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Original Research Article

Highland Bamboo (*Yushania alpina*) Cultivation Systems and Management Practices: The Case of Bamboo Growers in Guji Zone, Southern Ethiopia

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Abstract

The study was designed to investigate Highland Bamboo (*Yushania alpina*) Cultivation Systems and Management Practices in Guji Zone, Southern Ethiopia. Semi-structured interviews, field observations, focus group discussions, and key informant interviews were used to collect the required data. For semi-structured interviews, a total of 240 sample households were selected randomly from the study districts. The collected qualitative data was analyzed using simple descriptive statistics. The study results showed that, as compared to their long term experience, farmers area coverage of the land allocated for bamboo planting purpose was very minimum. Farmers of the study areas grow seven types of highland bamboo (*Yushania alpina*) landraces. Bamboo growers of the study areas were naming highland bamboo landraces based on their color, height, roughness and thickness of the culm, internode length, splitting nature and sprouting ability. The present study found that, farmers of the study districts were commonly planting the highland bamboo in homesteads (31.25%), road sides (20.8%), farm lands (18.75%), farm boundaries (16.6%), and river banks (12.5%) of growing niches. The time of bamboo planting is coincided with the start of the rainy season and farmers are usually planting highland bamboo in May each year. The majority (75%) of the bamboo growers of the study districts used culm off-set planting followed by rhizome planting technique (21%), and direct seed sowing (4%). Bamboo growers of the study districts used animal manure, compost, fencing, thinning, branch pruning, slashing and weeding management practices for better growth of bamboo culms and integrated crops. In terms of cutting cycle, (91.7%) of the farmers were used different cutting cycle and only (8.3%) of the households were didn't follow any cutting cycle. Moreover, (90%) of the farmers cut their bamboo culms during winter time and only (10%) of them were cut bamboo culms year round. Lack of extension and training, over and poor harvesting methods, lack of advanced planting material, expansion of agricultural land, livestock grazing and climate change were identified as the major challenges of highland bamboo production of the study areas. Therefore, attention should be given on sustainable utilization and conservation of highland bamboo resources and farmers should be encouraged by the government and non-government organizations through research and extension services.

Keywords: Bamboo growers, Cultivation systems, Growing niche, Landraces, Major challenges, Management practices

INTRODUCTION

Bamboo is an evergreen, erect, and perennial grass categorized into the plant family of Poaceae which includes around 1200 species and grows in tropical and subtropical regions of the world (Lucas, 2013; Desalegn

and Tadese, 2014; Darabant et al., 2014). Moreover, bamboo is one of the fastest-growing plants to meet the increasing needs of human population (Mera and Xu, 2014). The global land bamboo resource covers an area of around 14 million ha of lands. Out of the total cover, Africa's share is estimated to be about 1.5 million ha of land with around 40 species (Embaye, 2003).

Ethiopia accounts the largest bamboo resources in Africa, which is estimated to be 1 million hectares of natural bamboo forest, and sharing approximately 4.2% of the global bamboo resource and 8.3% of the country's total forest area (Sebrala, 2021). Highland bamboo (*Yushania alpina*) and lowland bamboo (*Oxytenanthera abyssinica*) are the two major indigenous bamboo species in Ethiopia, and they covered around 100,000 ha and 800,000 ha, respectively (Kindu, 2010; Mulugeta and Fantu, 2012). The highland bamboo (*Yushania alpina)* plays a very essential role socially, economically, and ecologically in areas where it occurs in both naturally and planted (Sebrala, 2021).

The two indigenous bamboo species, *Yushania alpina* and *Oxytenanthera abyssinica* (A.Rich Munro) are distributed in Benishangule Gumuz, Oromia region, Southern nationalities, and Amhara region (Teshome, 2020). The highland bamboo grows naturally in the Southern, South western, Central and North western highlands of the country with altitudes ranging from 2200m to 4000m a.s.l.; whereas the lowland bamboo grows in the western part along major river valleys and in the lowland within altitudinal range of 1100–1700 m.a.s.l (Kelbessa et al.,2014; Terefe et al., 2016). Bamboo constitute a very important and versatile resource world wide. A lot of Asian, African and South American people rely on bamboo products for their housing and farming tools (Troya et al.,2014). In Ethiopia, highland bamboo is an ecologically and economically important indigenous species with a narrow ecological range (Demissew et al.,2011). The current use of highland bamboo (*Yushania alpina)* is for furniture (traditional processors and modern workshops), house construction, fencing, water storage/water pipes, baskets, agricultural tools, beehives, household utensils and various artifacts (FAO, 2005). However, natural regeneration of highland bamboo (*Yushania alpina)* is usually hampered due to human interference, mass flowering, and climate change (Embaye, 2000; Demissew et al., 2011).

Bamboo can grow in different niches such as farmland patches, riverbanks, farm boundaries, roadsides, homesteads, and urban areas. It is also the most important agroforestry species cultivated around the homestead to improve productivity in a household (Yuming et al., 2004; Lobovikov et al., 2007). Likewise, bamboo plays a key role in restoring soil fertility through the accumulation of organic matter and nutrients during the fallow period (Embaye et al., 2005). In bamboo-based Agroforestry systems, the presence of bamboo also reduced the weed density under the Agroforestry practice (Dev et al., 2015).

Ethiopia has a significant bamboo resource on farms, especially highland bamboo (Raven et al., 2006). In recent times, farmers have significantly increased the size of their bamboo stands in response to increased demand for wood substitutes (INBAR, 2005; Mekonnen et al., 2014). Highland bamboo (*Yushania alpina)* is growing in different pats of Oromia region, and a total of 102,396 ha of land is covered by natural and plantation of highland bamboo resources (Desalegn, and Tadesse, 2014). As well, highland agroecology of Guji Zone is well known for highland bamboo (*Yushania alpina)* production. In this regard, Guji Zone have five highland districts in which indigenous highland bamboo (*Yushania alpina)* is growing, and around 7,460 hectare of land is covered by highland bamboo plantation (Aschalew and Sintayo, 2022). Moreover, highland bamboo (*Yushania alpina)* resources of the area has vast potential for sustaining forest resources, maintaining land degradation and economi-cally supporting rural communities' livelihood. Therefore, the overall objective of the study was to identify Highland Bamboo (*Yushania alpina)* Cultivation Systems and Management Practices in Guji Zone, Southern Ethiopia.

