

INBAR Working Paper



Technical Paper

The Use of Bamboo for Landscape Restoration in Central and West Africa

Assessment of Barriers and Key Recommendations

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RESEARCH
PROGRAM ON
Forests, Trees and
Agroforestry



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About the International Bamboo and Rattan Organisation

The International Bamboo and Rattan Organisation, INBAR, is an intergovernmental organisation dedicated to the promotion of bamboo and rattan for sustainable development.

For more information, please visit www.inbar.int.

About this Working Paper

- This research was carried out by the International Bamboo and Rattan Organisation (INBAR) as part of the CGIAR Research Program on Forests, Trees and Agroforestry (FTA).
- FTA is the world's largest research for development programme to enhance the role of forests, trees and agroforestry in sustainable development and food security and to address climate change. CIFOR leads FTA in partnership with Bioversity International, CATIE, CIRAD, INBAR, ICRAF and TBI.
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List of Abbreviations

AFR100	African Forest Landscape Restoration Initiative
ANAFOR	National Forestry Development Agency
ANR	Assisted natural regeneration
BARADEP	Bamboo and Rattan Development Programme (Ghana)
BFT	Bois et Forêts des Tropiques
CAR	Central African Republic
CAFI	Central African Forest Initiative
CIFOR	Centre for International Forestry Research
CIRAD	Centre for International Cooperation in Agricultural Research for Development (France)
CO ₂	Carbon dioxide
DRC	Democratic Republic of the Congo
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organization of the United Nations
FODER	Forest and Rural Development
FLR	Forest landscape restoration
GFC	Ghana Forestry Commission
GIZ	Society for International Cooperation (Germany)
ICRAF	International Centre for Research in Agroforestry
IFAD	International Fund for Agricultural Development
INBAR	International Bamboo and Rattan Organisation
IRA	Institute of Agronomic Research
IRAD	Institute for Research in Agricultural Development
IUCN	International Union for Conservation of Nature
LDN	Land Degradation Neutrality
MEFDD	Ministry of Forest Economy and Sustainable Development (Congo)
MINREX	Ministry of External Relations (Cameroon)
MIPROMALO	Local Materials Promotion Services
NGOs	Non-governmental organization
NTFP/NWFP	Non-timber forest product/Non-wood forest products

ORSTOM	Institut Français de Recherche Scientifique pour le Développement en Coopération
PPP	Public-private partnership
REDD+	Reducing Emissions from Deforestation and Forest Degradation
USD	United States dollar
WRI	World Resources Institute

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Executive Summary

Africa is one of the most ecologically vulnerable continents in the world, with over 700 million hectares of degraded land and degradation progressing at a rate of 3% per year. However, evidence points to historical efforts for landscape restoration. Among the options for responding to key challenges is the use of species with considerable potential for restoring degraded lands, such as bamboo. This report aims to share lessons from the contribution of bamboo to restoration initiatives in Central and West Africa, which remain limited.

Key findings

Restoration opportunities and contribution of African countries

The Bonn Challenge, launched in 2011, is a global initiative aimed at restoring 150 million hectares of degraded and deforested land by 2020. Support provided in 2014, included in the New York Declaration on Forests, extended this target to 350 million hectares by 2030. The African Forest Landscape Restoration Initiative (AFR100) contributes to the fulfilment of national commitments to the Bonn Challenge. To date, 111 million hectares have been allocated to forest landscape restoration (FLR). Cameroon and seven West African countries are among 27 African countries committed to FLR under the AFR100 banner.

Place of bamboo in FLR in Central and West Africa

The Great Green Wall programme in arid African countries, which brings together actions to restore land, conserve biodiversity, develop agricultural and pastoral systems, and fight poverty, does not yet include bamboo species in the list of species identified as priorities. However, several other initiatives are underway to reconcile the development of the existing potential and the contribution of exotic bamboo species, from which the use of bamboo for the regeneration of landscapes could liaise. Bamboos, with 1,642 species globally, cover over 35 million hectares worldwide. However, African bamboo forests account for only 7% of all bamboo forests in the world. Bamboo is used as a stake for certain fetishes, medicine, and food, as well as for building houses and making furniture. It is also an ornamental plant.

