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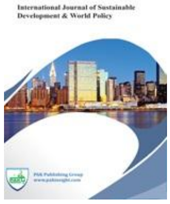

# LAND USE/LAND COVER CHANGE AND ITS EFFECTS ON BAMBOO FOREST IN BENISHANGUL GUMUZ REGION, ETHIOPIA

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## ABSTRACT

*Bamboo deforestation has become a serious problem in Ethiopia threatening the bamboo biodiversity and the people who depend on bamboo income. Previous studies mostly emphasize on mechanical, physical and biological characterization of the lowland bamboo. Earlier studies rarely relay on measuring the trend and magnitude of bamboo deforestation. The purpose of this study is, therefore, to examine the rate and magnitude of bamboo deforestation and identify the driving factors of LU/LC change. Data for the study were obtained from geographic information system (GIS) with ground verification. To supplement the GIS and normalized difference vegetation index (NDVI) result, a random sample of 384 households was interviewed. In addition, key informants interview and focus group discussions were held to validate the required data.* The *result generally revealed the declining state of bamboo forest over the past 26 years. The 2006 year's NDVI value shows that a household owned 3.846 hectares of forest land. The result indicated a decline in forest to 2.027 hectare in 2012. The result showed 52.704 percent decline in forest land cover. Moreover, the survey result indicated that from 2009-2013, about a 0.014 hectares of bamboo forest was converted to agricultural land. On average, a household has converted an average of 0.081 hectares of forestland into agriculture land. Our evidence also shows that the lowland bamboo forest cover in the region has devastated due to anthropogenic and natural factors. This result implies that if the same trend continues, the available bamboo stock will vanish in shorter period of time. Therefore, quick rehabilitation and mass bamboo restocking policy shall be designed by the regional government in order to regenerate and conserve the lowland bamboo resources.*



**Keywords:** Land cover changes, Bamboo deforestation, GIS, Ethiopia.

## Contribution/ Originality

This study has used appropriate research methodology and hopped to contribute to the bamboo based existing literature.



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## 1. INTRODUCTION

Although no reliable information on the extent of the past deforestation, historical sources indicated that about 42 million hectare or the equivalent to some 35 percent of Ethiopia's total land area was covered with forests (Ensermu *et al.*, 2000). Their estimate further pointed that in the early 1950; about 19 million hectare or 15 percent of forest had only remained. In the early 1980, the forest coverage was reported at 3.6 percent, and in 1989 it only remained to be 2.7 percent (Bishaw, 2001). Literature indicates that in the late nineteenth century, about 30 percent of Ethiopia was covered with forest. According to Melaku (2008) forest coverage is only 3.56 percent and still decreasing. Currently, of the total land area, only four percent is covered with forests with an estimated deforestation rate of 140,000 hectare per year (Million, 2011). According to FAO (2011) estimate, between 1990 and 2010 Ethiopia lost an average of forest 140, 000 hectare annually. In total, in this period the country had lost 18.6 percent of its forest cover or around 2, 818, 000 hectare. The total forest cover loss from 1990 to 2015 is predicted to be in the range of 803, 000 hectare (WBISPP (Woody Biomass Inventory and Strategic Planning Project), 2004). This study reveals that there is tremendous decline in the forest resources of the country.

Ethiopia took the first place in bamboo potential in Africa comprising about 67 percent of the continent's bamboo forest area (Demissew *et al.*, 2011). However, deforestation nowadays is burning issue in Benishangul Gumuz region. In the 1960s, the total area of bamboo in Ethiopia was estimated at less than 2 million hectares. The 1997 Global Forest Resources Assessment, estimated 0.8 million hectares of bamboo resources in the region. Near to this figure was cited by International Network for Bamboo and Rattan (INBAR, 2005) their estimate was also supported by the estimate of Melaku (2006) and Luso Consult (1997).

Even if the region accounts for about 55 percent of the lowland bamboo in the country, the size of bamboo forest has been shrinking rapidly due to various reasons that has gradually contributed to the fragmentation and loss of the lowland bamboo forest. INBAR (2010) revealed that enormous hectares of lowland bamboo in the region are cleared and converted into agricultural land. Benishangul-Gumuz Regional Food Security Strategy Report (BGRFSSR) also attested an increasing rate of degradation of forest resources because of various factors, such as encroachment, forest fires, absence of secure land use policy, effects of agricultural expansion and intensive resettlement programs (BGRFSSR, 2004). Consequently, such challenges create adverse effect on equitable natural resource allocation, and this in turn brings failure to achieve their intended agricultural aim. This study examined land cover changes for the last 26 years and identified its causative factors using GIS and remote sensing data.

