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Determinants of Highland Bamboo (Yushania alpina) Culm Supply: The Case of Loma and Tocha Districts, Dawuro Zone of Southern Ethiopia

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Abstract
The overall objective of this research was to increase better understand of the challenges that influence highland bamboo culm supply in Dawuro zone with the specific objectives of mapping highland bamboo culm marketing channels of the study districts and analyzing determinants of highland bamboo culms supply. Data were generated by individual interview and group discussions by using questionnaires and checklists. This was supplemented by secondary data collected from different published and unpublished sources. Multistage sampling technique was applied. Sample of 109 bamboo producers and 34 traders and 2 small and medium bamboo culm processors were main sources of primary data. Descriptive statistics and econometric analysis were employed. Producers, traders (collectors and wholesalers) and bamboo handicraftsmen are chain actors in study areas. Bamboo producers supplied (348,940 culms) to different buyers in 2015 production year. Since there is heteroscedasticity problem in the data set, robust OLS regression econometric model was used to analyze determinants of highland bamboo culms supply to market in study districts. Bamboo culms supply determinants such as quantity of Yushania alpina produced, distance to nearest all weather road, silvicultural management of bamboo stands, access to market information, land allocated for bamboo plantation, and Yushania alpina farming experience were found to significantly affect the household market supply of bamboo culms. Of these explanatory variables, quantity of Yushania alpina produced, distance to all nearest weather road, silvicultural management of bamboo stands were the strongest factors that determine bamboo culms supply to market ($p<0.001$). To improve output of bamboo culms and increase their own incomes; farmers should apply intensive bamboo silvicultural management. But bringing about a meaningful change in the production and utilization of bamboo resources in the study areas requires a combined effort of all relevant stakeholders.
Keywords: Culms supply, Dawuro, highland bamboo (*Yushania alpina*) value chain, multiple linear regression model

1. INTRODUCTION

Bamboo is most economically important NTFP, with its renewability and accessibility to the rural poor (Ensermu *et al.*, 2000). It also has great potential for commercialization and can drive rural development (Tefera *et al.*, 2013). It can be utilized at all levels of industrial activity from small crafts based industries to modern highly integrated plants (pulp, paper and clothing, furniture, flooring) as a substitute for traditional hardwoods). Bamboo industry is making important contribution in providing food, housing and income generation more than 2.2 billion people in the world. Market for environment friendly green bamboo is growing. Smith and Marsh (2005) reported global market for bamboo products was approximately USD 7 billion which is expected to triple by the year 2017.

Globally there are more than 1250 bamboo species belonging to 75 genera (Heinz and Patrick, 2013) that covering 36 million ha of land, which are distributed in the tropical and sub-tropical belt between 46^0 North and 47^0 South, latitude at elevation as high as 4000m above sea level. About 11 genera and 43 species bamboo is found in Africa that covered over 1.5 million ha (Kigomo, 1988). Bamboo species grow naturally on the lowlands and highlands of Eastern African Countries (KEFRI, 2007). Ethiopia has the greatest bamboo resources in Africa and representing a significant proportion of Africa's total bamboo resources. The country has more than 1 million hectares of bamboo which is 67% of African bamboo resources and more than 7% of the world total area covered by bamboo. In Ethiopia has two bamboo species namely highland bamboo *(Yushania alpina)* and lowland bamboo (*Oxytenantheria abyssinica)*

Two indigenous bamboo namely highland bamboo and lowland bamboo species are scattered in the south, south-west and central parts of Ethiopia. Of these resources are largely found in four regions, namely Benishangul Gumuz, Oromia, Southern Nations and Amhara. There has been general intuition that Ethiopia has one million hectares of bamboo resources, but the volume and place of resource distribution statistics is not well explored. Bamboo resources are largely distributed in Dawuro, but the amount was not reported anywhere. Cultivation of the highland bamboo variety is largely carry out in Dawuro. The share of lowland bamboo is very small and not cultivated in farm yards. The distribution of bamboo resources in study districts was estimated about 2008.7ha (from 2013 report of Dawuro agricultural department). This resources account 0.43% of total

land of the area. Out of total bamboo resource, highland bamboo (*Yushania alpina*) covers 1848.04 hectare (92%). Highland bamboo is widely cultivated at homestead which is locally named 'kerkeha' (Amharic) and 'Wosha' (Dawurotsuwa).