Barriers to the use of bamboo in landscape restoration

Some international forestry institutions still tend to ignore the role of bamboo when it comes to translating political commitments into implementation on the ground.

Barriers related to the level of knowledge and sensitivity

Information on the policy and regulatory frameworks that govern the bamboo sector is limited or lacking. Regulations are non-existent or poorly adapted or implemented. In many areas, bamboos are perceived as non-timber forest product (NTFP) species instead of industrially valuable woody forest products. Knowledge of the exact natural potential and technological properties of stubble is limited. The success of previous restoration initiatives remains poorly documented, with most achievements remaining in researchers' drawers. The relatively recent design of large-scale FLR programmes limits the understanding of motivations, real needs, and critical success factors. Data on the involvement of women in the various links of the bamboo sector are lacking. Regional or local authorities have poor knowledge of the specifications of their mandates, and farmers are unaware of their rights and obligations.

Technological barriers

Knowledge of species adapted to specific ecological conditions, seed sources, propagation methods, nursery operations, and plantation establishment and management is extremely limited. A lack of research and technological innovations is the main obstacle to the use of bamboo as a source of fibre alternative to lumber in the region. The structural weakness of technological transformation microenterprises further limits the support of actors in the sector.

Barriers related to land management, governance, policy, and regulation

There are many reasons why models of small individual or family farms may not represent the scale required to achieve restoration at the landscape level, including individual visions, means, topographical position, and road access. Not all stakeholders share the same views on the models or expected outcomes of restoration initiatives. Moreover, spatial planning is in its infancy, and the land regulations currently in force are inadequate. Bush fires pose an additional serious problem. Furthermore, an environment conducive to maximizing bamboo's contribution to the green economy is lacking. In most countries, organization is fragmented at the sector level, and integration of sectoral policies is unlikely. Special bamboo policies in countries' laws are limited. Political, security, or even health risks in certain countries can pose obstacles to the mobilization of financial resources for the implementation of programmes in the field.

Financial and marketing barriers

Administrations within governments are slow to translate regulations to incentives. Moreover, prior financial investments by the public and private sectors are insufficient for supporting the key links of the bamboo sector. Financing forest regeneration is a risky enterprise, especially for companies and farmers, who prioritize profitability. In arid zones, it is difficult to render FLR profitable through direct production. A lack of funding and the absence of national policies and strategic programmes for promoting the use of bamboo also slow progress in this area.

Conclusions and recommendations

Land degradation does not spare the countries of Central and West Africa. The Bonn Challenge and the New York Declaration stand out as a consensual path to achieving the targets of corrective actions. FLR initiatives must simultaneously target various sectors (such as agriculture, animal husbandry, forestry, and town development) and take the form of mosaic restoration. Below is a non-exhaustive list of recommended key actions:

Research and awareness: Further research should be conducted, and technical documents should be produced to enhance knowledge on site-species matching, uses and economic values of different bamboo species, establishment of bamboo nurseries and plantations, and sustainable management of bamboo forests. Field studies should be conducted to document how bamboo value chains contribute to strengthening the role of women, youth, and disabled people in livelihood improvement.

Capacity building: Farmers' skills should be developed for growing and maintaining bamboo crops, supporting seed supply, and establishing partnerships with the large companies to process raw material and increase its added value.

Policy and regulation: To promote FLR, countries must create a reliable and conducive policy environment of good governance, responsible regulation, and robust mechanisms for conflict resolution between stakeholders. Moreover, legal frameworks should promote the harmonization of laws by reconciling national laws with traditional local codes.

Governance and funding: Governments, the private sector, international cooperation and donors should increase their efforts to mobilize funding for the promotion of actions that can boost the contribution of bamboo to FLR. The mobilization of different types of national and international funds should be promoted, including through qualified technical partners. The capacities of actors should be built on how to get access to carbon finance to provide funds during the first years preceding the production phase.

