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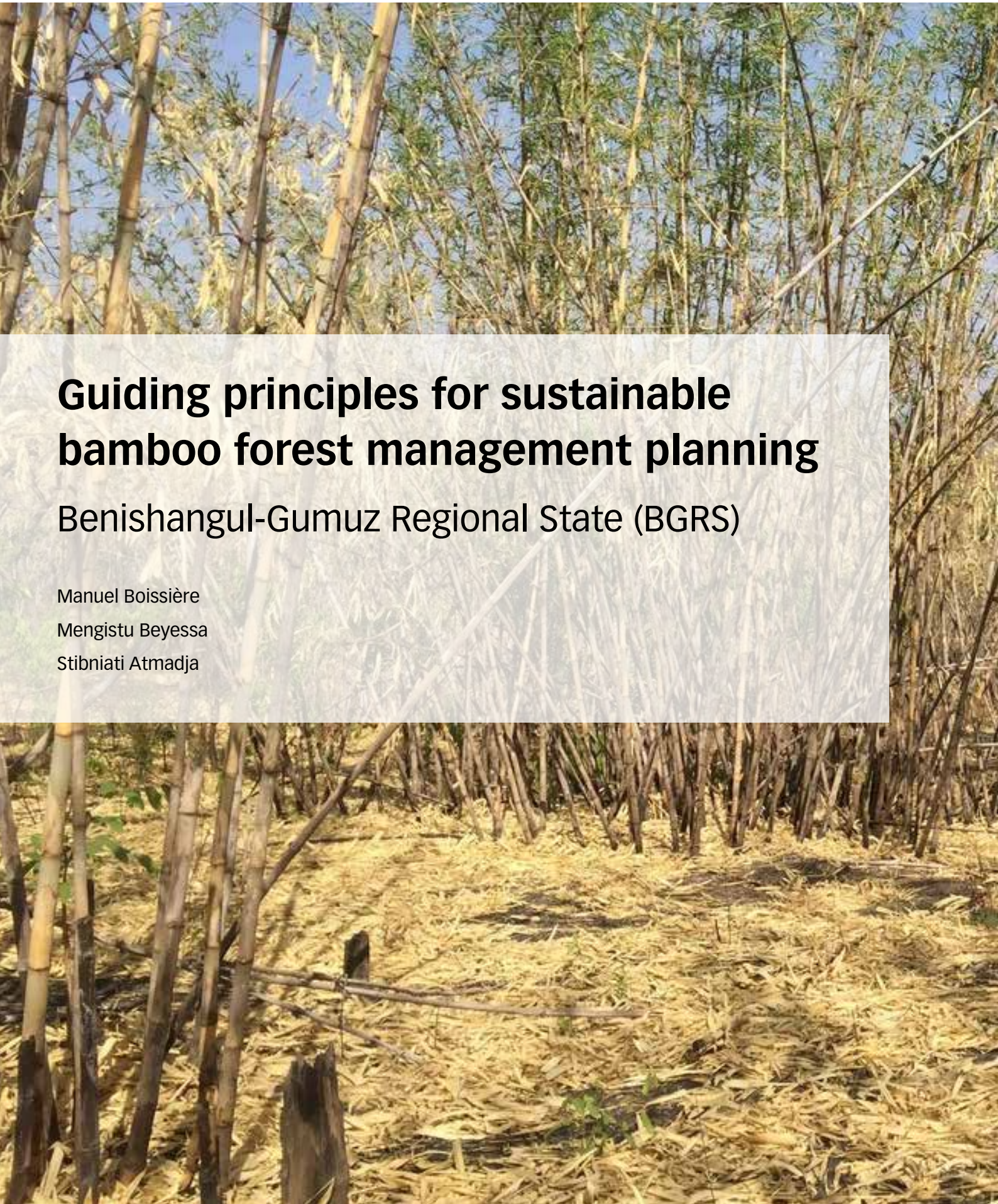

Guiding principles for sustainable bamboo forest management planning

Benishangul-Gumuz Regional State (BGRS)

Manuel Boissière

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Lowland bamboo forest in Benishangul-Gumuz Regional State

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Published by the Food and Agriculture Organization of the United Nations and Center for International Forestry Research
Rome, 2019

Required citation:
Boissière M., Beyessa M., Atmadja S. 2019. *Guiding Principles for Sustainable Bamboo Forest Management Planning : Benishangul-Gumuz Regional State (BGRS).* Rome, FAO. 32 pp.

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Acknowledgements

The authors would like to acknowledge the UN-REDD for its financial support, through the Food and Agriculture Organization of the United Nations.

This research was carried out by the Center for International Forestry Research (CIFOR) and the Centre de coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), as part of the CGIAR Research Program on Forests, Trees and Agroforestry.

The authors would like also to thank the Ministry of Environment, Forest and Climate Change for its support and technical guidance, the Ethiopian Environment and Forestry Research Institute, for its valuable expertise. They also want to thank the regional administration of Benishangul-Gumuz Regional State, especially the Bureau of Environment Forest Land Administration, for its support, the Woreda administration in Assosa, Bambessi, and Kurmuk.

They want to express their gratitude to the local communities and PFM forest management group committees in the villages of Abramo, Abende Engeda, Agole, Famesare, Agubela, and Beshir, for their availability and the information they provided on the local management of bamboo forest.

Last but not least they would like to thank the Civil Society Organizations based in Assosa or in Addis Ababa, especially the Assosa Environment Protection Association(AEPA), International Network for Bamboo and Rattan Organization (INBAR), FarmAfrica, and all the individuals who shared their knowledge and expertise with the authors of this document, review it and contributed to its improvement.

Acronyms

AEPA	Assosa Environment Protection Association
BGRS	Benishangul-Gumuz Regional State
BoEFLA	Bureau of Environment Forestry Land Administration
BoFED	Bureau of Finance and Economic Development
CIFOR	Centre for International Forestry Research
CIRAD	Centre de coopération Internationale en Recherche Agronomique pour le Développement
CSO	Civil Society Organisation
EEFRI	Ethiopian Environment and Forestry Research Institute
EFCCC	Environment, Forest, and Climate Change Commission
FAO	Food and Agriculture Organization of the United Nations
FMG	Forest Management Group
GDP	Gross Domestic Product
INBAR	International Network for Bamboo and Rattan Organization
MEFCC	Ministry of Environment, Forest, and Climate Change
MSE	Micro Small Enterprise
NGO	Non Governmental Organisation
NTFP	Non Timber Forest Product
PFM	Participatory Forest Management
REDD+	Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
SBFM	Sustainable Bamboo Forest Management
SE	Smallholder Enterprise
SFM	Sustainable Forest Management
TA	Technical Assistance
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization

1 Introduction

Ethiopia has committed to develop the bamboo sector (see FDRE 2009, Bamboo Sector Strategy Framework: framework document for discussion, cited in MEFCC 2018). Benishangul-Gumuz Regional State (BGRS) is the region with the highest presence of bamboo in Ethiopia, especially lowland bamboo, *Oxytenanthera abyssinica*. This species is adapted to dry land, poor and shallow soil, and degraded landscape. Bamboo forests play a crucial role as a buffer to desertification that is expanding from neighbouring Sudan. In the last 10 years, bamboo in BGRS has been highly degraded due to unsustainable agricultural practices (e.g. use of fire), land conversion for agricultural investments, and mass bamboo flowering followed by subsequent death, starting in 2006 (Sertse et al 2011). Bamboo has the potential to become an important economic resource, by bringing additional income to poor farmers, and can also help with land restoration in the lowlands. A shift in the perception of bamboo is therefore necessary, from being perceived as a weed to an economic resource. A plan for bamboo forest management is also required, first at the regional level, to be further translated and adapted to the local level (district or Woreda).

This work is based on the combination of a desk study, workshop and field visits between March and June 2018, in the context of a technical assistance (TA) implemented by CIFOR for the Food and Agriculture Organization (FAO). The objective of this TA is to adapt the FAO "Guidelines on sustainable forest management (SFM) in dry lands of sub-Saharan Africa"[1] to the Ethiopian context, with activities specific to BGRS.

1 http://www.fao.org/sustainable-forest-management/toolbox/tools/tool-detail/en/c/218000/

The TA seeks to facilitate planning for REDD+ implementation on the ground, building on the existing and on-going REDD+ readiness work in this area.

FAO support focuses specifically on enhancing the competencies of the Forest Directorate within the Ministry of Environment, Forestry and Climate Change (MEFCC), now the Environment, Forest, and Climate Change Commission (EFCCC), to enhance carbon stock and to sustainably manage the existing forest resources through the development of a framework document for sustainable forest management in support of REDD+ activities. In BGRS, activities focused on sustainable forest management, forest and landscape restoration, and approaches to incentivize investments in the forest sector, especially concerning bamboo forest.

This document should be used in support of decision makers (e.g. regional authorities) for developing a sustainable bamboo forest management plan for BGRS. The document also explores ways to link bamboo production to the market and the private sector. This document is only the first step for Sustainable Bamboo Forest Management (SBFM) planning; it provides guidance and suggestions, but does not replace any national or regional regulations, and cannot substitute official government management planning for bamboo. Management plans will still need to be developed by each district authorities, in collaboration with all concerned stakeholders. However, we hope this document will help to identify key challenges and opportunities to the sustainable management of bamboo forest in this region.

