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Determinants of Bamboo Deforestation in Benishangul Gumuz Region, Ethiopia

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Abstract
In Benishangul-Gumuz, one of the nine regional states of the Federal Democratic Republic of Ethiopia, bamboo considered as an important cash crop; while serves as immediate source of income. However, currently, despite its importance in sustaining the livelihood of farmers, the depletion of bamboo forest appears to be a serious problem. Previous studies have examined the causes and processes of bamboo deforestation in this particular area. Yet, they are deficient in several respects particularly in prioritizing and substantiating the effects of each variables that determine the deforestation. As a result, little is known regarding factors influencing the magnitude of bamboo deforestation. The present study aimed at estimating the intensity of bamboo deforestation and identifying the deriving factors that contributed for the depletion of the forest. To this end, the study utilized cross-sectional survey to select 384 households, through multistage stratified random sampling and purposive sampling. Also, focus group discussions and key informant interview were employed to gather data from farmers, members cooperatives, employees and experts. Descriptive and econometric analyses were employed to analyze the data. Then, the results of thr has showed, between the years of 2009 and 2013 averagely about 0.014 hectare of bamboo forest was deforested and converted to agricultural land. These implies that if this pattern continues the entire bamboo stock of the region will be lost within a short period of time. Of the fourteen explanatory variables, that included in the Tobit regression model eight were significantly affected the intensity of bamboo deforestation, with predicted probability of 0.158 hectare per annum. Ownership of oxen, shifting cultivation and perception towards the nature of bamboo forest were the three major factors seem to have contributed positively to the intensity of bamboo deforestation; whereas, gender of the heads the households, family size, proximity to bamboo forest, duration in residence and participation in collective forest management action influenced the situation negatively. Policies for restraining the pace of deforestation should be enforced.
Keywords: Bamboo deforestation, Tobit, Benishangul Gumuz region, Ethiopia
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INTRODUCTION

Over the past twenty years, bamboo has been receiveing an increasing attention around the globe, mainly for its economic and environmental values (Chirwa and Meliczek, 2014). It provides considerable economic, social and environmental values (Bowyer et al., 2014); among others, fuel wood, timber and non-timber products, construction materials, medicinal uses and cultural values (Stein *et a*l., 2000). Millions of people live in bamboo houses; for which, a 4500 years old bamboo house was found in Ecuador (Takahashi, 2006). Worldwide, over 600 million people generate income from bamboo[1] in which about 2.5 billion depend on bamboo with an estimated value of 7 billion USD per year (Liese, 1992; FAO, UN and INBAR 2005).

On the other hand, however, in Africa bamboo has a very limited uses (Lipangile, 1998). Furthermore, deforestation and land degradation are still pressing issues; which resulted in contemporary development challenges (*e.g.* climate change) that impede the economic growth and development of agrarian countries and thereby, huge resources and biodiversity losses. Empirical evidences indicated that Asia, America and Africa accounts for 65, 28 and 7 percent of global forest, respectively (FAO, 2009).

Ethiopia was known as the land of lowland bamboo forest with the highest bamboo potential in Africa, comprising 67 percent of the continent's bamboo forest (Demissew *et al*., 2011). Nevertheless, deforestation particularly massive bamboo depletion has been taking place in many parts of the country. For instance, in the 1960s the total area covered with bamboo was estimated around 1.5 million hectares; of these one million hectares were belong to the lowland bamboo while the rest to the highland bamboo. Yet, later in 1997, as the study of global forest resources assessment revealed Ethiopia was only remained with about 0.8 million hectares of bamboo forest. Several international and national authors have also reached at these same conclusion (Luso Consult, 1997; Ensermu *et al.,* 2000; INBAR, 2005). Now adays, the country have possessed approximalty less

[1] Some authors have classified bamboo as a tree while others as a grass. Technically, bamboo is a woody grass belonging to the subfamily of Bambusoideae (INBAR, 2010; Lobovikov et al, 2009). Whereas, duet to its use and appearance bamboo closely related to trees. Moreover, FAO (2012) defined bamboo as a tree. In a similar way, some Ethiopian authors as well as the government documents itsef (i.e., "The forest development, conservation and utilization proclamation No.542/2007") have considered bamboo as a tree (Federal Negarit Gazeta, 2007). Accordingly, these very definition that considered bamboo as tree has been used throughout this study.

than 0.83 million hectras of lowland bamboo (INBAR, 2013). Over half of Ethiopian babmoo forest is found in the Benishangul-Gumuz region[1]. In the region bamboo is considered as a historic economic commodity. Approximately 20,000 rural households are hoped to generate monthly income of 600 birr in the forthcoming GTP-II. However, the overall sizes of the forest have been shrinking down which may gradually lead to the elimination of the lowland bamboo. Studies have shown that several factors have contributed for the depletion of the bamboo forest in the Benishangul-Gumuz region.

