Indigenous management practices of highland bamboo (Yushania alpina) in West Amhara, Ethiopia

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**Abstract:** This research was designed and conducted to explore indigenous management interventions and experiences carried out by farmers west Amhara, Ethiopia. Therefore, we choose Farta, Banja, Dega Damot, and Sinan districts purposely based on the existence of highland bamboo production to study indigenous management practices applied. A total of 180 farmers were interviewed to collect information on the management of bamboo. Key informants survey, focus group discussions, and field visit observations were taken to support, validate and triangulate interview data collected for identifying and documenting indigenous management interventions applied by farmers. Quantitative data were analyzed in descriptive statistics by using SPSS and Microsoft Excel while quantitative data were summarized and narrated by texts. Farmers in west Amhara, study areas grow two to four landraces of highland bamboo. Vegetative propagation is a common propagation technique. Farm boundary, homestead, riverbank, roadside, and woodlot plantations were common growing niches of highland bamboo. Farmers harvest culms older than two years with different harvesting season. Drying of new shoots (shoot abortion) and lack of training and extension services were identified as bottlenecks of highland bamboo production. Whereas, its adaptive nature, sustainability of yield, increased demand for products, upholding the capacity of several stakeholders in its production and marketing are taken as opportunities for them.

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**PUBLIC INTEREST STATEMENT**

Bamboo is woody grass plant that provides able to produce numerous functions, services and products that come from forest resources. As plays a vital role for climate changes mitigation, adaptation and resilience responses due to its fast growth rate and wide adaptive nature. Moreover bamboo is one of a crucial socio-economic species that holds several actors and beneficiaries along its production value chain. Such versatile benefits of bamboo contribute to the reduction of users pressures in natural forest. Therefore, an investigation that generates baseline information for forecasting productive management plans and interventions becomes a vibrant tasks. Characterization of existing landraces/cultivars, periodic assessment of potential enemies and prediction of factors that contribute to productivity loss of bamboo are recommended for future research.
Promotion of good experiences of one area to the other localities plays a vital role in enhancing productivity and secure sustainability of bamboo resource.

**Subjects:** Agriculture & Environmental Sciences; Environmental Sciences; Agriculture and Food; Biodiversity & Conservation

**Keywords:** Future prospects; growing niche; landrace; threats

1. **Introduction**

   Bamboo is broadly accepted multi-functional perennial flowering plant under grass family of Poaceae with more than 1250 species that plays an imperative role in grower demand (Desalegn & Tadesse, 2014). Among these number of species highland bamboo (Yushania alpina) and lowland bamboo (Oxytalantheria abyssinica) are the two indigenous species found in Ethiopia with 15% and 85% proportions from whole bamboo resource of the country (Desalegn & Tadesse, 2014; Mulatu & Fetene, 2014).

   Highland bamboo (Yushania alpina) a species that was grown and distributed around South, South-west, Central and North-west highlands areas of the country, which were between altitudinal ranges of 2200 m to 4000 m a.s.l. It is commonly grown in backyards/homesteads, farm boundary and gully sides, woodlots, around the river banks and following roadside (Nduwamungu, 2018) as traditional agroforestry systems in many parts of districts of Amhara Region. In Amhara Region as general and targeted districts particularly, highland bamboo plantation management and maintenance highly conventional exercise by farmers to subsidize their livelihood needs (Assaye et al., 2014), making some local furniture and agricultural equipment). Bamboo is one of the essential part of agricultural tasks and practices for most of households and a source of income for many farmers (Antonio et al., 2014) and for those who were engaged in off-farm activities (Lin et al., 2019). Bamboo as a forest resource contributes to numerous ecological (Chen et al., 2016; Houdanon et al., 2018; Mulatu & Fetene, 2014), socio-economic (Kebede, 2018) and cultural functions and benefits (Antonio et al., 2014).

   Land races were categorized into classes based on the differences in physical/morphological characteristics (Irawan et al., 2019; Mulatu & Fetene, 2011). The naming of the landraces is based on the natural outlook of the culm, other bamboo parts and the interest of farmers (Gebrekidan et al., 2018; Irawan et al., 2019; Mulatu & Fetene, 2011). Color of the culm, internode length, thickness of the culm, surface roughness of the culm, surface area and length of leaves, sprouting ability, response for splitting, and thorniness at nodes are the criteria for the classification of the bamboo land races (Gebrekidan et al., 2018; Irawan et al., 2019; Mulatu & Fetene, 2011).