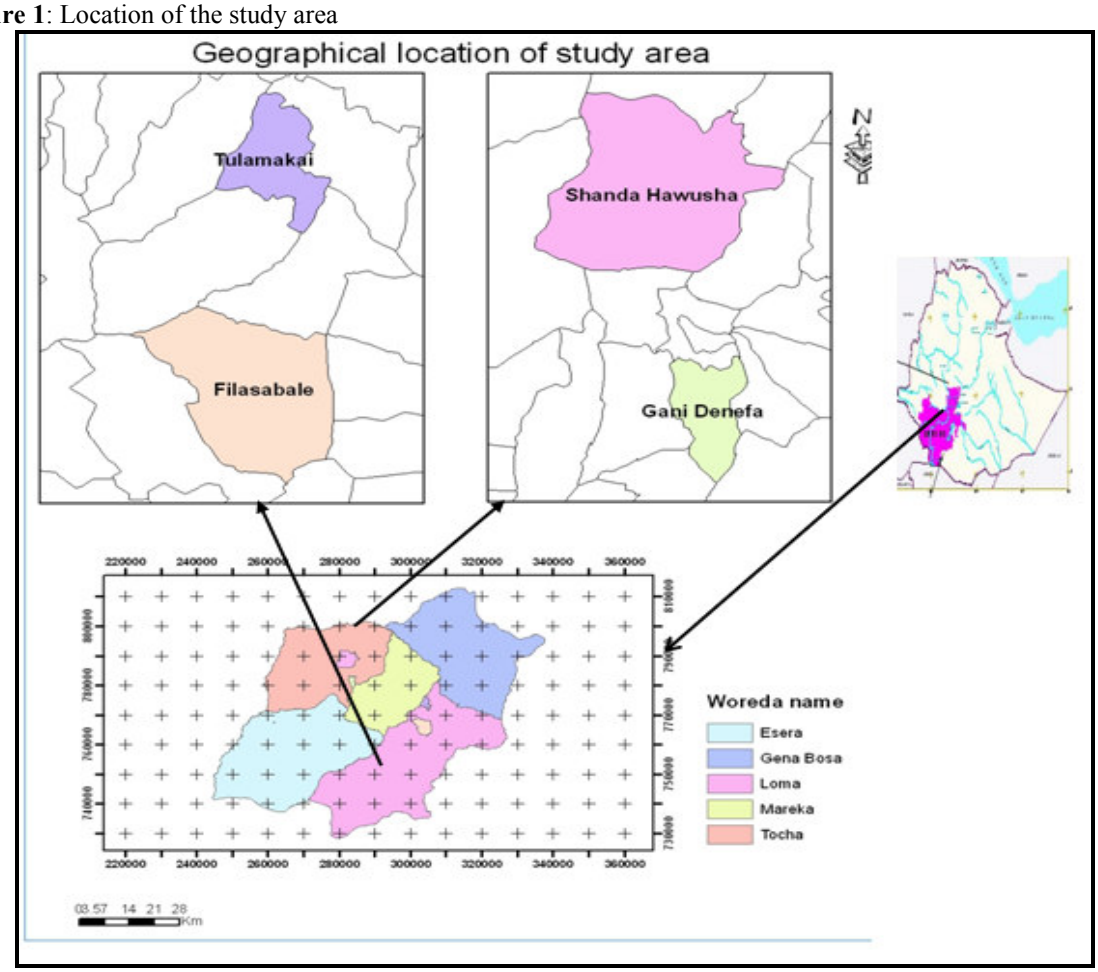
There is an increasing demand of wood in the global markets due to the increasing quality of life. The rapid economic growth and unprecedented construction sector boom is driving a continuous increase in the demand for wood and wood products in Ethiopia. However, the gap between supply and demand is already very large and widening (Mulegeta, 2013). Bamboo culm has become a high-tech industrial raw materials and substitute for wood. But, INBAR (2006) described that there is shortage of bamboo raw culms supply to market in Ethiopia. Again the recent bamboo value chain analysis in Ethiopia at different sites are showed that there is increasing price per bamboo culm but problems of the bamboo culms supply (Zenebe *et al*., 2014). The factors that are affecting supply of bamboo culms to the market are not well studied in Ethiopia. Homestead cultivation of the highland bamboo (*Yushania alpina*) diversity is the part of main livelihood strategies in Dawuro. Bamboo producers produce large quantity of bamboo culms in homestead, but they unable to supply culms to market. However, little research was performed concerning the challenges that influence highland bamboo culm supply to market. Hence, this study was purposively proposed to analyze determinants highland bamboo culm supply mainly at two highland bamboo potential districts in Dawuro.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

This study was undertaken in two major highland bamboo growing districts of Dawuro zone. The name "Dawuro" represents both the land and the people. Dawuro is one of the 14 zones of Southern, Nations, Nationalities, and Peoples Region (SNNPR). Dawuro has 5 districts (woredas) namely Loma, Gena, Maraka, Essera and Tocha. Dawuro zone is located about 500 km South West of Addis Ababa. Total coverage area is about 466,082 ha (Tigicho *et al*., 2012). Dawuro zone is located at $6^0.59'–7^0.34'$ latitude and $36^0.68'–37^0.52'$ longitudes, with elevation ranging from 500 to 3000 meters above sea level. Current total population is more than 608,947 (projected from 2007 CSA result).

Figure 1: Location of the study area

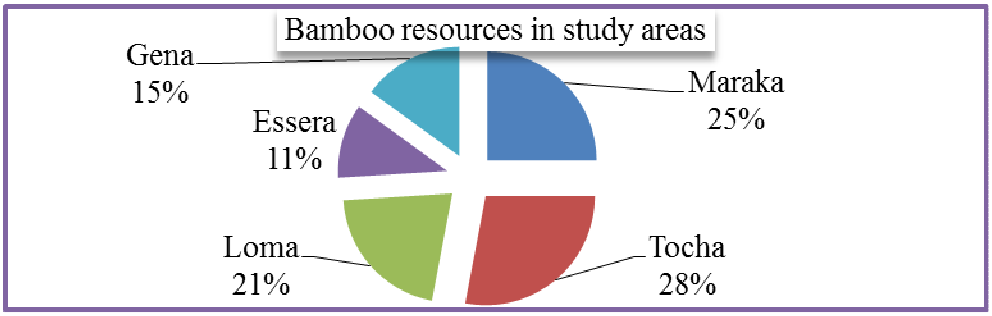


Regarding the agro-ecology of the Dawuro zone, out of the total land size 55.6% is kolla (500-

1500masl), 41.4% weinadega (1500-2500 masl) and 3% Dega (> 2500 masl). The annual mean temperature ranges between 15.1^{0}c to 27.5^{o}c and the annual mean rainfall range from 1201mm to 1800mm. According to the land utilization statistics/data of the region, out of total land 55.49% is cultivated land, 13.39% is grazing land 16.81% is forest bushes and shrub land, and 14.31% is covered by others. Mixed agricultural is main livelihood strategy in the districts. Enset and maize are major subsistence crops for highland and lowland inhabitants. Livestock and crops are source of food and cash income in study areas.