By and large, studies have broadly categorized factors that have contributed for the deforestation of lowland bamboo as manmade and natural factors (INBAR, 2011). These includes: population explosion, wildfire, illegal export, firewood collection and charcoal preparation, lack of management and land tenure policy. However, the impact of each factor was not studied well separately in such a way policy makers can make informed decisions. Furthermore, the suggested factors have got inconsistent emphases across studies. For example, the Benishangul-Gumuz Region Food Security Strategy (BGRFSS, 2004) report has identified state sponsored resettlement program (during Dergue regime), encroaching highland neighbors, spontaneous migration, wildfire and absence of land tenure policy as the main factors of deforestation. Although, studies conducted by INBAR (2005; 2010; 2011 etc.) have indicated fuel and firewood production as the main causes of bamboo forest degradation. Thus, considering the complex and multivariate variables of lowland bamboo deforestation, it is imperative to empirically scrutinize and identify the major causes of deforestation. Accordingly, the study at hand purses to estimate the magnitude of the deforestation and to identify the deriving factors that contributed much for the deforestation of bamboo forests in Benishangul-Gumuz region.

METHODOLOGY

Study Area

The Benishangul-Gumuz National Regional State (BGNRS) was established as one of the nine regional states by the constitution of the Federal Democratic Republic of Ethiopia (1994). Heretofore, the southern part of the region belonged to the Wollega province while the areas above the Abay (Nile) River belong to the province of Gojjam. The region is located in the western part of the country between 09.17^0 - 12.06^0 North latitude and 34.10^0-37.04^0 East longitude. It shares boundaries with Sudan and South Sudan in the West, with the Amhara region in the North and Northeast and with the Oromiya region in Southeast and South. Asossa is the capital of the State located at the distance of 687 km from Addis Ababa.

The region has a total area of approximately 50,380 km^2 with altitude ranging from 580 to 2,731 meters above sea level. Administratively the region divided into 3 zones (provinces) and 21 to districts (commonly known as *woreds*). Based on projected data, the current total population of the region is about 9975,988 (CSA, 2013). Population density is sparse with a regional average of 14 people per square kilometer. The smallest population density is estimated at 3 persons per square kilometer in Guba, Yaso, Dangur and Sirba Abay districts; while the largest density is about 62 people per square kilometers in districts like Assosa, Mandura, Bambasi and Pawi (CSA, 2007). As a result, agricultural land is abundant in the region with the mean land holding size 3.7 hectare. The average number of family members per household is 6.7. The vast majority (92.2%) of the total population of the region lives in the rural areas (BGRFSS, 2004).

