(Pedon 2)</b>									
0-20	AP	19.36	13.71	1.57	0.26	34.9	58.8	59.4	0.4
20-52	B1	25.51	16.28	2.98	2.26	47	58	81	3.9
52-80	B2	22.88	14.00	2.33	1.62	40.83	53.6	93.6	3.7
80-126	BC	25.36	15.38	3.03	2.45	46.22	48.8	94.7	5
126-200 <sup>+</sup>	C	14.09	6.94	2.26	1.95	25.24	28	90	4
<b>Lower slope South east facing(LSEF)(Pedon 3)</b>									
0-23	AP	21.27	5.45	0.73	0.97	28.14	57	49	1.7
23-72	Bss1	22.29	13.00	2.68	2.07	41.9	55	76	3.7
72-97	Bss2	26.11	14.89	3.68	2.82	50	66	75.8	4.3
97-150	Bss3	29.36	17.41	2.84	1.91	47	55	85.6	3.5
150-200 <sup>+</sup>	BC	17.91	11.05	3.04	2.42	34.4	51	67.5	4.7
<b>Bottom slope (Pedon 4)</b>									
0-14	AP	15.39	7.15	0.92	0.19	23.3	40	58	0.48
14-53	AC	20.63	6.58	0.53	0.26	28	36	78	0.7
53-87	C1	11.99	3.81	0.44	0.31	16.55	24	68.9	1.3
87-113	C2	9.34	3.86	0.40	0.28	13.97	20	69.9	1.4
113-152	C3	9.43	4.42	0.72	0.28	14.85	24	61.9	1.2
152-200 <sup>+</sup>	2B	23.47	15.45	2.24	0.82	42	31.8	132	2.6
<b>Lower slope North west facing(LNWF)(Pedon 5)</b>									
0-28	AP	16.36	5.17	0.80	0.61	23.22	51.2	45	1.2

28-62	Bss1	17.81	9.51	1.81	2.54	31.67	53.6	59	4.7
62-102	Bss2	20.59	10.55	2.06	1.86	35.06	53	66	3.5
102-140	Bss3	23.67	13.36	2.64	1.39	41.06	40	102	3.5
140-200 <sup>+</sup>	Bss4	28.71	15.79	2.54	2.35	49.39	45	110	5
<b>Middle slope North west facing(MNWF)(Pedon 6)</b>									
0-24	AP	15.03	10.35	2.27	0.45	28.5	49.6	57	0.9
32-49	Bt1	18.65	16.29	2.59	1.65	39.2	54	72.5	3
49-75	Bt2	25.38	18.42	2.57	2.49	48.9	47	104	5.3
75-105	Bt3	17.73	16.41	2.12	2.38	38.6	49	79	4.9
105-162	Bt4	16.39	9.53	1.78	1.79	29.5	49	60	3.7
162-200 <sup>+</sup>	BC	17.43	10.71	1.46	1.37	31	40	77	3.4
<b>Upper slope North west facing(UNWF)(Pedon 7)</b>									
0-20	AP	12.87	7.71	1.26	0.45	22.3	45.6	49	0.99
20-49	B	18.55	12.85	3.09	2.71	37.2	56.8	65.5	4.8
49-67	BC	19.49	15.10	3.70	3.11	41.4	42	99	7.4
67-102	C1	11.61	2.43	2.40	2.14	18.6	27.6	67	7.7
102-200 <sup>+</sup>	C2	9.55	4.57	2.62	1.50	18.2	25.6	71	5.9

TEB = Total exchangeable bases; CEC = Cation exchange capacity; PBS = Percent base saturation; ESP = Exchangeable sodium percentage

### 3.3.5. Cation exchange capacity and percent base saturation

Cation exchange capacity (CEC) of the soils in the surface and subsurface horizons ranged from 20 cmol(+) kg<sup>-1</sup> in Pedon 4 to 66 cmol(+) kg<sup>-1</sup>soil in Pedon 3 (Table 3). The highest value of CEC 58.8 cmol(+) kg<sup>-1</sup> was recorded in Pedon 2 followed by that of Pedon 3(57 cmol (+) kg<sup>-1</sup>) while the lowest was observed in Pedon 4(40 cmol (+) kg<sup>-1</sup>). Although bottom slope soils formed from accumulated soil materials, their basic contents and CEC were found to lower than those in upland positions. This might be attributed to the deposition of young materials and leaching of basic cations.

