EVALUATION OF THE NATURAL REGENERATION OF LOWLAND BAMBOO *(Oxytenanthera abyssinica) FORESTS* AFTER MASS FLOWERING AND MASS DEATH IN HOMOSHA DISTRICT OF BENISHANGUL GUMUZ REGION, NORTH WESTERN ETHIOPIA

M.Sc. THESIS

GEBREMEDIHIN WOLDEGEBRIEL

HAWASSA UNIVERSITY, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES, WONDO GENET, ETHIOPA

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GEBREMEDIHIN WOLDEGEBRIEL

A THESIS SUBMITTED TO THE DEPARTMENT OF FOREST RESOURCE ASSESEMENT AND MONITORING, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES, SCHOOL OF GRADUATE STUDIES, HAWASSA UNIVERSITY, WONDO GENET, ETHIOPIA

IN PARTIAL FULFILLMENET OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOREST RESOURCE ASSESEMENT AND MONITORING

MAY, 2018

APPROVAL SHEET-I

This is to certify that the thesis entitled **"Evaluation of the Natural Regeneration of Lowland Bamboo(*Oxytenathera abysinica*), After Mass Flowering and Mass Death in Benishangul Gumuz Region, Northwestern Ethiopia"** submitted in partial fulfillment of the requirements for the degree of Master of Science with specialization in Forest resource assessment and monitoring of the graduate program of the Department of Forestry, Wondo Genet College of Forestry and Natural resources, and is a record of original research carried out by Gebremedhin Weldegebriel ID No. MSc/FrAM/R006/2017, under my supervision, and no part of the thesis has been submitted for any other degree or diploma. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

______________________	________________	_______________
Name of major advisor	Signature	Date
______________________	________________	_______________
Name of co-advisor	Signature	Date

APPROVAL SHEET-II

We, the undersigned, members of the Board of Examiners of the final unprotected defense by Gebremedhin Weldegebriel have read and evaluated his thesis entitled **"Evaluation of the Natural Regeneration of Lowland Bamboo*(Oxytenathera abysinica),* After Mass Flowering and Mass Death In Benishangul Gumuz Region, Northwestern Ethiopia"** and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Forestry in Forest resource assessment and monitoring.

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Name of Internal Examiner	Signature	Date
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Name of External examiner	Signature	Date
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GS Approval	Signature	Date

Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the School of Graduate Studies (SGS) through the Department/School Graduate Committee (DGC/SGC) of the candidate's department.

Date: _____________

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DECLARATION

I, Gebremedhin Weldegebreil, hereby declare that this thesis is my original work and has not been presented for a degree in any other University.

G.Medhin…………………Date…………………………

ACRONYMS AND ABREVATIONS

BGR	Benishangul Gumuz Region
BGNRS	Benishangul Gumuz National Regional State
BGRFSSR	Benishangul-Gumuz Regional Food Security Strategy Report
B O F E D	Bureau of Finance and Economy Development
BOIPPCSA	Bureau of Information and Public Participation Co-ordination and Social Affairs
CBOs	Community Based Organizations
CSA	Central Statistics Agency of Ethiopia
EABP	Eastern Africa Bamboo Project
EMA	Ethiopia Mapping Agency
HHH	House Hold Heads
HWAO	Homosha Woreda Agricultural Office
LLB	Lowland Bamboo
INBAR	International Network for Bamboo and Rattan
NRDEP	Natural Resources Development and Environmental Protection
NTFPs	Non-Timber Forest Products
DBH	Diameter at Breast Height
FAO	Food and Agricultural Organization
NGOs	Non-Governmental Organizations
HWAO	Homosha Woreda Agricultural Office
UNHCR	United Nation Higher Commission for Refugees

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ABSTRACT

Bamboo is a unique species with hybrid characteristics of woody species and herbaceous grass. It has a biological feature of natural death after flowering during which it become vulnerable to anthropogenic threats and subsequent degradation. This peculiarity, thus, requires a meticulous study of its ecology and regeneration status. This study was done to assess the regeneration status of lowland bamboo following its gregarious flowering and death in Benishangul Gumuz Region, Homosha District, Jima and Sherkole Kebeles, North West of Ethiopia. A systematic random sampling technique was used to assess the lowland bamboo and its regeneration status. A total of 20 and 11 sample plots were used form Jima and Shorkole kebeles respectively, and each plot was of a size 10 x 10 m, laid out in protected and unprotected bamboo forests. Inventory results were also complemented by Field observation, FGDs, and semi structured surveys of 80 households. Descriptive and inferential statistics were used for data analysis. The findings of this study showed that on average number of seedlings and culms on protected and unprotected site are 252250 & 121364 seedlings per hectare and 9185 & 3555 culms per hectare respectively. Moreover, it is found that there is significant difference (one way ANOVA, $p < 0.05$) in density, height of mature culms between the protected and non-protected sites. This implies that protecting of the area positively contribute to improve regeneration of bamboo after mass flowering. The height and diameter class distribution indicated highest number of individuals in the lower classes suggesting that the age of the forest after mass flowering and death is not more than 4 to 5 years hence regeneration could be sensitive to the anthropogenic disturbances. The results also revealed that there is intensive and selective harvesting of bamboo with larger size in the unprotected site than in the protected site. The trend of bamboo utilization and harvesting was increasing from time to time while unfortunately, the resource base is declining fast against the demand. HHs harvest bamboo at an age of <1 & ≥ 3 years and harvesting intensity was observed to be much focused on culms size rather than age class. Seventy five percent of respondents across the management systems confirmed they usd to cut culms whenever they need the resource with regad to the trend of bamboo culms utilization, the majority of the respondents (93.8%) ranked construction as their primary choice. Although there is intensive traditional use of bamboo, there is no similar engagement in its management. It is found that only 49% of the community involve in managing and conservation of bamboo. The present study further revealed several problems that are hindering the natural regeneration of lowland bamboo. Some of the most important problems were frequent fires, conversion of bamboo into farm land after mass flowering and death and over exploitation of bamboo by people from refugee camps. These problems may lead to unsuccessful future regeneration practices. Thus, unsustainable utilization and poor conservation practices lead to poor regeneration and subsequent shrinkage of bamboo forests in the study area. Based on the findings, it is recommended that enclosure of mass flowered bamboo areas until it fully regenerates and controlled utilization then after. For this purpose, an alternative management protocol should be developed for the region in order to save the remaining bamboo stand from further depletion and ensure its sustainable utilization.

Key words: Anthropogenic threat, bamboo regeneration, lowland bamboo, Management,

Utilization

1 INTRODUCTION

1.1 Background

Bamboo is a perennial grass belonging to the Poaceae (Gramineae) family and Bambusoideae subfamily. It is the fastest growing plant on earth (Desalegn and Tadesse 2014, Lucas 2013). Bamboo is a naturally regenerative plant which grows mostly within forests as a bushy grass in tropical and subtropical ecology. It is also naturally found as an understory plant, in most regions and can be referred to as woody grass classified into species ranging in number from 1439 to 1500 with 115 genera's across the globe (Akinlabi *et al.,* 2017). The bamboo plant plays a significant role in climate change mitigation as it sequesters about 35% more CO_2 from the atmosphere than other plants (Akinlabi *et al*., 2017) thus reducing more atmospheric carbon dioxide as compared to hard and softwoods.

According to some literature, the pure natural bamboo forest in Ethiopia estimated over 1 million ha, and this is the largest in Africa and 85% of this area is covered by *Oxytenanthera abysinica,* which is indigenous bamboo to Ethiopia and endemic to tropical Africa (Kelbessa *et al*, 2000; Kasahun, 2003). If managed in an intelligent way, bamboo is one of the fastest growing, highest productivity, most versatile, short harvesting cycle, and annually renewable and harvestable plant (Fumaoyi, 1998).

Bamboo is a highly utilized natural resource in many parts of the world. In Ethiopia the use of bamboo is limited to construction, fences and some rudimentary furniture and household utensils. Although bamboo is not an integral part of the Ethiopian economy, it plays a very important role socially, economically and ecologically in areas where it naturally occurs as well as where it is planted (Kelbessa *et al*., 2000, Embaye, 2000).

Recently, bamboo has received increasing attention because of its easy propagation, vigorous regeneration, fast growth, high productivity and quick maturity.

It provides goods and services useful to mankind from birth to death. Bamboo is a source of food, fodder, furniture, building materials, industrial inputs, medicinal plant and fuel. It also plays a vital role in environmental amelioration, bio-diversity and soil conservation and waste purification (Ayer –Smith, 1963, Woldemichael Kelecha, 1980, Amare Getahun, 1992, kao, 1996, Embaye, 2000).

According to report of the bamboo sector in Ethiopia, the BGR has got 328,211ha of land covered with bamboo of which 43,383 ha is found in Homosha wereda as agricultural office of Homosha reported in 2006 EC. If properly managed and rationally utilized, these resources can contribute a lot to the region's development. Among the well endowed natural resources of the region, bamboo plays a significant role in the livelihood of communities. However now a days, the size of bamboo forest in the region is getting shrinking due to human and natural influences.

INBAR (2010) pointed out that enormous hectares of lowland bamboo in the region are cleared for crop production purposes. Benishangul-Gumuz Regional Food Security Strategy Report (BGRFSSR) has also identified various factors for the shrinkage, such as encroachment, forest fires, absence of secure land use policy, effects of agricultural expansion and intensive resettlement programs (BGRFSSR, 2004), land use changes, and damage by bio deteriorating agents such as termites, beetles and fungi (Getachew and Wubalem, 2014). In addition (Yigardu *et al.*, 2010) informed the none existence of comprehensive research on bamboo, despite the fact that forestry research has been conducting in the country for the past 30 years. Could be due to lack of sufficient awareness about its multiple uses, bamboo is still not considered as a research commodity in Ethiopia that hindered actions for development and conservation interventions.

Problems related to over use and depletion of bamboo forest arises because of paying less attention and least priority to the resource. Their ecological requirements also need further investigation.

As a result of cumulative effect of these challenges, currently, resource scarcity and conflicts on bamboo resource has become serious. In addition to human influence and natural factors, the lowland bamboo in BGR has been under high pressure due to communities' lack of knowledge on how efficiently to use it. In order to reverse the situation, a lot of efforts have been taken by government sectors in the region (institutions were strengthen, issues designed on the development plan & implemented, established important by laws & practices), but still there is a research gap on how to manage and sustainably utilize the lowland bamboo potential of the region. Although the mass flowering exacerbates the problem, according to Demissew *et al. (*2011) assessment, flowering in lowland bamboo seems to be more frequent. It flowers every 30-35 years. Currently, mass flowering, thereby mass death, has reached over 85 % of the estimated total 400,000 ha bamboo in the region (Demissew *et al*., 2011).

The early flowered areas have regenerated & formed bamboo forest but, remarkably former bamboo land is also found changed into other land use system. The remaining also is critically challenged by wild fire which is traditionally set as management of range lands in the region. So far, there is also no record of new regeneration under dead populations. Accordingly, in order to use these vital resources of bamboo effectively in a sustainable way & to enable re-storing them through effective management in the aftermath of mass flowering, we need to have current & reliable information regarding the status of the natural regeneration & trends of management practices at community level, so that solution can be sought for the major constraints.

1.2 Statement of the Problem

In spite of a wide coverage and use of bamboo forest and other natural resources, the region obtains limited socio-economic benefits, owing to lack of knowledge about the resource and absence of sustainable natural resource management system, (Kelbessa et al., 2000; Embaye, 2000; Million, 2009; Demissew *et al*., 2011; Misreave, 2011).The area of lowland bamboo forest cover of Ethiopia has been diminishing at an alarming rate due to a combination of anthropogenic and natural factors (Arsema, 2008). So far some additional evidences show that the area of lowland bamboo forest cover in the region has been highly devastated due to anthropogenic and natural factors (INBAR, 2011).

According to Yigardu (2012), bamboo resource of the country has been deprived of research attention until recently. Up to now, only very few research activities have been done on vegetative propagation of highland bamboo (Tesfaye *et al*., 2005); physiological and morphological characteristics, large scale regeneration /propagation techniques, and knowledge on feasible rehabilitation and optimum silvicultural management techniques of bamboo is virtually absent in the country (FAO and INBAR, 2005). Although (Embaye, 2002) has conducted experimental studies on seed germination of Bamboo *(oxytenathera abysinica),* still lack of documented & clear research studies have been taken as constraints to the natural Regeneration of LLB.

Assessment on situation of re-growth, density, & stand structure is crucial & provides necessary input for management decision of bamboo resource. However until now, especially after mass flowering & mass death no attention has been paid to evaluate the status of the natural regeneration abundance in region wise.

The local people at the district are not aware on how to use & manage this versatile resource & additionally have no means on how to take care of the land for restoration at the time of mass flowering. Similarly, the responsible government sectors also do not have any efficient strategy or research results (record of new regeneration under dead populations) on LLB.

Available evidence shows that little research have been done so far on natural regeneration of lowland bamboo after mass flowering and death. Hence, this study provided empirical information on the status of natural regeneration of lowland bamboo after mass flowering and death as well as the socioeconomic factors affecting its management and utilization.

Objectives

1.2.3 General objective

The overall objective of this study was to investigate the regeneration status in different management systems and understand the management and utilization practices of lowland bamboo (*Oxytenathera abysinica*) at community level.

1.2.4 Specific objectives

- ✓ Determine regeneration status of lowland bamboo under different management system,
- ✓ Investigate factors fostering and limiting regeneration of bamboo after mass flowering and mass death
- ✓ Diagnose traditional management and utilization practices before and after mass flowering
- ✓ Identify the major constraints of bamboo management and utilization

1.2.5 Basic Research Questions

In line with the specific objectives specified, this particular study was expected to answer the following questions at the end of the study.

- How the regeneration status of bamboo does compared in different management systems?
- What factors affect the regeneration status of bamboo?
- What are the local management & utilization practices of bamboo forest including after mass flowering and mass death?
- What are the major constraints of LLB management and utilization in the study area?

1.2.6 The research out put

- ✓ Management and utilization trends of LLB in the study area were investigated & documented,
- ✓ Regeneration condition /status of LLB in the study area has been evaluated & documented after analyzing the stand density, age structure & growth characteristics (height & size).
- ✓ Major constraints on regeneration, management & utilization of LLB have been also identified and recorded /documented,

1.3 Significance of the study

- Bamboo is estimated to be one of the untapped and highly valuable natural resources Ethiopia has. With its rate of growth, sustainable harvesting is possible with higher harvest volume as compared to other resources in the country.

  Therefore, proper management and sustainable use of bamboo resources can contribute much to the quest for poverty alleviation in the study area as well as in the region.
- The result of this study could provide important information and knowledge related to regeneration of lowland bamboo under different management practices that will initiate communities, government and non-governmental organizations to apply relatively more productive techniques of management and sustainable utilization of the resources.

- The result of the study may also help the government to aware the local community about the contribution of bamboo to their livelihood so that they could put more effort on the proper management of the bamboo forest within their vicinity.

- The result of the study will also give inputs for national REDD+ MRV road map to consider bamboo resource potential for future carbon financing and payment of ecosystem services.

- Assessment and knowledge of natural regeneration potential after mass flowering and identification of determinants /constraints through village level studies can provide indicators for sustainability of resource utilization and management, which provides a basis for conservation planning.

1.4 Scope and Limitation of the Study

The scope of this study was mainly focused on the assessment of natural regeneration statues to investigate factors affecting natural regeneration, including management practices & utilization trends, in Jima, & Sherkole Kebeles, BGNRS, Asossa Zone, Homosha District.