## 2. DESCRIPTION OF THE STUDY AREA

Benishangul-Gumuz National Regional State (BGNRS) is one of the nine regional states established in 1994 by the new constitution of Ethiopia that created a federal system of governance.

The region is endowed with fertile land suitable for high value crops, livestock, apiculture, fishery, minerals like gold and marble, and economically important trees like bamboo and incense. Livestock production is important means of livelihood in the region next to crop production. It is important sources of food, cash income, and assets to buffer against shocks. In general, a mixed farming system, involving both crop production and livestock rearing activities, is the dominant type of production system. According to the Central Statistical Authority (CSA) (2007) agricultural sample survey, the region had about 0.4 million cattle, 0.3 million goats, 0.1 million sheep, and nearly one million poultry.

In terms of land-use patterns, the region's landmass is predominantly comprised of bushes and shrubs 77.4 percent, while forestland constitutes about 11.4 percent. Further, cultivated land, grazing land and marginal land constitutes about 5.3 percent, 3.2 percent and 2.3 percent, respectively. The vegetation classified into eight types, namely: dense forest, riverine forest, broad-leaved deciduous wood lands, acacia woodland, bush land, shrub lands, boswellia wood land and bamboo thickets (INBAR, 2010). About 0.2 hectare (89 percent) of the total land of the region is covered with vegetation. Evidences in the region revealed that the lowland bamboo forest grows between 1000 and 1800 m.a.s.l and on poor soil in dry vegetation formation (Luso Consult, 1997). It also tolerates poor rocky soil, in erratic annual rainfall even down to about 600 mm and in high temperature of above 35°C. The highland bamboo grows in altitudes from 2.200 -3.500 m.a.s.l and the lowland bamboo between 700-1800 m.a.s.l (Liese, 1985).