1.1 Importance of developing SFM plan for bamboo in BGRS

There are two species of bamboo in Ethiopia growing naturally: the highland bamboo (*Yushania alpina*) and the lowland bamboo (*Oxytenanthera abyssinica*), the latter being one of the dominant species in BGRS. Of the 1,470,000 ha of bamboo land cover nationally, an estimated 900,000 ha is found in BGRS (Tsinghua University and INBAR 2018, Durai et al. 2018). Figure 1 shows the map of bamboo cover at the national level. Lowland bamboo grows between 500 and 1600 m altitude, in places with a precipitation of 700–1000 mm (annual average), and survives on poor and shallow soils. As such, it represents an important buffer against desertification in the lowlands, especially near the boarder with Sudan, where strong winds bring sand and dust into BGRS. Bamboo is also a fast growing plant, representing a valuable source of energy (e.g. firewood and charcoal) for households, food (bamboo shoots and feed for cattle and wild animals), construction (bamboo culm), and other uses (furniture, flooring, and household utensils such as chopsticks etc). It has been part of the livelihoods of rural communities in the region for generations (Bessie et al 2016). So far, however, no management plan exists for the bamboo forest at the regional level, even if the regional government has developed a strategy on bamboo propagation and utilization (Sertse et al 2012). But no implementation guidelines exist so far. A sustainable bamboo forest management plan is therefore needed.

1.2 Administrative division and agro-climatic zones in BGRS

BGRS, a region of 50,380 km^2, is divided in three administrative zones: Assosa, Kemash, Metekel, and 20 districts or Woredas. The regional capital city is Assosa. The region has three agro-climatic zones (BoFED 2017): the lowlands is the largest zone, located below 1500 m altitude, representing more than 75% of the total area, with annual rainfalls in general lower than 400 mm. The second largest zone is between 1500 and 2500m and represents

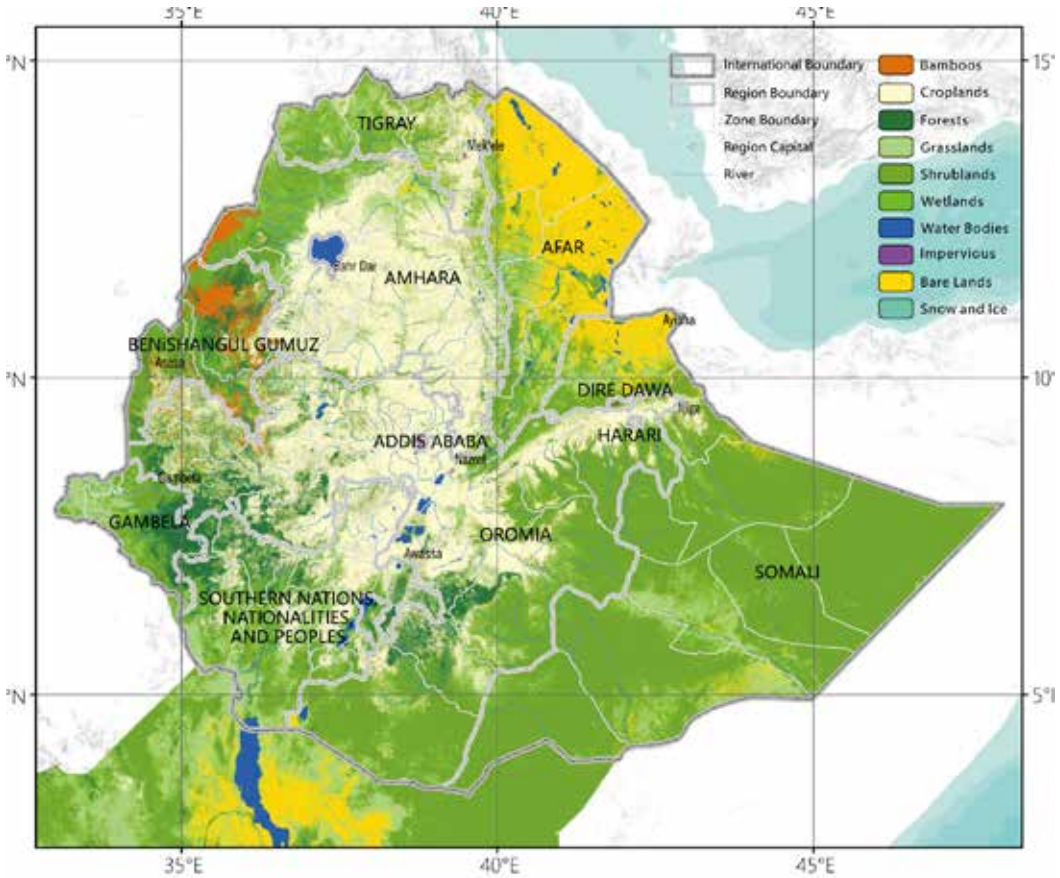

Figure 1. Bamboo land cover map of Ethiopia, overlaid on administrative boundaries.
Source: Tsinghua University and INBAR 2018

24% of the total area. The third and smallest zone (1%) is located above 2500m and includes mountain range and high plateaus. Lowland bamboo is located in the lowland agro-climatic zone and widespread throughout the region.

1.3 Existing bamboo management systems

According to Durai et al. (2018), bamboo follows four management systems: state forests, community bamboo, institutional bamboo and private bamboo. State forests and community bamboo apply to BGRS while institutional and private bamboo management are found mainly in other parts of Ethiopia. Bamboo growing on **state forest** is theoretically under the protection of the state and should not be harvested. In reality, bamboo is collected from these forests, sometimes through local institutions such as Forest Management Groups (FMGs) established under Participatory Forest Management (PFM), and sometimes through concessions granted to private companies. A fee is asked to the person(s) transporting and selling or buying bamboo if the harvest is for commercial use. The second category of **community bamboo** can be managed by institutions such as smallholder enterprises or cooperatives, but the land under which this bamboo is growing is communal, still under government management, with some particular land use rights given to communities. **Institutional bamboo** can be found in land managed by the Church or by schools, which can be observed mostly in Amhara region. **Private bamboo** is cultivated on privately owned lands, such as homesteads and agricultural lands. This mostly applies to highland bamboo, although more and more lowland bamboo can be found in homesteads, brought back by villagers from the forest.

1.4 Role of bamboo forest in Ethiopia economy

Although bamboo resources represent only 0,02% of the Ethiopia's exports, they contribute to the national economy, for household consumption on one hand but also as a marketable product at the national level on the other hand. The bamboo market represents ETB 56 millions and three quarters of a million people depend on it in the country (Durai et al. 2018). Although the bamboo market is small, it has substantial potential for development, with adequate resources and policies at national and regional levels. In the domestic market, the main bamboo product traded are bamboo poles (culm), followed by bamboo mats, basketry and furniture.

1.5 Challenges for bamboo SFM in BGRS

Bamboo in BGRS has decreased dramatically over the last 10 years, although recent reports (Tsinghua University and Durai et al. 2018) show a regeneration of bamboo after the recent mass flowering that started in 2006. Local livelihoods in BGRS depend essentially on subsistence agriculture and therefore the demand for agricultural land is high. The sources of change in bamboo forest cover include: natural (e.g., mass flowering, although natural regeneration has taken place during the last few years) and human (investment in small and large agricultural projects, and use of fire to clear the grasses for these investments or for a better access, or for hunting). About 350,000 ha of agricultural land have been transferred to 600 investors in the last few years, to produce cereal, pulses, oil crops, cotton, burlap, and for livestock production and agroforestry practices. Lack of awareness of farmers and of skills to exploit bamboo is also among the causes of bamboo forest degradation. Another challenge for sustainable bamboo use and trade is the lack of infrastructures in some of the Woredas, making bamboo difficult to be transported to the nearest market.

2 Methods

The Sustainable Bamboo Forest Management plan (SBFM plan) for Benishangul-Gumuz Regional State was developed using three different methods: desk study, participatory mapping workshop, field visit (i.e. key informant interviews, group discussion, direct observation).

2.1 Desk study

Part of the information was obtained from a desk study, through the analysis of relevant documents. A number of published documents as well as grey literature were used to identify the needs and constraints of the region, for example the Benishangul-Gumuz Regional State Profile (BoFED 2017), the forestry resource potential assessment from the BGRS Investment Office (2004), the Remote sensing-based bamboo resource assessment prepared by the Tsinghua university and INBAR (2018), the Value chain analysis and market assessment of bamboo products in Ethiopia prepared by INBAR, the Guidelines for cultivating Ethiopian lowland bamboo (UNIDO 2009) and other documents (INBAR undated a, b, c, d, e).

Recent (2018) and past (2013) satellites images were analysed to produce an updated map of bamboo resources for BGRS, and maps produced by the Bureau of Environment, Forestry and Land Administration in Assosa were also used to overlap the investment plans for the region.

2.2 Participatory mapping

A one-day workshop was organised in Assosa, in May 2018, with 23 key stakeholders in natural resource management, to discuss present and future bamboo management for the region. Stakeholders came from academia (University of Assosa, Agriculture Technical Vocational Training), government organisations (Bureau of Environment Forest Land Administration, Bureau of Investment, Bureau of Agriculture and Rural Development, Bureau of Economic Finance Development, heads of the three zones in BGRS, experts from 2 Woredas), CSO (FarmAfrica, Assosa Environmental Protection Association, INBAR), and community elders. The group discussions in the workshop were focused on 2 themes: 1) Identification of the key stakeholders in bamboo management, the types of bamboo management that could be used for the SBFM plan, and the criteria linking these management types to the locations where they should take place. 2) Mapping exercise integrating the local government investment plans where should the different types of bamboo management be implemented in the next 10 years. The participants to the workshop used a base map showing bamboo forest location, investments, and infrastructures.