The study was limited to sites in only these two Kebeles due to financial and time constraints. This study has delimited certain variables, such as stand density (number of seedlings, clump size & number of culms), age structure, growth characteristics (height, size), trends of management and utilization & their constrains etc..; discussed further on what measures have been taken by the communities, government sectors and other concerned bodies to restoring & sustain bamboo forest as their renewable resource. Given the complexity of the study, various efforts have been exerted to make the research more scientific, reliable and applicable.

Research studies, no matter the degree, usually face limitations. This particular study too, had certain limitations, which emanated primarily from shortage of time, budget, and facilities. There were also language barriers that made it difficult to fully understand by a translator while filling the questioner formats, during the formal & informal discussions and other communications on the site of the study. In addition to this there were also shortage of integrity from some officials and accessibility to secondary data was also other limitation that were faced while collecting the required data for this study. Moreover, wrong response, if any, from the respondents might have also affected robustness of the study.

2 LITERATURE REVIEW

2.1 Overview of bamboo resource Potential and distribution

Bamboo is a perennial grass belonging to the sub-family Bambusoidae of the family Graminae. It has a woody stem or Culm arising from rhizome buds. The buds develop into bamboo shoots at certain times of the year i.e. between May to September in Ethiopia. Generally, each bamboo clump produces 8-14 shoots annually. It takes 2-3 month for bamboo shoots to reach maximum height and another 3 months for bamboo culms to reach maximum height. Its growth habit and structure are similar to other grasses. However, it grows tall and larger, up to 25m in height and 24cm in diameter. For this reason, it is also known as 'trees grass' (Woldemichael Kelecha, 1980).

According to Kigomo (2007b) bamboo shoots and culms grow from the dense root rhizome system. There are two main categories of rhizomes: monopodial and sympodial. Monopodial rhizomes grow horizontally, often at a surprisingly faster rate, and thus, they are given the nick name 'runners. The rhizome buds develop either upward, generating a Culm, or horizontally, with a new tract of the rhizomalnet. Monopodial bamboos generate an unprotected clump with culms distant from each other and can be invasive. Sympodial rhizomes are short and thick, and the culms above ground are close together in a compact clump, which expands evenly around its circumference (Kigomo, 2007b; Lobovikov *et al*., 2005).

Bamboo is found naturally distributed in the tropical and subtropical belt between approximately 46° north and 47° south latitudes, and is commonly found in Africa, Asia and Central and South America. Some species may also grow successfully in mild temperate zones in Europe and North America (Muller & Rebelo, 2011).

2.1.1 Worldwide distribution of bamboo

Bamboo plants grow in the tropical and temperate regions, being preponderant in the former, particularly in Southeast Asia (Banik, 1985). More than 1500 bamboo species are found in the world (Ohrnberger, 1999; Wong, 2004), most of which grow in Southeast and Asia covering more than 14 million ha of land. Africa possesses about 40 of these species on over 1.5 million ha (Kigomo, 1988). Much of which is distributed over Eastern Africa (Kibwage *et al*., 2008).Bamboo habitat distribution overlaps with many economically impoverished developing nations (Kigomo 1988). Bamboo occupies about 1% of global forest land or approximately 40 million hectares (FAO 2005).

Asia has the most bamboo coverage with 25 million hectares, an area that continues to increase due to ongoing cultivation efforts. In Latin America, bamboo occupies 11 million hectares. Africa holds 3 million hectares of bamboo (Midmore 2009). About 67% of the bamboo in Africa and 7% of the world total are found in Ethiopia.

The major bamboo producing countries in Asia are India (having almost 11.4 million hectares), China (with over 5.4 million hectares) followed by Indonesia (2 million hectares) and the Lao People’s Democratic Republic (with 1.6 million hectares) (Lobovikov, 2007). In Latin America, there are at least ten countries that have significant bamboo resources. Of these, Brazil, Chile, Colombia, Ecuador and Mexico have the richest bamboo resources (Lobovikov, 2007). Africa has only 43 species and 11 genera occurring on 1.5 million ha. Of these, approximately 40 species are mainly found in Madagascar while the remaining 3 are in mainland Africa (Kigmo, 1988; Ohrnberger, 1999; Tesfaye, 2007).

Lobovikov (2007) shows that six African countries (Ethiopia, Kenya, Nigeria, Uganda, the United Republic of Tanzania and Zimbabwe) have in total over 2.7 million hectares of bamboo and regarding diversity of bamboo in the region a little higher than 13 genera and less than 40 species are reported.

2.1.2 Ethiopian bamboo forests distribution

Ethiopia is one of the countries in Eastern Africa that possesses considerable bamboo resources. There are two indigenous types of bamboo in Ethiopia namely, the high land of African alpine bamboo (*Arundinaria alpine* k.schamach) and a monotypic genus, law land bamboo (*Oxytenanthra abyssinica*) (A. Richard- Munro). They are indigenous to Ethiopia and endemic to African confined to the sub Saharan region (Kelbessa *et al*, 2000). Although bamboo is not an integral part of the economy of Ethiopia, it plays a very important role socially, economically and ecologically in areas where it occurs naturally and where it is planted. Both the highland and lowland bamboos are such a versatile type of resources that they can be used in many ways. Their paramount importance and multifaceted use in different parts of the country are reported.

The bamboo species are under evaluation in different parts of the country including specific localities known as Assosa, Injibara, Hagere-Selam, Debre-Zeit and Wondo-Genet. One giant bamboo species namely Dendrocalamus gigantus is found well adapted within a limited forest area of Munesa Forest Enterprise since the past 20 years.

Various researchers and institutes have attempted to estimate the area coverage of bamboo resources of Ethiopia. These include the studies made by Mooney (1959), Breitenbach (1963), Woldemichael Kelecha (1980) and LUSO CONSULT (1997). These researchers and organizations have made considerable contribution towards the understanding of the bamboo vegetation of Ethiopia (FAO and INBAR, 2005). Bamboo cover, as an integral part of Ethiopian forests, is not explicitly indicated in EFAP (1994) report.

However, later, from more recent reports, bamboo cover of the country is stated to be over one million hectare of which the total area coverage of *Oxytenanthera abyssinica* is estimated to be more than 800,000 ha, (LUSO, 1997; Kassahun, 2003).

Out Of the total estimated low land bamboo coverage about 480,510 hectares have been mapped (LUSO CONSULT, 1997). Also (Yigardu, 2012) affirmed that only 481,000 ha of the LLB was mapped and partially surveyed, While the high land bamboo is estimated to be 300,000 hectares (LUSO CONSULT, 1997). This means that 86% of the African bamboo resources are found in Ethiopia.

The natural stand of *Oxytenanthra Abyssinia* is found only in Ethiopia and in some other African countries, but not outside the African continent (Embaye, 2000). Low land bamboo in Ethiopia grows only in the western part along major river valleys and in the low land bordering Sudan. It occurs between 1100-1700 masl.). The species grows in savannah wood land, mainly in river valleys and often forming extensive stands (Phillips, 1995, Kelbessa *et al.*, 2000). The lowland bamboo accounts for 85 % of the total national coverage while the rest 15% is covered by Arundinaria alpina K. Schum - highland bamboo (Embaye, 2000; Embaye et *al*, 2003).

Low land bamboo grows on dry rocky hillsides where the mean annual temperature is above 30^0c and where an annual rain fall of about 700-1000mm is concentrated over a period of three to four months. It can also grow on a wide variety of soil types. Both species prefer however, well drained sandy loam to loamy clayed soils derived from river alluvial or from underlying rocks. The optimum soil acidity lies between pH 5 and 6.5. No species seem to adapt well to salty soils.

The lowland bamboo forest of Ethiopia is a clump-forming type with solid Culm, while the highland bamboo forest is non-clump forming (single-stemmed) species with hollow Culm. The former is deciduous while the latter is an evergreen (Kasahun, 2003, Vol. I and III).

The lowland bamboo species occur mainly in the western parts of the country towards the savanna woodlands of Sudan at elevation between 1200-1800m (Adnew et al., 2007). The lowland bamboo (*Oxytenanthera abyssinica*), is found in most of the Benishangul Gumuz regional state and covers about 300,823 hectares. Now days, bamboo is declining because of gregarious flowering and management problem. Farmers traditionally set fire to bamboo forest for livestock grazing (IMBAR, 2010).

2.1.3 Characteristics and Productivity of LLB

LL Bamboo is one of the fastest growing plant species with a growth rate ranging from 30 – 100 cm per day in one growing season and attains a maximum height of more than 36 m with a diameter of 1-30 cm (Diver, 2001; Nath *et al*. 2009). LL Bamboos get mature, strong and ready for utilization after 3 to 4 years (Kassahun, 2003; KEFRI, 2007).

The new bamboo shoots are produced every rainy season and attain full height and diameter in about 3 months (Kassahun, 2003; KEFRI, 2007). As mature culms grow older, they deteriorate and eventually die and rot. The life of a bamboo plant is however sustained by the new shoots and culms (Kelbessa et al, 2000).

Oxytenanthera abyssinica is sympodial bamboo with a height ranging and a diameter, a tufted, deciduous, & bright green in color. It has semi-solid to solid culms, it also has zigzag culms and no thorn (Kassahun, 2003; ABS, 2006).

According to FAO and INBAR (2005), this species can attain a maximum diameter of 10.16 cm with ranging from 5 to 10 cm and maximum height of 9.14 m with ranging from 3 to 10 meters. The young shoots of this species are distinguished by their bluish green color and their creamy yellow blades. The culms of *O. abyssinica* are useful for woven and plaited products such as basketry, mats, and other handicrafts. The plant is also useful for bio-energy (EABP. 2009). Scientific information on stand structure and productivity of lowland bamboo is limited.

Under natural conditions, where there is no management, the number of culms per ha of this species was reported to be only 8000 (LUSO, 1997). However, plot level records indicate that plantations of average/medium sized clump of this species with a 4 m X 4 m spacing , to have supported 73 culms/clump, meaning, over 40,000 culms ha^{-1} (Yigardu *et al*., 2016).

One hectare of the highland bamboo forest has an average of 5869 culms whereas, that of low land bamboo forest has an average of 8124 living culms and 4185 dead culms.The average stocking of the lowland bamboo forest is 8000 culms ha^{-1} and 6000 culms ha^{-1} in the highland bamboo forest. Mean culms size in the lowland- and highland bamboo forests is 5 cm and 7 m and 8 cm and 17 m of diameter and height, respectively (Anonymous, 1997).

Harvesting by the local people for various uses is very rare with no noticeable impact on the forest stocking or structure. However, increment is counterbalanced by death of trees due to age, disease and insect attack and the forest stocking remains more or less unchanged. These forests had remained out of sight in the remote areas of Ethiopia, preserved by their inaccessible locations.

However, they are now accessible as new settlements have been established in the forests and new roads have been built through them to connect the emerging villages. Consequently, they are being cleared at an accelerated rate for agricultural land expansion, burned to promote tender grass growth for grazing and to drive out or kill allegedly harmful insects. Large-scale coffee and tea plantations and urban expansion are also emerging as real and potential threats (Kasahun, 2003).

2.2 Flowering of Bamboo in Ethiopia

For the lowland and highland bamboo in Ethiopia the flowering age is not precisely reported. LUSO CONSULT (1997) stated that sporadic flowering of *Oxytenanthera abyssinica* takes place about every 7 years, and then the clumps die down but shoot up one year later from the rhizomes which then needs to be controlled by cutting back. Like most bamboos, each LLB plant flowers only once in its life time and then dies. So far the highland bamboo is more endangered by its mass flowering.

When flowering occurs, always a bigger part of the more homogenous bamboo stand becomes of more concern (LUSO CONSULT, 1997). After bamboos flowered and died, restoration of bamboo forests depends solely on natural regeneration from seeds (Tian, 1987). However, the restoration process is slow. One reason is delayed seedling germination due to seed dormancy. Regenerating bamboo area is subjected to resource change after die-off.

When bamboo flowers it dies! Anyone familiar with bamboo has probably heard this. Although this sometimes happens, it is not inevitable; this phenomenon can often be an opportunity in disguise. It is a good idea to try to save the flowering plant as well as trying to grow new plants from seed. Clones with special characteristics are often not reproduced when grown from seed, so it is important to try to conserve them vegetatively.

The phenomenon of gregarious flowering may involve many plants, but not necessarily all plants of that species or clone. Sometimes bamboo of a species growing over a large area may flower at the same time. As with all plants, flowering and reproduction from seed is necessary for the survival and spread of the species.

There are bamboos that do not flower and, therefore do not set seed. But these bamboos are not found growing in the wild. They are cultivated plants, and are dependent upon man for their survival. Once mankind finds them of no further value, they will perish (Ned Jaquith, 1980).

The local communities in the flowering lowland bamboo areas know that the event provides seed. Many of them in different bamboo mass death areas are also participating in collection and selling of seeds to different organizations. There also is quite a lot of newly regenerating seedlings under the dead populations (Demissew *et al*., 2011). The communities however, still believe that the phenomenon is associated with certain disease. They also believe that there is high prevalence of trypanosome disease and subsequently death of large number of their animals in bamboo flowering years.

2.2.1 Consequences of flowering in Bamboo:

The flowering event of bamboos might be a blessing in disguises having both positive and negative consequences (Demissew *et al.*, 2011)

2.2.1.1 Positive aspects of bamboo flowering:

Bamboo flowering and hence seed setting is seen as a blessing phenomenon in that it gives a chance to have genetically more diverse next generation. Most bamboo populations are established through vegetative propagations. Sometimes a population might be of a single rhizome clonally extended to a vast area. Hence, all individuals of a population might have same genetic makeup (Stern, 2004).

This might result in total loss of the population if a certain disease or pest rises. Flowering creates the opportunity of gene mix up and the next generation via seed can have more genetic diversity.

Bamboo is an out crossing a wind pollinated plant where there is high gene random mix up. Apart from the advantage of genetic diversity, seeds are easier to handle, transport and store for long time. As a result of lack of seeds, propagation in bamboos remains mainly to be vegetative, which mostly require planting rhizomes together with the whole Culm. This constrains the transportation of planting materials long distances and in large amounts. In addition, such planting materials are viable only for few days which affect their success after being transported long distances. Seeds therefore provide chance to be stored as germ material ex situ such as in gene banks for long time, transported long distances for safe establishment of new plantations and easy to handle.

2.2.1.2 Negative aspects of bamboo flowering:

The gregarious flowering and subsequent death of all bamboos of over vast area causes big ecological havoc and threatens the livelihoods of the area. Impact on physical environment: Study results indicate that there is a significant depletion of soil nutrient in dead bamboo sites (Takahashi *et al*., 2007). This is argued to be the effect of microbes as nutrient sink in dead bamboo sites where there is not further source (Rai, 2007).

The total population failure after bamboo death leaves the land bare and takes at least few years for a bamboo to regenerate again (Ramanayake, 2006). Subsequently, soil erosion, landslides prevail (Helen Keller International, 2008). Once the entire population is dead, it will take a couple of years for new cohort to regenerate again. Unless the area is protected, it might also result in permanent loss of bamboo due to possible land use change.

There fore, the sensitivity of the newly emerging seedlings and possible change in land use can also be a problem.

A decade ago, the mass flowering and subsequent death of vast population of lowland bamboo in Benishangul-Gumuz regional state of Ethiopia, Metekel Zone, Mandura district, left only few surviving patches in the area after new regeneration and the rest of the bamboo area has been converted to other land uses (Embaye, 2006; Statz, *et al*., 2007).