   Forest management is the practice of designing and implementing actions and interventions for maintenance/conservation, productivity enhancement, and sustainable utilization of forests to meet targeted environmental, economic, social and cultural objectives. It deals with administrative, economic, legal, social, technical and scientific aspects of managing forest resources (Pokharel, 2017; Tewari, 2016). Indigenous forest management practices are a self-developed processes of establishment, conservation, development and utilization of resources by communities/groups in specific geographical locations to satisfy their requirements (Kumar Rabha, 2020; Pokharel, 2017). They are shared actions of practices that are experienced for mitigating specific problem of event at common spatial territory, cultural setup, and social customs of the community (Pokharel, 2017).

   Indigenous forest management practices and experiences are site specific (Nigatu et al., 2020), problem driven, culturally developed and verbally transferred from generation to generation (Tewari, 2016). Assessment and documentation of indigenous forest management practices of
specific areas plays a crucial role for developing productive forest management plans (Irawan et al., 2019) and sustainable utilization guidelines (Gebrekidan et al., 2018; Mulatu & Fetene, 2011). Thus, this research survey was conducted to generate information about farmers’ indigenous knowledge on highland bamboo management practice in West Amhara, Ethiopia.

2. Materials and methods

2.1. Study site selection
Banja, Farta, Dega Damot and Sinan districts from West Amhara (Figure 1) were selected based on the existence of well-established and wide spread plantations stands of highland bamboo as well as agro ecological similarities. Based on agro ecological classification all of the target districts fall into “Dega” agro ecological zone. Specifically, the Banja district falls in the altitudinal range of 1800–2953 m above sea level having unimodal rainfall of 2300 mm with average temperature of 16–26°C. Whereas Farta district falls in 1970 to 4135 m above sea level having annual temperature range of 9.5–22.11°C with 1097 to 1954 mm annual rainfall. Likewise Dega Damot district receives annual rainfall of 1600 to 1800 mm with a temperature range of 5–28°C in 1650–4000 m above sea level range and Sinan district drops in 2300 to 4000 m above sea level altitude with mean annual record of 900–1445 mm and 0–15°C rain fall and temperature.

Figure 1. Map of study locations in West Amhara.
2.2. **Sampling technique and sample size**
Both purposive and random sampling methods were employed for selecting target areas/districts and respondents, respectively. Reconnaissance survey was undertaken prior to actual data collection in the study areas to get a general overview of the highland bamboo producers and baseline information of the areas. Following the indication of reconnaissance survey a total 180 highland bamboo growers (45 growers from each district) were selected randomly with the help of development agents. In line with interview farmers who have been engaged for relatively long periods of time and forestry and natural resource experts were selected purposively as key informants. Additionally, a group of 6 to 8 farmers (composed of farmers who have been practicing bamboo plantation for different ages) were again selected to conduct FGD.

2.3. **Methods of data collection**
Both qualitative and quantitative data were collected from relevant primary and secondary sources using a combination of data collection tools (growers’ interview, key informant interview and focus group discussion). A total of 180 highland bamboo grower farmers from 12 kebeles (15 farmers per kebele) were interviewed, KIS (key informants’ survey) from 6 individuals per district and 12 FGD (focus group discussion, three per each district) were conducted. Moreover, field visit observations were done to complement and triangulate data collected through questionnaires and verify types of landraces grown and maintained by farmers in each highland bamboo growing localities.

2.4. **Methods of data analysis**
The quantitative data collected from household survey and field observation of highland bamboo were analyzed using descriptive statistics by using Microsoft Excel and SPSS (Statistical package for social science) whereas the qualitative data gathered from key informants survey and focus group discussion were narrated and summarized by texts.

3. **Results and discussions**

3.1. **Types of maintained landrace**
Farmers classify landraces based on physical and/or morphological characteristics that they observe (Irawan et al., 2019). Color of the culm, internode length, thickness of the culm, surface roughness of the culm, surface area, and length of leaves, sprouting ability, response for splitting, and thorniness at nodes are the criteria for the classification of the bamboo land races (Gebrekidan et al., 2018; Irawan et al., 2019; Mulatu & Fetene, 2011). Based on the above traits, there are at least two landraces of highland bamboo were maintained and managed (Table 1) per farmer in highland bamboo growing areas of west Amhara more than two landraces.