Engagement of international organizations: International organizations should be encouraged to mobilize resources, build capacity, and conduct research to bring bamboo cultivation closer to communities and consolidate FLR efforts across sectors. They should

support awareness campaigns and integrate issues of training and technology transfer into capacity building packages. They should also support financial investments to ensure cooperation between the public and private sectors and reduce the risks related to financing forest regeneration on degraded lands.

1. Introduction

1.1 Context, rationale, and issues

Africa is one of the most ecologically vulnerable continents in the world, with over 700 million hectares of degraded land and degradation progressing at a rate of 3% per year (Akinnifesi, 2018). However, evidence points to historical efforts for landscape restoration. Examples can be found in various African countries, notably Ethiopia, Niger, Rwanda, Senegal, and Tanzania. While the most important efforts are focused on issues of advocacy, coordination, assessment of restoration opportunities, capacity development, and resource mobilization, publications on the characterization and rehabilitation of degraded lands in arid areas are not uncommon (IRA/ORSTOM/CIRAD, 1993).

The Great Green Wall programme (Dia and Niang, 2010), an important initiative for mobilizing resources, is limited to the Sahelian strip. Bamboo, which may not grow well in these mostly arid areas, is not among the species targeted by this multinational programme. However, in other regions of Africa that have more favourable ecology but are variously affected by degradation, forest landscape restoration (FLR) is also recognized as an important means of restoring ecological integrity and generating additional local benefits for the environment.

In a context where production and nature protection concerns must be compatible, the mosaics of forest, agro-pastoral, and even urban areas must be perceived as a coherent whole to promote the dual aims of production and protection. Under these conditions, among the options for responding to landscape restoration challenges is the use of special species, such as the bamboo plant. This plant has properties that may make it ideal for restoring degraded lands. It is able to grow on degraded or eroded soils, where many other species can no longer grow. Bamboo root networks are capable of stabilizing soil to prevent erosion. Its underground rhizomes and fibrous roots can grow up to 100 km per hectare of bamboo stand, reach a depth of 60 cm, and live for a century (FAO and INBAR, 2018). Furthermore, it is one of the fastest growing woody plants, reaching up to 1 m per day (Ben-zhi et al, 2005).

How can we conceive the place of bamboo in the landscape restoration of Central and West Africa? Due to its great potential, the number of countries interested in adopting it as a priority species for use in landscape restoration is increasing significantly. Cameroon in Central Africa and Ghana in West Africa are among the countries that now specifically include bamboo in their sustainable land management programmes. In 2014, INBAR Member States committed

to supporting the global Bonn Challenge for land restoration using bamboo and agreed to formulate a plan to regenerate millions of hectares of degraded land (INBAR, 2018).

While bamboos have already been used in many restoration programmes, information on the lessons learned from their contribution to landscape restoration initiatives remains limited. The success of expanding such programmes to other regions is contingent upon taking into account scientific data, such as information on adaptation to climatic and soil conditions, but also political and social acceptance aspects, as well as technical knowledge and technological developments. This report aims to contribute to this goal.

1.2 Study objectives

1.1.1. Primary objective

The main objective of this study is to facilitate the process of land restoration with bamboo for socio-economic development and environmental improvement in Central and West Africa.

1.1.2. Specific objectives

The specific objectives are as follows:

- To identify the factors that limit the use of bamboo for landscape restoration.
- To develop sets of recommendations to help countries use bamboo for land restoration.
- To suggest strategies to facilitate land restoration efforts with bamboo.

1.3 Scope of the study and research questions

We present here the results of this study in the form of a working Paper, which is a report drawn from various sources of information. The option of examining and analysing existing data is preferred, with primary data presented in appendices. Based on this report, we provide a summary serving as a final policy note not exceeding eight pages. The research questions are framed as follows:

- What are the relevant arguments concerning the issue of using bamboo for landscape restoration that can better inform green policies?
- What is the level of consideration of bamboo in landscape restoration?
- What are the factors that limit the use of bamboo for landscape restoration?
- What structured recommendations can help countries in Central and West Africa use bamboo for land restoration?