As Kassahun (2003) informed, gregarious flowering and eventual death of all bamboo plants in a forest is a characteristic that may seriously affect the sustainable supply of raw materials for bamboo-based industries.

The newly regenerating young bamboo plants might be constrained by fire which is traditionally set as management of range lands particularly in Benishangual Gumuz region. The effect of fire to bamboo seedling however, is debatable. Some authors claim fire favoring bamboo seedlings (Keeley and Bond, 1999; Franklin and Bowman, 2003) while others are arguing against this idea (Saha and Howe, 2001).

2.2.2 Bamboo Regeneration and Propagation

Regeneration is the natural process by which plants replace themselves from their seeds or vegetative material. Natural regeneration is the establishment of young trees through natural seeding, sprouting, suckering or layering (Stephen, 1992).

Bamboo is a natural regenerative plant which naturally grows mostly in the forest as a bushy grass in tropical and subtropical ecology. It is also naturally found as an understory plant, which can also grow in moist regions and can be referred to as woody grass.

Bamboos can be propagated through the use of seeds (sexual) or by vegetative (asexual) methods, depending on the species available for plantations (Ramyarangsi, 1988).

However, not all bamboo species produce seeds, and even with those which do, the seeds are sporadic, as it takes about 30–120 years for some species to flower after which the parent plant dies off. Mostly in bamboo plants, the parents die off.

Regeneration, Cultivation, and Sustenance of Bamboo just after flowering is associated to those species which flower gregariously. There are only a few bamboo species that flower frequently to produce seeds and can be used to propagate seedlings when required. However, bamboo seeds have relatively short lifespan that prevents their preservation for longer periods. If a longer storage period is required, then an intense and sophisticated drying technique is adapted to enhance drying, after which they need to be sealed in an airtight poly bags or other vessels. Bamboo species that do not flower to produce seeds for regeneration of seedlings has to be propagated through vegetative techniques, such as culms (stem) cuttings or rhizomes of non-clump species (Rao *et al*., 1989; Fu and Banik 1996).

Following, mass-flowering, regeneration is usually from surviving rhizomes and only very seldom from seed. Agnew (1985) and Bussmann (1994), found evidence that rhizomes can persist for decades before making clumps. Bussmann (1994) and Agnew (1985) emphasized the vulnerability of young shoots to large mammal browsing in Kenya, although there is no proof that this ultimately causes the extinction of a regenerating bamboo-area. Also (LUSO, 1997) reported flowering in Ethiopia to be scattered every year becoming more abundant every seven years. Besides waiting for regeneration from seed and persisting rhizomes, establishment of stands from rooted plants employing vegetative technique is a wider technique in bamboo.

Conventionally *O. abyssinica* can propagate both sexually and asexually from seed and Rhizomes, respectively. According to Kassahun (2003), vegetative method of propagation for *O. abyssinica* has been found to be less effective and a cumbersome activity for large-scale propagation compare to propagation by seed since it is difficult to extract and transport rhizomes to long distances. However, conventional propagation through seed is still not successful to fulfill the demand of the country due to the restricted availability of seeds and loss of germination capacity within short period of time. Seeds are viable, having up to 100% germination rate starting from three days after sowing in laboratories (Phillips, 1995; Kassahun, 2003).

Most bamboo plants flower only once in their lifetime (14-50 years in most species) and then die soon after (LUSO CONSULT, 1997; Kassahun, 2003). They emerge again from germinating seeds if the site is not severely disturbed by detrimental factors such as rodents, fire etc. These phenomena were observed in the lowland bamboo forest of Pawe, North Western Ethiopia where the whole forest flowered and died in 1998 (Kassahun, 2003).But this is not always the same for all bamboo species (LUSO CONSULT, 1997).

Some bamboo species are successfully regenerated using culm cutting (Liese, 1995). However, raising planting materials of *Oxytenathera abysinica* from cuttings has been found difficult (Kigmo and Kamiri, 1987; Abeels, 1961). On the other hand, although the gregarious flowering cycle of the species is about 20 years (Fanshwe, 1972), it also produces seeds from sporadic out-of-phase flowering in the intervening period (Adlard, 1964). This is not the case with most bamboo species, they flower only once in their life time gregariously and die. When they flower, they expend a tremendous amount of food or energy producing flowers and seeds that stresses them to such an extent that they die.

Thus, their survivorship is dependent mainly on the success of reproduction by regenerating seeds and in some cases coppices from remnant stumps on every occasion that they flower (Akifumi, 1992).

On field observations made by Yigardu (*et al.*, 2016), in north western Ethiopia, in a particular place called Sherkole (Homosha District), the density of germinating seedlings or wildlings of lowland bamboo within previously mass flowered and mass died stands was found to be as high as 6 seedlings per 50 cm^2, i.e. on average, about 9 cm2 area per seedling. Thus, under natural condition, such crowded seedling density, together with the overcrowded weed population of the area, passes under different phases of the seedling stage. And they have recognized, during the early regeneration process (seedling phase), under natural condition, different processes can be: the establishment of seedlings, thinning of competing seedlings and stabilizing density to the nearly constant mortality of seedlings. Progressively, the seedling phase transforms into the mature vegetative phase.

2.3 Uses of Bamboo Resource

Bamboo is one of the natural resource of the tropics, and because of its wide distribution, availability, rapid growth, easy handling and desirable properties, it has been well used in the daily life of the local community for a wide range of purposes. It is a multipurpose non-timber plant (Bystriakova *et al*., 2004) with over 150 documented considerable potential to the socio-economic development and environmental protection (Yiping *et al*., 2010). Bamboo provides considerable economic, social, and environmental values for local communities (Mohammadi *et al*., 2010), among others, fuel wood, timber and non-timber products, construction materials, medicinal uses, and cultural values. Over 600 million people around the world generate income from bamboo, and millions live in bamboo houses (Liese, 1985).

Bamboo is the most widely used plant in Ethiopia, especially by the economically disadvantaged, local poor groups/communities (Melaku, 2006). If the resources are properly managed and utilized, over 12 billion Birr can be generated every year (Tadesse,, 2008 as cited in Yigardu, 2012).

The low land bamboo has enormous importance for the rural society, because of the shortage of proper woody plants for construction in the low lands. Medical use of *O. abyssinica* is documented in different countries including Ethiopia. In Ethiopia the root of LLB is applied in the treatment of skin disease (Birhanu, 2015), it is commonly used as alternative for timber in house constriction, fences and also as fodder for cattle, human food and as an energy supply.

Bamboo has traditionally multiple-use, has not only deeply rooted in human beings culture and civilization, but also closely related to the peoples' industry, agricultural production and daily life as well as protected and beautified their living environment. So it is useful to know what our bamboo resources are and how they play important roles in the human history, how we should manage these resources and utilize them reasonably (Fumaoyi, 1998).

The region has vast bamboo resources which could provide raw materials for income-generating businesses. Bamboo has been shown to be an excellent source of off farm income in many developing countries and could be equally effective in Ethiopia (INBAR, 2010). Lowland Bamboo is the main material for the construction of house, fences, fuel or as an energy supply, human food and for beehives in Assosa zone of, BGRS. For the Jeblawi people in the zone, the shoots of bamboo are very important for their nutrition.

Bamboo provides most of the fodder for the livestock in the area (LLUSO CONSULT, 1997).

In Assosa, where bamboo is used as a source of fuel energy, there exists a high pressure on the remaining natural bamboo stands. In the rural and urban area of Assosa, bamboo is of enormous importance for the society. Bamboo is used for fuel wood, construction, and as fodder for animals. The bamboo bud or shoots are sources of human food, and are used to make utensils and local furniture, and are the means for catchment rehabilitation. However, it has become threatened by agricultural expansion.

Where the plant survives fire in its natural habitat, the small stems get cut for pipes and arrow shafts, larger ones for fences, buildings, furniture, bed and baskets (Azene, 1993). There is indiscriminate forest clearance; hence, the economically valuable bamboo resource will disappear before its economic and environmental advantage are appreciated, unless important reversing mechanisms take place (Embaye, 2004).

2.4 Management of Bamboo Resource

Forest resources and forest land should be sustainably managed to meet the social, economic, ecological, cultural and spiritual human needs of present and future generations (Collins *et al*., 2000). In Ethiopia, the private bamboo forests which are all highland bamboo forests are not degrading much despite being harvested mainly for own use and for sale in local markets. However, the government owned bamboo forests (natural forests of highland and lowland bamboos) are degrading and eventually disappearing fast, although there are no statistically sound sets of data available to substantiate this point of view.

The government could not manage to establish incentive mechanisms to value and prioritize them as useful commodities that should receive attention and planned action. As a result adequate budget allocated to protect, manage, and use them properly is not seen to be budgeted (Adnew et al., 2006).

In addition Yigardu (2012) has also indicated incentives to be too little for sustainable management of native bamboo forests; hence, degradation and land conversion have resulted in a significant loss of bamboo forests and resources throughout Ethiopia (Andargatchew, 2008; Kelbessa *et al*., 2000).

One third of this recourse, i.e. 5.5 million tons, could have been harvested every year without adversely affecting sustainability if appropriate management was to be implemented. This is huge amount of resource being forgone for lack of proper management and utilization (Kassahun, 2003). Also yigardu (2012) has informed that, in Ethiopia, there is no management plan for government owned natural bamboo forests.

No protection what so ever from illegal harvesting, wildfire, pests and disease; no protection from encroachment and clear felling; no practical arrangements exist to manage, protect and utilize the forests.

The government owned bamboo forests are actually nobody's forests that have been suffering from the "tragedy of the commons" (Adnew et al., 2006; Yigardu *et al*., 2016).

Silvicultural management of *O.abyssinica* bamboo is heavily based on its growth habit, particularly the way the underground rhizome develops leading to the formation of culms.

Effective management involves systematic but selective cutting of mature culms. Selective harvesting of the crop ensures a sustainable supply of valuable and useful raw material. The removal of mature culms also maintains the vigor of the plant and allows for the continuous generation of new shoots (EABP, 2009).

In Ethiopia there is a planting experience of the highland bamboo by individual farmers and rural communities. But there is no information concerning the planting experience of the lowland bamboo. (LUSO CONSULT, 1997).

2.4.1 Ownership of bamboo stands

According to the Forestry Conservation, Development and Utilization Proclamation No. 94/1994 (Negarit Gazette, 1994),two types of forest ownership are recognized in Ethiopia: forests that belong to the government (federal or regional) and private forests. "Private Forest" includes a private forest developed by any person and includes a forest development by peasant association or by an association organized by private individuals. Ownership of bamboo forests in northwestern Ethiopia is mainly private i.e. individually owned by farmers, communally owned by communities in peasant associations and institutionally owned by the Ethiopian Orthodox Church.

2.4.2 Cutting Intensity and Cutting Cycle

Harvesting of lowland bamboo is haphazard, resulting in wastage of the resource. No harvesting technique is followed to extract mature culms within the clump (Yigardu *et al.*, 2016). Cutting bamboo culms at higher positions does not relieve bamboo stands from below-ground congestion. Higher stumps interfere with and hinder the possible robust newly coming shoots. It also leads to coppicing that brings about unnecessary remobilization of the minimal food stored on the stump. It also results in prevalence of old stumps that are not easily decomposed and allow recycling of nutrients. Harvesting was observed to be related with culms size rather than age class across the management systems Arun Jyoti Nath (et al 2015). Cutting position of some bamboo species is recommended to be immediately above the second culms node, i.e. culms should be cut as low as possible leaving one inter nodes above ground.

2.4.3 Management implications

Excessive harvest of bamboo irrespective of culms age and harvesting season has resulted in the poor regeneration of the stand. The high percentage of current year culms along with low percentage of older culms ages reflects the lack of a sustainable management system in practice. Higher intensity of exploitation in a low productivity area can further degrade the stands, which can lead to the elimination of the species from a given area (Nath et al., 2007). Overexploitation can lead to the extermination of species with limited distribution, endangering bamboos existence in the long term (Banik 2000, Adkoli 2002).

2.5 Threats to wood land area includes lowland bamboo

2.5.1 Threats to lowland bamboo

The negative outcome of bamboo flowering is documented in many research findings.

For example, John & Nadgauda (2002) stated that the death of bamboo forest after gregarious flowering resulted in much loss, and precipitated an ecological crisis. Unless and otherwise the species is replaced by natural regeneration or artificial propagation, the survival of the species will be in question (Embaye, 2000; Kelbessa et al., 2000; Kassahun, 2003).

However, because of human interference, natural regeneration is becoming difficult (Kassahun, 2003) as closing the entire area is difficult because of increasing human population pressure and a corresponding increase in land demand.The same situation is well documented by Banik (1994).

2.5.2 Impact of refugees on woodland of bamboo resources

As far as refugees have settled, the demand for fuel wood will increase and easily outweigh demands for construction wood (UNHCR, 2005b). According to UNHCR (1997) and Getachew (2009), information regarding clearing of forests for wood; an average refugee camp 1800 acres in its first year and 1200 for very year after. As a result, "entire settlements have been completely cleared of all trees and shrubs. Inhabitants of 3 - 4 years old camps had to walk for several hours to find trees and shrubs to cut" (UNHCR, 1997).

Since the refugees are not provided with any kind of fuel energy, they are solely dependent on the natural resources surrounding the camp for their fuel demand.

The study conducted for exit strategy indicated that fuel consumption of refugees has been 3-4 kg/person/day (exit strategy- unpublished document, 2008). Loss of vegetation close to refugees' camps is evident, resulting from unregulated agriculture & removal of wood for firewood & construction. Significant alterations have taken place in the landscapes of most camp areas. The problem with these forms of forest disturbances is that the plants often do not have sufficient time to regenerate and recover adequately, and thus, affect the ecosystem succession. (EMA, 1999)

3 MATERIALS AND METHODS

The research methodology has incorporated a description of the study areas, sampling techniques, types and sources of data, survey instruments for data collection and methods of analysis.

3.1 Description of the Study Area

3.1.1 Location

Benishangul-Gumuz National Regional State (BGNRS) is one of the nine regional states Established in 1995 by the new constitution of Ethiopia that created a federal system of governance. The region is located in the western part of the country between 9° 30′- 11° 30′ latitude in the North and 34° 20′- 36°30′ longitudes in the East. The regional capital, Asossa is located at a distance of 687 km away from the capital city of the country, Addis Ababa. The region has also international boundary with the Sudan and south Sudan in West, and it is bordered by Amhara Regional state in the East and North, Oromiya Regional state in the East and South East and Gambella Regional state in the South (CSA 1994). The total land surface of the region is estimated to be 50,380 km^2 (BOIPPCSA 2005).

BGR is divided into 3 administrative zones and 20 'woredas'. Homosha Woreda is one of the 20 woredas of the region located at a distance of 36 km North of Assosa capital city of the region with an area of 708.42 km^2 & it is found in eastern parts of the Benishangul-Gumuz Region, under Assosa Zone. which is also bordered by Kurmuk in north west, Menge in the north east, and Assosa in south.