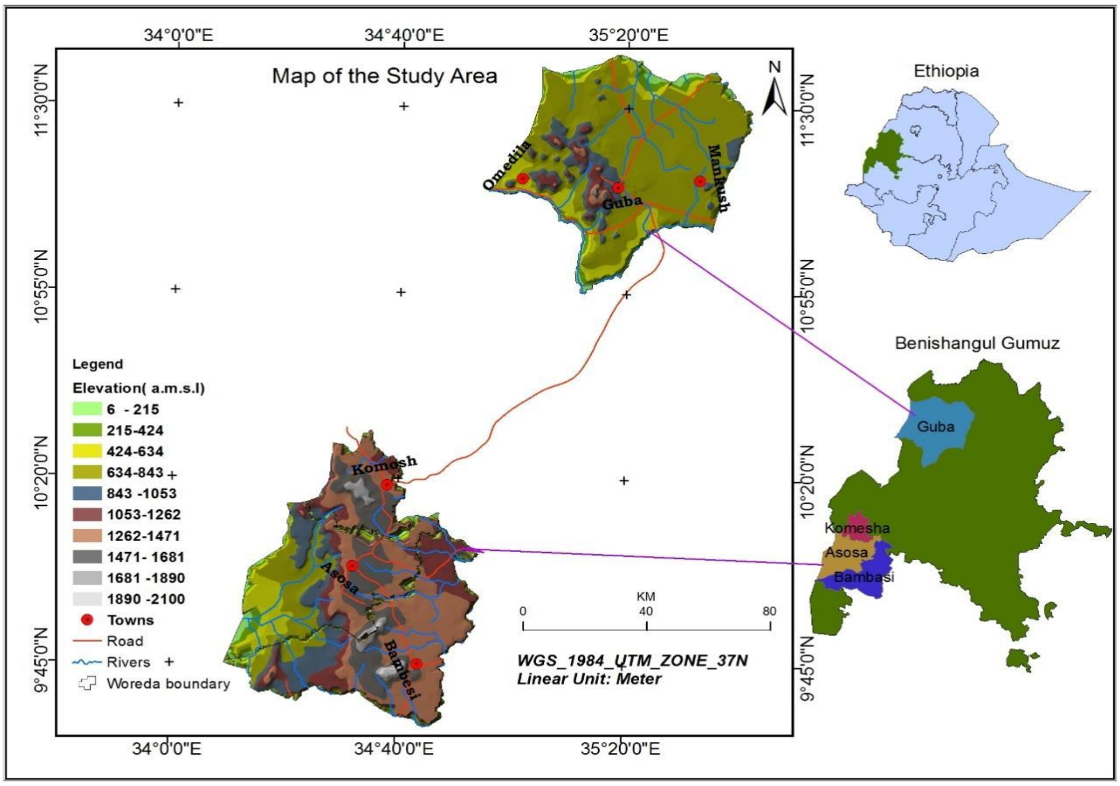
In general the region is characterized by ethnic and religious diversities. Among the "five indigenous[2]" ethnic groups of the region Berta (26.7 percent) and Gumuz (23.4 percent) are the majority followed by Shinasha (7.0 percent), Mao (0.6 percent) and Komo (0.2 percent). Amhara and Oromo are the largest non-indigenous ethnic groups respectively accounted for 22.2 and 12.8 percent of the population. Relative religious distribution is also found in Benishangul-Gumuz; in which Muslims (44.1 %) are the majority followed by the Orthodox (34.8 %), traditional religions (13.1%), Protestants (5.8) and others (2%).

Agro-ecologically, the region is categorized into *Midland* (i.e., lowlands below 1500 meters above sea level), *Woina Dega* (midland between 1,500-2,500 meters above sea level) and *Dega* (highland above 2,500 meters above sea level) and correspondingly accounted for 75%, 24% and 1% of the region. According to the National Meteorological Service Agency of Ethiopia, the region is characterized by a mono-modal rainfall, with a wet season from April to October. The annual rainfall varies from 800 to 2000 mm. The temperature reaches a daily maximum of 20^0C to 25^0C during the rainy season and rises up to 35^0C to 40^0C in the dry season. The minimum daily temperatures ranged from 12^0C to 20^0C, depending on the season and altitude. The hottest period of the region is from February to April.

[1] In Benishangul-Gumuz region, natural bamboo plants are mixed with other trees in poly culture natural forests. There are also few instances where bamboos plantations are found in monoculture forests. Due to its wider coverage, the study at hand has given more emphasis to the natural bamboo forest, commonly mixed with other species of tree.

[2] Indigenous ethnic groups refer to the five ethnic groups of the region: i.e., Berta, Gumuz, Shinasha, Mao and Komo peoples. According to the Ethiopian 1994 new constitutions, the responsibility to manage the region was given to these ethnic groups.

Figure 1: Administrative Map of the Benishangul-Gumuz region



In terms of land - use patterns, the region's landmass is predominantly dominated by bushes and shrubs (77.4%); while the remaining land consisted of forest (11.4%), cultivation (5.3%), grazing (3.2%) and marginal land (2.3%). The region is classified into eight vegetation zones, namely: dense forest, riverine forest, broad-leaved deciduous wood lands, acacia woodland, bush land, shrub lands, boswellia wood land and bamboo thickets (INBAR, 2010). Subsequently, about 0.2 hectare (89 %) of the total land of the region is covered with vegetation. As to the bamboo forest, in the region the lowland bamboo grows between 1000 and 1800 meters above sea level and on poor soil in dry vegetation formation (LUSO Consult, 1997). The bamboo also tolerates poor rocky soil with erratic annual rainfall (down to 600 mm) and high temperature (above 35 ℃). The lowland bamboo grows between 700 and 1800 meters above sea level as the highland bamboo is grows between 2200 and 3500 meters (Liese, 1985).

Sampling Design

The study employed (multistage) stratified and purposive sampling techniques to select 384 households. It is stratified in the sense that it includes only districts (*woredas*) and *kebeles* (the lowest administrative unit of the country). Once the districts and *kebeles* are determined by stratification; possible households were randomly chosen.