2.3 Other types of data collection

Field visits were conducted in several Woredas in Assosa zone: Assosa, Kurmuk, Bambesi, Homesha. During these visits, interviews were conducted with members of FMG committees established under PFM and members of bamboo cooperatives. Questions were asked about PFM and cooperatives, their history and challenges, and the potential for trading bamboo, including processed bamboo. We also asked about challenges facing these different institutions in protecting and exploiting the bamboo forest.

In Assosa town, more interviews were conducted with a bamboo enterprise (Bamboo Star and AgroForest PLC), banks (Commercial Bank of Ethiopia, Ethiopian Development Bank), farmers selling bamboo at Assosa market, and buyers. We tried to understand the role of Bamboo Star Agroforest PLC in the bamboo sector in BGRS, access to credit in Assosa, and the current bamboo market conditions (e.g., prices, fees, uses).

In Addis Ababa, interviews were conducted with experts from the Ethiopian Environmental and Forestry Research Institute (EEFRI), INBAR, and the Ministry of Environment, Forestry and Climate Change (MEFCC). These interviews provided information on the status of bamboo at the national level, the potential for improving the bamboo market, and the main constraints regarding the exploitation of bamboo in BGRS.

3 Determining opportunities and constraints for bamboo SFM in BGRS: participatory mapping

The development of a sustainable bamboo forest management plan (SBFM plan) was made using participatory mapping, during a workshop held in Assosa on May 7th, as presented in the previous section (methods). In preparation to the mapping exercise, the types of management were identified, as well as the criteria for identifying where each of these types of management should take place, and the stakeholders who should be involved. Figure 1 below shows how the different elements (stakeholders, management, criteria) were linked with each other. To make the interpretation easier, we split the figure into two tables (Table 1 and 2).

Figure 2 shows the map developed by INBAR in collaboration with the University of Tsinghua and MEFCC (Tsinghua University and INBAR 2018). This map represents the latest update on bamboo forest cover and shows an increase in bamboo forest cover in the country. At the time of this study, the map developed by INBAR in collaboration with the University of Tsinghua was not released yet. That map is based Landsat 8 with images acquired especially in 2016. Therefore, we used the map developed by FAO in 2013 and updated it with recent satellite images from Landsat, acquired in 2018. The participants to the workshop, based on their experience and knowledge, drew the map of potential sustainable bamboo forest management

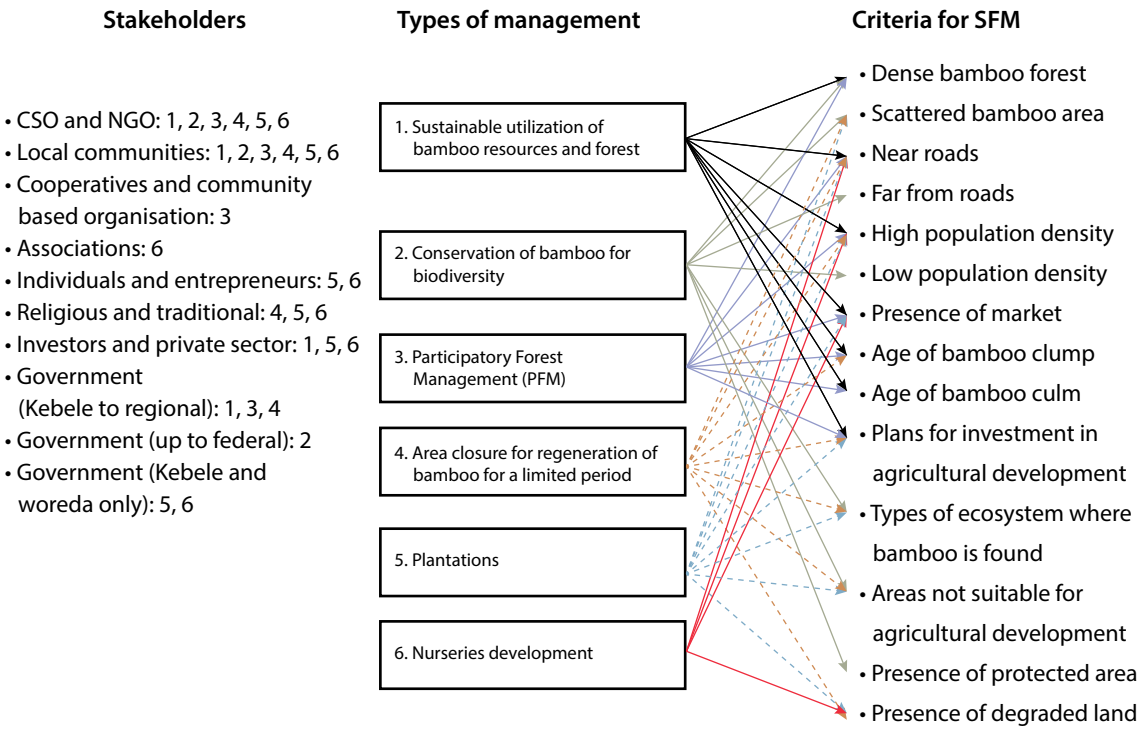

Figure 2. Integration of types of bamboo management, criteria for mapping exercise and stakeholders involved in the management.

planning taking into account the current bamboo forest cover in the region (Figure 5).

3.1 Forest and land use zoning: demarcating bamboo management though mapping

One of our main objectives were to identify areas in BGRS where bamboo management should be given a priority for protection, sustainable use and trade at the regional scale. Six different types of bamboo forest management were identified (Table 1). Below are the area selection criteria for each management type:

1. Sustainable utilization of bamboo resources and forest for production: this should be done in areas where bamboo forest is abundant, not far from infrastructures and from the market, and where bamboo has already reached maturity and is ready to be harvested.
2. Conservation of bamboo for biodiversity: this activity should target places of relevance for conservation, where population density is low, where infrastructure is rare or inexistent, near protected areas, and in degraded land (not suitable for agriculture). In protected areas, some bamboo culm should be removed annually to maintain the health of the bamboo forest.
3. Participatory Forest Management (PFM) for conservation and sustainable use: PFM has started in BGRS about 10 years ago, with the active involvement of two NGOs: FarmAfrica and Assosa Environmental Protection Association (AEPA). PFM was recognised during the workshop as one of the ways forward for SBFM. PFM should target areas where bamboo forest is present and mature, not far from roads and from market places, where population density is high, and where there are plans for agricultural investments nearby, which justify the necessity to protect and sustainably use these bamboo forests.
4. Area exclosure for forest restoration: a way to support bamboo forest regeneration is to decide with communities to stop any activity in some highly degraded areas where bamboo used to grow. This should be done in places where bamboo is scattered or has disappeared, or where the presence of roads, agricultural investment plans nearby and high population

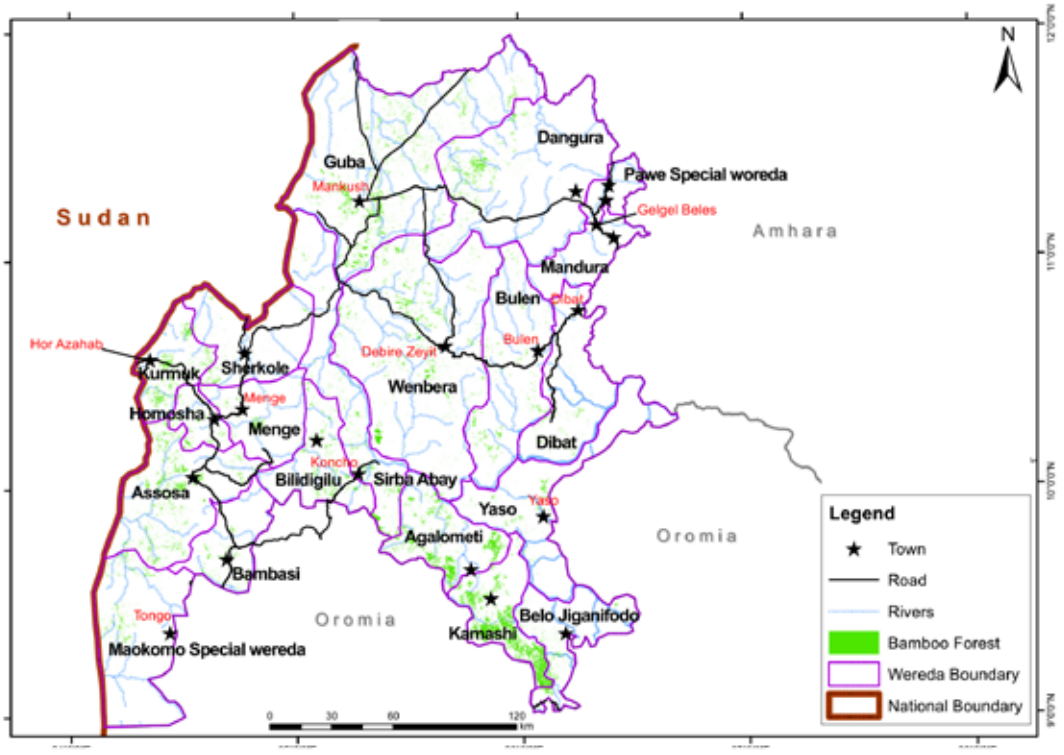

Figure 3. Bamboo land cover map of Benishangul-Gumuz Regional State.