MATERIALS AND METHODS

Description of the study areas

The study was conducted in Ana Sora, Dama, Dimtu Hambela and Uraga districts of Guji Zone, in Oromia Region, Southern Ethiopia. Ana Sora district is situated at a distance of 410km from Addis Ababa, capital city of Ethiopia. Astronomically, the district is located between 6°20'30" - 5°57'30" north latitudes and 38°39'30" - 38°57'30" east longitudes. Ana Sora district receives an annual rain fall of about 1400-1800 mm and the annual temperature of the district ranged from $17.5c^0$-$28c^0$ and the altitude ranges from 1900-2850 meters above sea level. The district is characterized by mixed economic activities, mainly agricultural practices which constitute the major livelihood of the people.The farmers of Ana Sora district produces diverse cereal crops such as bread wheat, food barley and maize, pulse crops such as faba bean and field pea and other horticultural and root crops.

Dama district is located at a distance of 401km from Addis Ababa, capital city of Ethiopia. The district has an area of 375.270km^2 . Astronomically, Dama district is located between 6°7'33" - 6°20'52" north latitudes and 38°20'46" - 38°39'4" east longitudes. The annual rainfall nearly about 1000-1500 mm and the annual temperature of the district is nearly about $15c^0$-$20c^0$. Dama district is bordered by, Uraga district in the south and Bore district in the east. The elevation of the district ranging from 2400-2932 meters above sea level. The district is characterized by two type of climatic zone, namely temp-

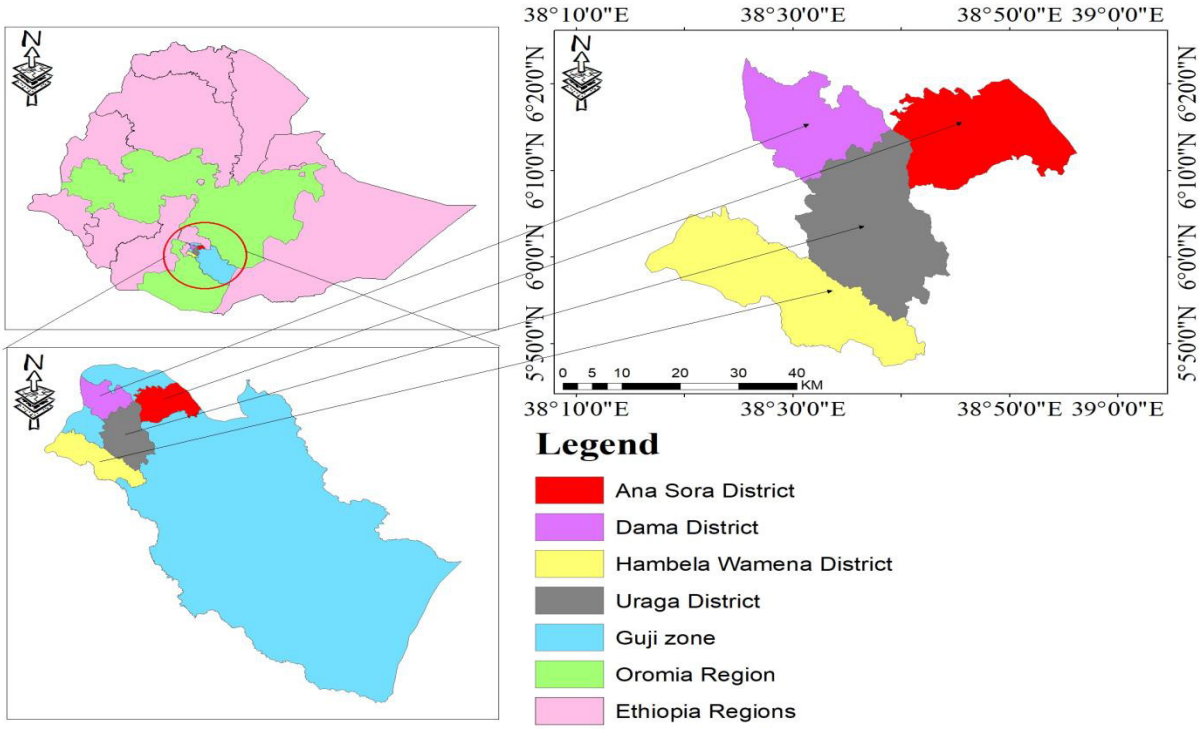

Figure 1. A map showing the study areas

erate (locally known as 'Dega') and Sub tropical (locally known as 'Woina dega'). The major soils of the district are Nitsols (red basaltic soils), and black soil (nitsol). Moreover, Dama district is an area where a mixed farming economic activity takes place, which is the major livelihood of the people.

Uraga district is found within the Geographical location of 66°34'02" to 67°70'67" north latitudes, and 45°80'88"to 46°57'87" east longitudes. The study district covers an area of 1,550.47km^2 and located at a distance of 417km from Addis Ababa. Topographically, it is characterized by rugged topography with steep hills slopes, ridges and small plateau. Uraga district is characterized by altitudes ranging from 1,850m to 2,350m meters above sea level. The district is bordered on the South,West, and East by Shakiso district, Borena Zone and Bore district respectively. The total population of Uraga district is 176,238, of whom 88,357 were men and 87,881 were women; 7,647 or 4.34% of its population were urban dwellers (CSA,2008).

Dimtu Hambela is one of the district of Guji Zone in the Oromia Regional State of Ethiopia. The weather condition of Dimtu Hambela district is categorized as temperate (locally known as 'Dega') and Sub tropical (locally known as 'Woina dega') type of climate. The altitude of the district lies between 1600-2200 meters above sea level. The soil composition of Dimtu Hambela district is generally loamy black brown to dark in colour which is very suitable for agricultural production. The climate of the district is characterized by short dry and long rainy seasons. The annual temperature of of the district ranged from 20c^0 -25c^0.

Sampling techniques and sample size

To select the study districts and respondent households both purposive and random sampling methods were used. Before the actual field data collection, reconnaissance survey was undertaken to get a general overview of the highland bamboo (*Yushania alpina)* resources of the study areas. Accordingly, from each districts 60 highland bamboo growers were selected and a total of 240 respondent households were randomly selected and participated on semi-structured interviews. In addition, from each districts 6 key-informants were selected and necessary information was collected from 24 key informants. Focus group discussion also conducted by selecting individuals from different areas including elders, youngsters, men, and women to have supportive data which was helpful to supplement information collected through semi-structured interviews.