## 3.4. Classification of the Soils

### 3.4.1 Classification according to soil taxonomy

The surface layers of pedons 1, 2, 4 and 6 had color values of 5 and less; and chroma less than 3 both dry and moist. They had OC content of 2.18- 4.02%, PBS greater than 50(by NH<sub>4</sub>OAc) and a thickness of 18 to 34 cm. According to Soil Survey Staff (2014), the pedons had a mollic epipedon, while the remaining three pedon (BLS3, BLS5 and BUS7) had color values less than 5 and chroma less than 3; PBS (by NH<sub>4</sub>OAc) less than 50, OC content (2.22-2.66%) and a thickness of greater than 18 cm. Thus, these properties would qualify the epipedons of BLS3, BLS5 and BUS7 as umbric epipedon. In the subsurface horizons, all pedons had thick B horizons (> 7.5 cm) with distinct clay increments from A to B horizons, except for the pedon at the bottom

slope position. Accordingly, the subsurface horizons had argillic diagnostic horizon (Boul *et al.*, 2003). Although few to many distinct clay coatings were present, the subsurface horizon of pedon4 did not meet the clay increment requirement of argillic horizon, and hence categorized as a cambic horizon.

Thus, considering the morphological, physical and chemical properties of the surface and subsurface horizons, the six pedons (pedon 1, 2, 3, 5, 6 and 7) fall under Vertisols Order of Soil Taxonomy (Soil Survey Staff, 2014). Vertisols are sub divided into six suborders based on the moisture and temperature regimes. The region is characterized by isomesic temperature and ustic moisture regimes, respectively (Van Wambeke (1992). Hence, the soils fall under Usterts of Soil Taxonomy (Soil Survey Staff, 2014). The pedons had no petrocalcic, duripan or plinthite horizons, and the soils fall under Haplusterts.

The B horizon of the Pedon at bottom slope position had base saturation greater than 50% (by NH<sub>4</sub>OAc) between the mollic epipedon and a depth of 180 cm. Thus, it was classified as Inceptisols. Inceptisols are sub divided into six suborders based on the moisture and temperature regimes Buol *et al.*, 2003). Considering the isomesic temperature and ustic moisture regimes of the region, the soils of the pedon at the bottom slope position fall under Ustepts of Soil Taxonomy (Soil Survey Staff, 2014).

### **3.4.2 Classification according to WRB legend**

The soils had mollic or umbric epipedons; and six of the seven studied pedons (1, 2, 3, 5, 6 and 7) had argic subsurface horizons, while the subsurface diagnostic horizon of the pedon 4 was cambic. The argic horizons had cation exchange capacity (by 1 M NH<sub>4</sub>OAc) of greater than 24 cmolc kg<sup>-1</sup> of clay throughout and hence the soils of pedons in the upslope positions of the catena were grouped under Vertic Luvisols. The soils at the bottom slope position having Cambic subsurface horizon and were classified as Cambisols.

## **4. Conclusions**

The studied soils were under intensive land use due to the growing population which resulted in decline of soil fertility by continuous removal of crop, vegetation, and erosion. There were

spatial variations of different levels with soil depth in a pedon and along the toposequence. The study showed that many soil properties and soil type are influenced by toposequence. The soils quality indicator values such as, pH, EC, Av. P, Zn, K, Ca and PBS at middle and lower slope positions were higher as compared to the upper slope position. Though, the CEC and exchangeable base increase with in pedon and along toposqunce goes to down the bottom slope position lower as compare to upper, middle and lower toposequence due to channel effect. Excepting the bottom slope which was young Cambisol, the remaining six pedons were Vertic Luvisols. The CEC and exchangeable base of the bottom slope lower compare to the knowledge on soil type is important to apply appropriate soil management practices. The study suggests integrated soil management practice to reduce decline in soil fertility because of the adverse effect erosion and intensive cultivation especially on upper slope positions which suffers more from runoff and surface soil removal. However, further studies of the areas is recommended especially with respect to soil landscape - land management relationships and introduce new agricultural technologies based on soil type so as to give sound conclusion for the sustainable use of the land.

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