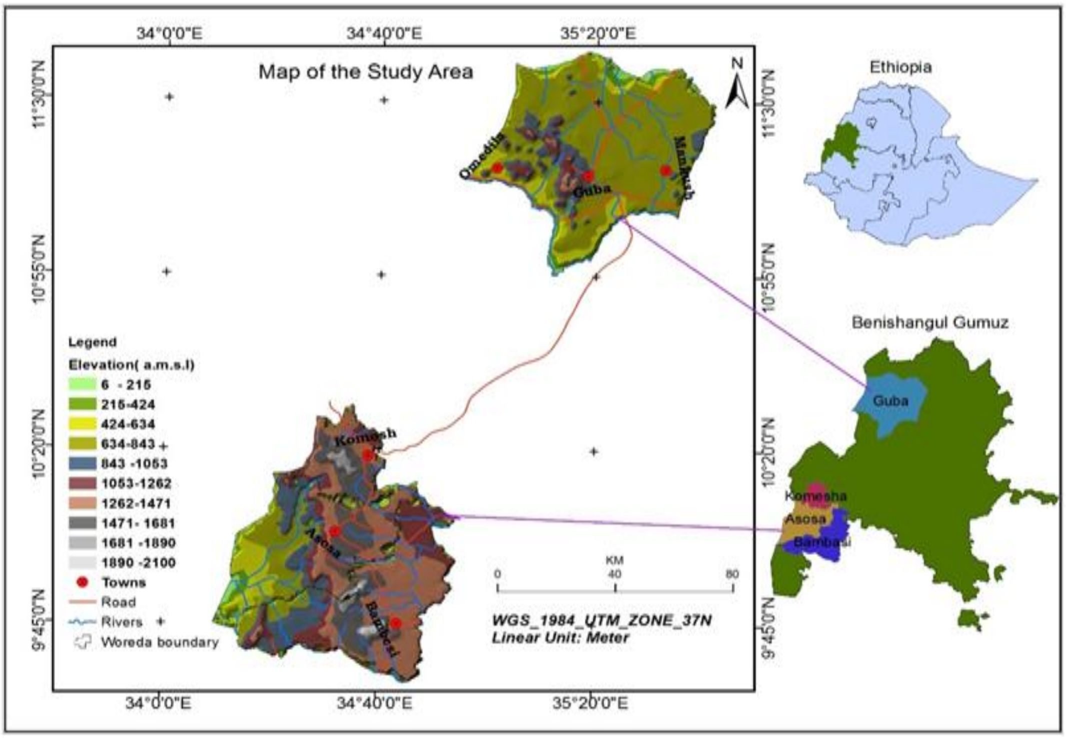


**Figure-1.** Administrative Map of BGR

**Source:** Dwnscaled *Landsat* Data, 2015

This study used geographic information system (GIS) and Satellite images, which were downscaled from NASA (National Aeronautics and Space Administration). In addition, seven years (2006 to 2012) annual mean values of NDVI[1]. To supplement the GIS and NDVI data, key informants interview and focus group discussions were held to validate the required data. The group discussions were led with local farmers, forest management cooperative members organized by FARM-Africa, Bamboo Star Agro-forestry employees, and natural resource experts from *woredas*, Zonal and regional offices. Purpose interview was also conducted with INBAR experts at Addis Ababa and Assosa regional office, BGR regional, zonal and *woreda* experts (those who do not participate in FGDs), government advisors (BGR president's economic and legal advisors), Moreover, BGR vice president office, bureau of agriculture, bureau of environmental protection land administration (environmental protection core process), and investment

[1] The Normalized Difference Vegetation Index (NDVI) is an index of plant "greenness" or photosynthetic activity used to estimate the status of deforestation. It is commonly used to assess the situation of green biomass and its inter-annual changes to draw conclusions about trends in deforestation. NDVI is based on the observation that different surfaces reflect different types of light differently. Photo- synthetically active vegetation, in particular, absorbs most of the red light that hits it while reflecting much of the near infrared light. NDVI is calculated on a per-pixel basis as the normalized difference between the red and near infrared bands from an image: Values of NDVI can range from -1.0 to +1.0, but values less than zero typically do not have any ecological meaning, so the range of the index is truncated to 0.0 to +1.0.

agency were interviewed to seek information on the general issues. Additionally, extensive field visit and transect walk were adequately performed by the researcher with the help of *woreda* DAs.

Information on land use land cover (LU/LC) changes that took place between 1985 and 2011 was compared using remote sensing and geographic information system (GIS) with field verifications. To understand these changes, working definitions were provided to the LU/LC classification types, which give a great contribution to understand the concepts, definitions and methods related to each classification. The working dentition is adopted from Global Forest Resources Assessment and FAO's definitions. Forest in our context refers to land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent. It does not include land that is predominantly under agricultural or urban land use (FAO, 2010). Woodlands are defined as open stands of trees of at least 8 meter tall with a canopy cover of 40 percent or more, whereas bush lands are open stands of bushes (usually between 3 and 7 meter tall) with a canopy cover of 40 percent or more. Bamboo forest includes trees and shrubs with a height of up to five meters. Communities in the study area use this land-cover type (bamboo forest) as the main source of thatch. They also serve as the source of grazing, browsing and firewood. Farmland encompasses areas allotted for crop production (both annual and perennial). Settlement areas are permanent residential areas where rural communities are residing in certain village. Refugee camps in the study area are also classified under this category. Finally, land areas that have no vegetation cover around forest are regard as bare lands.

NDVI is an index of plant "greenness" or photosynthetic activity used to estimate the amount of deforestation. It is commonly used to assess the situation of green biomass and its interannual changes to draw conclusions about trends in deforestation (Meneses-Tovar, 2011). This technique is based on the observation that different surfaces reflect different types of light differently (Chen *et al.*, 2014). Photo-synthetically active vegetation, in particular, absorbs most of the red light that hits it while reflecting much of the near infrared light. Vegetation that is dead or stressed reflects more red lights and less near infrared light. Likewise, non-vegetated surfaces have a much more even reflectance across the light spectrum. This technique is calculated on a per-pixel basis as the normalized difference between the red and near infrared bands from an image: Simple ecological formula used to calculate the values of NDVI is presented below.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Where NIR is the near infrared band value for the plant cell and RED is the red band value for the cell.