Data collection methods

To asses Highland Bamboo (*Yushania alpina*) Cultivation Systems and Management Practices of the study areas,

the following principal data collection techniques such as semi-structured interviews, field observations, focus group discussions, and key informant interviews were used to collect the required data. For semi-structured interviews, a total of 240 highland bamboo growers were selected from Ana Sora, Dama, Dimtu Hambela, and Uraga districts of Guji Zone. From each district three kebeles were selected and 20 farmers per kebeles were participated on semi-structured interviews. Moreover, 8 focus group discussions of two per each district were conducted with community elders, local bamboo processors, and bamboo growers of the study areas. The focus group discussions using the developed open questions was conducted to get additional information to contextualize and supplement the information from semi-structured interviews. A total of 24 key informants (Six KI's in each district) those living in the local for a long time and have a good knowledge about highland bamboo (*Yushania alpina)* cultivation systems and management practices were participated.

METHOD OF DATA ANALYSIS

The quantitative data collected from semi-structured interviews of highland bamboo cultivation systems and management practices of the study districts were organized and feed into SPSS (Statistical package for social science) and statistically analyzed by using simple descriptive statistics such as mean and percentage. In addition, MS-Excel was used to generate tables, pie charts and bar graphs. Whereas, the qualitative data gathered from key informant interviews and focus group discussions were narrated and summarized by texts.

RESULTS AND DISCUSION

Demographic and socio-economic characteristics

The majority (87.4%) of the respondents were male and only 11.6% of them were female. In terms of age group, 36.2% and 33.8 % fall in the range of the age class of 35-50 years and more than 50 years respectively. Whereas, 30% of the respondents were categorized in the range of the age class of 20-35 years. In the case of marital status, the majority (93.8%) of the interviewed households were married and only 4.5% and 1.7% of the households were single and divorced respectively. Regarding family size, the majority of (35.5%) and (34.9%) of the respondents have 1-8 and 8-12 members respectively. The respondents educational level were; uneducated (30.5%), primary 1st cycle (33.4%), primary 2nd cycle (25%) and secondary and above (11.1%). The income sources of the respondents showed that, the majority (80.5%) of the households were depends on crops and livestock rearing and the remaining 19.5% of the households were depends on crops farming.

Farmers experience of bamboo planting and area coverage

Local communities of the study areas have culture of cultivating and managing highland bamboo resources and it plays a crucial role in their livelihood. This study showed that, highland bamboo plantation area coverage of the respondents were varied based on their allocated lands for bamboo planting. Accordingly, (36.1%) and (33.3%) of the respondents have <0.25 Ha, and 0.25 Ha of bamboo plantation respectively. Whereas, the remaining (15%), (10%), and (5.5%) of the interviewed households highland bamboo area coverage in hectares were 0.5 Ha, 1Ha, and >1Ha respectively (Figure 2). Regarding farmers experience of planting highland bamboo in the study areas, (44.4%) and (36.1%) of the respondents have greater than 30 years, and 20-30 long years experience of bamboo planting respectively. The remaining (11.1%),and (8.3%) of the respondents have 20-30 years, and less than 10 years experience of highland bamboo planting on their farm lands (Figure 3).

Therefore, this study indicated that as compared to their long term experience of bamboo planting, farmers area coverage of the land allocated for bamboo planting purpose was very minimum. This could be due to land scarcity, lack of land allocation for bamboo planting, weak extension services, and lack of advanced propagation techniques. Therefore, awareness creation is vital for local communities of the study areas to allocate necessary lands for bamboo planting. Moreover, for wider bamboo planting government and non-government organization could be involved in production and distribution of bamboo seedlings and advanced propagation techniques of bamboo could be supported by technical training and research. Similarly, Seyoum et al.(2018) reported that if local people are supported with techniques and inputs like trainings, working tools, planting materials and local administration involved in resolving such issues and allocate idle areas like river banks and valleys the size of the plantation bamboo forest would significantly increase.

Highland bamboo (*Yushania alpina)* landraces of the study areas

The term landrace is used for perennial crops and those with vegetative reproduction like bamboos, which have been cultivated and reproduced in a certain area for a long time (Calvet -Mir et al.,2011). Based on the indigenous knowledge of local communities of the study districts seven bamboo landraces naming as Dorori, Uratiti, Smooth culm node, Rough culm node, Red color, Black colour and Erkole were maintained and managed

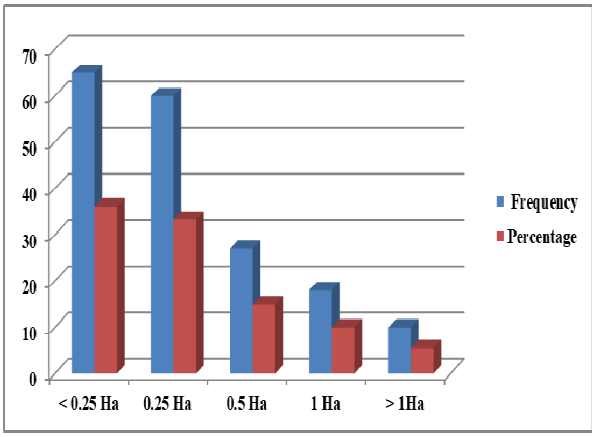

Figure 2. Highland bamboo area coverage of the respondents

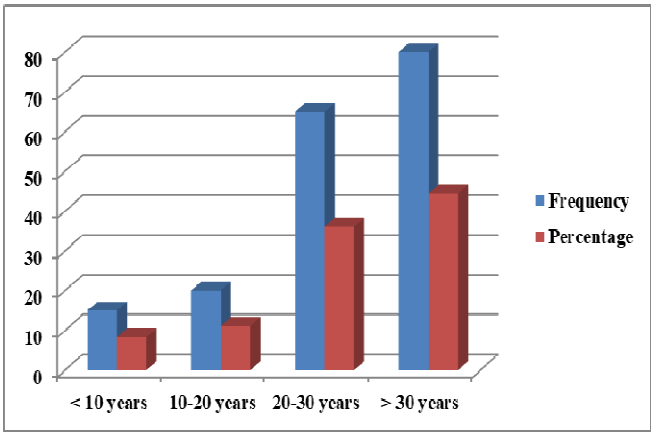

Figure 3. Farmers experience of highland bamboo planting

Table 1. Types of Highland bamboo landraces identified in Guji Zone, Southern Ethiopia

No	Study Districts	Number of identified Highland Bamboo Landraces	Name of Highland Bamboo Landraces
1	Ana Sora	4	Dorori Uratiti Smooth culm node Rough culm node
2	Dama	3	Red colour Black colour Erkole
3	Hambela Wamena	2	Smooth culm node Rough culm node
4	Uraga	3	Red colour Black colour

by bamboo growers of the study areas (Table1). Similarly, previous studies conducted on bamboo landraces showed that different types of highland bamboo landraces were reported in different parts of the country. In this regard, Amsalu et al.(2023) on their findings were reported nine bamboo landraces in Amhara region, Ethiopia. Berhane Kidane et al. (2023) also identified and reported 1, 3, 5, 7, and 8 highland bamboo landraces, in Oromia, South western Ethiopia, Amhara, Sidama, and SNNPR respectively. Moreover, Yigardu Mulatu (2012); Aschalew and Sintayo (2022) at Choke Mountain, Northern Ethiopia and Bore District, Southern Ethiopia were identified three highland bamboo landraces.