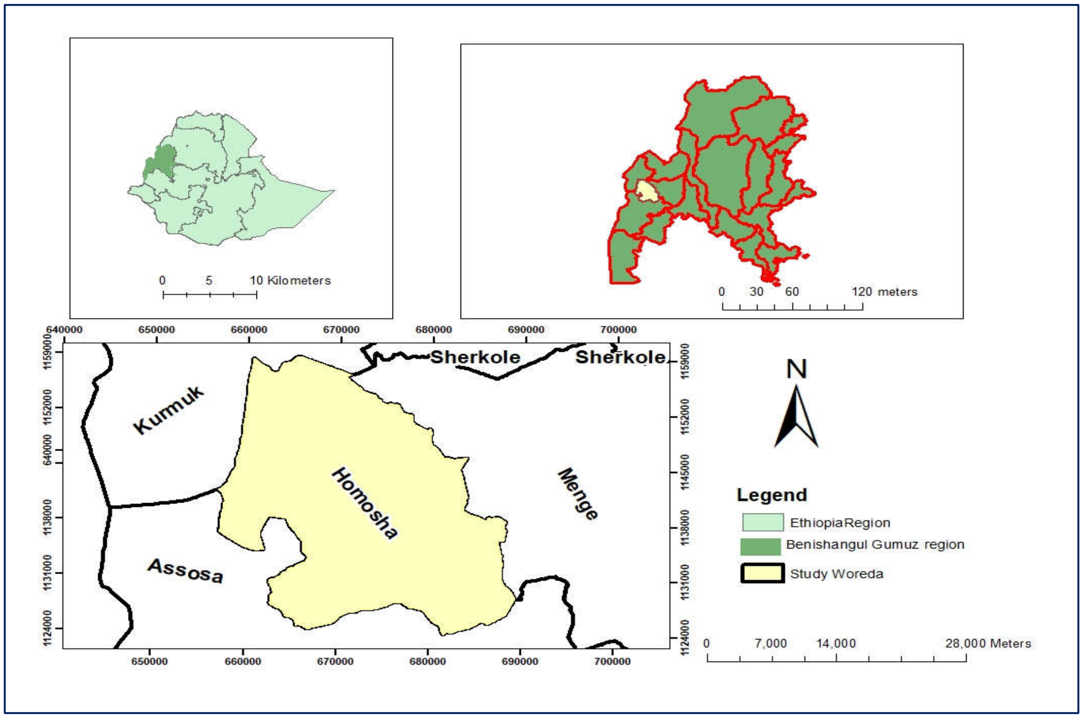

Figure 1: Geographical location of study area, Homosha Woreda

Jima kebele, which is agro-ecologically, classified as lowland (kola) is one of the study area, in Homosha Woreda. It is located on the asphalt road to Kurmuk Woreda at a distance of 9 Km from the woreda town. Protected bamboo forest area were used for inventory survey is found at the iterance of the village from Homosha (*Figure 2)*

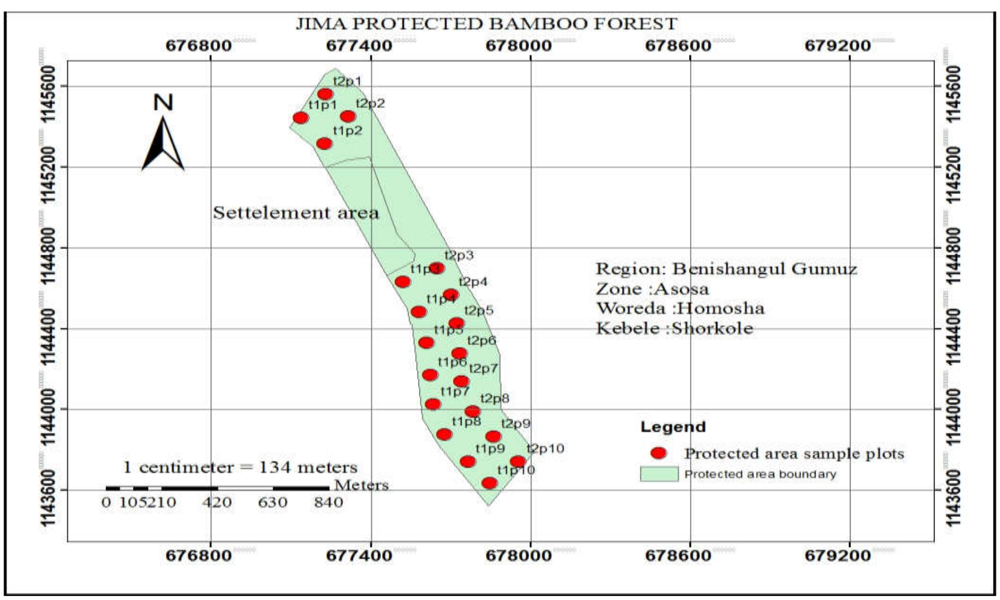

Figure 2: Sample plot distribution of Jima kebele protected bamboo forest

The other kebele which was proposed for this study is, Shorkole Keble on the same direction of North West on asphalt road to Kurmuk Woreda at a distance of 10 km from Homosha town. Unprotected forest area were used for survey is found in zone E at refugee camp (*Figure 3).* Currently these two Kebles do not have aged Bamboo population due to mass flowering and death phenomenon.

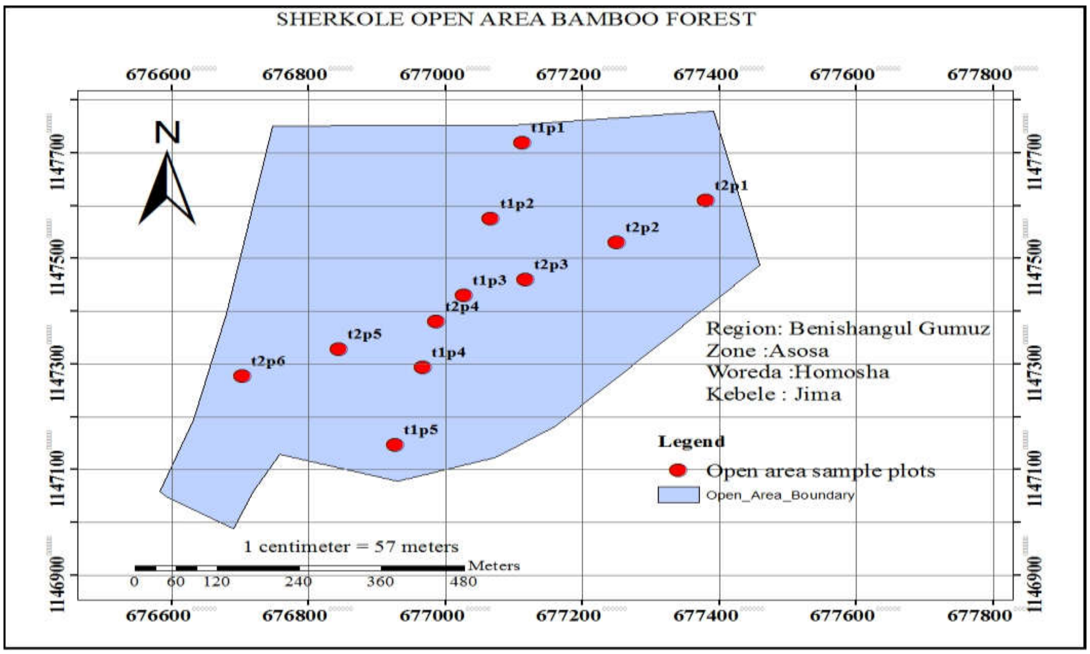

Figure 3: Sample plot distribution of Sherkole kebele open bamboo forest

3.1.2 Climate

According to the Assosa Metrological Service Agency the rainfall distribution pattern is mono-modal commencing towards end of April and ending in November with altitude ranging from 1100 to 1350 meters above sea level (m.a.s.l.), and the average rainfall ranges from 588-1,549 mm per annum. In the dry season, maximum daily temperature reaches to 21.4-31.5^{0}c, the hottest period is from February to April. The minimum temperature ranges, from 7.4-17.6^{0}c, depending on season and altitude (AMSA, 2017) (Figure 4).

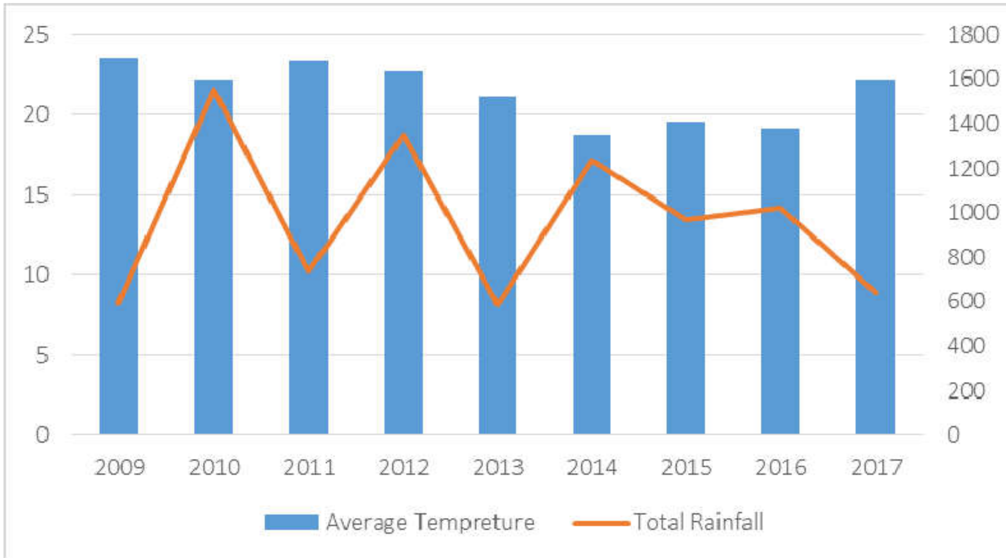

Figure 4: Climatic diagram showing average annual temperature and rainfall of Homosha District for 9 years (2009-2017).

3.1.3 Population

Based on projected data of CSA (2013), the current total population of the region is about 975,988. Currently, population density is sparse with a regional average of 15.91 people per square kilometer. Compared to the other Woredas, Homosha woreda is also not densely populated area in the region; it looks as if it is relatively of widely dispersed inhabitants.

Berta ethnic group is dominantly inhabited in the area. There are also other ethnic goups mostly from Oromiya and Amhara who came looking for of livelihood activities of which the majority are government workers. However, there is high number of refugee population around the study area of about 11,661 in on about 600ha area, due to its strategic location for settlement of refugees' (UNHCR, 2017).

As per an information obtained from the Homosah woreda Agricultural office the total number of population of Homosha woreda without the refugees is 29252 of which 14,894 is Male & 14358 is female (HWAO, 2009). Specifically, in the study Kebeles, the number of households is 146 in Jima and 231 in Shorkole. Total population wise, 722 are in Jima of which 356 are males and the remaining 366 female. In Shorkele, the total population is 3015 of which 1415 are male and the remaining 1600 female.

The total population of refugees in Sherkole Kebele is far higher than the native inhabitants accounting to 51.5 % (i.e. 11,661 refugees) Gender wise 6192 of these refugees are males and 5469 are females (Table 2).

Table 1: Total population of Sherkole Refugee community

Age group	Male	%	Female	%	Total	%
1-4	1053	90.03%	991	8.50%	2,044	17.5%
5-11	1474	12.64%	1384	11.87%	2858	24.5%
12-17	968	8.30%	873	7.49%	1841	15.8%
18-59	2594	22.25%	2122	18.20%	4716	40.4%
60 and >	105	0.88%	99	0.85%	202	1.7%
Total	6192	53.10%	5469	46.90%	11,661	100%

Source: UNHCR, 2017

3.1.4 Soil and Topography

Soil is often defined as the outer, mostly unconsolidated, layer of the earth's crust ranging from a few centimeters to more than 3m in thickness. It is further described as a natural body composed of a mixture of organic and mineral materials in which plants grow. The soil of the study area is deep reddish, brown sandy clay loam with PH 5.5.

The organic matter content is about 3.18% (BOFED, 2002). The larger area of the woreda has a diversified topography such as deep gorges with very steep slopes, very steep mountain ranges, valleys and flat to almost flat low land plains (BOIPPCSA, 2005).

3.1.5 Land use and Vegetation

The rugged terrains of the landscape are almost all under natural vegetation cover, mainly comprising of woody shrub grass land, shrub grass land, dense wood land, bamboo thicket and unprotected grass land.

In very few spots of the area along the valleys and plateaus where some settlements are seen, there exists cultivation to some extent. The reason for low population pressure on these areas is because of unfavorable climatic conditions (high temperature and high humidity), tsetse fly infestation and rampant malaria problems (BOIPPCSA, 2005). The vegetation of the region can be classified in to eight-vegetation types. Those are dense forest, riverine forest, broad leaved deciduous wood lands, acacia wood land, bush land, shrub lands, *Boswellia papyrifera* wood land and bamboo thickets (BOFED, 2017).

3.1.6 Socio Economic Condition

According to 1994 population & housing census, about 56% of the population was economically active. The major economic sector of the region is subsistent agriculture mainly through shifting cultivation, where maize and sorghum are the most dominant, from which 70.31% of the income is generated.

Compared to others, the unemployment rate is low (0.69) especially, in the rural areas (0.3). The government gave emphasis to the community participation and mobilization to enhance productivity both in rural & urban areas (BOIPPCSA, 2005).

3.2 Materials used

Materials like; measuring tape for measuring distance, plot size, and measuring the circumference of the clump, Hand compass for direction measurement (reading bearings), Diameter tape for Root collar diameter measurement, graduate measuring stick for measuring height, GPS (S62) for locating sample plots /ground reference, measurement of distance, and altitude, photo camera for image data collection, and other instruments like Rivan , rope, data collecting formats, writing pad, sheet of papers and pen were used and all primary data from field inventory & from HH respondents were collected.

3.3 Research Methods

3.3.1 Data Source

For the purpose of this research both primary and secondary data has been used to accomplish the desired objective. Primary data was collected using household survey, formal (focus group discussion), and informal discussion, field inventory of bamboo regeneration stands. The annual activity reports from relevant offices to supplement the information obtained from the primary sources was from thesis inputs, books, journals, census record, literature review, research article and annual activity reports from relevant offices.

3.3.2 Sample size & Sampling Determination

3.3.2.1 Field observation

Before the actual research work and data collection, a reconnaissance survey was conducted to have a general overview of the research sites. Direct field observation to see how the prospective area is suitable to this study (geographic features), to determine lay out and number of transect lines, sample sizes and to understand if the study sites are in different management system.

Participant observation was also another method used in this study. This involves direct observation in the field during the survey period and households data collection.

3.3.2.2 Sampling techniques

The study was carried out by which composite of an inventory assessment to see the density of natural regeneration of LLB after mass flowering and HHH survey activities for the management, utilization and institutional support practices of trends. A total of Eight bamboo growing kebeles have been categorized from the study district based on the information of natural resources development experts at woreda levels. Two representative Keble's selected purposely, due to their accessibility for transport, due to their location near to each other /adjacent enabling to comparison & as other kebles, which have missed their original stand cover of bamboo areas at the same time on the case of gregarious flowering and were compared a regeneration status of the areas have to be understood a management practices.

These respectively selected kebeles are Jima kebele which has bamboo areas relatively protected, the local people keeps it as protected area with no intervention of people and domestic animals, that they make a suitable condition for possible to restore the natural cover by its natural regeneration.

The other keble which have selected for the study was Shorkole, has a bamboo areas after flowering is severely disturbed due to more interference of refugees' for different activities & their home animals. The local people who lives around shorkole keble have not have taken care & makes a suitable condition for the land of bamboo areas after gregarious flowering enabling to bring back the natural cover on normal natural regeneration. Consequently to see this assessment, two areas of the study were identified as comparatively (site with good management and unprotected site) on bamboo regeneration status, Systematic random Sampling design technique was applied.