- What strategies can facilitate land restoration efforts with bamboo in Central and West Africa?

1.4 Outline of the report

Besides this Introductory section, this report consists of three main additional sections. Section 2 presents an inventory of the issues related to FLR and bamboo development in Central and West Africa. This section reviews the key elements of the concept of FLR, the state of landscape degradation and its weight in Central and West Africa, restoration opportunities with an emphasis on the contribution of African countries, and the place of bamboo in the restoration of forest landscapes and its potential in Central and West Africa. It also attempts an analysis of the main actors involved in restoration programmes and the place of bamboo in these programmes. Section 3 deals with the barriers to the use of bamboo in landscape restoration. Section 4 summarizes the conclusions, recommendations, and proposed strategies.

2. FLR and development of the bamboo sector in Central and West Africa

This section begins with definitions of key concepts related to the topic under examination. Subsequently, an assessment of the issues of degradation in Central and West Africa is performed. Then, opportunities for FLR are discussed, using the Bonn Challenge, the New York Declaration on Forests, and African commitments to them as guidance. Moreover, we present our perception of the place of bamboo in FLR based on data from a sample of countries in Central and West Africa. Subsequently, we discuss the potential, uses, and economic importance of bamboo in the study area. The section ends with an analysis of the actors involved in restoration programmes.

2.1. The concept of FLR

FLR is an ongoing process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes. FLR is more than just planting trees – it is about restoring a whole landscape to meet present and future needs and to offer multiple benefits and land uses over time (IUCN, 2018). Forest degradation refers to a reduction in the capacity of forests to provide goods and services (FAO, 2011). Halting forest and land degradation is imperative for humanity. On a planet where the effects of human activity are almost ubiquitous, the concept of restoration must also take human well-being into account. Restoration efforts should be planned at the landscape level with the aim of restoring ecological integrity and promoting human well-being (Maginnis and Jackson, 2007).

A landscape can be considered a heterogeneous mosaic bringing together various land uses (such as management of the human environment, agriculture, pastures, water, soil conservation, forestry activities, and biodiversity conservation) within a vast territory or watershed.

The term “forest landscape restoration” was adopted in 2000 in Segovia, Spain at a meeting on forestry as a planned process aimed at recovering ecological integrity and increasing human well-being in landscapes and deforested areas or degraded forests (Sabogal et al, 2015). According to the most coherent definition, proposed by the Global Partnership on Forest Landscape Restoration, FLR is an active process that brings people together to identify, negotiate, and implement practices that can restore an agreed optimal balance of ecological, social, and economic benefits from forests within a broader land use framework (Sabogal et

al, 2015). FLR further refers to treating a landscape as an integrated whole, which means considering both different land uses, connections, and interactions and a mosaic of interventions that together are likely to make restoration more efficient than a single land use approach (Sabogal et al, 2015). By integrating forests, living hedges, or trees of an agroforestry system into a coherent whole, FLR ascribes to the term 'restoration' a much broader role than simply restoring to a previous state. It seeks a balance between the restoration of ecosystem services in terms of wildlife habitats, biodiversity, water regulation, carbon storage, and other services and support for the productive functions of the land for agricultural and other uses (McGuire, 2014).

The concept of FLR is based on intersectoral and comprehensive approaches including:

- Assessment of the state of landscape degradation and its weight in Central and West Africa.
- Assessment of restoration opportunities (Bonn Challenge, New York Declaration, and commitments of African countries to them).
- FLR in Central and West Africa and the place of bamboo (overview of the situation in countries such as Cameroon, Congo, Ghana, and Nigeria).
- The potential of bamboo in Central and West Africa (basic data on bamboo and the importance and uses of bamboo).
- An analysis of the actors in charge of restoration programmes and the place of bamboo in these programmes.