The survey results showed that, in Ana Sora District the maximum of four highland bamboo landraces such as, Dorori, Rough culm node (that has nail like protrusions), Uratiti, and Smooth culm node were recorded (Table 1). In Uraga and Dama Districts of Guji Zone bamboo growers were familiar with two and three types of highland bamboo landraces in their area. The following highland bamboo landraces such as Red colour and Black colour were identified and maintained in Uraga District. In Dama District farmers naming the three identified highland bamboo landraces as Red colour, Black colour and Erkole. However, in Hambela Wamena District only two highland bamboo landraces such as Smooth culm node and Rough culm node (that has nail like protrusions) were maintained and managed by bamboo growers of the area (Table 1).

In the study Districts, bamboo grower farmers were naming highland bamboo landraces based on their different characteristics such as splitting nature, color of the culm, thickness of the culm, culm height, internode length, roughness of the culm and sprouting ability. In support of this study, Calvet-Mir et al.(2011); Irawan et al. (2019) indicated that a landrace is the local category for grouping the bamboo plant according to characteristics reflected in specific vernacular names and farmers categorize landraces based on physical and morphological characteristics that they observe. Furthermore, on their study results Mulatu and Fetene (2011); Yigardu Mulatu (2012);

Seyoum et al.(2018); Aschalew and Sintayo (2022); Amsalu et al.(2023) reported that local people in different

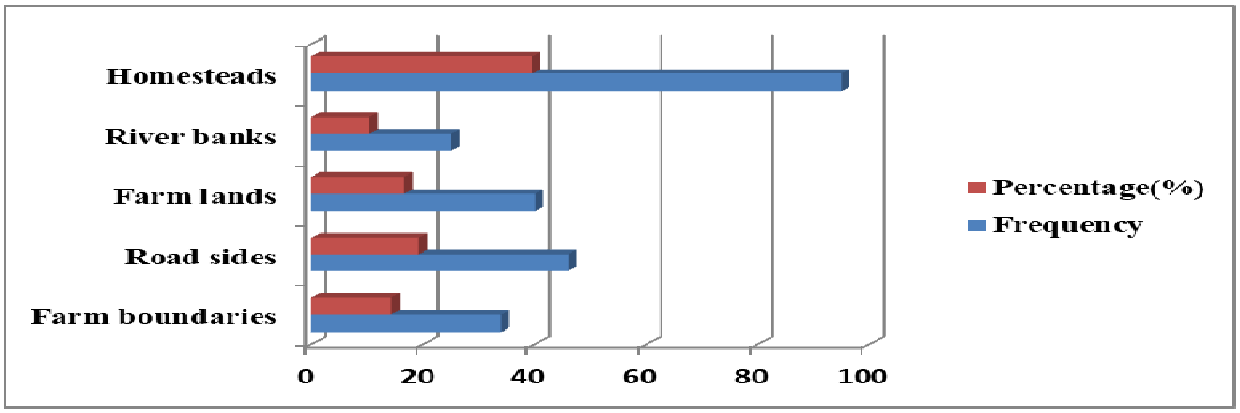

Figure 4. Commonly growing niches of the highland bamboo plantation of the study areas

Table 2. Bamboo growers reason of practiced different growing niches of highland bamboo of the study area

Farmers reason of practiced different growing niches of highland bamboo	Frequency	Percentage (%)
Due to scarcity of land	47	19.6
For soil fertility improvement	40	16.7
For wind break	36	15
For erosion control	39	16.3
For better growth of bamboo culms	41	17
For boundary demarcation	37	15.4

parts of the country classify bamboo landraces based on various characteristics they noticed from highland bamboo (*Yushania alpina*) species.

Highland bamboo (*Yushania alpina*) growing niches of the study areas

In the study districts, farmers are experienced in planting the highland bamboo stands in different growing niches. The present study found that, farmers of the study areas commonly planting the highland bamboo in homesteads, farm boundaries, farm lands, road sides and river banks of growing niches (Figure 4). The majority (31.25%) of the respondents were growing highland bamboo around homesteads followed by road sides (20.8%) and farm lands (18.75). The remaining (16.6%) and (12.5%) of the respondents were planting bamboo in farm boundaries and river banks respectively (Figure 3). Similar finding was reported by Chala and Elsabet (2024) which indicated that, farm boundary, homestead, woodlots, riverine and road side are commonly growing niches of highland bamboo in Arbegona District,Sidama, Ethiopia. Moreover, this result agrees with the study result of Amsalu et al.(2021) which were reported that homesteads, farm boundaries, road sides, river banks and patch plantation are growing niches of highland bamboo in West Amhara, Ethiopia.

Based on the findings of this study, farmers of the study areas were growing bamboo in different niches due to various reasons (Table 2). In this regard, homestead growing niche of highland bamboo were preferred by majority of the respondents because of highland bamboo planted around homestead is protected by fencing from animal grazing. In addition, as compared to other growing niches the highland bamboo planted around homestead is obtained necessary managements such as weeding, hoeing and manure application which ensures the highest productivity. The road side growing niche is preferred by farmers due to shortage of lands and the road side land is not being used for any other purposes. It was found that, farmers planted bamboo in river banks due to it serves as an efficient agent in preventing soil erosion and strengthening embankments and drainage channels. Moreover, bamboo growers of the study areas revealed that, those farmers which have small land holding size were planted bamboo in farm boundary and river banks. This study also showed that, farmers of the study districts were planted bamboo around agricultural fields as a boundary planting to protect the crops from high wind speed. In-terms of on farm bamboo planting, it was practiced by farmers during the first 1-3 years of the newly established bamboo plantation with crops and vegetables. As well, farmers of the study districts were practiced on farm bamboo growing niche for soil fertility improvement through bamboo leaf litter and fine root decomposition.