Forest covers an area of about 32000 hectare (ha). Out of these bamboo covers an area of about 2008.7ha. Cultivation of the highland bamboo (*Yushania alpina)* variety is largely undertaken in highland areas in Dawuro zone. Bamboo resources are providing large economic, environmental and aesthetic values for districts. Total number of bamboo producer households in five districts is estimated at about 6273. Of these 90% are male bamboo producers while 10% are female bamboo producers. Highland bamboo species is unevenly distributed in all highland areas of Dawuro zone

Figure 2: Distribution of highland bamboo resources by districts



Bamboo resources in the two (Loma and Tocha) study districts account more than 49%. Bamboo production scale is smallholder based and disaggregated among thousands of producers homestead in study districts. The two study districts are described below.

Loma district is composed of 36 rural kebeles and 4 urban kebeles. Loma is bordered on the south by the Gamo Gofa zone and on the East by the Wolayita zone. The eastern and southern border of Loma is demarcated by the Omo River. According to central statistics agency (2007) total population of 109,192, of whom 50.57% are male and 49.43% are female and 3,999 or 3.66% of its population are urban dwellers. Geographically, Loma district lies between 6˚55′N and 7˚01′30″N latitude and 37˚15 E and 37˚19′E longitude. It is at about 470 km in south west of Addis Ababa. Altitude ranges or lies between 1160 and 2300 m above sea level and receives 1400 mm-1600 mm rainfall annually. The mean temperature ranges from 15.1˚C to 27.5˚C.

Tocha district: According to Central Statistical Agency of Ethiopia (2007) total population of 102,848, of whom 51.35% are male and 48.64% are female. This district falls into three agro-ecological regions, of which, kolla within (500-1500masl), weinadega within (1501-2500 masl) and Dega above (> 2500 masl) Tocha District: Compared to other districts, Tocha is the largest highland bamboo potential district in Dawuro. Highland bamboos (*Yushania alpina*) are growing in 21 rural kebeles out of 37 rural kebeles

2.2. Data Collection and Respondent Sampling

Both primary and secondary data were used. The primary data were collected from bamboo culm producers, culm traders and local bamboo handicraftsmen and small and medium bamboo enterprises. Detail surveys using semi-structured questionnaires and checklist was used for data collection. Formula for calculating sample size, Cochran (1963) equation was used in this study. Multistage sampling techniques were implemented to select sample from highland bamboo producers' kebeles and households. The sample size was distributed to all actors along the chain.

Table 1: Sample size distribution of the sample producers, traders

Study districts	Actors	Population	Sample size
Loma	Producers	**164**	34
	Collectors	13	7
	Wholesalers	8	5
Tocha	Producers	**359**	75
	Collectors	26	15
	Wholesalers	12	7
Total		**592**	**143**

2.3. Methods of Data Analysis

The methods of data analysis used in this study include descriptive statistics and bamboo culm marketing channel analysis. The collected raw data were systematically coded and analyzed using descriptive statistics by employing Statistical Package for Social Sciences (SPSS) version 20.0.and STATA version 11. These methods of data analysis use percentages, means, standard deviations, and t-test and value chain maps to describe sample respondents.

2.3.1. Econometric model

In this study, multiple linear regression model used to identify factors affecting farm level highland bamboo culms supply to the market because of all highland bamboo producers participate in the market and they supply different quantity of culms. Analysis of factors affecting farm level market supply of highland bamboo culms was found to be important to identify factors constraining highland bamboo culms supply to market. This model is also selected for its simplicity and practical applicability (Greene, 2000) and based on the relationships of independent variable and explanatory variables.

The econometric model of this study was specified as: Yi = F (X_{ij}):

Where Y_i = Quantity of highland bamboo culms supply to market
X_{ij} = Explanatory variables as defined below:

X_1	=	Age of HH
X_2	=	Sex of HH
X_3	=	Education level HH
X_4	=	Bamboo farming experience
X_5	=	Family size
X_6	=	Woredas/Districts
X_7	=	Quantity of culms harvested
X_8	=	Distance to nearest all weather roads
X_9	=	Access to market information
X_{10}	=	Price of culm
X_{11}	=	Bamboo producers expectations to future price
X_{12}	=	Silvicultural management of bamboo stands
X_{13}	=	Land allocated bamboo plantation
X_{14}	=	Access to extension service of bamboo production

Econometric model specification of supply function in matrix notation is the following:

$$Y = X'\beta + u_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: Y = is quantity of highland bamboo culms supply to market, X' = Vectors of explanatory variables, β is a vector of parameters to be estimated, u_i = disturbance terms

It was indispensable to test multicollinearity problem among continuous variables and check associations among discrete variables, which seriously affects the parameter estimates. According to Gujarati (2003), multicollinearity refers to a circumstance where it becomes difficult to identify the separate effect of independent variables on the dependent variable because of existing strong affiliation among them. The two measures that are often recommended to test the existence of multicollinearity are Variance Inflation Factor (VIF) and Contingency Coefficients (CC). Thus, Variance Inflation Factor (VIF) is used to check multicollinearity among continuous variables. As a rule of thumb, if the VIF is greater than 10 (this will happen if R^2 is greater than 0.90), the variable is said to be highly collinear (Gujarati, 2003). A measure of multicollinearity associated with the variance inflation factors is computed as:

$$VIF = \frac{1}{1 - R_i^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where: R_i^2 is the multiple correlation coefficients between explanatory variables, the larger the value of R_i^2 is, the higher the value of VIF_i causing higher collinearity in the variable (i)