The output of NDVI can range from -1.0 to +1.0, but values less than zero typically do not have any ecological meaning, so the range of the index is truncated to 0.0 to +1.0. Higher values signify a larger difference between the red and near infrared radiation recorded by photosynthetically-active vegetation. Low NDVI values mean there is little difference between the RED and NIR signals. This happens when there is little photosynthetic activity, or when there is just very little NIR light reflectance (i.e.., water reflects very little NIR light). Water typically has an NDVI value less than 0, bare soils values are between 0 and 0.1 and vegetation values are over 0.1 (Pettorelli *et al.*, 2005).

The disadvantage of this approach is that the determination of whether vegetation degradation is climate or human induced is not indicated. This is because many factors affect NDVI values like plant photosynthetic activity, total plant cover, biomass, plant and soil moisture, and plant stress. Because of this, NDVI is correlated with many ecosystem attributes that are of interest to researchers and managers (*e.g.*, net primary productivity, canopy cover, bare ground cover). Although NDVI is affected by soil background, atmospheric scattering, and is relatively insensitive to high biomass levels, it provides sufficient stability to capture seasonal and inter-annual changes in vegetation status (Huete *et al.*, 2002). Hence, this technique is widely accepted and applied as a good indicator for providing vegetation properties and associated changes for large scale geographic regions. Thus, vegetation indices like NDVI make it possible to compare images over time to look for ecologically significant changes. Such vegetation indices, however, might not be a useful estimate of vegetation cover or biomass in semi-arid rangelands, especially when bare soil cover is greater than 20 percent (Sankey *et al.*, 2009). Consequently, studies conducted in estimating deforestation relay largely on geographic information system (GIS) and remote sensing, which seldom include information from local people's characteristics (socio-economic and demographic factors) that stimulate deforestation.

## 3. RESULTS

The findings of the study demonstrated six major land-cover types on the basis of 1985, 1990, 2001 and 2011 satellite images taken from three *woredas.* These classifications were: woodland, bamboo forest, bush land, bare land, farmland and settlement. The finding shows that woodland and bamboo forests were the predominant types of LU/LC (land-use/land-cover) in 1985. Wood land and bamboo forests occupy estimated areas of 127,436.76 and 123,706.71 hectors, respectively. Ensermu *et al.* (2000); Kassahun (2003) and INBAR (2005;2010) among others reported predominance of bamboo forest in 1985. Later on, bamboo forests have alarmingly reduced from 25.6 percent to 11.6 percent in 1985 and 2001, respectively (Table1). Woodland, bamboo forest and bush lands have decline by 31.7 percent, 53.9 percent and 39.3 percent, respectively. A rapid decline in woodland could be due to ever increasing firewood demand in the study area. Moreover, increasing the number of human population coupled with climate change may contribute to the problem. Local communities in the study area largely depend on wood and charcoal for cooking meals and heating homes. Previous studies show that in Ethiopia about 90 percent of forest is removed for the purpose of firewood and the charcoal production. This has increasingly contributes to the country's overall deforestation rates of 141,000 hectares per year (FRA, 2010; FAO, 2011; Boucher *et al.*, 2014). The problem is believed to be more serious in our study area as the livelihoods of rural and semi-urban areas of the region highly rely on fuel wood, construction charcoal preparation, and traditional farm equipment. Moreover, within ten years' time periods, the amount of bare land has increased by 58. 7 percent (table1 below).

Bush land has showed increasing pattern of change during the first period comparison. It has increased from 38696.94 hectare to 151, 106.85 hectare for 1985 and 1990, respectively. This implies the fact that bush lands encroach wider areas following deforestation. During this time period, an episode of famine was encountered due to severe droughts in 1984/85, which harmed the people and the environment. As a result, a large number of immigrants were resettled around bamboo areas of Assosa, Bambasi and Pawi *woredas* (BGRFSSR, 2004). These factors intensified deforestation and posed other environmental challenges. Between 1895 and 1990 the proportion of farm land has decreased by 4.4 percent. The result should not be surprised as the drought could affect faming system during the period. Latter on the farmland has amusingly increased by 79.4 percent within 10 years. The findings indicated that farmland and settlement areas have proportionally increased in the study area. Zelalem (2007) found similar result in Ethiopia.