According to the geographical condition and homogeneity of the species, a total of 31 sample plots were set up for this inventory activities, that was 20 samples from Jima protected area of bamboo (50.79ha.) and again 11 samples from shorkole unprotected / non managed area of bamboo (43.83 ha.).

Parallel line transects were laid out from North to south for the protected area as its topographical shape of the land and based on the area coverage and this was 140m distance apart from one another in left and right. To avoid bias, the 1^{st} transect line was taken entered 10 meters from the edge of the forest. The other unprotected bamboo forest land has an oval shape & used a cross transect line to accumulate representative data.

Along each transect line 10m x 10m ($100m^2$) sample quadrates were plotted for the protected & for the un protected one (in both sites) systematically at 150 m distance from one plot to the other interval and four sub plots of the main plot (10m*10m), that was 1 x 1m ($1m^2$) at corners were employed for count and record seedling (Tamene,2016).

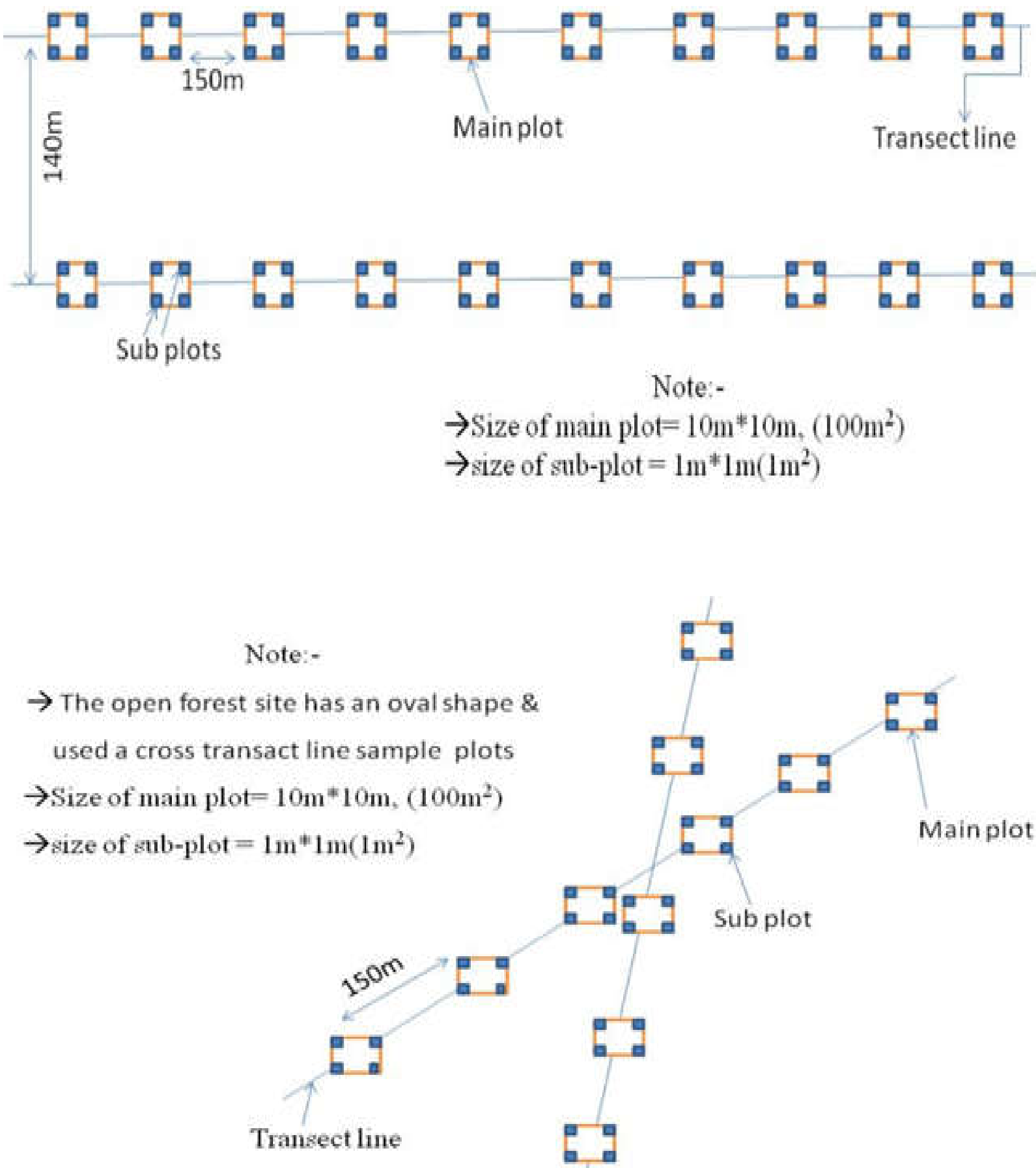

Figure 5: Schematic presentation of transects lay and plots sampled

On the other hand household sampling using simple random sampling technique was conducted to see the management & utilization trends of the local community., Structured and semi structured questionnaires were developed and administered to collect relevant information related to the management and utilization. Out of the total 377 house hold heads living in these two Kebles of study area, 80 HHH were randomly selected using the following simplified formula provided by Yamane (1967 cited in; Yilma, 2005) at 90 percent confidence level.

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

n= sample size for the research use

N= total number of HHs living in these two Keble of study area

e = margin of errors at 5-10%

Furthermore, formal pilot tests up on 15 households were carried out for a questionnaire format filling to check the ease with which respondents react to the questions, to make sure that the questions are relevant and easily understood by the interviewee. Also for those data collectors and participants of the inventory, one day orientation was given to enable them understand the questions and to provide them skill on how to approach individual households during the interview; how to communicate to each other on the field work during inventory technical activities. It was also found important to estimate the time required to accomplish the assessment.

All steps of these activities within the study area were done in consultation with the heads of both kebeles and the rural development agents at the kebles. In addition to these, experts (skilled personnel) from responsible governmental organization were allowed to participate on the inventory activities & to fill the questionnaires by the HHs and to follow up the technical process. A continuous close supervision was the main duty of the researcher who fully participated in all parts of data collection activities. Finally the survey questionnaire sheets from the households and the data from the field inventory were checked and collected from each study kebeles and were made ready for analysis.

3.3.3 Data collection

3.3.3.1 Bamboo Regeneration inventory

When sampling for bamboo regeneration data, a parallel and a cross transect line method were used to achieve a systematic distribution of the sample plots. After 4 transects and a total of 31 rectangular plots were laid out to census regeneration (20 samples from the protected bamboo forest (Jima Kebele, Arema Bamboo Forest) & 11 samples from the unprotected one (from Shorkole Kebele), the following parameters were recorded for farther analysis (Figure 3).

Within four sub-plots at the corners of each main plot, all available seedlings were recorded to determine the regeneration potential. The focus was on seedlings because the growth stocks were expected as seedling vegetative phase (Yigardu *et al.*, 2016). In each main plot (10m * 10m) bamboo plants /Culms, root collar diameters at 5cm above the ground (RCD) were measured for estimating size & density. Also measured were the heights & clump size (circumference) in order to know the growth characteristics & to see stand structure. The age of the stands was also identified, estimated & categorized as in order to compare the sites scientifically through these all parameters.

However, to analyze the size distribution of lowland bamboo forest under study the Root Collar Diameter (RCD) that was measured during the inventory was converted in- to DBH by diameter conversion model (David C. Chojnacky, 1999). So that to see if the size distribution of lowland bamboo in the area meets the standard (≥2cm) stated by (Tamene, 2016).

Plate 1: Field inventory activity at Jima Kebele/Arema protected (A, B & C) and Shorkele unprotected (D) Bamboo Forest.

The age determination of bamboo in each plot were differentiate by asking experienced community members with this regard and also based on Ronald (2005) criteria using internodes color, inter-nodes, epiphytes, Culm sheaths, sheath ring at node and branches (Table 2)

Table 2: Criteria used for bamboo culm age determination

Diagnostic feature	Age of plant		
	< 1 year	1-3 years	> 3 years
Internode color	light green	gets yellowish or darker	yellow, dusty or dark depending on landrace
Internode cover	Covered with white flour	Flour is falling off	No flour left
Internode epiphytes	No internode epiphytes	Has lichen and epiphytes	Has lichen and epiphytes
Culm sheaths	All or part of the culm sheath kept	Begin to fall off until none are left	No culm sheath remaining
Sheath ring	Whole sheath ring or part of it kept	Remaining sheath ring gets harder	No culm sheath ring , it falls off
Branches	Light colored, not tough; no secondary branches	Existing branches feel soft, turning in to yellow-green or dark after wards	Has secondary branches

Source: Ronald, p. (2005); Viet Ha Tran (2010).

3.3.3.2 Focus group discussions (FGD)

Focus group discussion was held to supplement and confirm information that was generated in the household questionnaire and in-depth interviews were also conducted with knowledgeable people about the ground situation. During information gathering, focus group discussion was carried out with 8-10 focus group members per study area and at worda office with relevant experts. The focus group of kebele members included kebele representatives of youth, religious leaders, Kebele administrators, extension workers, & others like bamboo planters having good knowledge of their locality and the natural resources were convened for discussion.

The issues addressed in the focus group discussion interview are indicated in Appendix 1 and Appendix 2 (Part I, II). Moreover, informal discussion were also held at the regional office, with department representatives of the Environment Forest & Climate Change, Agriculture & Rural Development, Extension, Biodiversity, Water Shad Management & Natural Resource experts and NGOs' representatives to dig out for more and reliable information.

3.3.3.3 Households interview

The sampling of households was made after the Kebeles were selected based on availability of the lowland bamboo forest and considering also accessibility. Attention was also given to livelihood base of the HHs towards bamboo resources. Household survey was then taken through structured & semi structured questionnaires to collect quantitative and qualitative data. As the composition of the population in the study area was homogenous who have the same ethnic and cultural practice, simple random sampling technique was employed using the village registers. This type of sampling was used to avoid biasness by giving all individuals equal chance for being selected /chosen. The technique is comparatively better to get more accurate data and representativeness of the population under consideration. Out of the total household heads living in the two Kebeles of study area, 80 representative house hold heads were randomly selected in proportion to each Kebele population (Jima 31 HHs & Shorkole 49 HHs).

Plate 2: Focused group discussion (Left) and interviews (Right) with different stack holders

3.3.4 Data Analysis

Data which were collected/recorded from the transect survey were sorted and organized in to tables with column of diameter at breast height, height, age group and number of seedlings as variables. These variables were tested across the two management regimes (protected and unprotected) using one-way Analysis of Variance (ANOVA). The stem/culms densities at the different diameter classes were tailed and analyzed by t-test to determine the bamboo population size class distribution. The regeneration potential was calculated by using the formula: Seedling Density/ha=No of seedling counts/plot area x10, 000. The resulting data were processed by SPSS statistical software Version 21 for comparison.

Before the questionnaires were entered in to appropriate statistical packages, they were edited and coded and the variables analyzed were the backgrounds of the respondents, in terms of frequency distribution, percentages, measure of central tendency, compare the behavior of various demographic categories (age, education gender, etc) in relation to use and management of lowland bamboo. Generally analysis for questionnaire was mainly descriptive as percentage, frequency, and table and associated graphs used in the interpretation of the results.

4 RESULTS

4.1 Regeneration status of lowland bamboo (*Oxytenthera abyssinica*)

Bamboo stand structure of lowland bamboo is mainly concerned with the number of plants per unit area and the age composition (age structure). These parameters are important in investigating bamboo stand dynamics and yield. The number of plants under the three age-groups varied under the two management regimes (protected & un protected sites) and were statistically significant at $p<0.05$. Moreover, plant height also showed variation between the two sites assessed and was statistically significant (*Appendix 4*).

4.1.1 Stand density

Number of seedlings per hectare of protected site (252250) was significantly higher than that of unprotected site (121364) (Table 3). Moreover similar trend was observed for the culms density which was is 9185 ha^{-1} for protected site and 3555 ha^{-1} for unprotected site. The species densities of culms in the two sites were significantly different (One-way ANOVA, $p<0.05$) (Table 5). This type of distribution indicates that the protected site had the highest level of seedlings recruitment. But no seedlings per culms is high for un protected forest.

4.1.2 Age structure

In general, based on the age structure data of the two sites, the study showed large variation in density of the lowland bamboo under each age classes. In protected LLB forest: <1 year old (4225 culms/ha), 1-3 years old (4960 culms/ha), and over 3 years old (0 culms/ha). The age structure of bamboo showed that about 54 % (4960 culms ha^{-1}) belonged to 1-3 years age class followed by 46% (4225 culms ha^{-1}) to the stand below one years of age and none was recorded in above three years age category. Moreover, the age structure of bamboo culms for unprotected area followed similar trends which was 60% (2146 culms ha^{-1}) for 1-3 year old and 40% (1409 culms ha^{-1}) for < 1 year old (Table 3).

The ratio 1.5:1 age structure indicates that the stand is at good age structure and well managed. The number of seedlings in protected area (252250 seedlings ha^{-1}) was significantly higher than that of unprotected site (121364 seedlings ha^{-1}). The density of seedlings between the two sites was also significantly different (One-way ANOVA, $p<0.05$) (Table 5).

Plate 3: Regenerating low land Bamboo (*Oxytenanthera abyssinica)* from seed in Jima kebele at Arema Bamboo forest

Table 3: Number of plants per hectare of the three age- groups under different management regimes (n=31, mean ±SE)

Scale	**Items compared**	**N**	**Mean Number of Culms /ha**
Age group protected	<1year	20	4225±406
	1-3 Year	20	4960±710
	>3year	20	0±0
Agegroup unprotected	<1year	11	1409±858
	1-3 Year	11	2146±535
	>3year	11	0±0
Seedlings	Unprotected	11	121364±2942
	Protected	20	252250±3205

Harvesting was observed to be related to culms size rather than age across the management systems (Figure 6). Average diameter of standing culms was 3.15 cm, while it was 4.1 cm for cut culms. This indicates that culms with larger size are usually harvested even at their early age depend on its size for preparation of rope and crafts. Culm size distribution was recognized to be related with management regimes, less disturbed sites with bigger culms and severely disturbed sites with smaller culms (Figure 6).