Even though farmers give different names for different landraces in different locations most of the landraces except Stripped, which is unique around Awí zone areas, some landraces show similar features. For example, the landrace named as Wondie in Farta, Dega Damot and Sinan Districts resembles to Red landrace of Banja. Our result is a line on the number of landraces maintained by farmers with the works of for Banja district of Awí zone and (Gebrekidan et al., 2018) for Sinan district of East Gojjam Zone.

3.2. **Propagation techniques and tending operations**
Propagation of bamboo is known to occur asexually in the branching of offset with rhizomes. Bamboo producers all over the locations use offset method. The planting of vigorous, two-year-old offset clumps with attached rhizomes (offset planting) is found the best method used by the bamboo growing farmers (Irawan et al., 2019). The full culm with rhizomes having nodal buds is planted in the soil. The rhizomes buds buried in the soil grow into rhizome and roots, while those above the ground develop into shoots to provide culm. Gebrekidan et al. (2018) indicated also most of the bamboo growing farmers use offset method to propagate the bamboo. Offset propagation is difficult for transportation and hard to manage it. This increases the cost of production. However, a rhizome can be enhanced through better management and compost application.
Table 1. Types of landraces of highland bamboo (Yushania alpina) over growing localities

| No | Location        | Number of Landraces | Name of Landraces | Frequency of Producers | Proportion (%) |
|----|-----------------|---------------------|-------------------|------------------------|----------------|
| 1  | Frata (n = 45)  | 2                   | Wondie            | 45                     | 100            |
|    |                 |                     | Setie             | 30                     | 67             |
| 2  | Banja (n = 45)  | 3                   | Black             | 45                     | 100            |
|    |                 |                     | Red               | 31                     | 69             |
|    |                 |                     | Stripped          | 10                     | 22             |
| 3  | Dega Damot (n = 45) | 3   | Tifrie            | 45                     | 100            |
|    |                 |                     | Wondie            | 35                     | 78             |
|    |                 |                     | Setie\Lemlem      | 14                     | 31             |
| 4  | Sinan (n = 45)  | 4                   | Tifro             | 45                     | 100            |
|    |                 |                     | Wondie            | 38                     | 86             |
|    |                 |                     | Wolelie           | 29                     | 64             |
|    |                 |                     | Enkotkut          | 18                     | 40             |

Production of new culms from offset propagation is influenced by the management (compost application or fertilization) and the amount of rainfall occurring during planting. It was confirmed by farmers that clear cutting of bamboo forest reduced its recovery. It may take 2–3 years to reach for marketable size. Regenerating shoots from the offset are more in number of culms and variable in size.

As bamboo is management sensitive for its productivity and sustainability (Hyunjin et al., 2019), growers in study areas use several management activities (tending operations) to improve their bamboo stand productivity (Hyunjin et al., 2019; Irawan et al., 2019). The results (Figure 2) illustrate important management practices applied by farmers for securing sustainability, improvement and enhancing yield and quality of their bamboo culms. Some of management interventions are dependent on site and specific situation (Kassahun et al., 2015). For example, farmers use prescribed flooding to maintain soil moisture, smoking for reducing or avoidance of aphid attack and clear cutting of the stand for enhancing regeneration after frost and insect damage in Banja and Farta areas. This result is parallel with the result of (Desalegn & Tadesse, 2014; Mulatu & Fetene, 2014). Generally, most of the management practices are adopted and applied by majority of bamboo growers in Banja area growers followed by Sinan than other areas. This might go together with the more adoption of the production system a (better integration of bamboo in the farming system, and commercialization) and high dependence of communities on bamboo production and trading for their livelihood.

Figure 2. Common management practices of highland bamboo (Yushania alpina) in different bamboo growing areas (Fen., Fencing; Sls., Slashing; PrFL, Prescribed Flooding; Cm & MI, Compost application & Mulching; UnPL, Under shade Planting; Sm., Smoking; Sym., Symbolling; HMCs., Harvesting Mature Culms; CC., Clear Cutting).
Figure 3. Common growing niches of highland bamboo (Yushania alpina) with respective average land coverage per farmer.