**Table-1.** Land uses/ covers change and rate of deforestation between1985 and 2001

| LU/LC classes | Change 1985-1990 | | Change 1990- 2001 | | Change 1985-2001 | |
|---|---|---|---|---|---|---|
| | Area in (ha) | Percent | Area in (ha) | Percent | Area in (ha) | Percent |
| Woodland | -34743.06 | -0.273 | -5629.31 | -0.061 | -40372.37 | -0.317 |
| Bamboo forest | -64263.33 | -0.519 | -2447.3 | -0.041 | -66710.63 | -0.539 |
| Bush land | 112409.91 | 2.905 | -127606.85 | -0.844 | -15196.94 | -0.393 |
| Bare land | -9917.91 | -0.111 | 62467.92 | 0.784 | 52550.01 | 0.587 |
| Farmland | -3962.16 | -0.044 | 68468.22 | 0.794 | 64506.06 | 0.716 |
| Settlement | 476.55 | 0.024 | 4747.32 | 0.230 | 5223.87 | 0.259 |
| Proportion of bamboo | **25.2.** | | **12.1** | | **11.6** | |

**Source:** Computed from GIS data

**Note:** (+) and (-) sign in indicates gain and loss of land use classes

Settlement area was the least available type of LU/LC in 1985. It only covered an estimated area of 20,149.65 hectare in 1985. Significant change was observed in 2011 in the area (Annex Table 2 and 3). The result shows that settlement area increased by 25.90 percent within 26 years. The trend seems to continue in the future as well. Secondary data and interview with key informants revealed the fact that resettlement sites were densely covered with bamboo forest prior to the resettlement program during the *derg* regime. However, as indicated by Guyu (2012) expansion of farmlands and establishment of settlement sites devastated natural plants accelerating the LU/LC changes. During that time, bamboo was destroyed because of farmland preparation and construction of houses for settlers. The results generally indicate that the amount of bamboo forest has been converted to farmlands and settlement areas.

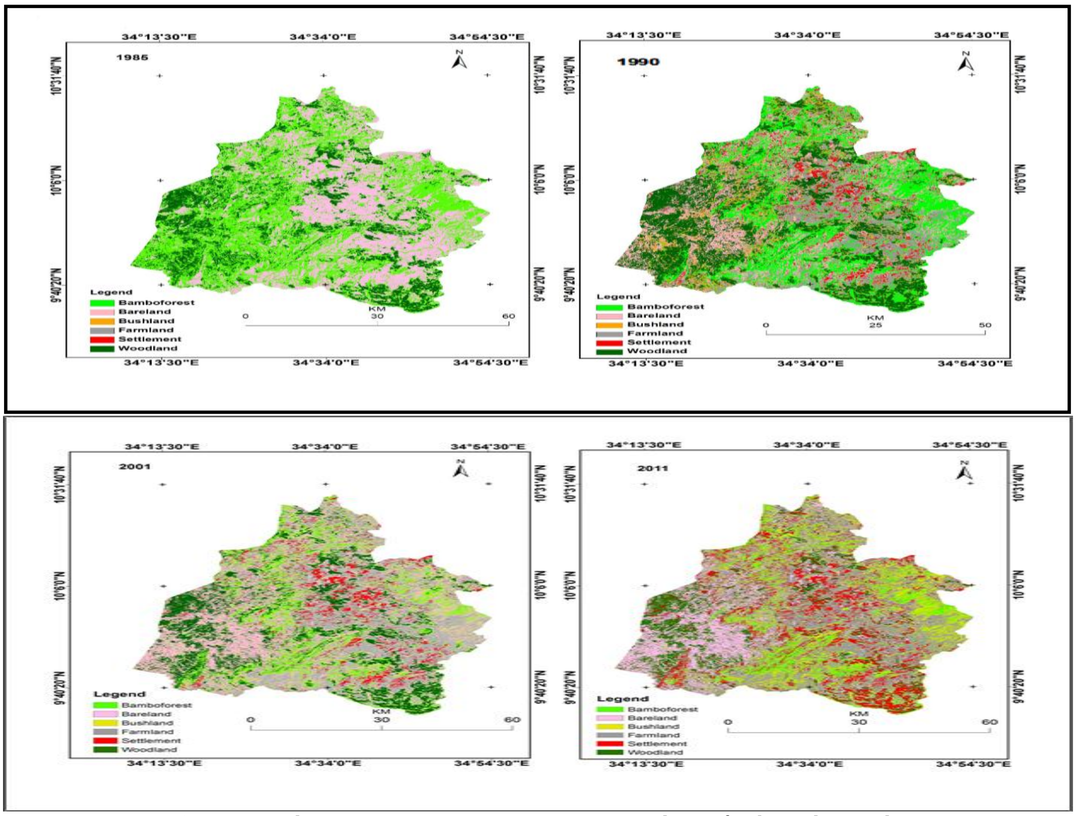


**Figure-2.** Land-use/cover images in 1985, 1990, 2001 and 2011 for the study *woredas*
**Source:** USGS, http://www.earthexplorer.usgs.gov