Source: Based on the map developed by FAO from 2013 satellite images, updated with Landsat, date of acquisition 28/02/2018, from http://www.usgs.org, software QGIS

density may exert pressure on the remaining bamboo resource. Bamboo area exclosure should be planned in degraded places with steep slopes, unsuitable to agriculture. This is one of the different options to forest landscape restoration, which applies to bamboo forests. Even in area exclosure, some bamboo culm harvest should take place once the bamboo has reached maturity.

5. Plantations for forest restoration and production: this is a complementary activity to area exclosure. Plantations can be made within areas under exclosure (enrichment plantings) or in new places, near infrastructures, with high population density, for which planting bamboo may become a good economic option as compared to other agriculture activities.
6. Nurseries: this activity is generally associated with plantations. Where plantations are established, seeds and seedlings are needed. Nurseries can produce seedlings from seeds, planted rhizomes or small seedlings transplanted from the forest. Seeds are only available after bamboo flowering, which happens approximately every 35 to 40 years. Nurseries can also be used to acclimate exotic bamboo species that might be developed later into plantations. Nurseries need to be developed near roads because of transportation needs, and near a permanent stream or river, for irrigating the young seedlings. The slope should be gentle (<5%) for water run off during the raining season, to avoid further erosion and water accumulation in puddles.

3.2 SBFM plan: who are the stakeholders in bamboo management?

Another main objective was to identify stakeholders that need to be involved in sustainable bamboo forest management. Stakeholders who would have the most direct role at the local level would be the NGOs and the local communities. The role of local communities in the development of nurseries was considered as minor, although local people may be individually working in nurseries as wage labor. The private sector was recognised as having a potential role in plantation development and nurseries. Religious institutions (e.g. church and traditional institutions) would have a role in area exclosures (e.g. church forests), but also in plantations and nurseries (for enrichment). The workshop participants identified three levels of government, which could be involved in sustainable bamboo management from local up to kebele (sub district), from kebele to regional, and from regional level up to federal level. Each level needs to be involved in different types of bamboo forest management (Table 2). Government organisations, especially at the local level, should be involved in the assessment and monitoring of bamboo management.

3.3 Cycle and map of SFM plan

An SFM plan should be done for a period of 10 or 20 years (See FAO SFM toolbox, http://www.fao.org/sustainable-forest-management/toolbox/en/), and should follow all the steps of planning, implementing, and monitoring. Here, because bamboo culm life cycle is short (10 years maximum), we suggest a management plan for a 10-year period.

The first map (Figure 4), produced by the Bureau of Environment, Forestry Land Administration, shows the investment plans at the regional level (agricultural investments, Renaissance dam construction), and was used during the mapping exercise to avoid overlap with other government plans. The second map (Figure 5) was developed during the workshop based on the bamboo management categories identified earlier. This participatory map was developed at the regional level only, and no ground check was done following the mapping exercise, because of time constraints. It was based on data available from the Bureau of Environment, Forest Land Administration BoEFLA, from a GIS desk study, and from each participant knowledge and experience. The level of accuracy is therefore not what should be expected for a detailed management plan. This map indicates trends and where and how should bamboo forest be managed in BGRS. The map should be used in each Woreda to produce a more detailed and specific management plan for bamboo forests (with clear responsibilities, products, monitoring system, and management types).

The map in Figure 5 takes into account the situation in each Woreda including: presence of an investment plan (e.g., dam, agricultural investment etc), infrastructure (e.g., roads, town with market nearby), and population (high or low density). According to each Woreda's situation, different types of management were proposed as described in the Table 1.

Table 1. Link between types of management and criteria for mapping

	Criteria for deciding where management types are best suitable													
Types of management	**Dense bamboo forest**	**Scattered bamboo area**	**Near roads**	**Far from roads**	**High population density**	**Low population density**	**Presence of market**	**Age of bamboo clump**	**Age of bamboo culm**	**Plans for investment in agricultural development**	**Types of ecosystem where bamboo is found**	**Areas not suitable for agriculture (steep slopes)**	**Presence of protected area**	**Presence of degraded land**
1. Sustainable utilization of bamboo resources and forest	1	0	1	0	1	0	1	1	1	1	0	0	0	0
2. Conservation of bamboo for biodiversity	1	1	0	1	0	1	0	0	0	0	1	1	1	0
3. Participatory forest management (PFM)	1	0	1	0	1	0	1	1	1	1	0	0	0	0
4. Area exclosure for regeneration for a limited period	0	1	1	0	1	0	0	1	0	1	1	1	0	1
5. Plantations	0	1	1	0	1	0	1	0	0	1	1	1	0	1
6. Nurseries	0	0	1	0	1	0	1	0	0	0	0	0	0	1

Note: is there a link? 1: yes, 0: no

Table 2. Stakeholders involved in the different types of management

	Types of management					
Stakeholders	**1. Sustainable utilization of bamboo resources and forest**	**2. Conservation of bamboo for biodiversity**	**3. Participatory forest management (PFM)**	**4. Area exclosure for regeneration for a limited period**	**5. Plantations**	**6. Nurseries**
CSO and NGO	1	1	1	1	1	1
Local communities	1	1	1	1	1	0
Cooperatives and community based organization	0	0	1	0	0	0
Associations	0	0	0	0	0	1
Individuals and entrepreneurs	0	0	0	0	1	1
Religious and traditional	0	0	0	1	1	1
Investors and private sector	1	0	0	0	1	1
Government (Kebele to regional)	1	0	1	1	0	0
Government (up to federal)	0	1	0	0	0	0
Government (Kebele and Woreda only)	0	0	0	0	1	1

Note: are stakeholders involved? 1: yes, 0: no

3.4 Identifying economic opportunities for bamboo SFM: PFM, smallholder enterprises

Sustainable management of bamboo forests needs to also generate economic benefits, to cover the cost of management and contribute to local livelihods. Durai et al. 2018 provides interesting recommendations on how to add value to bamboo harvesting in Ethiopia. BGRS is the region with the highest presence in bamboo forest, compared to all the other regions of Ethiopia. This gives the region a chance to be a national leader in the sustainable management and use of bamboo resources.

Bamboo can be used for many different purposes, for household consumption or to sell in markets. Local communities generally use bamboo for food (from bamboo shoot), firewood, fencing, house construction, and for mats. Bamboo has a good economic potential for, among others, construction (scaffolding), furniture, toothpicks, and industrial panels that can be produced from bamboo mats. Using bamboo for firewood or for charcoal development may be also a good way to reduce the pressure on trees, when bamboo grows faster and regular thinning of bamboo clumps increase their sustainability.

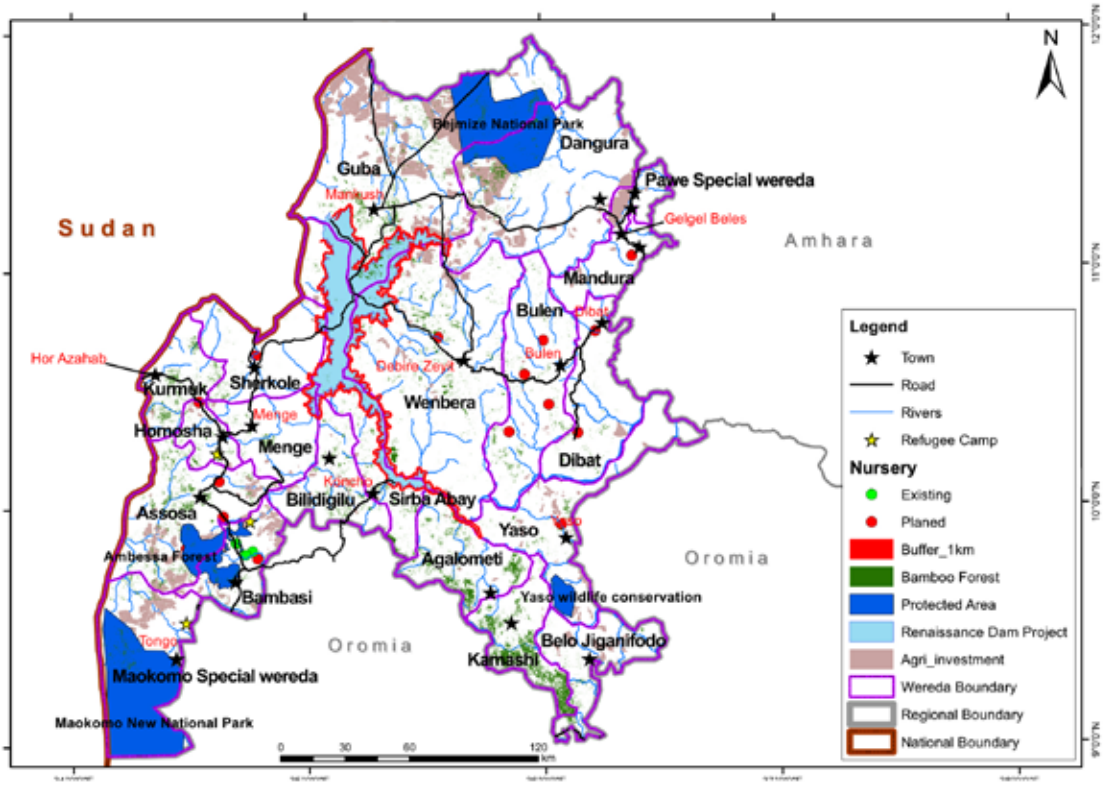

Figure 4. Agro investment map for BGRS.