3.3. Common growing niches and area coverage

Homestead plantations, planting following farm boundaries, roadsides and riverbanks and patch plantations as a woodlot are the common growing niches (Figure 3) or plantation practices exercised by farmers in study areas. Among growing niches homestead (practiced with area coverage between 0.018 and 0.030 ha), woodlot (experienced within area coverage of 0.125–1 ha) and river bank (0.018–0.075 ha) were the dominant plantation practices of highland bamboo that were managed by 88, 74, and 65% of bamboo grower farmers. While roadside (0.01–0.05 ha) and farm boundary (0.01–0.025 ha) were plantation practices of highland bamboo practiced by less growers (Figure 3) with the smallest area coverage.

The variability of average area of bamboo stand along growing niche is due to variability in the availability of land, type of ownership or use right, type of bamboo management/aim of plantation, access to road and diversity of bamboo. Moreover, the ultimate goal of the planted bamboo stand varies with growing niche variation. For example, the main objective of most of bamboo plantations along boundaries and road sides were planted for boundary demarcation, buffering and life fence, respectively.

3.4. Age and harvesting season of highland bamboo

The estimated period of time for bamboo to reach for harvesting is after 2 to 3 years (Table 2) of emergence of culm as new shoot (Irawan et al., 2019). Color of the culm, culm sheath characteristics, and the condition of node nails and silk are governing features of culm harvesting. In exceptional cases, for example bamboo from boundary and roadside plantation niches can be harvested in variable size and harvesting season to satisfy their immediate demands (Irawan et al., 2019).

The results revealed that the harvesting age of bamboo culm is determined by the type of product which they are going to sell or produce (Taylor, 2015). But the season of harvesting is governed by the time of shooting/reproductive period, moisture availability (dryness or wetness) and market demand. Based on the result, most of the famers harvest/cut their culm throughout the year except main rainy periods, which are responsible for reproduction. Farmers inform that culm harvesting was not an appropriate action at a time of reproductive season. Moreover, they were not practicing culm harvesting between March and April to avoid insect attack and prolong the durability of the culm.

4. Threats and futures prospects of highland bamboo production

4.1. Threats

Bamboo producer farmers revealed that, disease (bamboo aphid), shoot abortion and drying out, climate change, wild animal damage, propagation method of the species itself, lack extension and training, land shortage, expansion of monoculture plantation unwise harvesting methods and market problems (Table 3) are basic bottlenecks that farmers are encountered for highland bamboo production.
Among all challenges, drying and die back of bamboo culm because of various natural enemies and shoot abortion (lack of shoot to grow to mature culm), land shortage and lack of technical trainings and extension survives are the important challenge that farmers list in priority, and they are facing and fearing for future bamboo plantation management and their argument was in line with reports of (Desalegn & Tadesse, 2014; Sharma et al., 2018). During the survey, farmers concluded that even though bamboo is a very important and multipurpose forest species due to expansion of exotic short rotation trees species which receives better attention and extension service (Desalegn & Tadesse, 2014), the plantation of bamboo is reduced from time to time. Based on the results, the above challenges are bottlenecks of the majority of bamboo producers are factors that may gear farmers to change their bamboo stands into other monoculture of fast-growing exotic tree species, which were similar to governing factors of bamboo production in bamboo growing areas (Lin et al., 2019).

Bamboo as forestry is marginalized as compared to other exotic and indigenous forestry species (Irawan et al., 2019; Nigatu et al., 2020). The reason for the lack of attention from extension providing sectors is because of the unique nature of the species (bamboo) in relation to propagation and management techniques as compared to other fast growing forest tree species (Irawan et al., 2019; Kumar Rabha, 2020; Pokharel, 2017).

### 4.2. Future prospects

Information generated from social surveys designates the existence of several opportunities, encouraging and enabling conditions based on the nature of the species and the current and predicted state of their environment. Based on the sayings of bamboo producers, six basic inspiring opportunities were identified for future sustainable production and plantation expansion of bamboo.

Results of survey report revealed that environmental suitability and adaptive nature of the species (84%), sustainable yield supply, and multipurpose benefit of bamboo (63%), the nature of bamboo in relation to initial investment and rotation period (44%), increased demand of the species from various governmental, non-governmental and professional institutions (40%), the potential of bamboo in holding several actors and beneficiaries in its production system and product chain (30%) and the upcoming and ongoing climate change scenario (28%) were the promising prospects that were identified by bamboo growers with for future.