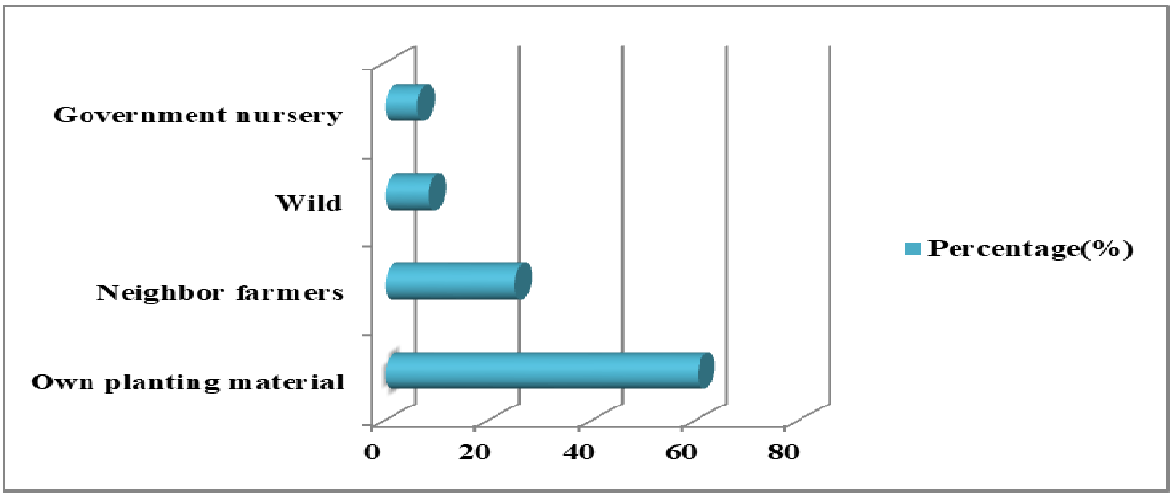

Figure 5. Highland bamboo source of planting materials of the study districts

Highland bamboo source of planting materials

The household survey revealed that bamboo grower farmers of the study districts have different sources to access the highland bamboo planting materials (Figure 5). The majority (60.4%) of the respondents used own planting material. The survey result has illustrated that, 25% of the respondents sources of bamboo planting materials were from neighbor farmers. This indicated that, in the study districts the culture of cooperation among the local communities are very strong. The remaining (8.3%) and (6.2%) of the respondents sources of bamboo planting materials were from wild and government nursery respectively (Figure 5). This study showed that, farmers collected wild young bamboo rhizomes from good naturally growing mature stands and used in place of seedlings and planted on their lands. Participants of focus group discussions and key informants indicated that contribution of the government and non-government organizations in terms of bamboo planting materials were very low. Therefore, local communities of the study districts could be supported by production of quality bamboo planting material of required species in quantity through strengthening of government, private and community nurseries. Moreover, farmers could be supported by research, technology development and dissemination for production of quality planting material especially through vegetative propagation.

Highland bamboo time of planting and propagation techniques

The findings of this study showed that, the time of bamboo planting in the study districts are coincide with the start of the rainy season. Because, the respondent households indicated that if planting of bamboo conducted during the start of rainy season it is vital to supply the young bamboo shoots with abundant water during their early growth period. Therefore, bamboo growing farmers of the study districts are commonly planting highland bamboo in May each year. The result of the study also showed that, local people have experience of bamboo planting space using their indigenous knowledge (Figure 6). According to the survey results, (37.5%) and (23%) of the respondents were used 3m and 2m of the closer planting space respectively. Comparatively, the remaining (20.8%) and (18.7%) of the respondents were used 4m and 5m of the wide planting space (Figure 6). The responding farmers indicated that, wide space of bamboo planting is used for intercropping/integration of bamboo into agricultural systems by planting other crops among the bamboo during the first 1–3 years of a bamboo plantation. In addition, participants of focus group discussion and key informants explained that closer spacing of bamboo planting is preferable for small sized of bamboo landraces and wide space of bamboo planting is preferred for large sized of highland bamboo landraces. Figure 6

The present finding confirmed that, culm off-set planting is the commonly and widely used propagation techniques by majority (75%) of the bamboo growing farmers of the study districts (Figure 7). The respondent households indicated that this method is the process through which farmers carefully uproot bamboo culms and transporting it together with the soil held by the roots. In line with this study, Seyoum et al. (2018); Amsalu et al.(2021) on their study findings indicated that most of the farmers use offset method to propagate the indigenous highland bamboo species in Kokosa Woreda, South East Ethiopia and in West Amhara, Ethiopia respectively. In addition, Irawan et al.(2019) in Indonesia reported that the planting of vigorous offset clumps with

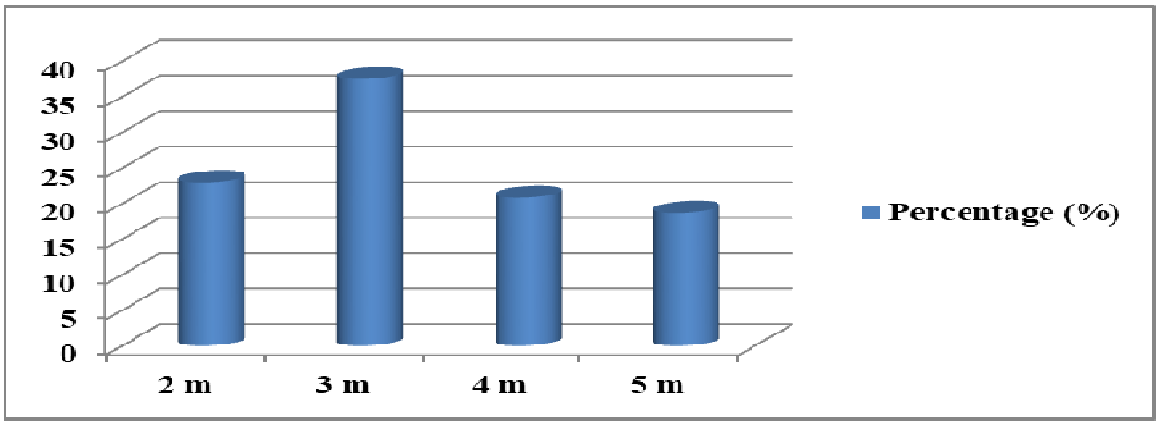

Figure 6. Farmers experience of highland bamboo planting space of the study areas