Source: BoEFLA, adapted using Landsat, date of acquisition 28/02/2018, from http://www.usgs.org, software QGIS.

Local communities were identified in the previous section as one of the major stakeholders in SBFM. There are three ways in which local communities can be involved in sustainable bamboo trade:

Individual: selling bamboo to vendors, who are going twice a week to Assosa market to sell bamboo culms, or directly selling at the market. In such cases, the payment of fees is the responsibility of the vendor or the person selling at the market in town.

PFM Forest Management Groups (FMGs) committee: Communities can organize themselves into forest management groups (FMGs) to manage bamboo forests for conservation and sustainable use. These groups are usually established as part of PFM, and receive initial help and training from NGOs. There are elaborate rules on who, how and when FMG members can exploit the bamboo resource (Farm Africa 2005).

Cooperatives/smallholder enterprises: organised through training provided by the local government (Bureaus of Agriculture/BoA), these enterprises do not follow the structure of Forest Management Groups (FMG) but have an objective which can also be both economic and protection-oriented. We visited one of these cooperatives/smallholder enterprises in Assosa Woreda but its activities on bamboo were limited (see the section below on *Market survey for bamboo trade*), the cooperative focussing more on the trade of basic products needed by villagers (e.g. cooking oil).

The difference between the cooperative/smallholder enterprise and the FMG is the objective: the cooperative/smallholder enterprise is income oriented, to get sustainable source of income, manage exotic and indigenous bamboo plantations, while FMG is more about conservation as a first goal, and income comes in second. Many FMG activities are related to

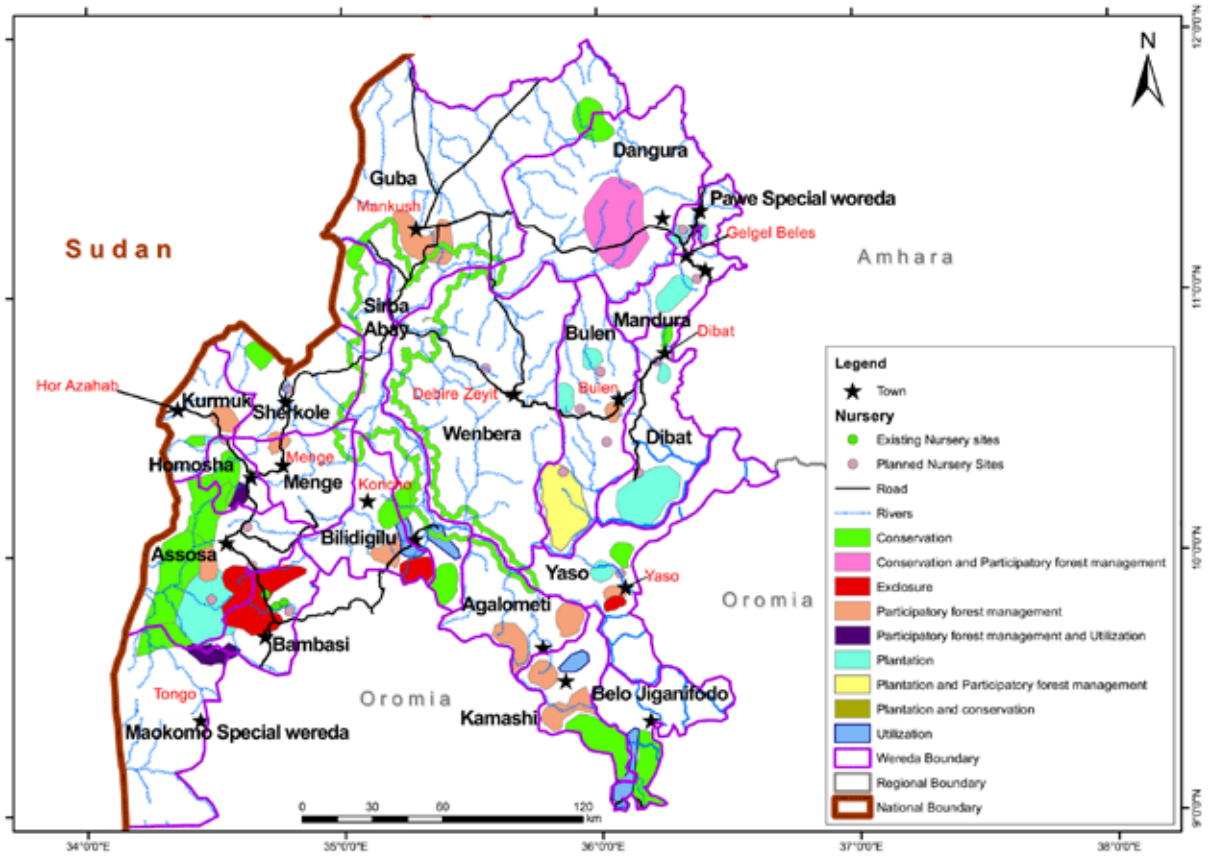

Figure 5. Map of potential bamboo forest management in BGRS.

Source: participatory mapping workshop, 2018, using Landsat, date of acquisition 28/02/2018, from http://www.usgs.org, software QGIS.

building firebreaks, controlling agricultural expansion near the bamboo forest under FMG, monitoring bamboo resource, and exploiting the bamboo as well as other NTFPs (e.g. frankincense, honey) in a sustainable way and in groups.

3.5 Clarifying major environmental, economic, development constraints

Several major constraints need to be taken into account for SBFM. Some are environmental (e.g., longer dry season contribute to fire spreading), some are development oriented (see the map of investment plans for the region, Figure 4) and may impact on the resource, especially when forestland for bamboo is converted into agricultural land, as it is the case in Bambessi Woreda. The pressure on the bamboo forest is increasing because of economic needs, as investors and farmers looking for land to develop their business or their farm. As explained in the introduction, about 350,000 ha of agricultural land have been recently transferred to 600 investors for agricultural investment. The Grand Ethiopia Renaissance Dam (GERD) occupies 220,000 hectares of land in Metekel and Kemash zones, previously a collection of different land uses including commercial agriculture, smallholder farms and bamboo forests.

The environmental constraints were analysed based on data provided by the meteorological station from Assosa, from six Woredas for the last 30 years. If we look at the mean monthly precipitations for the last 30 years, we observe a cycle of droughts and high precipitations approximately every five years: low precipitations in 1995, 2004, 2011, and 2015; and high precipitations in 1987, 2000, 2006, and 2014. Although the frequency of years with low precipitation is increasing in the last 10 years, this cyclical pattern makes us predict a period of high precipitations in the coming years. This variation in rainfall may have a limited impact on the lowland bamboo, which is quite resilient to difficult conditions, (both in terms of climate and soil fertility) (Figure 6).

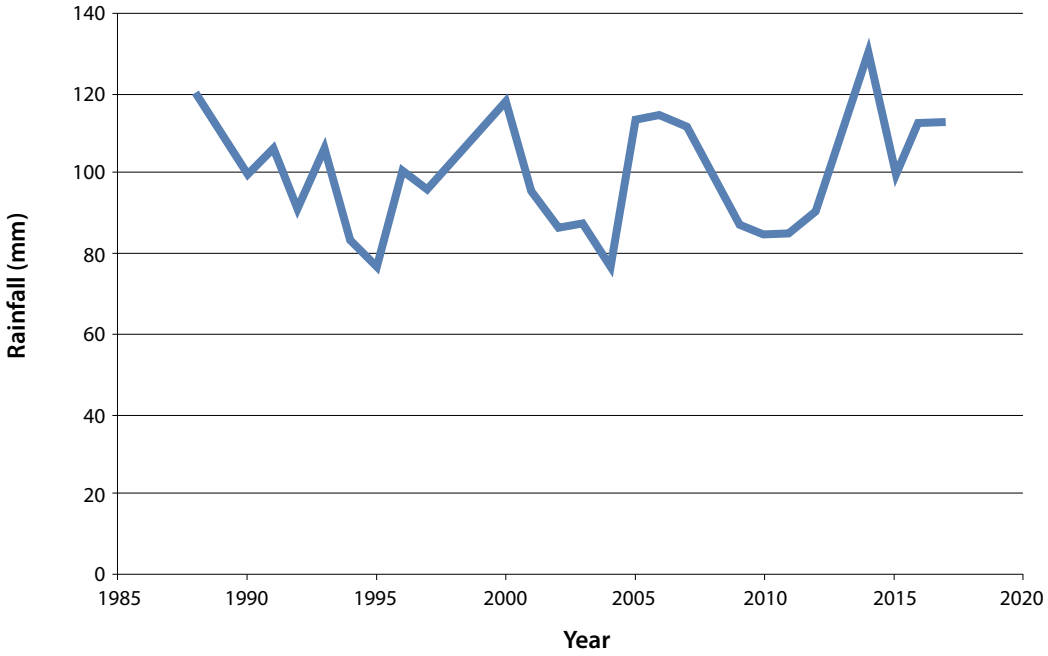

Figure 6. Mean monthly variation of rainfall from 1987 until 2017 in BGRS, based on the data from 6 Woreda.