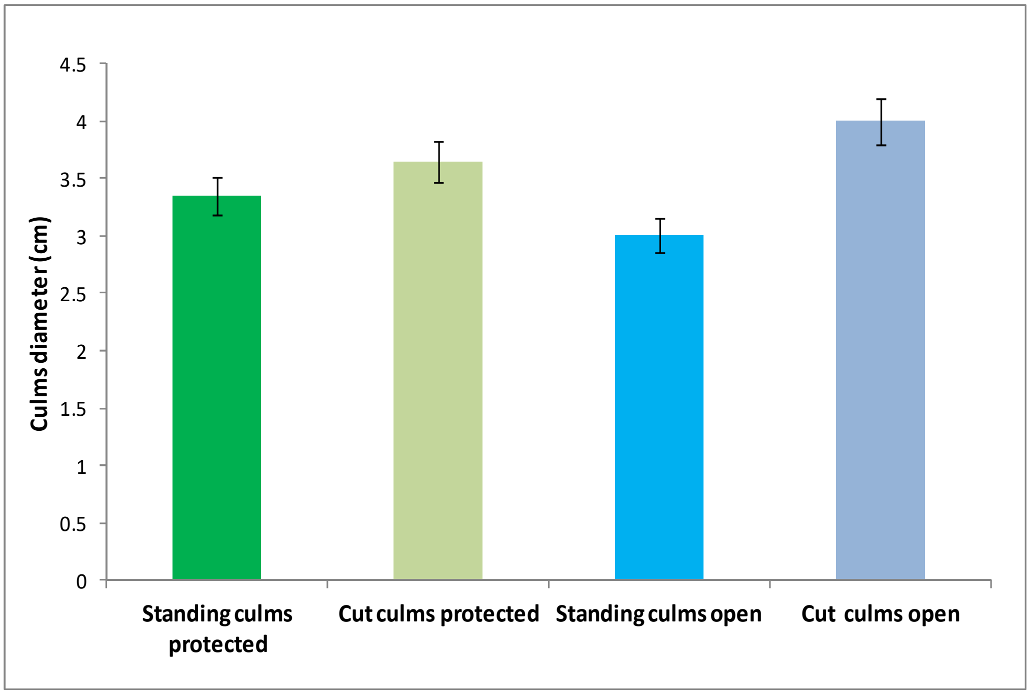

Figure 6: Average differences in culms diameter between standing and harvested culms in the two sites

Standing and cut culms size distribution was found to be statistically significant for unprotected sites (t=2.12, df =10, p<0.1) (Table 4).

Table 4: The size class of standing and cut culms in the two sites studied

	90% Confidence Interval of the Difference		
	t	Df	Sig. (2-tailed)
Culms DBH protected – Cut Culms DBH protected	-.409	19	. 687*
Culms DBH unprotected – Cut Culms DBH unprotected	-2.122	10	.043**

*"** significant at P<0.1 *insignificant"*

Table 5: Analysis of Variance (ANOVA) indicating significant differences in the regeneration potential of the two sites, in Jima and Sherkole Kebeles of Homosha District

Variables		Sum of Squares	df	Mean Square	F	*P.*
Protected Seedlings density (Unprotected)	Between Groups	5969.896	1	149.247	1.545	.009
Seedlings density (Protected)	Between Groups	39544.580	1	1581.783	5.368	.000
Culms density (Unprotected)	Between Groups	90.350	1	4.755	1.195	.0257
Culms density (Protected)	Between Groups	119.144	1	9.929	.908	.013
Culms height	Between Groups	40.89442	1	40.89442	26.4680	4.72

4.1.3 Growth characteristics

Both growth characteristics, namely Culm diameter at breast height (DBH) and Culm height showed different results among the studied areas. Higher DBH values were obtained from protected area (3.10 cm), and smaller from unprotected site (Table 6). Similar trend was observed for height with values 4.50 and 3.80, for protected and unprotected areas respectively. Height of the culms per plots studied was statistically significant between protected and unprotected sites ($t=2.831$, $df=10$, $p<0.05$) (Appendix 4)

Table 6: Diameter and height of plants per plot of the two sites studied

Management Regimes	**Maximum DBH (cm)**	**Mean DBH (cm)**	**Maximum height (m)**	**Mean height (m)**
Protected	3.85±0.1	3.10±0.1	6.7±0.2	4.50±0.28
unprotected	3.1±0.1	2.80±0.1	5.8±0.3	3.80±0.25

4.2 Demographic characteristics of households

Farmers' settings in different household situations affect the perception and management of bamboo and its contribution to livelihoods. In this study, from the total of 80 HHs interviewed 80% were male headed and the rest 20 % were female headed (Table 7).

The average age of the respondent HHs was 43 years with ages ranging from 25 to 69 years of the total sample HHs those in the productive age class (18-45 years) comprise about 58.8%. Regarding the marital status about 86.3% are married followed by 8.8% widowed and 3.8% divorced (Table 7).

The average family size of the respondent HHs in the study area was 8 persons, with minimum and maximum of 2 and 17 respectively. The number of years the respondents have lived in the study area can have effect on the knowledge about bamboo utilization, planting and its management. Thus, in this study, the average number of years the households lived in the study area was from 8 to 69 with average value of 41.84 years.

Education level of HHs may influence way of managing bamboo based livelihood practices or adoption of new technology. In terms of literacy level of the respondent HHs, about 40% were illiterate followed by those who have attended primary school (grade 1-6) 32.5% followed by those who are in read and write group (15%) and only 12.5% have attended secondary school (grade7-12).

With respect to the role of HHs in the community high proportion of households (62.5%) has responded that they are involved in many development activities in their communities as community members (ordinary citizen). About 26.3% HH respondents were in others category that is serving the community as leaders of women and youth representatives and social associations, 7.5% are religious leaders and 3.8% are community leaders. The respondents' livelihood/occupation has also an impact on the extent of bamboo resource utilization and its management.

According to the data collected the majority of HHs interviewed were farmers (90.0%) followed by forest guards (8.8%) and Merchants (1.3%), (Table 7).

Table 7: Socio-demographic Characteristics of respondents in the study area (N=80)

HH characteristics Variable)	Parameter	Frequency	Percent
Sex	Male	64	80.0
	Female	16	20.0
Age of the respondent	18-30 years	13	16.3
	31-45 years	34	42.5
	46-60 years	27	33.8
	>60 years	6	7.5
Occupation	Farmer	72	90.0
	forest guard	7	8.8
	Merchant	1	1.3
Household family size	1-5 numbers	21	26.3
	6-10 numbers	40	50.0
	11-15 numbers	16	20.0
	>15 numbers	3	3.8
Marital status of Household	Married	69	86.3
	Divorced	3	3.8
	Widow	7	8.8
	Single	1	1.3
Education Level	Illiterate	32	40.0
	Read and Write	12	15.0
	Primary	26	32.5
	Secondary	10	12.5
Years lived in the village	≥30years	76	95.0
	≥5 and <30	4	5.0
Role of household head in the community	Community member	50	62.5
	community leader	6	7.5
	religious leader	3	3.8
	others	21	26.3

4.3 Farmers' knowledge on Bamboo resources management, utilization and Processing

4.3.1 Farmers experience in bamboo stand management

In the study area bamboo stand managements like protecting bamboo forest from fire damage by making fire break, enriching the existing bamboo forest through reforestation, weeding, controlling illegal cutting through guarding were carried out. About 48.9% of respondents mentioned to be involved in one or more of these management activities. Accordingly, the survey results showed that, 21.25% of all respondents stated protection from domestic animals and illegal cutting by guarding to be the most common type of management; followed by fire break establishment (18.8%) and reforestation (3.8%). 5 % of the respondents also said they weed their bamboo clumps found in their farm land (home garden). However, the remaining 51.25% respondents were not involved in any of bamboo stand management activities (Table 8).

Nearly half of the respondents (48.9 %) get involved in management and 82 percent of all the management were found to be restricted to making fire break and guarding.

Table 8: Different bamboo management activities carried out by sample HHs (N=80)

Management activity	Yes		No	
	N	%	N	%
Making fire break	15	18.8	11	13.75
Reforestation	3	3.8	6	7.5
Weeding	4	5	16	20
Protection (guarding)	17	21.25	8	10
Total	39	48.9	41	51.25

Responses related to the status of the resource base indicated that there is a decreasing trend where (95%) due to agricultural land expansion, illegal cutting and mass flowering (32.5%), followed by lack of conservation efforts, Wild fire and mass flowering (28%), the combination of illegal cutting, wild fire, lack of conservation efforts and mass flowering have contribute (15%), The remaining HHs pointed all the causes witch mentioned except over grazing also to the bamboo stock shrinkage observed so far (10%) (Table 9**)**.

Table 9: Existing farmers knowledge on bamboo resource status in the study area (N=80)

	Number of responded HHs	**Percent**
Trend of Bamboo forest		
Depleting	76	95.0
Not depleting	4	5.0
Causes for its depletion		
Only mass flowering	7	8.8
Agricultural land expansion, Illegal cutting and mass flowering	26	32.5
Lack of conservation efforts, Wild fire and mass flowering	23	28.8
All except over grazing	8	10
Illegal cutting, Wild fire, Lack of conservation efforts and mass flowering	12	15.0

4.3.2 Farmers knowledge on bamboo resource ownership and legal status

In the study area the existence of law governing forest utilization and management were not well recognized by the community (57.5%). Even though there are task forces facilitating the protection of bamboo forest their role in creating awareness and enforcing the law was very limited so far (66.2%) (Table10). Although the sampled HHs responded that the ownership of the forest within their kebele belongs to be the administration of the community 34(42.5%), belongs to government 37(46.3%) and belongs to both Government and community 9 (11.3%). There is a confusion to name the forest of the study area as state-owned forests (forests owned by communities and local authorities) or privately owned forests because of the absence of any legal concessions, licenses, permits and legal agreement documents governing the bamboo forests in the area.

According to the focused group interview result insufficient enforcement capacity is often due to institutional weaknesses coupled with a lack of responsibility and accountability in the implementation of the forest policy and legal frameworks. Powerful vested interests that are directly or indirectly involved in illegal forest operations were also due to lack of alternative economic opportunities for local people.

Table 10: HHs responses to the legal status of forest law enforcement (N=80) Condition of laws

<table>
<tr><td rowspan="2">Conditional of laws</td><td colspan="2">Yes</td><td colspan="4">No</td></tr>
<tr><td>N</td><td>%</td><td colspan="2">N</td><td colspan="2">%</td></tr>
<tr><td>Forest governing law</td><td>34</td><td>42.5</td><td colspan="2">46</td><td colspan="2">57.5</td></tr>
<tr><td>Law enforcing body</td><td>71</td><td>88.8</td><td colspan="2">9</td><td colspan="2">26.8</td></tr>
<tr><td rowspan="3">Effectivness of forest law enforcement</td><td colspan="2">V.good</td><td colspan="2">Medium</td><td colspan="2">Poor</td></tr>
<tr><td>N</td><td>%</td><td>N</td><td>%</td><td>N</td><td>%</td></tr>
<tr><td>5</td><td>7</td><td>19</td><td>26.8</td><td>47</td><td>66.2</td></tr>
</table>

4.3.3 Farmers' experience in bamboo growing/cultivation

The study has revealed that farmers in the study area have some experiences in cultivating bamboo. Moreover, the farmers have largely gained the experience from NGOs as well as from parents, friends, neighborhoods and government (Table 11).

Farmers' knowledge on season of bamboo planting is almost similar. With regard to supply of planting material, about 44.7 % of the respondent households mentioned to get it from NGO's support followed by personal collections from wild and some from government supply. Most of the households use seedlings donated by different bodies (42.1%) followed by own collections from wildlings of about 50 cm long shoots through offset method of propagation (23.7%) and very few uses seed sowing (Table 11).

Table 11: Practices and Sources of knowledge and skill for bamboo cultivation (N=80)

	Yes		**No**	
	N	**%**	**n**	**%**
Bamboo growing experience	38	47.5	42	52.5
Sources of Experience for bamboo cultivation				
NGOs	13	34.2	-	-
Government	10	26.3	-	-
Parents, neighbor and friend	15	39.5	-	-
Sources of planting material				
NGOs	17	44.7	-	-
From wild	13	34.2		
Government	8	21.1	-	-
Kind of planting materials used				
Seedlings	16	42.1	-	-
Seed sowing	7	18.4	-	-
Collections from wildlings	9	23.7	-	-
Seedlings and Seed sowing	6	15.8	-	-

4.3.4 Utilization of bamboo resource

This study revealed that the trend on bamboo harvesting and utilization by framers has increased since the last twelve years (Table 12). Views related to utilization indicated that there is an increasing trend in this respect due to better access to roads and wood resource limitations resulting in more utilization of bamboo particularly in areas where it vigorously flowered and died (Table 12).

According to the households' response, after mass flowering and death of bamboo, most of the resources were getting exported massively to Sudan by merchants after being collected by local farmers through the guidance/order of administrators at different levels. Now, the actual continuous and huge bamboo forests have disappeared and in their place, only patches of new regeneration from seeds and rhizomes are seen here and there.

This new regeneration, because of both anthropogenic and other factors, has come to be completely different from the original bamboo resource stock in the study area.

As a result, local people of the study area are now forced to search for the resource either from communal bamboo forest areas, too far from the village, or to collect from the regenerating bamboo stock nearby their village by any means (43.8%). Moreover, the other villagers were forced to walk too far distances to collect the resources basic to their livelihood (26.3%) followed by those either who can buy the resource from market or collect from the regenerating bamboo forest and this is mostly done by the HHs who can't go farther distances for bamboo resource collection (16.3%).

4.3.5 Bamboo processing

The study tried to assess some value addition practices, and small number of people processed bamboo culms to different materials /products like bamboo shelf, mat, baskets, bed, beehive, different sized table and chairs informed through FGD. The majority of community members were not participated on kind of activities. Households close to road side have shown a relatively better activity on bamboo processing.

Table 12: Bamboo utilization trends during the last 5-12 years in the study kebeles (N=80)

Trend	**Trend of resource base**		**Trend of bamboo utilization**	
	n	%	n	%
Increased	0	0	73	91.25
Decreased	78	97.5	7	8.75
No change	2	2.5	0	0
The source of bamboo for HHs after mass flowering	HHs(n)		%	
From areas too far to the village	21		26.3	
From market	7		8.8	
From the regenerated & under aged stock	2		2.5	
From areas too far to the village and From market	2		2.5	
From areas too far to the village and From the regenerated & under aged one	35		43.8	
From market and From the regenerated & under aged one	13		16.3	

The knowledge of bamboo harvesting season and stand age is important to get quality and better stand of bamboo Culm. About 56.2 % of the respondents harvest their bamboo at any time/season as they need the resource and the remaining 43.8 % harvest during the dry season (Table 13) due to the reason that most of HHs was free of work load, they thought as period of construction and they also believe cutting in dry season will keep the culms healthy and strong. The farmers in the study area harvest bamboo at different ages, the majority of respondents (67.5 %) harvest bamboo culms at the age of less than one year and greater or equal to 3 year, about 25% greater or equal to the age 3 and few (5%) harvest bamboo of all ages (Table 13).

Table 13: Farmers knowledge on bamboo harvesting season and age of harvesting (N=80)

Knowledge on bamboo harvesting season and age		Any time needed		Dry season
N		45		35
%		56.2		43.8
Harvesting age	1-2 years	≥3 years	<1 & ≥3 years	All age category
n	2	20	54	4
%	2.5	25	67.5	5

The majority of HHs living in both Jimma and Sherkole kebeles (93.8%) use bamboo resource for construction, Only few households (16.3%) sale bamboo in local market to generate income. However the remaining HHs use bamboo for fence (58.8%), wood rope (23.8%), making mate (18.8%), export to Sudan (21.3%), use for furniture making (26.3%), feed directly the new shoots (33.8%) and the remaining 20% responded bamboo as their animals feed (Figure 7, Appendix 5).