There are 21 administrative districts in the Benishangul-Gumuz National Regional State. Based on the availability of bamboo forest all the 21 districts were categorized into two groups: districts with bamboo forest (13) and those without bamboo (8). In line with the purpose of the study, the 13 districts that identified with bamboo resources were entirely taken as the research target of the study. The districts were further subdivided pertaining to the bamboo species found in their respective areas into two: districts with lowland bamboo species (11) and districts with highland bamboo species (2). In accordance with the study of INBAR (2010) which corroborated with the filed observation the lowland bamboo is found in 11 districts: Assosa, Bambasi, Homosha, Dibate, Bulen, Dangur, Mandura, Guba, Kamashi, Pawe and Sherkole; while, the highland bamboo in Balo Jiganfoy and Kurmuk districts.

Moreover, based on their agro ecology the 11 districts that identified with the lowland bamboo forest were again classified into two: lowland and midland. The rationale for stratifying districts according to their agro-ecology is due to the differences in terms of bamboo resource endowments owing to human and natural factors. Accordingly, out of the 11 districts five (namely, Assosa, Bambasi, Dibate, Bulen and the most parts of Dangur) were categorized under the lowland (*woynadega*) agro-ecology; as the rest 6 (i.e., Sherkole, Homosha, Kamashi, Guba, Mandura and Pawe) under the midland. Then after, a total of four districts (two from each) stratified agro-ecological districts, were chosen randomly; i.e., Assosa and Bambasi from the lowland and Homosha and Guba from the midland.

Consequently, the lowest administrative units, i.e., the *kebeles*, were selected purposively from the above mentioned four districts. At first, *kebeles* were divided as those with and without bamboos. Of them, 11 *kebeles* endowed with bamboo forests were purposively chosen from the determined four districts. Of these, six *kebeles* were selected from the two lowland bamboo districts: Assosa (i.e., Afasisim, Yambasisim and Amba-14) and Bamabasi (i.e., Amba-46, Amba-47 and Amba-48); while the remaining 5 *kebeles* are from midland bamboo districts of Homosha (namely, Tumet, Dunga and Angela) and Guba (namely, Ayicid and Beshat). In the process of choosing the *kebeles*, besides the availability of bamboo forests, other criteria were also determined; in orer to ccomodate the opinions of experts, officials of NGOs and regional beraues. Thus, in the selection of 6 *kebeles* from Assosa and Bambasi districts the fact that they possessed higher bamboo forest with higher population pressure and deforestation was underpinned. Also, in the case of the five *kebeles* of Homosha and Guba districts the common practice of smuggling that resulted with the higher rate of bamboo depletion was taken in to account. As these *kebeles* shared boundaries with Sudan and South Sudan illegal bamboo export is a very common practice. Thus, a total of eleven *kebeles* were purposively selected out of the stratified four districts. Finally, from the 11 *kebeles* 384 households were selected based on the population proportionate to the sample size.

Types and Sources of Data

The study used both primary and secondary sources of data obtained by structured interview, focus group discussions and key informant interview. Structured interview/questionnaire was utilized to collect data from 384 sampled households through face to face interview.

Focus group discussion (FGD) was employed to gather data from local farmers, members of forest management cooperatives (organized by FARM-Africa), employees of Bamboo Star Agro-forestry factory and experts of district natural resource offices. A total of 16 group discussions were conducted; in which 11 were made with local farmers (of those previously chosen from 11 *kebeles*), four with the natural resource experts representing the formerly selected four districts and the remaining FGD was carried out with employees of the bamboo factory. On average each FGD consisted of 8-12 members.

Key informant interview was used to collect data from the participants of International Network for Bamboo and Rattan (INBAR) selected from Addis Ababa and Assosa regional offices, experts from the regional and zonal offices of Benishangul-Gumuz as well as advisors to the regional government (includes the president's economic and legal advisor).

Analytical Framework

The annual bamboo forest area cleared per household within the period of five-years (i.e., 2007/8-2012/13) was considered as the dependent variable in this study. The time period was chosen as a reference point because during these years Ethiopia has brought substantial and sustainable economic growth (MOFED, 2010); which might have facilitated deforestation. Moreover, the period was reasonably short and historically remarkable among Ethiopians due to the 2010 national election. Hence, these may help the target householders to easily remind the size of their land during this particular period of time.