Source: Station of meteorology, Assosa.

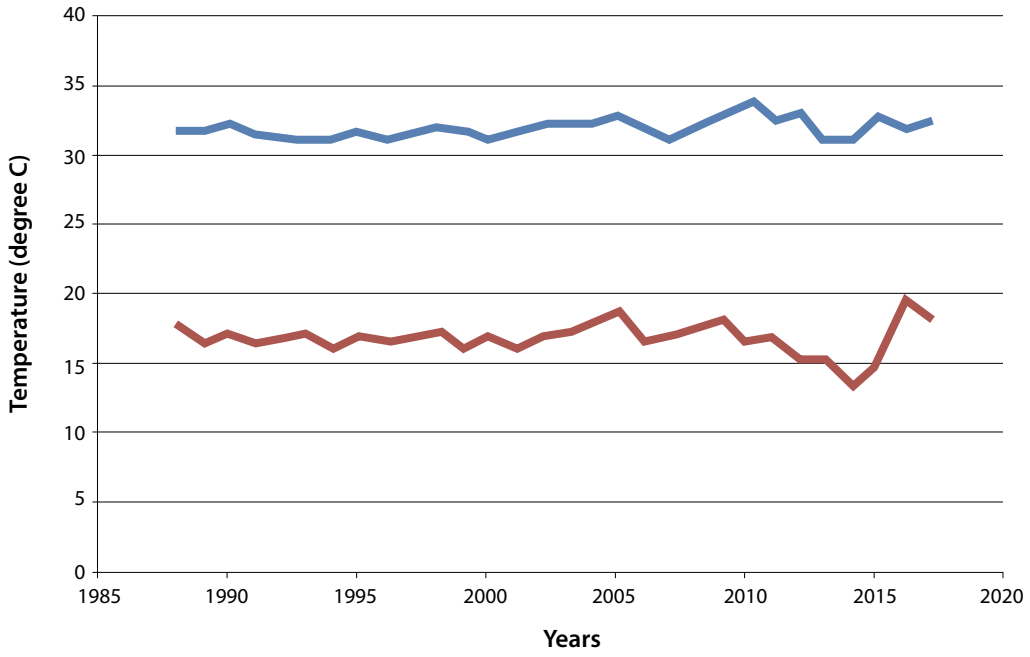

Figure 7. Mean temperatures minimal (in red) and maximal (in blue) from 1987 until 2017 in BGRS, based on the data from 6 Woreda.

Source: Station of meteorology, Assosa.

When we look at the mean minimum and maximum temperatures for all the 6 districts during the last 30 years, there are no clear trends (Figure 7).

4 Sustainable harvesting of bamboo

Techniques of harvesting are mostly inspired by the guidelines developed by INBAR on Ethiopian lowland bamboo cultivation (INBAR 2009), and discussions with experts and farmers.

4.1 Harvest in bamboo forests

Lowland bamboo grows in difficult conditions (e.g., steep slopes, places difficult to reach by road, like in Kamashi Woreda) and therefore can be difficult to harvest. The lowland bamboo is a fast growing plant: bamboo stands (i.e. clumps) takes three years to reach maturity, i.e., the age at which it can be harvested. Each clump consists of individual bamboo culms/sticks. After five or six years the culm dries and dies. It develops in clumps with the older culms at the central part of the clump and new culms developing outward. The lowland bamboo is smaller and thinner than the highland bamboo: 3-10 meters high and 4 to 10 cm of diameter, compared to 10 to 20 meter high, 5 to 12,5 cm diameter for highland bamboo. Internodes of lowland bamboo are in general solid for the lower part of the culm and hollow for the rest, expect when the soil is of poor quality (then the culm can be entirely solid). Harvesting of lowland bamboo in the forest needs to follow some rules. Harvest of the mature culms must therefore be done in the middle of the clump when the bamboo culm is three years old and older. By regularly harvesting bamboo culms, farmers can increase the vitality of the clump if the harvest is done properly (see the techniques of harvesting described below).

4.2 Yield per hectare and per year

The production of 1 hectare of forest of lowland bamboo depends on the natural conditions of the forest and the species of bamboo. According to Tesfaye Hunde (personal communication), bamboo culms should not exceed 18,000 culms per hectare and about 25% should be removed annually through regular thinning. There is little information on the average yield of lowland bamboo per hectare. Unasylva vol 13 (1)[2] proposes numbers ranging from 6,000 up to 15,000 culm per hectare, using an example of India, but lowland bamboo in Ethiopia may follow different trends. LUSO CONSULT (1997) shows the number of culms per hectare for lowland bamboos is about 8100, as compared to 5900 culms per hectare for the highland bamboo.

4.3 Techniques for harvesting

In a clump, the culm needs to be selected wisely according to the age and a number of mature culms needs to be left in the clump. If the bamboo has been planted, then harvesting small culms for thinning should be done starting three years after planting. Harvesting the culm needs to be done from the centre of the clump as this is where the oldest culms are located. Potential harm to young culms should be avoided. Ideally the tool used for harvesting (e.g. machete or a small curved hand saw) should be sharp and disinfected, although it is not always easy to do for farmers. The cut should be done right above the first node to avoid accumulation of water and possible infection by parasites. Harvest should be avoided during rainy season for the same reasons. The best time to harvest is at the end of the rainy season and harvest should be avoided at the end of the dry season, when the culm is full of carbohydrates, useful for the development of new shoots. Therefore,

2 http://www.fao.org/docrep/x5390e/x5390e05.htm

lowland bamboo should not be harvested from June to September (Tesfaye Hunde, personal communication). Ideally, each clump, which has been just harvested, should be mulched right after the harvest, using the leaves of the culms freshly cut.

4.4 Cycle of bamboo harvest

There are two levels in the cycle of bamboo: one is the cycle of each bamboo stand or culm, the other one is the cycle of the entire plant, through its rhizome development. The culm reaches maturity three years after the development of its shoot and dries after five or six years. This is therefore the window for harvesting depending on the quality of bamboo that is being sought (young, mature or dry culm). The plant sexual cycle is difficult to predict: bamboo flowers every 40 to 50 years, leading to the death of the rhizome and the development of bamboo seeds and new seedlings. Lowland bamboo generally flowers in mass, although sometime it doesn't follow that pattern and individual clumps flower independently, or some do not flower during mass flowering. The harvest needs to follow the life cycle of the culm and, after mass flowering, harvesters need to wait until the bamboo seeds ripe and start to fall on the ground. Then the dry culms can be cut and used. The site should then be under strict protection until the seedlings regenerate and develop in mature culms.

4.5 Other resources present in bamboo forest

When bamboo is planted, intercropping is possible for the first two years, with cash crops and vegetable. One particular crop, called Noog (*Guizotia abyssinica)* produces valuable and edible oil from its seeds. Farmers are interested in developing this crops in BGRS and this doesn't necessary enter into competition with the lowland bamboo. In the bamboo forests visited especially in Assosa zone, near the boarder with Sudan, frankincense was present, mixed with bamboo forest, and could produce an additional source of income for farmers. Frankincense, or *Bostwelia papyrifera,* can be found in the forests of South West Ethiopia (Combretum-Terminalia deciduous woodlands) and produces incense by tapping the trunk of the tree. Beekeeping is also another important source of income for farmers, who are even using bamboo culms to produce the beehives that are hanged at the branches of trees in their backyard or in allocated communal spaces.

5 Incentivising bamboo sustainable management

Understanding the link between bamboo forest management and the market or the private sector requires knowledge of the main stakeholders in the bamboo market at the regional level, the current demand, and the potential for adding value to the bamboo resource exploitation (Endalamaw 2015).

5.1 Role of the private sector

The current situation of the private sector in bamboo forest management is as follows: In 2010, Bamboo Star Agroforestry PLC was formed but has not been active for the last two years. Bamboo Star Agroforestry PLC has a factory in Assosa, which still exists in 2018, but is not active anymore. The reason given by its factory production manager is the lack of cash for hiring staff. Bamboo Star was given land by the local government for exploiting bamboo in BGRS, but this resulted in tensions with local communities. The bamboo has been processed in many different products, some of them being not competitive in national and international markets. For example, the production of bamboo floor in Assosa cannot compete with the companies in Addis that use highland bamboo, which are larger in diameter and need less imported glue. Another example is the production of chopsticks, which cannot compete with Chinese producers. The lack of involvement of local communities, due to the tensions regarding land tenure when the factory in Assosa was still active, is also a concern.

Developing links between bamboo management and the private sector should look into supporting and improving the trading capacity of grassroots organisations, such as FMG and smallholder enterprises or cooperative harvesting and selling bamboo culms. Some of these cooperatives have tried to transform the raw material and not just sell bamboo culms, but their success has been limited because of lack of semi-mechanical tools for processing (Seyoum Kelemework, and Fiker Assefa, personal communication), lack of information on the market demand, and high labour cost in processing the bamboo versus the price of the final product. Semi-mechanical tools include drills and small circular saws, which cost under 2000 ETB (73 USD). When using manual saws, the metal should be made of steel special for tools, which then require sharpening every six months. However, locally-available saws are made of steel from car springs, which require sharpening at least once a day and is time consuming.