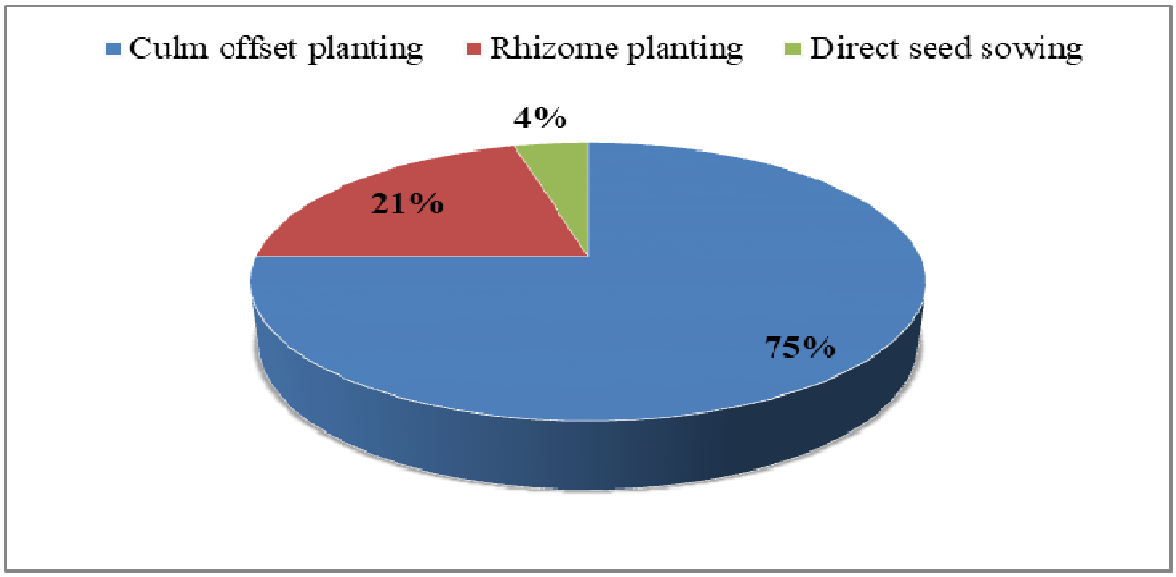

Figure 7. Highland bamboo planting techniques commonly used by bamboo growing farmers of the study area

attached rhizomes (offset planting) is found the best method used by the bamboo growing farmers. However, as the key informants explained bamboo offset propagation techniques is only practicable for cultivating a few clumps due to the extensive labor and cost this techniques require. In conformity with this study, Mudoi et al.(2013) ; Singh et al.(2013) reported that the bulky offsets, and labour-intensive extraction and transportation are the major limitations of this method. Also, the number of offsets available per clump is limited to one or two, and hence, the method is not feasible for raising large-scale plantations.

Based on the findings of this study, (21%) and (4%) of the interviewed households were used rhizome planting technique and direct seed sowing respectively (Figure 7). Bamboo growing farmers of the study districts explained that when they are used rhizome planting technique based on their indigenous knowledge carefully separate the rhizome attached to the bamboo culm using sharp material and transported to the planting area. Participants of focus group discussion and key informants also stated that rhizome planting technique required skills due to damage to rhizome buds during extraction and transportation often leads to failure of propagation. In the study districts, as compared to other planting techniques contribution of direct seed sowing for highland bamboo planting material is very scarce. Similarly, LUSO (1997); Razvi et al.(2011) which were reported that seeds of highland bamboo (*Yushania alpina*) are not available on regular basis, besides their low viability and hence are not reliable source of planting material.

Highland bamboo management practices

Bamboo growers of the study areas have good experience

Table 3. Highland bamboo management practices commonly used by bamboo growers of the study areas

Highland bamboo management practices of the study areas	Frequency	Percentage(%)
Fencing and slashing	32	13.3
Thinning, branch pruning and weeding	40	16.6
Animal manure, compost and fencing	60	25
Thinning and branch pruning	35	14.6
Weeding and slashing	30	12.5
Animal manure and compost	43	18

on management of highland bamboo stands through different management practices for sustainable productivity of highland bamboo culms (Table 3). Highland bamboo growers in the study districts used organic fertilizers such as animal manure and compost at every growing season of the highland bamboo stands. The respondent households indicated that organic fertilizers (animal manure and composts) are very significant for new established bamboo plantations and after the harvesting of matured bamboo culms for better sprouts of the new bamboo shoots. Moreover, participants of focus group discussion and key informants explained that farmers conducted these management activities for fastest growth of bamboo stands and to improve yield and quality of their bamboo culms. This result is agreement with the findings of Danesh et al. (2002) which were reported that farmers use organic fertilizers for enrichment of the soil fertility surrounding the bamboo culms.

The other highland bamboo management practice conducted by bamboo growing farmers of the study districts were fencing (Table 3). Through fencing farmers protected the highland bamboo stands from livestock and wild animals. The interviewed households indicated that, the newly sprouted bamboo shoots and young branches are very palatable by animals. Therefore, if it could be damaged by animals the growth performance of bamboo stands are very slow and difficult to obtain the matured bamboo culms for utilization. In consistence with this study, Seyoum et al.(2018); Fekadu et al.(2024), on their study results showed that fencing is one of the management activity applied by bamboo growers farmers to protect from some damaging agents.

The findings of this study showed that, weeding and slashing of highland bamboo management practices were also conducted by bamboo growers of the study areas (Table 3). Farmers employed both management activities for highland bamboo stands integrated with other crops and for sole plantation of highland bamboo stands. Through these management practices farmers removed unwanted competent vegetation for better growth of bamboo culms and those integrated crops. In conformity with this study, Danesh et al.(2002); Seyoum et al.(2018) on their previous study findings indicated that regular weeding and slashing away of unnecessary vegetation is very important practices in the bamboo stand management.

The study result obtained has also revealed that, thinning and branch pruning of highland bamboo management practices were conducted by some of the respondent households of the study areas (Table 3). Bamboo growers in the study districts explained that, to minimize the shade effect of bamboo plants on under story crops thinning and branch pruning are commonly practiced. In addition, the respondents in the study districts stated that old and mature culms, and any culms which have died are removed from the clump by thinning and branch pruning management activities. In support of this study, Amsalu et al.(2021) reported that bamboo growing farmers in West Amhara, Ethiopia were used tending operations to improve their bamboo stand productivity. Moreover, Danesh et al. (2021) also indicated that most of the farmers cut lower branch of bamboo for the requirement of immediate use and the practice facilitated easy access and extraction of the felled culm from the groves.

Highland bamboo harvesting time and techniques

The study results showed that, bamboo growers of the study districts have their own harvesting time and techniques of highland bamboo stands using their indigenous knowledge. It was revealed that (33.33%), (31.25%) and (27.12%) of the surveyed households were used 4 years, 3 years and 2 years cutting cycle respectively (Figure 8). However, the remaining (8.3%) of the respondents were did not follow any cutting cycle (Figure 8). In terms of harvesting time, majority of the farmers (90%) cut their bamboo culms during winter time, except at the time of rainy season and only (10%) of the respondents were cut bamboo culms year round. Bamboo growing farmers of the study areas indicated that, November to March was the main time for harvesting of matured bamboo culms for different utilization.