With understanding of one offsets the limitation of the other, the GIS result was supplemented with NDVI analysis. The result shows decline in the natural forest cover for the first five consecutive (2006-2010) years. However, it starts to recover in 2011 and seems to further improve in 2012. This result is consistent with what have been currently reported by the Ethiopian government regarding vegetation cover all over the country (EPA, 2012); (Yetebitu *et al.*, 2010). In fact, the improvement in these time periods could be due to the effects of massive tree planting (afforestation and reforestation) since the last three years. For example, BGR agricultural and rural development bureau reported that 8, 715 hectares of land were covered with tree plantation in 2013 year alone. During that time, about 4,345.5 kg varieties of forest seeds and 23, 616, 666 seedlings were distributed to farmers (BOA, 2014). According to INBAR's Newsletter No.4, about 100 kg of the lowland bamboo seed was collected and distributed to the beneficiaries, and one pilot research site was established in Assosa *woreda* Afasizim *kebele* (INBAR, 2013). Moreover, Bamboo Star Agro-forestry PLC has distributed about 5 hundred, 1million, and 1.5

million bamboo seedlings to the local farmers in 2012, 2013 and 2014 years, respectively (Bamboo Star Agro-Forestry, 2014).

Figure 2 below illustrates the mean annual bamboo forest cover and patterns for bamboo deforestation during (2006 to 2012) years. Similar to the decline in vegetation cover in the area, changes in bamboo forest cover between these time spans depict a general decline in natural bamboo forest cover. The general cumulative decline in bamboo forest cover was the replica of declining values of calculated NDVI. For the first five consecutive years, the value of NDVI and the corresponding bamboo forest cover has sharply declined and so does the value of NDVI. However, natural bamboo cover seems to improve since 2011. During the seven years (2006-2012) period, about 14,090 hectare improvements in bamboo forest cover were measured.

The GIS result shows that in 2006 the bamboo cover in four study *woredas* was estimated to be 105, 618 hectares while in the year 2012 it falls to 55,671 hectares. This estimation is close to the report provided by Mulugeta and Bekabil (2011). They presented that in 2010 about 64,400.89 hectares of land was covered by lowland bamboo in the seven study *woredas* in the region. They estimated about 50 percent of bamboo deforestation. Close to their result, in the present study, the gross natural bamboo forest cleared was estimated to be 49,946 hectares, which is equivalent to 12 percent of the total regional lowland bamboo cover. The highest rate of bamboo deforestation was encountered in 2009 year while low rate of bamboo deforestation occurred in 2011. In general, the amounts and trends of cultivated land, bush land and shrub land have increased while the total bamboo vegetation cover has experienced a drastic decline because of various factors (natural factors and human activities).