Contingency coefficient is used to check multicollinearity or association between discrete variables. The value ranges between 0 and 1, with 0 indicating no association between the variables and value close to 1 indicating a high degree of association between variables. A popular measure of multicollinearity associated with the CC is defined as:

$$\mathrm{CC} = \sqrt{\frac{X^2}{N + X^2}} \quad \ldots \ldots (3)$$

Where, CC is contingency coefficient, X^2 is chi-square test and N is total sample size. If the value of CC is greater than 0.75, the variables are said to collinear

Test for heteroscedasticity had undertaken for this study. Heteroscedasticity refers to the case in which the variance of the error term is not constant i.e. heteroscedasticity occurs when the variance of the error term change with changes in explanatory variables. In existence of heteroscedasticity (i) the least squares (OLS) estimators are still unbiased but inefficient (ii) the estimates of the variances are also biased and as a result the tests of significance will become invalid. If we persist in using the usual testing procedures despite the presence of heteroscedasticity, whatever conclusions we draw or inferences we make may be very misleading. There are a number of test statistics for the detecting heteroscedasticity; According to Gujarati (2003) there is no ground to say that one test statistics of heteroscedasticity is better than the others, but White's Heteroscedasticity testing was applied in this thesis.

2.3.2. Definition of variables and hypothesis

It is not possible to include a complete list of all possible variables that could affect the household level of agricultural products supply to market. But, in this study, an attempt was made to identify determinants of highland bamboo culms supply to market in study districts (namely Loma and Tocha) by including potential variables which were supposed to influence the quantity of bamboo culms supply was explained below.

Dependent variable

Quantity of highland bamboo culms supply to market**:** It is a continuous variable that represents the dependent variable and the actual supply of bamboo culms by individual households to the market, which is measured in number of culms. The size, height and quality difference of culms are related with price in this particular study i.e. bigger bamboo culms products fetched higher prices while smaller ones fetched lower prices

Independent (explanatory) variables

Explanatory variables are assumed to influence quantity of highland bamboo culms supplied to market. Selection of independent variable needs to be born in mind that the omission of one or more relevant variables or inclusion of one or more irrelevant variables may result in error of specification which may reduce the capability of the model in exploring the economic phenomena empirically (Gujarati 2003). The explanatory variables expected to influence the dependent variable are the following:

Age of the household head: It is a demographic continuous variable and measured in years. Aged households are believed to be wise and acquired skills in bamboo resource uses hence decide to allocate more land and produce more and supply more than young household heads. Therefore, the expected influence of age is assumed positive. This in line with Ayelech (2011) who indicated the age of household heads are prone to use resources with expected positive effect on market participation and marketable surplus in fruits value chain.

Sex of the household head: This is dummy variable that takes a value of 1 if the household head is male and 0 otherwise. Both men and women participate in highland bamboo (*Yushania alpina*) production. Male households have been observed to have a better tendency than female household in agriculture production and supply of products due to female household face more obstacles on racecourse access and control in certain groups of people. Male households expected supply more bamboo culms than female households. This in agreement with the analysis of Tshiunza *et al*., (2000) who discussed the determinants of market production of cooking banana in Nigeria and assert the male farmers tended to produce more cooking banana for market than female farmers.

Highland bamboo farming experience: This is a continuous variable and refers to the number of years the farmer is engaged in bamboo production activity and the high bamboo producers experience with the production activities like vegetative propagation, flied planting and establishment, maintenance, harvesting, matured culms collection and marketing the resource is expected to influence supply of highland bamboo culms to the market positively. This is in line with Abay (2007) who illustrated as farmer's experience to increase the volume of tomato supplied to the market increased.

Education level of the Household Head: It is a continuous variable and refers to the formal schooling of a respondent during the survey period. Those household heads who had formal education determines the readiness to accept new ideas and innovations, and easy to get supply, demand and price information and this enhances farmers' willingness to produce more and increase volume of sales. Education has a positive effect on honey sale quantity per household per year (Assefa, 2009). Holloway *et al*., (1999) observed that education and visits by an extension agent had significant and positive effect on quantity of milk marketed in Ethiopian highlands. This is because educated households are more informed about sources, utilization and rising of agricultural products, then less constrained than their counter parts.

Family size: This is a continuous variable measured in terms of number of family members in the

household. Families with more household members tend to have more labor which in turn increases bamboo production and then increase bamboo culms market supply. Hence, it is assumed to have positive relation to the dependent variable.

Woredas dummy: This is related to the difference between Woredas in access to information, access to market, bamboo production potential, access to bamboo nurseries, good silvicultural management of bamboo stands and agro ecological zone accessibility. This variable is a dummy taking the value 1 if the Woreda is Loma and 0 if the Woreda is Tocha, which consists of a number of characteristics of the Woredas and the variable influences quantity of highland bamboo culms sales either positively or negatively. In the case of North East India; the prices of bamboo shoots vary significantly within a district of a state and between states (Bhatt *et al*., 2003).