INBAR has tried to provide training on bamboo processing for farmers and staff from the Rural Technology Centre (RTC) in Assosa, and purchased tools for bamboo transformation (i.e. softener, manual press, electric saws, splitting tools, charcoal production tool). After INBAR project ended, the tools were not maintained at the RTC and – because of staff turn over - the knowledge of how to use them was forgotten.

A system of loans is in place with the Commercial Bank of Ethiopia and the Ethiopian Development Bank, which targets mainly investors who have capital and who are looking for additional credit. These loans do not cater to farmers because of the minimum amount of loans required (ETB 500,000) and the high interest rates (about 9.5% per year). As far as we know, there is no micro-credit is in place that could support farmers in developing bamboo-oriented business.

5.2 Market survey for bamboo trade

A market survey was conducted in May 2018 in Assosa and in two villages from two different Woredas (Kurmuk and Asossa Woredas), to understand how the bamboo trade is organised.

Assosa market: this is based on interviews of two groups of sellers.

Bamboo is sold in Assosa twice a week, every Saturday and Wednesday. The location of the market is on the road to Abramo, still inside the town, but in a separate place from the big market. Sellers used to come in the main marketplace, but because it is now overcrowded, the city authorities have moved this bamboo market out, on the side of the road, near the stadium. Sellers come to town from the neighbouring villages using donkey-carts. It takes them up to four hours one way to come to Assosa. They sell bamboo because they have no farmland or the production of their farm is not enough as source of income and livelihood. One cart can carry 100 culms in one trip, organised in 10 bundles. Each cart has a plate number and is taxed 50 ETB (USD 1.81) when passing the bureau of agriculture checkpoint at the gate of the town. Another cost is the cart itself, which the seller rents for 300 ETB a month for using it eight days in the month (i.e. twice a week). Buying a new cart costs 10,000 ETB. The donkey in general belongs to the seller but needs to be fed during the market day.

Each culm is bought from individuals, members of FMGs, or members of cooperatives, in the villages near a bamboo forest, at the cost of 4 up to 5.5 ETB per culm. In Assosa market, culms can be sold between 6 and 6.5 ETB, or even 7 when the buyer doesn't bargain or when the bamboo is of particularly good quality. There are two criteria used to assess the quality of the bamboo culms: the diameter: large-diameter bamboos are more expensive because there is higher demand; and the colour, which depends on the age: old and dry bamboo are grey (with fungus), and more resistant to outdoor conditions. Good bamboo should not crack when using nails on it. Poor quality of bamboo culm has insect holes visible on it.

When the seller cannot sell all the content of his cart during the market day, then he generally leaves the remaining culms at the market place, without any supervision, to avoid repaying tax for the same culms. Sometimes the leftover culms get stolen but the sellers are willing to take the risk, as the cost of guarding the bamboo would be too high for them. At the end of the day, the net benefit from selling bamboo culms can be about 200 ETB (about USD 7.25) if the 100 culms (one cart) are sold.

We interviewed five different buyers on the market. The buyers, in general citizens, need to build fences or a house and come to the market only when they need to, a few times a year. If the buyer buys the entire content of the donkey cart, then the seller brings the culms to his house for free. Otherwise, the buyer has to bring his own cart. All the buyers interviewed were using bamboo for these two purposes (construction and fencing), although one of them admitted that he had a table made of bamboo, which lasted for more than 10 years, and that he would be interested in purchasing more furniture made of bamboo.

Links between PFM and the bamboo market:

We visited three villages involved in PFM, one in Assosa Woreda and two in Kurmuk Woreda. People from a FMG committee established under PFM in Assosa Woreda admitted to sell bamboo only in places where bamboo is already mature and access to the road is easy. There are two ways to sell bamboo: 1) as an individual, in small quantities to vendors passing by the village. The price is between 3.5 ETB and 4.5 ETB per culm. Or 2) as a PFM cooperative, with a letter of authorization from the Woreda authorities. Those already selling mature culms could sell up to 10,000 culms to big buyers (e.g. the owner of a hotel in Assosa, looking for bamboo to build fences for a big goat fattening farm), but this has to be done before the rain season. The PFM cooperative sells one culm 2 ETB but the buyer has to collect the culms himself directly from the forest, and also needs to pay the royalties and load the culms on a truck. The villagers who are members of the cooperative are just cutting the bamboo for the buyer. Bamboo cutting is generally done during the dry season or at the end of the rainy season. The royalties are 1.20 ETB per culm, and car rental for transportation is generally 1.25 ETB per culm, plus 0.60 ETB for loading. The total is therefore 3.05 ETB per culm, added to the 2 ETB that goes to the PFM cooperative.

Bamboo market in Assosa. © CIFOR/Boissière.

In some places, in Kurmuk Woreda, people from the PFM FMG are individually transforming bamboo into different products: baskets, which are sold 10 ETB piece (for an investment of 2.5 ETB for one culm used to make it); beehives, which are not sold, only for local consumption; praying carpets, sold 20 ETB (using five mature culms for a total of 12.5 ETB).

Smallholder enterprise/cooperative:

Micro and small enterprises (MSEs) transform bamboo into furniture and other processed products. In Ethiopia, they are generally found in urban centers (Durai et al., 2018). We could not, however, confirm the presence of MSEs during our survey in BGRS. Instead, we found cooperatives of bamboo collectors or groups of collectors organized in smallholder enterprises. Members of one of these cooperatives were interviewed. This particular cooperative benefited from the help of INBAR for getting exotic bamboo species to be planted in nurseries. These cooperatives have difficulty to control who accesses the bamboo forest, and how the harvest of bamboo is made. They have little support from the government (e.g., BoA) in terms of training and capacity building, especially when it comes to processing the bamboo into furniture or other transformed products, to build saving institutions in the village, and to cut the bamboo culms. But because of their statute as a cooperative, organised in an association, they do not have to pay royalties on the bamboo culms they collect. The buyer still needs to pay royalties when transporting the bamboo to the city. When a deal is made with a buyer, members of the cooperative will help collect the bamboo and load it in trucks. They sell the culms at 4 ETB each, and the result of the transactions is put into a bank account. A part of the revenue is shared among the cooperative members. Awareness on bamboo forest needs to be raised in the village and more financial incentive is needed for community members to join the cooperative. For that, the market needs to be present with a clear demand on specific bamboo products.

5.3 Potential for increasing resource generation

Technical options for improving economic benefits for local communities need to be explored, such as cheap and low-technology tools to make the transformation process cost and labour effective. Economically viable solutions need to be found to make the productions from lowland bamboo in BGRS competitive as compared to the highland bamboo and to the international market. Careful investment planning is needed to add value to such a cheap forest product. At the local level, the number of shops selling transformed bamboo products needs to be increased. Such products can also be sold along roadways between Assossa and Addis Ababa. Producers need to be better connected to industries and factories based in Addis Ababa, who are using bamboo products. At the international level, Ethiopia needs to identify and produce products that can be internationally competitive.

Local people are traditionally weaving bamboo to build walls for their houses and to make carpets. These weaved bamboo panels can be used in the industry, pressed together to become boards. Factories in Addis Ababa, for example, could be supplied with semi-processed bamboo. Other products from bamboo can include curtains, dishes, lampshade, and toothpicks. Using semi-mechanical (and cheap) tools, the production of processed bamboo can become cost-effective. Without these tools the production of processed bamboo will be time consuming for the farmers and not cost-effective. Training will be needed for local communities to learn how to use the tools and also how to connect to the market.

Any other product, such as chopsticks or flooring, should not be encouraged in BGRS because of the physical properties of lowland bamboo that make it less competitive compared to highland bamboo.

There is a high demand for bamboo by companies located in Addis Ababa. Unprocessed bamboo culms are transported by truck from Assosa to Addis Ababa, which results in a loss of volume due to the reduction of moisture in the culms (Fiker Assefa, personal communication). To make the trade more profitable at a low cost, one way would be to transport semi processed culms to Addis Ababa. The parts that are generally not used (bottom and upper parts of the culm) should be cut in Assosa, and could be used for charcoal production. The middle part would be cut to the size needed according to the final product (2-3 m culm for floor production, various size for furniture production) and could be transported to the capital.

6 Potential role of PFM and SME

More information is available on PFM than on smallholder enterprises.

6.1 PFM activities in BGRS

Participatory Forest Management is a forest management system in which communities (forest users & managers) and government services (forest department) work together to define forest resource uses, identify and develop forest management responsibilities, and agree on how forest benefits will be shared.

To establish PFM systems, three steps need to be followed, as proposed in the PFM guidelines developed by Farm Africa (FarmAfrica 2005). These are defined in Box 1.

6.2 Areas covered by PFM

In BGRS, PFM is not only about bamboo forest management, but also includes the management and production of frankincense, honey and other NTFPs. There are 22 Kebeles in BGRS implementing PFM. The forest area delineated under PFM varies from one Kebele to another and from one Woreda to another, based on the forest resource availability. Table 3 summarize the areas under PFM in three Woredas of Assosa zone.

6.3 Local participation in PFM

Communities are consulted through all the steps of the PFM implementation. The communities identify forest resources; they contribute to resource assessment and to delineation of forest under PFM. The local government (Woreda and kebele levels) are fully engaged in the management of the project.