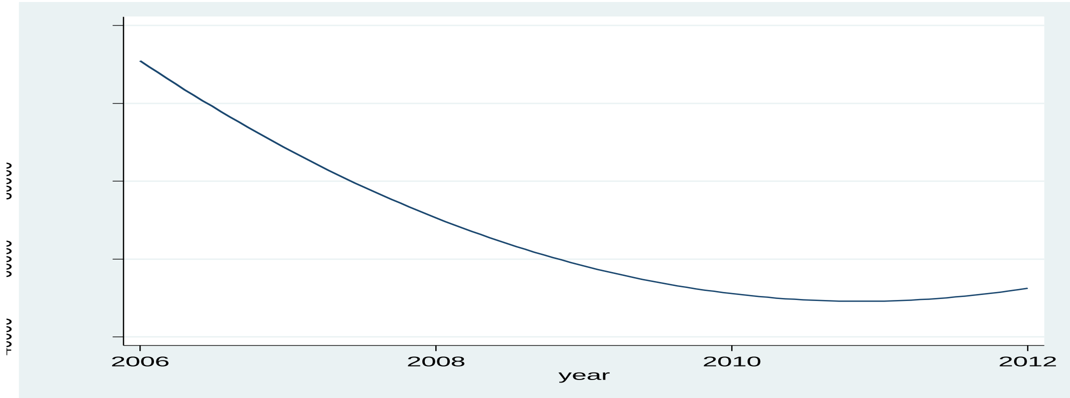


**Figure-3.** Bamboo forest covers between 2006 to 2012 years in hectare

**Source:** Dwnscalled *Landsat* Data, 2014

The survey tried to identify the causes of bamboo deforestation. The main responses are shown in figure 3. The first cause of bamboo deforestation includes: agricultural land expansion, increase in grazing livestock, illegal bamboo harvesting for fuel-wood collection and construction material preparation, and uncontrolled wildfire. The second cause of bamboo deforestation comprises population pressure, weather variability, resettlement, poverty, establishment of the bamboo factory, weak forest sector governance and institutions, and insecure tenure in the region. Scholars classified these following causes of deforestation (1) proximate or direct causes, which are human activities and actions that directly impact bamboo forest cover, and (2) underlying or indirect causes of deforestation (Geist and Lambin, 2001). In order of their importance in the study area the following factors are considered.

Wildfire emergence has become the most important factors affecting bamboo deforestation. For example, about 69.3 percent of the respondents reported uncontrolled wildfire as one of the major causes of bamboo deforestation (refer Appendix Table 1). Almost all respondents (95.23 percent) replied that in the study area wildfire occurs twice a year. The frequency of wildfire occurrence and the damage it causes to bamboo forest in Guba *woreda* was found to be very high, followed by Homosha *woreda*. This shows that still in the *kolla* agroecologies the intensity of occurrence of wildfire is higher. From time to time, the magnitude, intensity and the damage on bamboo forest and other vegetation cover is still getting higher and higher. The highest wildfire occurrence and sever damage was reported in 2012 years. For instance, annual wildfire occurrence has increased from 53.2 percent to 98.1 percent in the 2008 and 2013 years, respectively. As to the causes of wildfire, the majority (78.5 percent) of the respondents mentioned honey production while 42.5 percent of the households identify tobacco smoking. About 26.5 percent of the households identify charcoal production as the main cause of wildfire outbreak. Hunting was reported as the least cause. On the other hand, most survey respondents, and some of the individuals who participated in focus group discussion do not know the real causes of wildfire; but some key informants blame neighboring villages for the fire occurrence.

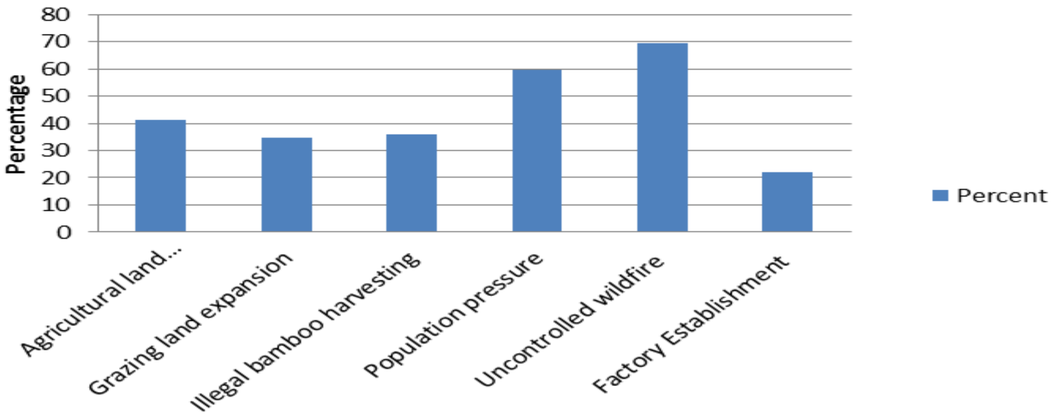


**Figure-4.** Causes of bamboo deforestation

**Source:** Survey data, 2014

Unlike the case in India, which found poverty as important causes of wetland degradation (Das *et al.*, 2014) in BGR, bamboo deforestation is closely linked to the ongoing population pressure (but this study lacks critical macro level analysis). Of the total 384 respondents, a large number (59. 6 percent) of respondents claim that high population pressure was the central cause of bamboo deforestation. The survey result revealed high rate of bamboo deforestation in a highly populated study areas. As observed in the GIS data and the 2013 CSA population report, deforestation in the region has risen as population continues to grow in their inexorable increase. These could be attributed to the cutting of trees for various uses, such as firewood, timber production and land clearing for agricultural purposes. From the field observation massive in-migration of people from various parts of the region was attested. Consequentially, vegetation cover of the lowland bamboo is highly threatened in highly populated areas of Assosa and Bambasi *woredas*. In the same way, smaller proportion of (22.1 percent) of the sample respondents believes that Bamboo Star Agro-forestry is the main cause of bamboo deforestation. Other causes, such as increasingly growing demand for construction material, and locally perceived bamboo disease (*e.g* gregarious bamboo flowering and death), and institutional inefficiency in managing the bamboo forest were identified during the discussion with focus groups and key informants discussions.