The main reason farmers did not harvest bamboo culms during rainy season is to minimize damage on new culms or sprouts, that grow from the underground stems of bamboo plants and for better growth of young bamboo

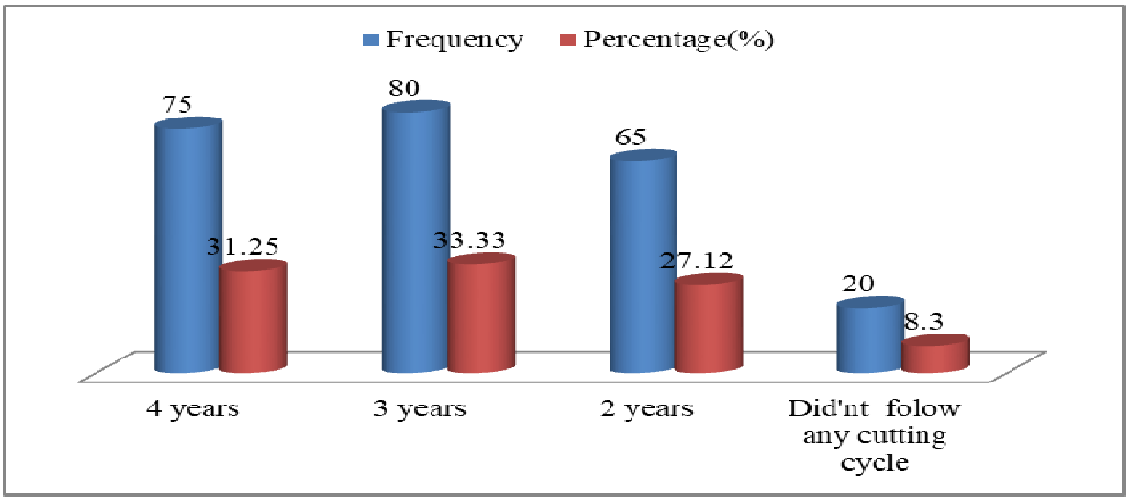

Figure 8. Cutting cycle of highland bamboo culms commonly practiced in the study areas

shoots. This statement agrees with the study results of Fekadu et al.(2024) who reported that farmers cut bamboo culms all the time except when they are sprouting to minimize damage that might happen to rhizome. Moreover, Amsalu et al.(2021) showed that bamboo growers cut their culm throughout the year except main rainy periods, which are responsible for reproduction. Similarly, Ediningtyas and Winarno (2012) indicated that during the rainy season, generally young culms are at growing phase from old rhizomes, therefore, harvesting bamboo culms during this period will disturb the young culms. Earlier findings of Banik (1997) also showed that cutting in winter season is quite scientific as it increases the durability of bamboo by reducing the insect and fungal infection and does not hamper the growth of new culm.

As the findings of this study showed that, some bamboo growers of the study districts were harvested/ cut bamboo culms all over the year during dry and rainy season of the study sites. This could be due to the growers harvest their bamboo culms when they need income for their livelihood supplement and when demanded bamboo culms to fulfill household needs for different utilization. In accordance with current study, on their findings Seyoum et al.(2018); Berhane et al.(2024) which were reported that farmers harvested their bamboo culms through out the year and sell it in small local markets for income generation. Figure 8

According to semi-structured interviews and key informants, bamboo growers of the study districts have their own indigenous knowledge of harvesting/cutting method. In this regard, local communities of the study areas usually harvest the matured bamboo culms by selective cutting method rather than total cutting. This study showed that, farmers employed selective harvesting techniques to prevent the depletion of resources and to allow for the natural regeneration of bamboo stands. Because, bamboo growers of the study areas explained that clear cutting decrease the availability of bamboo stands and recovery takes longer and difficult to obtain bamboo culms for utilization and income generation. The findings of this study is consistent with the findings of Nadeak (2009); Budi et al.(2019). On their study findings reported that bamboo growers conducted selective cutting to maintain the sustainability of bamboo clumps which is vital for availability of bamboo culms to fulfill various purposes of household daily needs. Moreover, Yigardu and Mengistie (2010) reported that the annual selective cutting is very significant for sustainable utilization of the bamboo resources.

The results of this study revealed that, bamboo growers of the study areas have good experiences on felling techniques of bamboo culms. Based on the semi-structured interviews, it can be revealed that the majority (76%) of the respondents were carefully harvested matured bamboo culms at stump height of one node. Whereas, the remaining (24%) of the respondents were harvested old bamboo culms at stump height of two nodes without destruction of other bamboo culms within one bamboo clump (Figure 9). Bamboo growers of the study districts explained that cutting bamboo culm above the 1st and 2nd node from the ground ensures the clump remains healthy and productive for future growth cycle. This is in accordance with the study results of Budi et al.(2019) who reported that the technique of felling bamboo culm is done by leaving a few centimeters above the ground and keeping the old stump to get new shoots growing. Moreover, in line with this study Chaturvedi (1988); Danesh et al.(2002) which were showed that the reason of farmers cutting matured bamboo culms at ground level is to increase utilization by reducing the wastage and for better growth of rhizome systems which could be vital to give new culms. In support of this study Brias and Hunde