6.4 Income generation from PFM

As an example, in one year of PFM implementation, in Kurmuk and Assosa Woredas and Mao and Kumo Special Woreda, the 245 (165 male and 80 females) community members engaged in incense management produced about 14,000 kg of incense, which resulted in ETB 660,000 (USD 24,000) of income, and the 787 (464 male and 178 female) community members

Box 1. 3 stages for establishing PFM (FarmAfrica 2005)

I. Investigating PFM – gathering information about the resources in the forest, understanding who are the forest users and other stakeholders, setting up an appropriate forest management group, assessing and mapping forest resources.

II. Negotiating PFM – negotiating and signing forest management plans (specifying forest management activities), and forest management agreements (clarifying roles, responsibilities and rules).

III. Implementing PFM – implementing the forest management plan, monitoring the adherence to the forest management agreement by the community forest management group, planning jointly, reviewing and revising agreement as part of monitoring and evaluation systems.

Table 3. Recently established PFM in BGRS

No	Woreda	Target Kebele	Ha of forest managed	Members of Participatory Forest Management PFM			Signatory bodies
				Male	Female	Total	
1	Assosa	Abramo	1035	200	100	300	• PFMC leaders, • Kebele office, • Woreda environment forest and land administration office, • Woreda administrative • Woreda Justice office
		Agole	2873	152	170	322	
		Mengele39	258	52	12	64	
		Sherkole Afendu	634	1200	589	1789	
	Sub total		**4800**	**1604**	**871**	**2475**	
2	Kurmuk	Dilash	5949.80	57	68	125	
		Obe Beloumu	4418.73	72	38	110	
		Husher Guma	843.3	40	76	116	
	Sub total		**11,211.83**	**169**	**182**	**351**	
3	Mao & komo Special Woreda	Zebsher	259	120	174	294	
		Ya'a	70	145	224	269	
		Tsotsora	90	98	132	220	
	Sub total		**419**	**363**	**530**	**783**	
	Grand Total		**16,430.83**	**4272**	**3166**	**7218**	

Source: Interviewed AEPA Staff

involved in honey production collected about 12,000Kg, which resulted in ETB 629,000 (USD 22,900) of income. A bamboo - oriented PFM in Abramo village, Assosa Woreda, with 232 members (170 females, 60 males), produced about 10,000 culms of bamboo in a year, which resulted in ETB 20,000 (USD 725) of income. This shows that income generation from bamboo is still far from reaching its full potential.

6.5 Smallholder enterprises (SE) for bamboo management

The East African Bamboo Project was implemented by the Ministry of Agriculture and Natural Resources, in consultation with INBAR from 2009 until 2011 (Mulatu and Kindu 2010). It was supported later on by World Vision for two years, mainly through training. About seven species of exotic bamboo species were produced in nurseries, along with lowland bamboo. These nurseries still exist today and are used by community-led cooperatives, although the SE institutions are weak. We do not have information on the area covered by bamboo under the management of these SE.

6.6 Potential of PFM and SE for future bamboo SFM development

CSOs and government organizations are targeting bamboo forest for rehabilitation and sustainable management. The new forest development, conservation and utilization proclamation, gazetted in January 2018, is giving a chance for devolving bamboo forest management to local communities. Infrastructures are improving, although slowly, and will increase the opportunity for remote villages to market their bamboo resources. In PFM and SE, through training organized by NGOs or government offices, communities are improving their understanding of how bamboo can be utilized and propagated. This trend needs to be supported.

7 Potential role of bamboo SFM for restoration

7.1 Needs for restoration in BGRS

BGRS is bordering Sudan. As such it plays a role of buffer against the desertification of the region. A UNDP report states that: "The forest in Benishangul-Gumuz services as the major green wall against the expansion of the Sahara desert on the one hand, and land degradation of the highlands" (UNDP Ethiopia 2017). Lowland bamboo is resistant to difficult ecological conditions: it grows on poor soils and in the lowlands between 600 and 1500m above sea level (asl). It is therefore a resource with a high potential to fight desertification and land degradation. Planting bamboo on degraded slopes will decrease erosion and loss of soil fertility, and increase water conservation. Termites in general infest degraded lands. But termites do not attack lowland bamboo, because it is rich in silica (Tesfaye Hunde, personal communication). This makes lowland bamboo a key species for the rehabilitation of these degraded lands. The fact that intercropping is possible at least during the first few years will help to keep bamboo plantations economically attractive for the local communities until they reach maturity and can start being harvested.

7.2 Bamboo for land restoration: potential and constraints

According to a recent technical report by MEFCC (MEFCC 2018), the potential for tree-based landscape restoration in BGRS is 83% of the total area of the region. This represents a large area that could be targeted for restoration. Bamboo has a high potential for landscape restoration because it is a fast growing plant adapted to difficult weather and soil conditions. There are four ways to use bamboo forests for land restoration:

1. Plantation of seedlings developed in nurseries will help to stabilise soil degradation and buffer against desertification. Plantations can provide benefits to communities as well (not only environmental benefits), because the exploitation of mature bamboo increases the health of the bamboo forest.
2. Area exclosure: by capitalizing on the engagement of local communities in bamboo rehabilitation (and therefore on the subsequent benefits they may get from the restored bamboo forest), the best way to support land restoration is to let the bamboo grow back. Building social fences or bamboo fences on communal land or under the management of a user group, cooperative, or PFM committee, will help the rehabilitation of degraded land.
3. PFM: fighting against land degradation means keeping bamboo forests from being more degraded and protecting and managing the existing bamboo forests. PFM, by engaging local communities in the sustainable management of bamboo forests, brings a high potential to ensure the sustainable use of these forests.
4. Conservation: bamboo forests located in conservation areas (wildlife reserve, national park, and other protected areas) also need to be protected. Although these conservation areas are generally managed by the government organisations, engaging local communities who are inside or near these areas will help manage and monitor the resource, and avoid further degradation. Even in conservation areas, bamboo requires regular thinning to reduce the density of culms and to promote understory vegetation.

The main constraint in using bamboo for restoration is the general negative perception

of bamboo as an invasive species, a weed, with very little potential for economic return from its utilization, and which needs to be burnt in order to give way to agricultural expansion and other bigger economic investments. Another constraint is the difficulty to obtain seeds, as bamboo is flowering approximately every 40 years. The vegetative multiplication from young plants collected in the forest or from the rhizome is time consuming and costly. It is difficult to know at what time of the bamboo life cycle seedling is developed into nurseries. If the seedling or young plant comes from an already old rhizome, it may not take long before it flowers and dies. The limited infrastructures (i.e. roads) in BGRS also make the transportation of seeds and seedlings difficult. Because sustainability of the resource is linked to its sustainable harvesting and exploitation, sustainable management of bamboo forests becomes more challenging when transportation infrastructure is lacking. BGRS is seasonally confronted to uncontrolled fires. Fires spread rapidly in bamboo forests because the understory is made of grass (e.g. elephant grass or *Pennisetum purpureum),* which dries during the dry season. Fires are often started for hunting small games, getting rid of snakes and parasites to the cattle, and easing human and livestock movements in savannahs.

7.3 Developing nurseries

A land restoration project that involves the plantation of bamboo needs to develop nurseries. But developing nurseries is time consuming and costly. It cannot be done everywhere. Nurseries are often developed near the location of the future plantation to reduce the transportation costs, on a gentle slope, with easy access (e.g., by road or path), and near a source of irrigation (e.g. a pond, a well, or a river). Building a place to store equipment and seeds/seedlings is also important, as well as beds to plants the seeds and seedlings. For about 50 ha of plantation a nursery of 2 hectares may be necessary. But for land restoration made in different sites in a Woreda, multiplying the number of small size nurseries may be the way to go, although more costly than a single big nursery.

Seeds are hard to find, but remain the best way to propagate bamboo. Seedlings and rhizomes are the most common way to develop bamboo in nurseries but it takes more time and human resources to grow, and is therefore more costly.

7.4 Capitalizing on existing projects

A way forward to support the use of bamboo resources for degraded land restoration is to capitalize on existing projects. One idea may be to collaborate with government-managed nurseries, but also with existing projects such as village cooperatives or smallholder enterprises supported by the bureau of agriculture, NGO-led projects such as PFM, whose achievements are increasingly getting recognition by policy makers (there is now a PFM directorate at MEFCC). PFM projects have been in place for many years, building long-term relationships with local communities and local government, negotiating rights for communities to be able to trade bamboo resources and other associated NTFPs, and developing training for sustainable bamboo management, harvest and exploitation.

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Benishangul-Gumuz Regional State (BGRS) is the region of Ethiopia with the greatest bamboo forest cover. The resource has, however, encountered heavy degradation in recent years due to fires for farming and for hunting, mass flowering, unsustainable harvest, and land conversion. Bamboo, if harvested correctly, can become a valuable resource and a source of income for the rural population of BGRS. In order to do so, a management plan is needed at the regional level to provide guidance for future planning at the district level. This document, based on a desk study, field survey, direct observation, and a participatory mapping workshop, intends to provide this guidance for a sustainable bamboo forest management plan. It also gives recommendations on how to sustainably harvest bamboo, how to develop nurseries for future bamboo plantations, how to link bamboo forests with the private sector and the market, and the role bamboo could play in degraded land restoration.

This publication was made possible through support from Denmark, Japan, Luxembourg, Norway, Spain, Switzerland and the European Union.

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CA3700EN/1/03.19