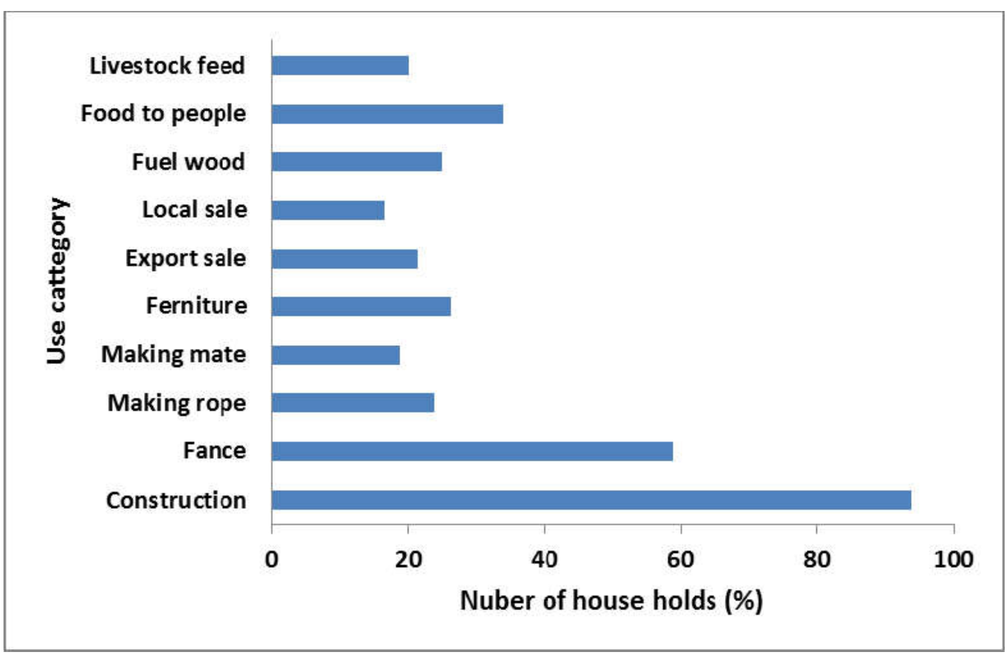

Figure 7: Ranking use of bamboo resources by respondents

Plate 4: Use of bamboo resources by local people of the study sites

4.4 Extension services on bamboo development, utilization and processing

The provision of training on development, management and utilization of bamboo in the last five years (2012-2017) by government and nongovernmental organizations was assessed. Accordingly, of the total respondent HHs only 21.1% received training on bamboo development, management and utilization (Figure 8). This training was given by NGOs (16.3%), Government (3.8%) and by both government & NGOs (1%).

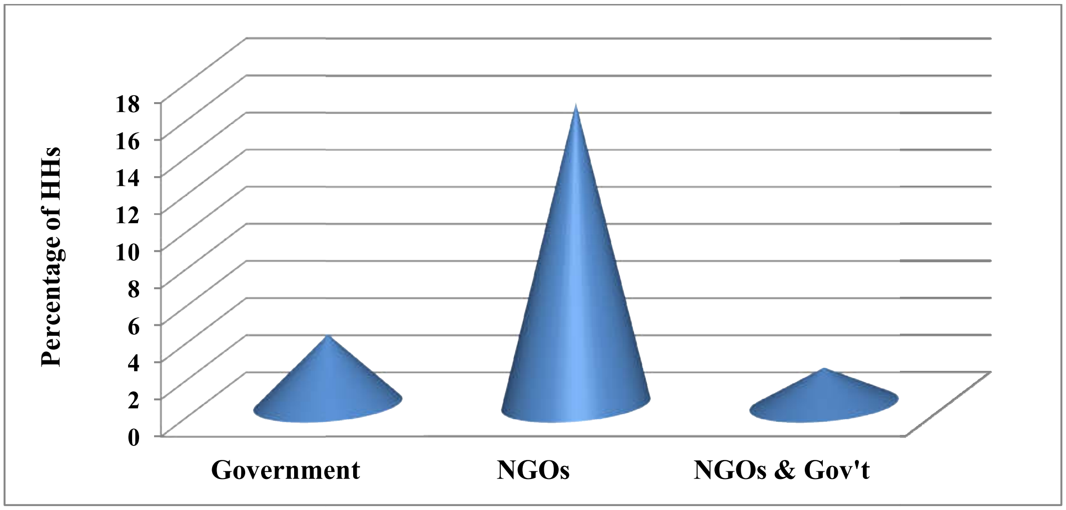

Figure 8: Farmers who received extension services and trainings on bamboo development, management, utilization and processing

4.5 The current threats to the regenerating bamboo population in the study area

Despite the fact that some conservation practices were taking place in the two kebeles considered in the study surrounding the bamboo forests, the present study revealed several problems hindering the natural regeneration of lowland bamboo at Jima and Sherkole kebeles. Some of the most important problems were frequent, like the year to year fire occurrence, conversion of previously bamboo areas in to agricultural land after mass flowering and death, continuous harvesting of bamboo by people from refugee camps which according to 100% of the respondents view, may lead to absolute failure of future regeneration**.** (Table14). Other problem was associated with the collection of flowered bamboo for export to Sudan which accounts 95% (n=80)

Table 14: Constraints to naturally regeneration bamboo after gregarious flowering

Threats to regeneration of bamboo	Yes	No
Fire hazard	80 (100%)	0
Change in to agricultural land after mass flowering	62(77.5%)	18(22.5%)
Over harvesting by settlers (Refugees)	80 (100%)	0
Massive harvesting of flowered & died bamboo for export to Sudan by Merchant	76 (95%)	4(5)

Plate 5: Disturbance of bamboo forest by refugees at Sherkole Kebele

5 DISCUSSION

5.1 Regeneration Status of lowland bamboo

Bamboo stand structure is mainly concerned with the number of plants per unit area (stand density) and the age composition (age structure) and the resulting parameters (Maoyi *et al.*, 2005).

Low seedlings density per hectare (252,250 ha^{-1}) in the protected lowland bamboo forest at Jima kebele 'Arema Bamboo Forest' was manifested by low regeneration of lowland bamboo from seed germination and its establishment. The seedling is affected by a suit of biotic and abiotic factors, including amounts of viable seeds produced during mass flowering and high disturbances which is much smaller than the seedling density by Yigardu (*et al.*, 2016), research report made in Sherkole Kebele (Homosha District), which informed that the density of germinating seedlings or wildlings of lowland bamboo within previously mass flowered and mass died stands was found to be as high as 6 seedlings per 50 cm^2 (12,000,000 seedlings ha^{-1}). To the contrary Tamene Yohannes (2016) reported that the seedling density of bamboo in Anbesa Forest was 427.50 per ha. Likewise, comparable culms density with DBH ≥ 2cm in the protected area (9185 culms ha^{-1}) implies the existence of a good potential for the restoration of bamboo communities. This is also supported by Tamene Yohannes (2016) stating that the Density of bamboo culms in Anbessa forest with DBH ≥ 2 cm was 12,458.56 stems per ha. The density of both the culms recorded was higher than the one recorded by Yigardu *et al*. (2016) and LUSO (1997) which states that under natural conditions, the number of culms per ha of lowland bamboo was reported to be only 8000. However, plot level records indicate that plantations of this species can have at least 40,000 culms per ha which is much lower than the natural seedlings recorded in the study area.

The differences observed may be due to much viable seed set because of mass flowering and age of the forest. Also the low proportion of seedling and culms density at unprotected site (121364 ha^{-1} & 3555 ha^{-1} respectively) indicates the impact of human and animal interference on their regeneration.

Stand density between the two sites varied markedly. The lowland bamboo stand structure of the study area (both protected and unprotected) was mainly represented by < 1 year and 1-2 year old culms. This is similar with the study by Banik (1993) stating that smaller and thinner bamboo culms recruited up to third year of stand age reported in *O. abyssinica*. So immature culms, their small size can't yield the desired output of villagers and therefore not harvested at initial stage of stand development. A stable population structure with preponderance towards young aged culms is key for maintaining the stand productivity (Yuming *et al*. 2001; Nath & Das 2011). However, the size of culms is a main factor to indicate the stand condition. Usually big bamboo can produce and accumulate more nutrients for stand growth because it occupies more space and absorbs more mineral elements (Yigardu 2012).

Growth performance of lowland bamboo culms is influenced by site productivity, disease, fire, and management type. The overall mean height growth of bamboo at the study site (both protected and unprotected) was 4.5 m and 3.8 respectively which is greater than 3.5 m at the age of two year reported by Yigardu *et al,*. (2016). ENBAR (2009) also reported that the height of green culms for lowland bamboo ranged from 2 to 12m. The overall average diameter at breast height for both protected and unprotected areas was 3.1 cm and 2.8 cm respectively. This result was slightly lower than values report by Tamen Yohannes (2016) indicating an average values of 4.5cm, with range between 2.8 and 6.2 cm. It is also slightly lower than values reported by Yigardu *et al.,* (2016) indicating 3.5cm. This may be because the bamboo population of the study site is much younger that the rhizome is not well established to give new shoots that gives rise to larger culms. Analysis of data revealed a loss of 75% of the total stock in both unprotected and protected belonged to culms with bigger DBH (4.5cm) and none culms with the age greater than three year was recorded in the standing clump in both study sites. Culms of bigger diameter are usually harvested for construction purposes in their third or fourth year and younger ones of the some size for preparation of crafts (Lybeer *et al*., 2006; Nath *et al*., 2007).

5.2 Farmers knowledge on management, utilization and processing of lowland bamboo

In the study area standard and scientific bamboo management practices such as mulching, application of manure, selective thinning, and weeding etc… were minimal. However, there are sorts of cultural management practice recorded during an interview. According to the survey result of all respondents only 21.25% stated that protection from domestic animals and from illegal cutting by guarding to be common management practices they observed so far. This is in agreement with report of Adnew et al., (2006) that indicated the non-existence of management practice in Ethiopia, for government owned natural lowland bamboo stands. No protection what so ever from illegal harvesting, wildfire, pests and disease; no protection from encroachment and clear felling; no practical arrangements exist to manage, protect and utilize natural lowland bamboo forests.

According to the Forestry Conservation, Development and Utilization Proclamation No 94/1994 (Negarit Gazette, 1994), two types of forest ownership are recognized in Ethiopia: forests that belong to the government (federal or regional) and private forests. In the study area majority of the respondents know that bamboo forest in their area belongs to either the government or to the community. Whereas a very few respondents stated that the forest belongs to both the government and the community. But the existence of laws governing forest utilization and management were not well recognized by the community. This is in agreement with the report of Kelbessa*, et al.,* (2000) and Adnew *et al*., (2006) that indicated government owned bamboo forests to be are actually no body's forests that have been suffering from the "tragedy of the commons" due to lack of awareness and limited law enforcements.

In the study area, there is a limited experience of bamboo cultivation. The observed bamboo plantations in the homesteads and agricultural farms were natural regeneration with some cultivation experiences from NGOs. This study concurs with the report by Kelbessa et al*.,* (2000) that indicated, as a result of lack of value addition on bamboo resources, farmers to have been slow in promoting cultivation of indigenous bamboo. This is also supported by (Ananta Ghimire, 2008) indicating that in western Ethiopia most farmers to have very few clumps (1-4 Clumps) of bamboo in their homesteads and that they don't do any silvicultural operation in natural bamboo plantation. However, with the strong technical and financial support from NGOs, they have started bamboo plantation in the community forest in a small scale using scientific methods of cultivation.

In the study area bamboo is harvested for construction and fuel wood during the dry season because most HHs are free of work load at that time and it is also the right time for construction. They also assume no seedling is in its active growth time so that it is not getting hampered by harvesters. Moreover, they also believe if they are cut during the dry season the culms can remain healthy and strong. In the dry season the starch content of bamboo culms becomes less and hence, bamboo product remain less sensitive to insect and pest attack (EABP, 2009).This is also supported by Tran (2010) who advised harvesting should be carried out during the dry season when the culms nutrient and starch content are at their the lowest level in order to prevent culms from being attacked by borers.

In addition, newly sprouting shoots will not be damaged when bamboo is harvested during this time. According to Tran (2010), a good harvesting age for bamboo culms ranges from 2 to 3 years. To the contrary, majority (67.5%) of the households in the study area harvest bamboo culms every year at the age of <1 and ≥ 3 years depending on the end use, Culms of the age of 3 and above are harvested for construction. This is done because bamboo can attain its maturity and better quality culms within this age class. But on the other hand people of the study area harvest bamboo at its young stage (<1 year) mainly for rope and hand crafting and the newly sprouting shoots for food. This idea agrees with the report of Ueda, (1960) and Fu & Banik, (1995), who indicated methods for sustainable harvest of plantation bamboo to exist while for wild stand does not. As per their suggestion, a sustainable harvesting technique requires to be worked out.

According to Lybeer *et al*. (2006) and Nath *et al*. (2007) culms are usually harvested for construction purposes in their third or fourth year and younger ones for preparation of crafts. This activity may damage the newly sprouting shoots and may hamper its regeneration. Almost majority of the respondents (75%) selectively harvest young culms for rope and handcrafting, matured for construction, dead, diseased and malformed, for fuel wood and new shoots for human food, new leafs and branches for animal feed. This is also supported by INBAR (2003, 2005, 2006, and 2007), where in Eastern Africa, local people harvest bamboo year round especially when there is scarcity of food.

With regard to bamboo culms processing, there is very little experience at the study site though some respondent households living close to refugee camp in Sherkole kebele have better experience in processing bamboo in to different products such as shelf, mat, basket chair, beehive, tables, beds etc…. This is because bamboo resource users close to the Sherkole refugee camp have got better training and material support to process bamboo culms in to different products from some NGOs and projects like World Vision (WV) and

Natural Resource Development and Environment Protection (NRDEP). Bamboo culms were also sold to Sudan by merchants during mass flowering and death.

With regard to extension services such as training, material and technical support and advices about bamboo management, utilization and processing, less attention is given. However, a few farmers had got technical and material support from NGO and project link World Vision (WV) and Natural Resource Development and Environment Protection (NRDEP).

The finding showed that the contribution of bamboo to livelihood is crucial to local community. In addition to income generation, the community uses bamboo for house construction, fencing, for making of different furniture, for animal fodder, for human food and a lot of other benefits. This report agrees with the study of Tefera Belay (2015) indicating that there are differences in use and skill distribution of people among regions. In Sheka bamboo is used for fence (94%), house construction (61%) and fuel (27%) of interviewed households. They do not use or know mats and basketry and only an insignificant number of informants mentioned it as useful for furniture.

5.3 The current threats to the regenerating bamboo population in the study area

Despite the fact that some management practices were taking place in the two kebeles considered for the study, the present study revealed several problems hindering the natural regeneration of lowland bamboo at Jima and Sherkole kebeles to still exist. Some of the most important problems were frequent and year to year fire occurrence, land use change after mass flowering and death by local people, continues harvesting of bamboo by people from refugees, etc. This may cause future regeneration practices to be unsuccessful which was also the belief of all 100% (n=80) respondents. This concurs with the report of UNHCR (1997), which stated that refugee camp depletes 1800 acres in its first year and

1200 for every year after. As a result, "entire settlements have been completely cleared of all trees and shrubs. Inhabitants of 3 - 4 years old camps had to walk for several hours to find trees and shrubs to cut". This is also supported by Saha and Howe, (2001) who indicated that the newly regenerating young bamboo plants might be constrained by fire which is traditionally set as management of range lands particularly in Benishangual Gumuz region.

Another problem was associated with the harvesting of dried bamboo during mass flowering and death for export to Sudan, which accounted for 95% (n=80) of the respondents. This agrees with the report of Kigomo (1998) who stated clear cutting depresses the rate of recovery of bamboo after cutting. According to Embaye (2006) and Statz, *et al*., (2007), after the mass flowering and subsequent death of vast population of lowland bamboo in Benishangul-Gumuz regional state of Ethiopia, Metekel Zone, Mandura district, only few surviving patches in the area were left after new regeneration where the rest of the bamboo area has been converted to other land uses. Degradation and land conversion have resulted in a significant loss of bamboo forests and resources throughout Ethiopia (Andargatchew, 2008, Kelbessa *et al*., 2000).