Quantity of highland bamboo culms produced: It is a continuous variable measured in number of culms per hectare. The variable is expected to have positive contribution to the amount of culms supplied to the market. Farmers who produce more output per hectare tend to supply more culms to the market than those with less produce. A marginal increase in bamboo production has obvious and significant effect in motivating market supply. Therefore, this variable is hypothesized to have a positive effect on saleable superfluous.

Distance to nearest all weather roads: It is continuous variable and is measured in kilometers which farmers spend time to sell their bamboo culms to the market. If the farmer is located in a village or distant from the market, he/she is weakly accessible to the market. The closer to the market the lesser would be the transportation cost and time spent. Therefore, it is hypothesized that this variable is negatively related to quantity highland bamboo culms supply to market.

Access to market information: This was a dummy variable expected to influence market supply positively. It assumes a value of one if a farmer got information and zero otherwise. Farmers marketing decisions are based on market price information, and poorly integrated markets may convey inaccurate price information, leading to inefficient product movement.

Price of culms: When price increases, producers are likely to expand production to take advantage of the higher prices and higher profits that they can make. In general, quantity supplied will rise if the price of the good also rises. Price is expected positively related with quantity bamboo culms supply. This is in agreement with Butler (2005) who indicated that price is one of the most important factors that influence supply of products.

Producers' future expectation to bamboo culms price: The decision to produce bamboo culms today depends on expectations of future prices. Bamboo producer seek to sell the good at the highest possible price. This is dummy variable that takes a value 1 if bamboo producer expect the price to increase in the future and 0 if they expect the price to decline in the future. Bamboo producer expect the price to rise in the future, they are inclined to sell less culms now. If they expect the price to decline in the future, they are inclined to sell more culms now.

Silvicultural management of bamboo stands: Less bamboo silvicultural bamboo management and unprotected bamboo stands minimize the fertility of soil hence it affects the productivity of bamboo stands. This variable is measured as a dummy variable taking value of 1 if the best bamboo silvicultural system is the one which satisfies all requirements for maximum productive capacity of bamboo stands i.e. if the bamboo producer is implementing bamboo silvicultural systems such as rising of planting materials, nursery techniques and management, field planting and establishment and plantation maintenance and harvesting on bamboo stand and 0 otherwise. It hypothesized that to affect quantity of bamboo culms supply to market positively.

Land allocated for bamboo plantation: Increase the area of land covered by the bamboo plantation can directly increase the marketable supply of culms. Branson and Norvell (1983) and DNIVA (2005) found that expanding area under crop increased the marketable supply of the crop. Kindie (2007) indicated that area of land allocated for sesame production in Metema District significantly and positively affected farm level marketable supply of sesame. Similarly, Larsen (2006) found that the size of land holdings positively affected the volume of cotton sales at the household level in Tanzania. Therefore this variable is assumed to have a positive relationship with the dependant variable and is measured in hectare.

Access to extension service of bamboo production: A dummy variable taking a value of 1 if *Yushania alpina* producer household has access to bamboo production extension service and 0 otherwise and representing extension services as a source of information on technology. Ayelech (2011) indicated that extension access significantly and positively affect marketed supply of mango. She was suggested that access to get extension service avails information regarding technology which improves production that affects market supply. The objective of the extension service is introducing farmers to improved agricultural inputs and to better methods of production. Therefore, extension services in bamboo culms production is expected to have positive relation with farm level marketable supply of culms.

3. RESULTS AND DISCUSSIONS

3.1. Socio-economic Characteristics of Sample Respondents

Socio-economic characteristics of sample bamboo producers

- Average age of the sample households was 42 years, but minimum and maximum age was 23 and 68 years, respectively. Bamboo producers are found under productive age. This nearly similar to work of Zenebe *et al.* (2014).
- Mean family size of household in study districts was 4 persons. Maximum and minimum family size of households was 10 and 2 years, respectively.
- Average education level of HH was 3 (numbers of schooling (grades)). But education level is a vital factor for skill development and enhancing marketing decisions in agribusiness in general and bamboo business in particular. Formal education determines the readiness to accept new ideas and innovations, and easy to get supply, demand and price information and enhances farmers' willingness to produce more and increase volume of sales.
- Average highland bamboo (*Yushania alpina)* farming experience was 19 years
- Of the total bamboo producer sample respondents, 86.2% was male-headed households and only 13.8% was female-headed in study districts. The motivation behind this was most of rural households are male head and they are access to and control over resources. This observation is in line with Zenebe *et al.* (2014

Socio-economic characteristics of sampled bamboo culms traders

- Average age of bamboo culm trader was 28 years. Average age values of traders are implying involvement in bamboo culms trading is mainly the work of youth. Bamboo culms marketing activities such as assembling, loading and unloading need more physical strength.
- The average family size of trader was 4 persons.
- Mean education level of traders was 8 and average bamboo culms trading experiences was 5 years. Mean education level of trader was higher than the mean education level of bamboo producer and bamboo handicraftsmen. Bamboo marketing participants who had formal education level perhaps readiness to accept new ideas and innovations, easy to get supply, demand and price information and this enhances trader willingness to operate business more and increase their benefits.
- The initial and current working capitals of bamboo culms traders were shown huge variation in five tentative business operating seasons. This indicate bamboo culms trading functions was money making. According to respondents, the minimum and maximum initial working capital of traders before five years was 800 and 5,000 birr. But this after five tentative businesses operating seasons; the minimum and maximum current working capital of traders was 5,000 and 40,000 birr.
- Most of the bamboo culms traders were male (97.1%) and only 2.9% of bamboo culms trader were female. Bamboo culms collection and loading and unloading activities are mainly done by men in study areas. This why female culm traders less experienced and they also belief that bamboo culm trading activities need more physical strength.
- Among sampled bamboo culms traders in study districts, 64.7% were rural collectors and 35.3% were wholesalers.