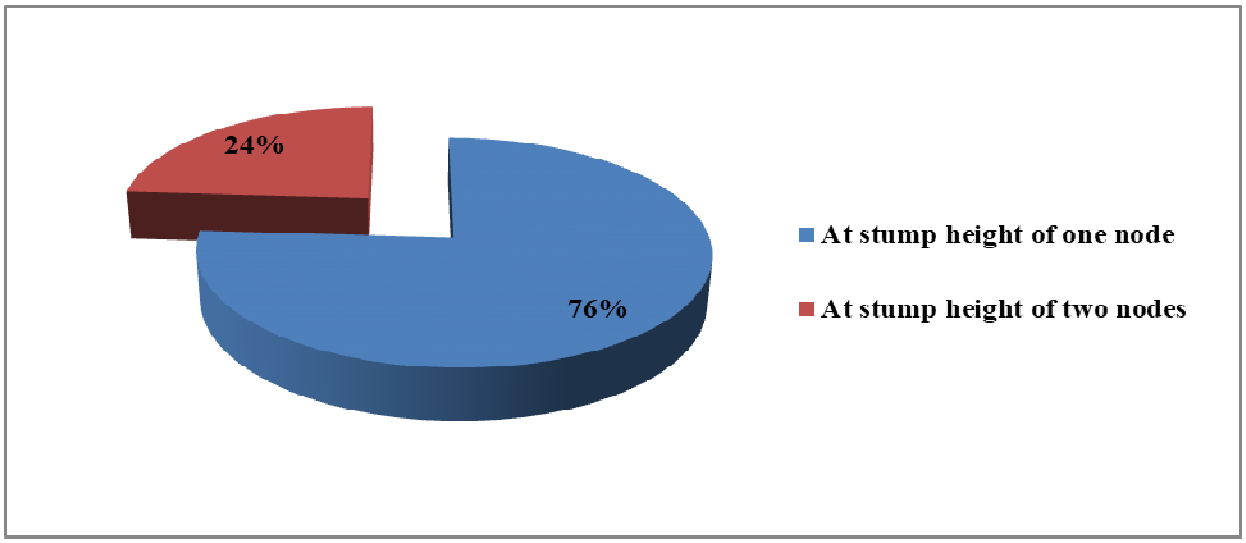

Figure 9. Bamboo growers experience on felling techniques of highland bamboo culms of the study areas

Table 4. Major challenges of cultivation systems and management practices of highland bamboo resources of the study districts

Highland bamboo challenges of the study areas	Frequency	Percentage (%)
Lack of extension and training	55	22.9
Over and poor harvesting methods	53	22.1
Lack of advanced planting materials	47	19.6
Expansion of agricultural land	34	14.2
Livestock grazing	26	10.8
Climate change	25	10.4

(2009); Seyoum et al.(2018) also reported that culm cutting should be done between the 1st and 2nd nodes below the first branch of leave from the ground. Figure 9

Challenges of highland bamboo resources of the study areas

Bamboo resource in Ethiopia is under high pressure that led to depletion due to multiple interactive factors hindering sustainable bamboo resource management and it remained getting less attention (Getachew and Wubalem,2014). Similarly, this study showed that sustainable cultivation system of the highland bamboo resources of the study areas were faced many challenges. Bamboo growing farmers revealed that lack of extension and training, over and poor harvesting methods, lack of advanced planting material, expansion of agricultural land, livestock grazing and climate change are the major challenges of highland bamboo production of the study areas (Table 4).

The survey results showed that, expansion of agricultural land and lack of advanced planting materials are the major bottleneck of highland bamboo cultivation systems of the study districts. According to participants of key informants and focus group discussions local communities of the study areas clearing their owned bamboo plantation to create space for crops to feed their household members and for source of income. Moreover, key informants indicated that due to highland bamboo flowers take long intervals to produce seeds local communities of the study areas used offset propagation methods. However, they indicated that this method is inefficient and ineffective for large scale plantation. Therefore, for the study areas suitable propagation methods are very significant for sustainable management of highland bamboo resources of the study districts.

The other challenges bamboo growers of the study areas encounters on sustainable management of highland bamboo resource is livestock keeping and grazing system. Participants of focus group discussion and key informants explained that, unless highland bamboo plantation protected by fencing, the young bamboo shoots and new rhizome could be devastated by free grazing system and it have negative impact on sustainable management and utilization of bamboo resources. From the semi-structured interviews and focus group discussions able to identify over/poor harvesting

challenges on highland bamboo resources of the study areas. They were mentioned that due to lack of knowledge on the management of bamboo when they need income bamboo growers over harvested bamboo culms with out keeping the cutting cycle, which have great impact on sustainable growth of new shoots.

In terms of climate change, lack of extension and training challenges on cultivation system of highland bamboo resources, bamboo growers of the study districts confirmed that highland bamboo resources are highly affected by fluctuation of climate change. According to key informants, during dry season bamboo plantations are susceptible to damage through prolonged exposure to frost. They also indicated that due to for a long time bamboo plants affected by frosts, the bamboo culms completely dried. Bamboo growers of the study areas reflected that there is lack of extension systems and capacity building trainings on bamboo cultivation systems and management practices. Therefore, it is very significant to provide local communities of the study areas with intense training and strong extension services to improve their understanding on bamboo harvesting time and techniques, production systems, management practices and advanced propagation methods of highland bamboo resources (Table 4).

CONCLUSION AND RECOMMENDATION

Bamboo growers of the study areas had long years experience in highland bamboo (*Yushania alphina*) cultivation systems and management practices based on their indigenous knowledge acquired for a long time. However, the survey results showed that as compared to their sound experience, farmers area coverage of the land allocated for bamboo planting purpose was very minimum. The result of the study indicated that seven commonly known highland bamboo (*Yushania alphina*) landraces were identified in the study districts. Bamboo growers of the study areas were naming highland bamboo (*Yushania alphina*) landraces based on their different characteristics such as splitting nature, color of the culm, thickness of the culm, culm height, internode length, roughness of the culm and sprouting ability. The present study found that bamboo growers of the study areas are experienced in planting the highland bamboo (*Yushania alphina*) stands in different plantation niches. Accordingly, local communities of the study districts commonly planting the highland bamboo (*Yushania alphina*) in homesteads, farm boundaries, farm lands, road sides and river banks of growing niches.

The study results showed that, the time of bamboo plantation was coincided with the start of the rainy season and bamboo growers of the study areas are commonly planting the highland bamboo in May each year. In terms of highland bamboo (*Yushania alphina*) propagation techniques, culm off-set planting is the commonly and widely used propagation method by majority of the bamboo growing farmers of the study districts. Highland bamboo growers in the study districts used organic fertilizers (animal manure and compost), fencing, thinning, branch pruning, slashing and weeding management practices for better growth of bamboo culms and integrated crops. Moreover, local communities of the study districts have their own harvesting time and techniques of highland bamboo stands using their indigenous knowledge. Accordingly, the surveyed households were used 2-4 years cutting cycle and only few households were did not follow any cutting cycle. This study also showed that, majority of the farmers (90%) cut their bamboo culms during winter time, except at the time of rainy season and only (10%) of the respondents were cut bamboo culms year round.

Regarding the challenges of highland bamboo resources, this study showed that lack of extension and training, over and poor harvesting methods, lack of advanced planting material, expansion of agricultural land, livestock grazing and climate change were the major challenges of highland bamboo cultivation systems and management practices of the study areas. Therefore, attention should be given on sustainable utilization and conservation of highland bamboo (*Yushania alphina*) resources and farmers should be encouraged by the government and non-government organizations through research and extension services to improve the significant of ecological, economical and social role of highland bamboo resources of the study areas. In addition, establishing research and development initiatives to improve propagation and harvesting techniques, and raising awareness among local communities about the significant of sustainable highland bamboo cultivation systems and management practices are very important.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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