6 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

From the preceding results and discussion of this study, it can be concluded that, stand density of the two sites showed marked variation. Lack of protection and unregulated harvesting from villagers, merchants and people from refugees caused such drastic decline in stand density in unprotected site at Sherkole kebele than the protected sit at Jima kebele /Arema Bamboo Forest. A stable population structure with preponderance towards young aged culms was observed in the protected site and this is a key for maintaining the stand productivity in the future.

Significant difference in total interned stand density and height of culms have been observed among the two sites (protected & un protected) and cut culms have been observed between the two sites studied. Farmers living close to the refugees have better experiences of planting bamboo due to trainings, market access, increase in bamboo products and better knowledge and skill than the distant ones.

In the study area, there is a limited experience of bamboo management and cultivation. The observed bamboo plantations in the homesteads were natural regeneration with some cultivation experiences from NGOs. However, with the strong technical and financial support from NGOs, they have started bamboo plantation in the natural forest in a small scale by the scientific method of cultivation.

The finding further depicted that extension services such as training, material and technical support and advices about bamboo management, utilization and processing, is reported as useful, less attention is given to implement. However, a few farmers living close to the main road and Sherkole refugee camp had got technical and material support from NGO and project link World Vision (WV) and Natural Resource Development and Environmental Protection (NRDEP).

The contribution of bamboo to livelihood diversification is significant in the study site. Collection from wild and production of bamboo is one of the major means of income and livelihood of the local community. In addition to income generation, the community use bamboo for house construction, fencing, for making of different furniture, music and weapon instruments, animal fodder and human food and contributes a lot for income and livelihood of the HHs. The trend of bamboo use by local community has been increasing through time but the resource base is getting depleted.

Despite the fact that some conservation practices were taking place in the two kebeles, it was not significant to counterbalance the depletion of the standing stock. Similarly, the research identified several problems which hinder natural regeneration of lowland bamboo. These include frequent fire occurrence, land use change by both local farmers and investors after mass flowering and death, unresponsive harvesting of bamboo by people from nearby refugees and intensive harvesting of dead bamboo for export to Sudan by merchants.

6.2 Recommendation

The bamboo resource in the study area is found in precarious situation and treat continued unchecked. Therefore urgent attention is needed to allow for restoration of the previously existing bamboo stock. To this end, the following suggestions are offered;

- There is need to improve compliance with the existing forest laws and the regions' lowland bamboo protection and development strategy for sustainable utilization of bamboo resources and the regions' land administration and use proclamation.

- There is also a need to regularly review the existing bamboo off-takes with a view of reducing the harvesting pressure being exerted on the deteriorating bamboo stock in Homosha District, This requires strong linkage and full participation of all stakeholders including bamboo harvesters, religious organizations, governmental organizations, community based organizations (CBOs) and NGOs.
- Bamboo growers and processers need to be supported by providing them with improved technologies and inputs, trainings, technical manuals and other necessary technical support;
- Further research in the wider scope is needed on the status of lowland bamboo after its mass flowering in the region in order to generate better technical recommendations, management and utilization of bamboo in the region.
- Management plan for natural lowland bamboo should be prepared for sustainable management and utilization of the bamboo resources.
- Sherkole Kebele is currently hosting refugees with 11661 populations settled on 600 hectares were intensively using the bamboo resource. So all the responsible bodies should treat the refugees according to the refugees' administration regulations and should expand the energy alternative supply that reduces pressure on natural bamboo stand.
- Finally, there should be a ban on live bamboo export to Sudan including the use trucks which often ferry bamboo from the region in general and from Homosha in particular. The diminishing bamboo in Benishangul Gumuz Region which is the home of lowland bamboo cannot satisfy the ever-increasing demand especially for commercial purposes unless supported with plantation development.

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APPENDIXES

Appendix 1: Household Survey Questionnaire and Checklist for Focus Group Desiccation

Questionnaires to collect data for assessment indigenous management trends and to identify major constraints of LLB in Homosha district, Ethiopia.

Dear respondents,

My name is G.Medhin W.Gebriel, Msc student of Hawassa University Wondo Genet college of Forestry and Natural resources. The Research that I am currently conducting is ‘Evaluating the Natural Regeneration of Lowland Bamboo *(oxytenathera abysinica),* After Mass Flowering and Mass Death in Benishangul Gumuz Region, Northwestern Ethiopia’’**.**

My humble request is that you kindly answer the questions through this questionnaire which concerns an assessment of traditional management trends of low land bamboo & identifying major constraints on its sustained, which supports the objective.

I would have used that all the responses for the research (academic) purpose. Thus, I kindly request you to read all the questions and give your response clearly.

Thanks in advance for all your co-operation!!

Part I: Community Level (HHH) Questionnaire:

Remark:

- For all closed (structured) questions, circle the answer/s that apply
- Write short and clear explanation for the open-ended ones
- For any choosing article” others “pleas list what you know on the side of it

1.1. Household interview:

1. Name of enumerator ………………………Signature…………………….
2. Date of interview: ……………………………………………..
3. Name of district …………………………………………………
4. Name of kebele administration: ………………
5. Questioner no………….

1.2 *Household Identification characteristics:*

6. Name of the household head.............................
7. sex: a)Male:.……. b) Female
8. Age of household head: ………………
9. Job /Occupation:……………………………
10. Household's family size: Male……..Female …….. Total………….
11. Marital status of the household: a)Married, b)Divorced, c)Widow, d)Single
12. Education level: a)Illiterate, b)Read and write, c) Primary (1-6), d)Secondary (7-12), e) Complete (grade12 and above)
13. For how long have you lived in this kebele? ………… years
14. Social role of household head in the community, a) Ordinary citizen /community member, b)Community leader, c)Religious leader, d) Other social leader

1.3.Questionnaire: On Bamboo Management practices & its constraints

1. Do you think that the bamboo forest is diminished? A) Yes B) No
2. If your answer for Q 1 is yes, how you evaluate the changes and put the main causes orderly? ____
3. Who is the owner of natural bamboo forest in your village? A)The Government B) Community C) Individuals D) Others, list them_____________________
4. Have you ever participated in conservation of communal bamboo forest? A) Yes. B) No
5. If your answer for Q 4 is yes, in which activities you participate or willing to participate? A) Afforstation B) Risk avoidance (eg. Fire protection) C) Information provision
6. Are there any task forces to protect NF in your kebele? A) Yes. B) No
7. If your answer for Q 6 is yes, Judge its effectiveness? A) Very good B) Medium C) Poor
8. Is there community by law to administer natural Forest in your keble? A) Yes B) No
9. Do you manage bamboo? A)Yes B)No
10. If your answer for Q 9 is yes, what type of management methods were you apply to improve bamboo stand quality? ____

11. How you observe trend of bamboo management in the last five year (2013-2017)? A) Increasing B) greatly decreasing 3) slowly decreasing D) No change
12. What about the trend of bamboo acquire to harvest experiences in the last five years?
    1= Increasing 2= Decreasing 3= No change

13. If decreasing, by how much you expect with comparing before & after mass flowering?
14. How were you access the bamboo? A) Legally B) illegally, if it is legally, how it is performed? ____

15. How many intervals of years did you observe for bamboo mass flowering at your kebele? ____
16. Do you think bamboo is regeneration well? A) Yes B) NO
17. If your answer is yes, for Q 16 how?
18. If your answer is no, for Q 16 why not?
19. Is there bamboo land changed to Agriculture land after mass flowering is take place at Your keble? A) Yes B) No
20. If your answer for Q 19 is yes, by whom it takes place? A) Investment Activity B) Resettlement activity C) locale people for expansion agricultural D) outsiders to obtain land E)others________________________________
21. In what way you think Investment influences bamboo deforestation? A) getting agricultural land B) Mass Harvesting for house Construction C) Fencing D) Fire wood/Charcoal. E) Others_______________________________
22. Have you ever planted bamboo? 1) Yes 2) No
23. If your answer for Q 22 is yes, from where you got an experience & how many hectares do you have as your property? _____________________________________
24. Whom you gave you the planting materials (seedling) of bamboo? A) From the government support, when………. B) From NGO's support ………. C) From own D) If others specify__________________________
25. What type of bamboo propagation methods where you apply? A)Seedling B) Vegetative propagation C) Sowing /using seed D) Other E) Nothing was tried
26. For what purpose were you cultivating bamboo? A) For Income generating B) for domestic use C) for both of the above

27. Which age category of bamboo you were preferred to utilize most of the time? & why?

Young/less than 1 year/____

Intermidate/1-3 year/____

Older age/≥3 year____

28. When were you cut /harvest a bamboo? A) any time as you need it B) summer (rainy season) C) winter (dry season) D)Spring E)Autumn What were your reasons for preferred this season?_______________________________________

29. By what manner you were harvest bamboo? A) By clear cutting B) by periodically selective matured bamboo only C) By Cutting matured bamboo at any time D) other____

30. Have you ever received any external support in relation to bamboo management? A) Yes B) No

31. If your answer for Q 30 is yes, from whom where you got & when you got it? A) Government B) NGOs C) Private bamboo factory D)Others(specify) & list the type of support____

32. For what purpose were you using bamboo before mass flowering is happened? Pleas rank in number in order to your choice/preference

For construction	For fuel wood
For fence	For Rope
For furniture/handicraft	For food
For Animal feed	For making mate
For export sale	
For lokal *sale*	

33. How were you utilized the huge dried bamboo stands /a number of culms at time of mass flowering? A) Sold for outsiders B) we were left as it is C)other (specify)____

34. If you were left as it is what happens was it after A) was burned by fire hazard B)was mulched on its area C)other_______________________________________

35. Did you collect a seed of bamboo on the time of mass flowering? A) Yes B)No

36. If your answer is yes, for what purpose were you collected? A) For own plantation B)Sold to others C) Collected but not get a market & it was became out of use

37. Is there a fire hazard problem on bamboo forest? A) Yes B) No,

38. If your answer for Q 38 is yes, what causes you think for fire outbreak? A) deliberately ignite by some one B)Hunting C)Agricultural land clearing D)Beekeeping E)Charcoal production F) Smoking tobacco G) Others________________

39. Do you get extension services or advice concerning planting and utilizing of Bamboo?
    1) Yes 1) No, If yes,
    Bywhom? ____
    When? ____
    Aboutwhat? ____

40. Do you get training of bamboo propagation, management and utilization in the last five years (2013_2017)? 1= Yes 2= No

41. If your answer for Q 40 is yes what type of training and from whom you or your family gets the training? Thick under the articles & list the time on remark place

42. Have you ever received any type of training concerned mass flowering of bamboo & its Impact? If yes,
    When? & by whom? ________________________________
    If not why not? _____________________________________

43. From where you get bamboo culms at present /after mass flowering?

44. Do you think refuge people make high influence on bamboo forest A)yes B)No

Appendix 2: Checklist for focus group discussion

Part I. Check list for kebele level/community base on concerning Management of Bamboo & its Constraints

1. What changes do you observe and how you measure bamboo coverage in the last ten years in your local area?
2. What are your traditional Practices/trend on management, conservation, plantation /propagation & utilization of bamboo?
3. Can you specify the action you have taken on the time of mass flowering to manage the resource & the area of bamboo for natural regeneration?
4. How you were utilizing the dead Culm/ resource & its seed on the case of mass flowering?
5. Have you trained on bamboo species? If that specify the type & the performer.
6. What were the Major problem / constraints regarding to bamboo management & utilization at your area?
7. Do you think bamboo is regeneration well? If yes, how? If no why?
8. Do you specify especial limitations/constraints for Regeneration after mass flowering is happened?
9. What positive & negative impacts you observed concerned bamboo forest as refugees living in your kebele ? pleas spiffy if any correction by government
10. What you are suggesting for bamboo sustainability in your area as well as in your woreda?

Part II. Checklist for woreda office/experts level

Concerning Management of Bamboo & its Constraints

1. How changes do you observe and how you measure bamboo coverage in the last ten years in your woreda as well as the region?
2. What were the Challenges and opportunities of LLB management and utilization activities in the last five years?
3. Is there any rule & regulation or guide line based on the forest low confirmed for bamboo species management & proper utilization activities? If yes, how you implemented & supervised it?

4. What management and conservation practice of LLB have you implemented? Is there any special treatment for natural Regeneration?
5. For what reason do you use management practices?
6. What Types of bamboo propagation and cultivation methods you applied in your woreda? & Is it practices by individual farmers
7. Does the local community prefer bamboo from other trees? If yes, why & specify the Main reasons.
8. How you measure the trend of bamboo management and utilization at local /community level?
9. How partners are working together on bamboo development & management?
10. What type of supporting or training have you given for woreda community concerned to bamboo spices on last five years?
11. Specify if there is GOs and NGOs extension services about bamboo development and management in last five years at community level?
12. What impacts were emerging on the case of mass flowering & how you were controls it? (for all +ve &-ve impacts)
13. What overall significant changes have been observed in socio-economic and environmental aspects due to decreasing of bamboo resource?
14. What do you think on bamboo regeneration status?
15. Do you specify any limitations/constraints for regeneration of bamboo after mass flowering is happened?
16. Is there any insects and pests that affect the bamboo seed germination & plant at the regeneration age?
17. What positive & negative impacts you observed concerned bamboo forest as refugees living in your woreda? Pleas spiffy if any correction you have taken.
18. What you are suggesting for bamboo sustainability in your woreda as well as in the Region?

Appendix 3: Bamboo inventory Data Record Sheet

Field data collection format for Bamboo seedling / Include Saplings ≥ 2−< 5 cm RCD, and Bamboo matured ≥ 5cm in DBH

Date of Collection: _____________; Name of data collector: _______________; Woreda:_________; Kebele: _______________;

Transect No_______________________ Slope ___________________ Altitude _________________________

Location /GPS Coordinates: X _________________Y___________________

Plot No.	**Seedling / Include Sapling ≥2−< 5cm Root collar diameter**				**Clumps with Bamboo includes ≥ 5cmDBH (Matured)**					**Plant age Distribution**					**Remarks**
	Counts	**Plant No**	**RCD (at 5cm)**	**Ht(m)**	**Clump No.**	**Clump Size(m)**	**No of culms**	**DBH (at 1.3m)**	**Ht(m)**	**No**	**DBH**	**<1 yr**	**1-3yrs**	**>3 yrs**	

NB: Use 10x10m ($100m^2$) size plot for Bamboo tree inventory and 1x1m ($1m^2$) size plot for counting Seedling

Appendix 4: Diameter (cm) and height (m) of plants per plot of the two sites studied ($n=11$; $p<0.05$)

	95% Confidence Interval of the Difference		
	t	df	Sig. (2-tailed)
Culms DBH protected – Culms DBH open	1.970	10	.077*
Culms height Protected – Culms height Open	2.831	10	.018**

Appendix 5: Bamboo use matrixes ranking in number of respondents on their Choice /preference

Purpose of use	**Value**	**Percent**	**Rank**
Construction	75	93.8	1st
Fence	47	58.8	2nd
Wood rope	19	23.8	6th
Making mate	15	18.8	9th
Export sale	17	21.3	7th
Local sale	13	16.3	10th
Furniture	21	26.3	4th
Fuel Wood	20	25.0	5th
Food for people	27	33.8	3rd
Animal feed	16	20.0	8th