The present study assumed that over the time there is a significant and random variation of land size among household; as land for agricultural purpose has been acquired through landownership (i.e., purchase, inheritance, gift and illegal forest clearing) or by sharecropping. Therefore, the difference between the size of the household farm plot measured before 2009 and in 2013 was used as the proxy measurement. Since agricultural land expansion accounted for about 80% of worldwide deforestation (Kissinger *et al.,* 2012); the present study has also used change in farm plot size to estimate the annual average bamboo deforestation. Accordingly, the Tobit regression model was employed to measure the stochastic relationship between the rate of forest degradation and the expected determinants. As noted in the Tobit analysis, the regress can assume a value of zero due to the reason that some farmers may not actually deforest any forestland. The stochastic model underlying Tobit analysis is displayed as follows.

$$y_i^* = X_i \beta + \mu_i = 1, 2, 3, .., n \quad (1)$$

$$y_i = \begin{cases} 1 & if\ y_i^* => 0 \\ 0 & if\ y_i^* \le 0 \end{cases} \quad (2)$$

As illustrated in the above formula, *n* is the number of observations, μ_i is assumed to be independent and normally distributed with *N* (0, δ^2) and β is a vector of unknown coefficient parameters to be estimated, y_i is annual forest area cleared in hectares as a proxy for rate of bamboo deforestation, y_i^* is unobservable latent variable and X_i is vector of explanatory variables.

Many prior studies have tried to explain deforestation using an econometric model. In few cases (such as Angelsen and Kaimowitz, 1998; Scrieciu, 2001), farm household economic modeling was applied to explain and to establish the relationship between deforestation and factors affecting the rate of deforestation. Yet, most studies have utilized the Tobit regression model (Oyekale and Adeleke, 2012; Dolisca, 2005; Faris, 1999). Basically, the model depends on the nature of the dependent variable, in other words, the truncated nature of the dependent variable (i.e., the bamboo deforestation) that can be attained by the Tobit regression model. Tobit model was also used largely when the dependent variable is observed to be zero for some individuals in the sample while having continuous values for others. Accordingly, for instance, using cross-sectional data, Oyekale and Adeleke (2012) have applied methods of Tobit regression model to predict the rate of deforestation with socio-economic and institutional variables in the Delta region of Nigeria. Correspondingly, employing cross-sectional data obtained from the randomly sampled 243 households, Dolisca (2005) applied the Tobit regression analysis to determine the link between deforestation and socioeconomic variables. By and large, using Tobit regression model various previous studies have estimated the socioeconomic, demographic and institutional variables assumed to influence bamboo deforestation.

In consequence, the study at hand has used Tobit regression model as the analytical framework to identify the magnitude of bamboo deforestation and the deriving factors that contributed for. In this study, the dependent variable is measured as bamboo forest area cleared per households per annum within five-year of periods (2007/8-2012/13) to estimate the intensity of bamboo deforestation, in the Benishangul-Gumuz regional state of Ethiopia.

Table 1: The Definition and Measurements of Explanatory Variables

Variables	Definition and Measurements	Expected Sign
Sex of a household head	Gender of the household head (dummy)	-
Educational status	Age of the household head (years)	+
Household Size	The total number of family a household has in terms of AE.	+
Educational status	1 if households head literate ; otherwise,0	-
Ethicality	1 if households head is Beta; 0, otherwise.	+
Access to credit	1 if the household head obtained credit, 0 otherwise (dummy)	-
Total income	Households' annual income per capita (ETB)	-/+
Land holding	Land ownership (dummy)	+
Off-farm income	Total income from non-agriculture activities (continuous)	-
Wealth	Welfare index (1 if the HH is poor otherwise 0)	+/-
Livestock	Total number of livestock holding HH own in terms of TLU	+
Bamboo income	HH attitude towards establishment of bamboo PLC (dummy)	+/-
Benefit	Perceived forest benefits by HH head (Ranked on scale)	+
PRICEBAM	The value of a bamboo stand sold at the local market	-/+
Distance	The numbers of hours walk to get /harvest bamboo	-
shifting cultivation	Practice shifting cultivation by HH head (dummy)	-
Wild fire	Perceived adverse impact forest fire (dummy)	-
Settlement	1 if the HH head is inhabitant ; 0 otherwise	-
Property right	1 if secured bamboo use right, otherwise 0	+/-
Heterogeneity	Perceived that income heterogeneity is important (dummy)	+/-
Group size	Perceived that large group is advantageous (continuous)	-
Trust	The overall trust index ranked on scale 1 to 4	+
Network	Relation of bamboo users, ranked on scale 1 to 4	+
Conflict	Dummy variable, bamboo resource conflict (dummy)	-
External support	Presence of NGOs 1, 0 otherwise	+

RESULTS

Household Characteristics

Descriptive statistics were computed to analyze the demographic and socio-economic characteristics of the households. As the results of the descriptive analyses revealed, three-fourths (293, 76.3%) of the households were male–headed; while female-headed households comprised 23.7% (91) of the total sample of 384 households. The age range of the respondents was between 16 and 83 years; with the mean age 42.21. Regarding their educational back ground, about half (49.74 percent) of the respondents were illiterate, as 30.47 percent had completed their primary school and 19.8 percent of them had attended elementary school. Observed from the analysis the literacy level of the communities was significantly low; which could be related with their occupation, particularly farming.