The research conducted in South eastern part of the country witnesses the multifunctional role well managed and planned production of bamboo resource production when practiced in well

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Table 2. Description of Harvesting Age and Season of Highland Bamboo (Yushania alpina) across Growing Areas

| No | Location | Culm Age | Harvesting Season | Reason |
|----|----------|----------|-------------------|--------|
| 1  | S/Gondar | 2-3      | All over the year except May-August | To minimize shock of newly emerging |
| 2  | Awi      | 2-3      | All over the year except June-September (& April) | Sprouting Season (Minimize fungal attack of culm) |
| 3  | W/Gojjam | 2-3      | All over the year based on market demand | |
| 4  | E/Gojjam | 2-3      | All over the year based on market demand | |
Table 3. Challenges for Plantation management of Highland bamboo (Yushania alpina) in Different Areas

| No | Threats                        | Banja (n = 45) | Farta (n = 45) | Damot (n = 45) | Sinan (n = 45) | Mean (N = 176) |
|----|--------------------------------|----------------|----------------|----------------|----------------|----------------|
| 1  | Disease\abortion\drying out   | 45(100)        | 45(100)        | 28(62)         | 32(71)         | 150(83)        |
| 2  | Animal damage/Browsing         | 25(56)         | 33(73)         | 29(64)         | 31(69)         | 118(66)        |
| 3  | Lack of training & extension service | 36(80) | 34(76) | 38(84) | 27(60) | 135(75) |
| 4  | Unwise use of resources        | 28 (62)        | 28 (62)        | 39 (87)        | 31 (69)        | 126 (70)       |
| 5  | Climate variability(frost)     | 23 (51)        | 45 (100)       | 19 (42)        | 26 (58)        | 113 (63)       |
| 6  | Land shortage                  | 36 (80)        | 39 (87)        | 33 (73)        | 28 (62)        | 136 (77)       |
| 7  | Propagation                    | 31 (69)        | 21 (47)        | 37 (82)        | 29 (64)        | 118 (66)       |
| 8  | Market problem                 | 7 (16)         | 19 (42)        | 38 (84)        | 23 (51)        | 87 (48)        |
managed and organized plan (Gebrekidan et al., 2018). The conclusions and arguments of were supportive to the above opportunities identified by farmers.

The biological natures, environmental friendliness, multipurpose nature twined with short time and continuous economic return as well as its role as escaping forest sector are important triggers of bamboo plantation. (Lobovikov et al., 2012), conclude that because of lifecycle, long-lasting rhizomes support bamboo to increase adaptation to changing environment and versatility of products assists the rural communities in adapting to change and mitigating the impact which is supportive of our results.

In addition to life nature of bamboo increased demand for forest and forest products is also strong opportunity for expansion of bamboo forest due to its versatility. Bamboo is versatile forest crop that can substitute forest products (Rockwell et al., 2014). Activities initiated in gully and degraded area rehabilitation around Awí zone (especially by Agricultural office Banja district) is good example that confirms the positive advantages of climate change and environmental degradation for the expansion of bamboo forest (Assaye et al., 2014).

5. Conclusions and recommendations
Prescribed flooding and clear cutting of culms after frost damage is important indigenous management practice ensures efficient use of resources (during prescribed flooding of bamboo stand eroded soil from agricultural lands is accumulated in bamboo stand and clear cutting of frost-damaged culms prevents drying of culms) initiated in Banja areas are best management practices that will be fruit fruitful if promoted to other sites.

Smoking under bamboo stand, practiced mitigating aphid damage by farmers around Farta district (South Gondar Zone) is also important intervention which will stimulate to other locations with special care as indigenous and/or chemical control mechanism for protection of bamboo weevils and insects in other parts of the country is limited.

Assessment of the cause of drying of highland bamboo as well as identification of existing and potential pathogens and insect pests with their controlling and prevention measures should be done as it is the important challenge of highland bamboo production.

Provision of extension services and updated trainings on management and utilization of the species have to be given to growers by coordinating government, farmers and other stakeholders which were engaged directly or indirectly in bamboo management-related tasks.

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