3.2. Bamboo Culms Marketing Channels

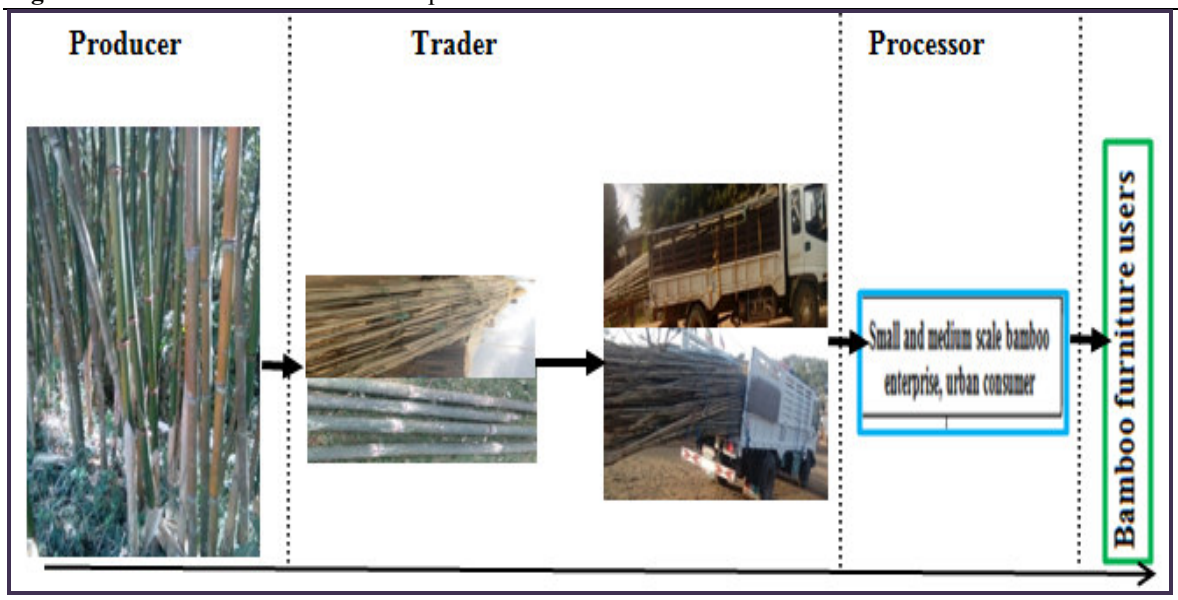
The analysis of marketing channels was intended to provide a systematic knowledge of the flow of goods and services from its origin of production to final destination (ultimate consumers). In both study districts, bamboo culms marketing participants perform almost analogous functions and product flow was also similar. Farm gates transactions were carrying out at to nearest roadsides, or local informal markets. The major buyers of harvested bamboo culms were rural consumers, bamboo traders, bamboo handicraftsmen, small and medium scale bamboo culm processors and urban consumers.

Bamboo culm is stored temporarily for short period of time at nearby roadsides for sale. During 2014/15 bamboo culm harvesting season, bamboo producers supplied 348,940 culms to different buyers (namely rural collectors, wholesalers, and rural consumers) involved in bamboo market (informal market) at village or district roadsides that nearest to bamboo plantation stands. There were three main bamboo culms marketing channels/flows channels. From three marketing channels, one channel flow is remained within the districts. According to the survey results, 15%, 60%, and 25% of producers' annual sale of bamboo culms was sold to rural consumers, rural collectors and wholesalers respectively.

Table 2: Bamboo culms output supplied to different market channels by farmers (N=109)

Market participants	Bamboo culms sold (No.)	Proportion of culms supplied to traders and rural consumers (%)
Rural consumers	52,341.00	15
Rural collectors	209,364.00	60
Wholesalers	87,235.00	25
Total	348,940.00	100

Figure 3: Flow of bamboo culms from production to final destination

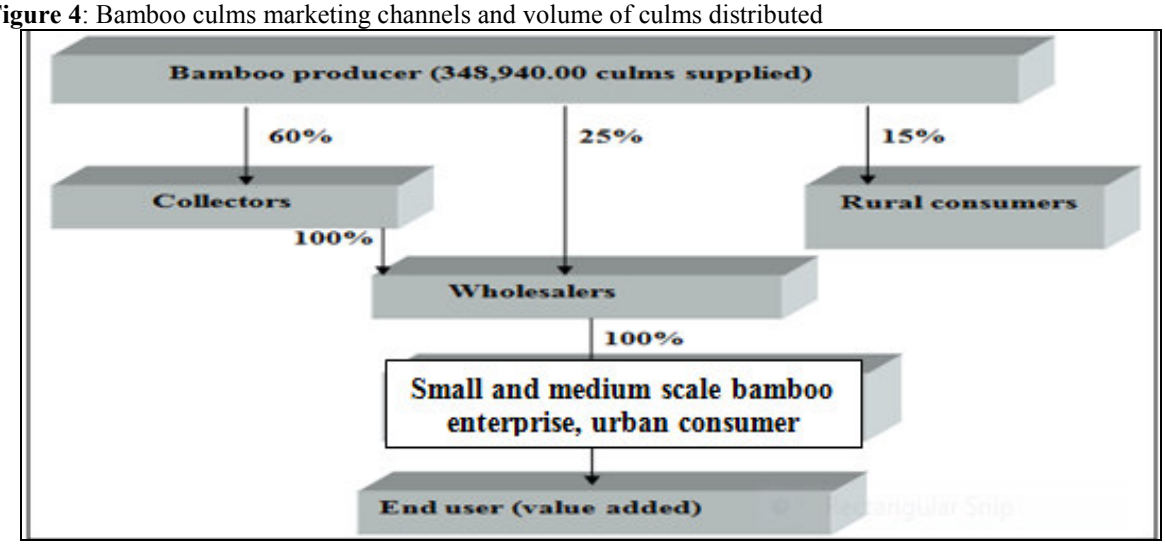


The volume culms that passed through bamboo culms producer → culms collector → culms wholesaler → bamboo medium and small processors/enterprise was very important channel. The three identified bamboo culms marketing channels and volume of flows was mapped as follows (Figure 4)