The vast majority (95.31%) of the respondents were engaged in crop and livestock productions; whereas the remaining few (4.69%) depended on petty trading, traditional gold mining and trophy hunting. Pertaining to the marital status, the highest majority of the respondents (86.2 percent) were married; while the rest of them reported single (5.47 percent), widow (4.43 percent), divorced (2.8 percent) and separated (1.04 percent). Household size was ranged from 1 to 22 children with average of 6.07 people. Significant difference was found between male-headed and female-headed households regarding the family size; in which male-headed households had 6.36 family members and the female-headed had 5.09.

Agro-ecologically, more than half (58.33 percent) of the total respondents were found to live in the *Midland* area; as 41.67 percent of them in *Woynadega*. In terms of settlement conditions, nearly two-thirds (244, 63.54%) of the respondents were migrants (settlers) from the various regions of Ethiopia and only over one third (140, 36.46%) of the population were natives (mainly the Berta community).

Determinates of Bamboo Deforestation

The Tobit regression model was used to identifying factors that affect the bamboo deforestation of the Benishangul-Gumuz region. The results of the Tobit regression analysis is presented in Table 2. Prior to model estimation, the nature and distribution of error term for the dependent variable was tested. The standardized normal probability plots for the error term (which capture random influences on the relationship) were found to be linear, indicating constant and normally distributed residual. The result implies that the model pass the test for homoscedastic variance, which used as one of the caveat assumptions in cross-sectional survey study. Moreover, test for multicollinearity using VIF has showed no problem with multicollinearity.

In general, for this study, fourteen explanatory variables that correlated with the dependent variable were included in the Tobit model. Of the fourteen, eight explanatory variables have significantly affected the intensity of bamboo deforestation, with predicted probability of 0.158 hectare per year. These suggested that approximately a household deforest about 23.58 percent of his total land size between 2009 and 2013 years, ceteris paribus. What follows is a description of the eight explanatory variables: access to oxen, experiences in shifting cultivation, perceived bamboo deforestation, sex of a household head, household size, proximity to bamboo, duration in residence and collective action.

Access to Oxen:

A statistically significant and positive coefficient (put the actual statistical figure here) of access to oxen implies that owning of oxen exacerbated bamboo deforestation. These may possibly explained that usually households who owned oxen required a larger piece of land to cultivate as compared to traditional hoe based farmers. In other words, accesses to oxen increases the probability of cultivating more farm land; which in turn facilitated the chance of clearing forest. Furthermore, oxen plowed lands are often cultivated three times that leads to the complete uproot of the bamboo forest. The regeneration of the uprooted bamboos may take longer time. Again, the negative consequences of oxen to bamboo deforestation could be explained by its implications for livestock holding; since households who owned oxen have more herds to directly affect the bamboo forest.

These corroborates with the findings of previous studies particularly conducted in the Brazilian Amazon area that discussed the removal of forest for cattle as the leading cause of deforestation (Fearnside, 2005). Also, a study carried out by FAO (2010) in Central and South America has showed that the expansion of pastures for livestock production was one of the driving forces that contributed for the distractions of forests. Besides, participants of the FGD and the researchers' personal observations during the filed visit has confirmed the presence of same situation in the region; that farmers owned oxen and donkey are relatively richer and tend to clear more bamboos than others. Therefore, the study findings asserted that having oxen aggravated bamboo deforestation; while considering the existence of farmers who cultivated non forest areas in to account.