With the intention of protecting the ever-deteriorating condition of forest cover in general and bamboo forest in particular, the respondents feeling were assessed. Their feelings were summarized into four sets of possible solutions. Table 10 depicts that collective management of the natural bamboo forest (53. 3 percent), ensuring secure forest property rights (51.3 percent), continuous awareness raising training for farmers (47.1 percent), and establishment of strong monitoring and evaluation mechanism (41.1 percent).

**Table-2.** Perceived solutions to bamboo deforestation

| Solution | Response | Frequency | Percent |
|---|---|---|---|
| Collective management | Yes | 206 | 53.6 |
| | No | 178 | 46.4 |
| | Total | 384 | 100 |
| Secure property rights | Yes | 197 | 51.3 |
| | No | 187 | 48.7 |
| | Total | 384 | 100 |
| Awareness creation | Yes | 184 | 47.9 |
| | No | 200 | 52.1 |
| | Total | 384 | 100 |
| Monitoring and evaluation | Yes | 158 | 41.1 |
| | No | 226 | 58.9 |
| | Total | 384 | 100 |

**Source:** Computed from survey data, 2014

## 4. CONCLUSION

Environmental and natural resource degradation is the major concern in Ethiopia. The study shows negative consequences on the livelihoods of the people. The problem of deforestation, particularly bamboo degradation is the sever problem in Benishangul Gumuz region. Our empirical findings generally show continuous degradation of bamboo forest in the study area. However, the changes vary in magnitude and direction from year to year. For instances, after a sharp decline (for five years), the bamboo forest tends to improve in 2011. The result pointed out the highest and the minimum rate of deforestation in 2009 and 2011 years, respectively. A significant decline in lowland bamboo is mainly associated with human influences. The forest cover change was induced by factors such as traditional agricultural production system, improper grazing system, illegal logging and wild fire. In conclusion, this finding attested continuous depletion of bamboo forest in BGR, but with possibility of future regeneration if appropriate policy is designed. This calls for an enormous investment on restocking, regeneration and protection of the lowland bamboo forest by the regional and federal governments.

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## APPENDIX TABLE

**Appendix Table-1.** Wildfire occurrence and the damage on bamboo forest (2008-2012).

| **Year** | **Percent of case occurrence** | | **Damage on bamboo (percent)** | |
|---|---|---|---|---|
| | **Yes** | **No** | **Sever** | **Light** |
| 2008 | 94.1 | 5.9 | 57.4 | 42.3 |
| 2009 | 95.4 | 4.6 | 52.6 | 47.6 |
| 2010 | 96.5 | 3.5 | 54.4 | 54.5 |
| 2011 | 98.7 | 1.3 | 66.8 | 33.2 |
| 2012 | 99.2 | 0.9 | 73.1 | 26.9 |

**Source:** Own survey data, 2014

**Appendix Table-2.** Land-use/cover in 1985, 1986 and 2007 in Benishangul Gumuz Region.

| **SR.NO** | **LU/LC Classes** | **LU/LC in Area in hectare (1985-1995)** | | |
|---|---|---|---|---|
| | | **1985** | **1990** | **1995** |
| 1 | Woodland | 127436.76 | 92693.7 | 87064.39 |
| 2 | Bamboo forest | 123706.71 | 59443.38 | 56996.08 |
| 3 | Bush land | 38696.94 | 151106.85 | 23,500 |
| 4 | Bare land | 89575.65 | 79657.74 | 142125.66 |
| 5 | Farmland | 90149.76 | 86187.6 | 154655.82 |
| 6 | Settlement | 20149.65 | 20626.2 | 25373.52 |
| Proportion of bamboo | | 0.252 | 0.121 | 0.116 |

**Source:** Own survey data, 2014