- **Channel I:** Bamboo producer and harvesters → rural consumers (15%)
- **Channel II**: Bamboo culms producer → culms collector → wholesaler → large and small processors, urban consumers (60%)
- **Channel III:** Bamboo culms producer → wholesaler → large and small processors, and urban consumers (25%)

Regardless of differences in volume of trade, the relationships and structures of the bamboo culms marketing channels originating in the two districts is more or less similar. Figure 11, shown the main receivers from the farmers and successive receivers were exposed below

Figure 4: Bamboo culms marketing channels and volume of culms distributed



Buyers prefer to harvest bamboo culms size, quality and shape. Bigger bamboo culms products fetched higher prices while smaller ones fetched lower prices. But culms prices were fixed by negotiation between

producers and buyers. The average selling price of bamboo culms at producer stage was different at each marketing channels. The average price of bamboo culms at producer level was 4 birr per 11.25m tall. The mean culm thickness is 5.10 diameters in centimeter. The culm thickness/diameter in Tocha district was larger than Loma districts. This is due to bamboo silvicultural management methods and stand density per ha difference between two study districts. This is in agreement with INBAR (2001) that reported the height of *Yushania alpina* culm as 12-20m tall and thickness of 5-13 cm in diameter.

3.3. Determinants of Raw Bamboo Culms Supply

Bamboo culms are produced mainly for market and home consumption. According to the study findings, all the sample households supply bamboo culms to market during the survey period. For the parameter estimates to be efficient, assumptions of Classical Linear Regression (CLR) model should hold true. Hence, multicollinearity and heteroscedasticity detection test were performed using appropriate test statistics. Test for multicollinearity show that, all VIF values are less than 10. This indicates absence of serious multicollinearity problem among independent continuous variables. Contingency coefficient (CC) results were indicated absence of serious multicollinearity problem among the independent dummy variables. After OLS estimation, the existence of heteroscedasticity was detected by White's Test. Because the Prob > chi^2 = 0.0072 or (p-value = 0.0072) i.e. the small p-value (the lowest significance level) that rejects the null of homoskedasticity that there is heteroscedasticity in the explanatory variables. Since there is heteroscedasticity problem in the data set, the parameter estimates of the coefficients of the independent variables cannot be BLUE. Therefore to overcome the problem, finally White's heteroscedasticity-robust adjusted OLS statistics is used. The overall goodness of fit of the regression model is measured by the coefficient of determination (adjusted R^2). It tells what proportion of the variation in the dependent variable, or regressand is explained by the explanatory variable. Adjusted R^2 tends to give an overly optimistic picture of the fit of the regression, particularly when the number of explanatory variables is not very small compared with the number of observations (Gujarati, 2003). Over 95% of the household were correctly predicted out of the 109 household heads. Variable like access to extension services to bamboo production was omitted from model because no statistics are computed because extension services access to bamboo production is constant i.e. all sampled respondents revealed that there was no access to extension services to bamboo production. The econometrics analysis results of determinants of bamboo culms supply to market is given below.

Table 3: Determinants of highland bamboo culms supply to the market

Variables	Coefficient	Robust Std. Err.	t-ratio
Woredas dummy	-6.737	71.064	-0.09
Age of the household head	1.5	3.274	0.45
Sex of the household head	64.65	85.307	0.76
Education level of the Household Head	32.8	22.177	1.48
Quantity of *Yushania alpina* produced	0.454***	0.063	7.18
Family size	26.723	25.798	1.04
Distance to nearest all weather road	-65.756***	24.759	-2.66
Land allocated for bamboo plantation	284.7*	151.564	1.88
Yushania alpina farming experience	9.1*	5.363	1.69
Silvicultural management variation of bamboo stands	280.34***	97.959	2.86
Price of culms	0.112	70.598	0.00
Access to market information	269.5**	111.155	2.42
Bamboo producer expectations to future price	98.6	73.375	1.34
_cons (constant)	85.10	309.26	0.28

Dependent variable = quantity bamboo culms supplied, N=109, Adjusted R-squared = 0.95, ***, ** and * shows the values statistically significant at 1%, 5% and 10% respectively

In Table 3 shows that among the 13 regressors, only 6 variables (namely quantity of *Yushania alpina* produced, distance to access to all weather road, silvicultural management variation of bamboo stands, access to market information, land allocated for bamboo plantation, and *Yushania alpina* farming experience) were found to be significantly affecting the household marketable supply of bamboo culms at household level and this results were discussed as follows.