Table 2: Determinates of Bamboo Deforestation

Variables	Coefficients	Standard error
Gender of a household head	-0.190*	0.059
Educational status	-0.032	0.052
Access to ox	0.110*	0.059
Proximity to bamboo	-0.010*	0.006
Duration in residence	-0.105**	0.053
Household size	-0.004*	0.002
Off-farm income	0.027	0.021
Poverty status	-0.117	0.088
Experiences in shifting cultivation	0.167***	0.039
Perceived bamboo deforestation	0.016*	0.009
Collective action	-0.032*	0.017
Property rights	-0.125	0.089
Knowledge on resource condition	0.093	0.061
Dependence on bamboo	0.115	0.109
Constant	0.119	0.307
Sigma	0.462	0.018

Source: model output

Experiences in Shifting Cultivation:
Shifting cultivation was identified as one of the principal causes of bamboo deforestation in the Benishangul-Gumuz region. The relationship between shifting cultivation and bamboo deforestation was found to be significant 1 percent. This implies that households who practiced shifting cultivation may clear more bamboo than others; in line with the aforementioned hypothesis. In areas covered by this study, small-scale slash-and-burn farmers often cleared bamboo forest for growing crops. Whereby, eventually they caused forest degradation and other related environmental problems. That is, a unit change in the amount land retained due to shifting cultivation by households would increase the intensity of deforestation by 16.7 percent. The negative correlation result found in this study between shifting cultivation and deforestation was in consistent with several previous studies conducted in Asia, Africa and America (Brown and Schreckenberg, 1998; Brunner *et al.*, 1999; Rahman *et al.*, 2011; Seidenberg *et al.* 2003; Ickowitz, 2006).

Perceived Bamboo Deforestation:
Knowledge regarding the benefit of bamboo forest to the local livelihoods and income is critical to the cooperative action and served as incentives for successful local forest management. Households who have adequate knowledge about bamboo forest can easily cooperated and contributed their share in managing the bamboo resources; and thereby, reduced the deforestation. The results of this study have indicated that the perceptions of the heads of the households pertaining whether the surrounding natural bamboo forest were belongs to the common-pool resources has influenced the bamboo deforestation at 10 percent significance level. Accordingly, the heads of the households who perceived the natural bamboo forests as a common-pool resources were conserved more bamboo than those who considered as a state or private property.

Gender of a Household Heads:
The relationship between the sex of the heads of households and bamboo deforestation was negative with 10 percent level of significance; which is in consistent with priori hypothesis. This indicates that male-headed farmers cleared more forest as compared to their female counterparts. Naturally, unlike females, male-heads of households play many roles and livelihood activities that lead them more to bamboo deforestation. Such livelihood activities that males may take in part includes harvesting of bamboo culm for firewood, expanding farm land, collecting bamboo for construction and so on. Therefore, keeping all other variables constant, the marginal effect result shows that male headed households were increased the intensity of bamboo deforestation by 10.9 percent. A study that explored the causes of deforestation in Sumatera (Indonesia) has also reported similar findings (Suyanto and Ostuka, 2001).

Household Size:
The family size of households determines per capita collection and utilization of bamboo culm; and therefore, adversely influences bamboo forest. From the analysis of Tobit regression model, household size appears to have a positive effect on bamboo deforestation; which implies that a unit increases in the size of household increases the intensity of bamboo deforestation by 0.4 percent. However, in contrast to the previous literatures (e.g., Boserup 1965; Godoy et al., 1998) that suggest large size of household is not threat to deforestation, as they

carried out intensive agriculture using agricultural technologies; in the current study, households with fewer family members are found more likely to clear lesser bamboo forestland and the vice versa. In other words, the result of the study has indicated that households with more members are more likely to clear forests for cultivation; while endangering the bamboo forest. Yet, these corroborates with the findings of Mitnje *et al.* (2007) argued that household size significantly contributes to the degradation of forest resource in the case of in Miombo woodlands of Kenya. Likewise, Dolisca (2005) confirms that households with fewer members were more likely to clear less forestland than the larger family.

Proximity to Bamboo:
The distance found between the respondents' home and the natural bamboo area has a a negative regression coefficient at 5 percent level of significance. This implies that a unit increases in distance from the area of bamboo forest decreases the likelihood of bamboo deforestation. Because, as the distance from the bamboo forest increases; it limits the access and use of the bamboo for the local communities, due to its cost implication. In line with the findings of this study, a previous study conducted in Tanzania on Bereku forest reserve has showed positive correlation between distance from homestead and woodland degradation (Giliba *et al.,* 2011). Again, a cross-sectional analysis on a highly heterogeneous forest community groups in Nepal has evidenced inexorable negative association between proximity to the forest and forest degradation (Sapkota and Oden, 2008).