Quantity of *Yushania alpina* produced: The variable was significant at 1%, significant levels and has a positive coefficient implying that an increase in quantity of bamboo culms produced increase marketable supply of farmers. It indicates that households who produce more quantity of culms had also supplied more to the market. Regression coefficient of the variable tells us that with the influence of other variables held constant, as bamboo production increases by two units, *Yushania alpina* culms supply to market increase by 1 culms. This

is in agreement with Abrahama (2013) who reported that quantity produced significantly affected potato, cabbage and tomato quantity supplied to the market at 1% significance level and Ayelech (2011) who described that avocado quantity produced was significantly affected avocado quantity supplied at 1% level.

Distance to nearest all weather roads: It affects *Yushania alpina* culms market supply negatively and significantly at 1% significance level as expected. The result shows that as the distance from the nearest market increase by 1 kilometer the quantity of *Yushania alpina* culms supplied to the market approximately decreased by 66 culms. This may be due to the fact that as the distance to the market center increases transportation cost increases; since bamboo culms are bulky products. Again Ayelech (2011) who indicated that distance to market caused market surplus of avocado to decline in Gomma district and again distance to the market showed a significant and negative correlation with degree of commercialization in Awi, Sidama and Sheka (Tefera *et.al*, 2013).

Land allocated for bamboo plantation: This variable was significant at 10% significance level. The positive coefficient for land allocated to bamboo production implies that an increase in land allocated to bamboo production increases marketable supply of culms. Keeping other factors constant, increase in bamboo production area by 0.1 of hectare resulted in an increase in farm level marketable supply of culms by 285. In line with this result, Bosena (2008) indicated that the area of land allocated for cotton production in Metema district significantly and positively affected farm level marketable supply of cotton.

***Yushania alpina* farming experience:** It affects bamboo culms market supply positively and significantly at less than 10% significance level. The result suggests that as farmers have high bamboo culms production experience the amount of bamboo culms supplied to the market increased as expected. Thus, the result implied that, as farmer's experience increased by a year, bamboo culms supplied to market increased by 9 culms. This result is also consistent with other results which show significant effect of experience on avocado production (Ayelech, 2011).

Silvicultural management of bamboo stands: This variable was the strongest explanatory variable of bamboo culms supply in districts. As hypothesized, this variable affects the quantity of *Yushania alpina* culms supplied to market positively. It affects marketed supply of bamboo culms significantly at 1% significance level. On average, if bamboo producers implement different bamboo silvicultural management on bamboo stands such as raising of planting materials, nursery techniques and management, field planting and establishment and plantation maintenance and harvesting correctly, the amount of bamboo culms supplied to the market increases by 280 in culms. This result is also in line with the findings of Tefera *et.al* (2013) which states that bamboo silvicultural management types are significantly correlated with the degree of commercialization in Awi, Sidama and Sheka. Most of the bamboo producers in the study areas have not been appropriately applying bamboo silvicultural management activities. Among those, bamboo plantation maintenance, appropriate culms harvesting techniques and bamboo stand guarding from grazing animals are not well practiced and hence hindering the productivity of bamboo stands.

Access to market information: This variable influences market supply positively as expected. It affects market supply of bamboo culms significantly at 5% significance level. On average, if bamboo producer gets market information, the amount of bamboo culms supplied to the market increases by 270 culms. The implication is that obtaining market information helps to supply more quantity of culms. Most of studies in agriculture suggest that access to market information reduces farmers risk aversion behavior of getting a market and decreases marketing costs of farmers that affects the marketable surplus. It is also in line with the suggestions that farmers marketing decisions are based on market price information, and poorly integrated markets may convey inaccurate price information, leading to inefficient product movement (Jari and Fraser, 2009).

On the other hand, the remaining seven variables namely price of culms, family size, woredas dummy, bamboo producer expectations to future price, age of the household head, sex of the household head and education level of the household head were not significantly influencing the quantity of bamboo culms supply in the study areas as they expected.

CONCLUSION

This study shows that variation in socio-economic profile of highland bamboo marketing participant is one of challenges that influencing highland bamboo value chain actors' performance. The study result shows that there are three main bamboo culms marketing channels/flows channels. But large quantity of culms passed through bamboo culms producer → culms collector → culms wholesaler →bamboo medium and small processors channel. From the econometrics analysis shows explanatory variables like quantity of *Yushania alpina* produced, distance to nearest all weather road, silvicultural management of bamboo stands, access to market information, land allocated for bamboo plantation and *Yushania alpina* farming experience had significance influence on household level marketable supply of bamboo culms to market. Of these variables, quantity of *Yushania alpina* produced, distance to nearest all weather road, silvicultural management of bamboo stands were the strongest

explanatory factor that have been influencing of bamboo culms supply to market.

RECOMMENDATION

To gain the large economic benefit from the recent huge bamboo products demand in national and local bamboo markets, domestic supply of bamboo culms should increase through enhancing the extent of bamboo production from small scale to large scale or upgrading bamboo production functions. The horizontal and vertical linkages of bamboo value chain actors and the internal and external bamboo value chain governance should be developed in bamboo producing areas like "Dawuro" to exploit their untapped potential from bamboo subsector fully and effectively to propel their economy hence mainly defeating poverty in rural areas. Vehicle accessible roads or infrastructure should be constructed to transport bamboo culms from production areas to reach out markets. Again formal bamboo markets place should be formed by local government. Bringing about meaningful changes in the production and marketing of bamboo resources in the study areas will require a concert effort of all relevant stakeholders. Different non government supportive organizations should be invited to participate in capacity building and technical training activities. The researchers should additional explore on bamboo production, culms harvesting standards and post harvest treatment practices to solve pressing bamboo production and marketing problems, and popularize their findings with appropriate governmental departments and production and marketing units.

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Conflicts of Interest

The authors declare no conflict of interest.

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