Duration in Residence:
The period of time households lived in a particular place or residence is associated with lesser bamboo forest deforestation at 10 percent level of significance. The negative and highly significant coefficient (put the actual statistical figure here) for this variable shows that the longer households stayed in the particular village, the lesser likely of the bamboo forest clearance. This may be due to the reason that household farmers who lived for a longer period of time may have more secured their rights to the natural bamboo forest than those who lived shorter. Furthermore, farmers who lived longer tend to keep bamboo for their children for future use; wherefore, from their experiences they are aware of the effects of deforestation. The fact that most of the respondents of this study were stayed in their respective villages for a while they have adequate knowledge and trends of bamboo deforestation in their localities. Consequently, they accumulated experiences along with indigenous knowledge on the causes and effects of bamboo deforestation; which in turn, equipped them to propose appropriate remedial measures for problems. Evident from the focus group discussions peoples who have stayed longer in a certain area (mainly indigenous elders) were found to provide historical causes and consequences of bamboo deforestation in their villages. Nduwamungu (2001) and Kajembe (1994) have observed similar result which shows that people who have stayed longer in an area are likely to provide a relatively reliable historical data on forest cover.

Collective Action:
Bamboo deforestation is significantly and negatively influenced by collective action at 10 percent level of significance. The negative coefficient value has indicated the inverse relationship between collective action and bamboo deforestation; which denotes that farmers who participate in collective bamboo forest management are less likely to deforest bamboo compared to none participants. This is mainly because of the fact that various types of trainings were provided to households participated in collective action by NGOs (such as INBAR and FARM Africa) and local authorities that might have effect a change in a way to manage and properly utilize the bamboo forest. In this study, the marginal value showed that household head participation in collective action decreases the intensity of bamboo deforestation by 3.3 percent, ceteris paribus. This result is consistent with the findings of Berhanu *et al.* (2000) who suggested that collective action as an effective means of redressing resource degradation.

Table 3: Marginal Effects of Explanatory Variables

Variables	Marginal Effects
Gender of a household head	-0.109*
Educational status	0.031
Access to ox	0.110*
Proximity to bamboo	-0.010*
Duration in residence	-0.105**
Household size	0.004*
Off-farm income	0.027
Poverty status	-0.118
Experience in shifting cultivation	0.167***
Perceived that deforestation is a problem	0.016*
Collective action	-0.033*
Property rights	-0.125
Knowledge on resource condition	-0.105**
Dependence on bamboo	0.115

***, ** and * indicate the level of significance at 1%, 5% and 10%, respectively
Source: Model output

In closing, what is worth to be mentioned here is that contrary to what have observed in the literatures estimation results for certain variables were found not significant in this particular Tobit regression model. Despite their importance variables like educational status, off-farm income, poverty status, property rights, knowledge on resource condition and dependence on bamboo did not significantly affect the pace of bamboo deforestation. Worth noting, wealth inequality is statistically insignificant with negative sign in the model estimation, suggesting that wealth heterogeneity across districts had no significant effect on bamboo deforestation. However, income differences across households are found to have a positive effect on bamboo deforestation.

CONCLUSIONS

The present study was intended to estimate the intensity of bamboo deforestation and to identify factors that contributed for the deforestation in the Benishangul-Gumuz region of Ethiopia. Evident from the findings of the study is that depletion of the bamboo forest appears a serious problem; which may result with the total loss of the lowland bamboo soon. There are many manmade and natural factors that affect the bamboo forest of the region. The study has identified eight explanatory variables that particularly influenced the deforestation of bamboo. Accordingly, the empirical result has showed that livestock ownership (i.e., oxen), shifting cultivation and farmers' knowledge of the bamboo resource conditions as the main causes of bamboo degradation. Besides, the study established that bamboo deforestation is negatively influenced by gender of the heads of households, family size, proximity to bamboo, residence duration in the area and participation in collective forest management action. Policies for regenerating the degraded bamboo forest should be enforced. These calls for a critical thinking in designing viable policy direction.

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Appendix 1: Multicollinearity Test for Variables in Regression Model

Variable	VIF	1/VIF
Off-farm income	1.78	0.561853
Poverty staus	1.63	0.611862
Perceived bamboo deforestation	1.61	0.622473
Owning oxen	1.53	0.651907
Duration in a resident	1.19	0.840990
Experience in shifting cultivation	1.16	0.862244
Educational status	1.16	0.862244
Knowledge on resource condition	1.15	0.869172
Participation in collect action	1.12	0.893189
Sex of the head	1.10	0.906967
Dependence on bamboo	1.09	0.920568
Household size	1,o8	0.926329
Property right	1.07	0.934110
Distace	1.07	0.934110
Mean VIF	1.27	