2.2. The state of landscape degradation and its weight in Central and West Africa

Close to 1.6 billion people – more than 25% of the world's population – rely on forest resources for their livelihoods and most of them (1.2 billion) use trees on farms to generate food and cash (Röttgen and Khosla, 2011). Forests are also home to up to 80% of terrestrial biodiversity and play a vital role in stabilizing the climate through natural carbon sequestration.

The destruction of forests for the benefit of agricultural and pastoral production represents about half of global deforestation. Each year, an average of 13 million hectares of forests are lost, often with devastating effects on communities and indigenous peoples. Urban and infrastructural development, energy needs, mining, and firewood collection also contribute to this loss of forest areas to varying degrees (Climate Summit 2014, 2014). According to Roose

(1985), any increase in agricultural production increases the risk of ecosystem degradation, especially if it is not supported by the development of the entire rural community of farmers, pastoralists, and foresters.

With more than 240 million hectares of forest coverage, the central part of Africa is home to the Congo Basin, the second largest tropical forest in the world (Jacquemot, 2018). The humid forests now cover only 37% of their estimated initial area in Africa, which is indicative of the long-term process of deforestation, which has accelerated since the 1990s (FAO, 2015). Africa as a whole is estimated to be responsible for only 5.4% of the global loss of tropical rainforests between 2000 and 2005, compared to 12.8% in Indonesia and 47.8% in Brazil (Hansen et al, 2008). Deforestation and forest degradation have remained at a low level in the Congo Basin, although they have markedly accelerated in recent years (Megevand, 2013). They are currently largely associated with the expansion of subsistence activities (agriculture and energy) and concentrated around densely populated areas. Agriculture there is still characterized by traditional subsistence systems with low input and production levels and with huge gaps between potential and actual yields.

2.2.1 Focus on the Congo Basin

The annual rate of deforestation is between 0.4% and 0.6% in Central Africa, where the forest still covers more than half of its surface, without irremediable threat. On the other hand, deforestation exceeds 2% per year in West Africa, where 85% of the forest coverage has been lost. Fortunately, while soil degradation in tropical settings is rapid, it is generally reversible, and the hotter and more humid the climate, the faster the fertility restoration potential (Roose, 1985).

Deforestation in the Congo Basin is a complex phenomenon associated with three types of activities: collection of fuelwood by local populations, exploitation of forest logs for industrial purposes, and agricultural clearing. Of the 400 million hectares of the Congo Basin, nearly 268 million are covered by more or less degraded forest formations (Tchatchou et al, 2015). According to Annunzio (2019), between 2000 and 2018, the combination of deforestation and degradation reduced tree coverage from 269 to 255 million hectares in the six countries of the Central African Forest Initiative (CAFI). In these six countries (Cameroon, the Central African Republic (CAR), Congo, the Democratic Republic of the Congo (DRC), Equatorial Guinea, and Gabon), several factors can explain deforestation, including direct causes, such as infrastructure development and agricultural expansion, and indirect causes, such as economic

development and population expansion. Of those, agriculture, especially slash-and-burn agriculture practiced by local populations, is the main factor (Tchatchou et al, 2015).

The countries of the Congo Basin which aspire, for the most part to the emergence, at various deadlines, have developed strategies based on the development of key sectors such as the development of infrastructure, the development of agriculture, logging or mining, as well as the underlying factors (Tchatchou et al., 2015). As a consequence, Cameroon, a country for which data are available, could lose more than 2.018 million hectares of forest by 2035. It is therefore feared that, in the absence of firm decisions and actions, deforestation will increase substantially in these countries as a result of the vast programmes implemented with a view to their economic emergence (Tchatchou et al, 2015). Preliminary results from a comparison between actual and potential forest coverage suggested that more than one billion hectares of deforested and degraded forest landscapes offer opportunities for rehabilitation (Röttgen and Khosla, 2011).

2.2.2. Focus on West Africa

Since 1975, West African forests have declined from about 131,000 km² to just 83,000 km². Much of this deforestation has been caused by agricultural expansion, doubling farmlands between 1975 and 2013, which now cover over 1,100,000 km² (USGS EROS, no date). Large tracts of land in West Africa are deforested at high rates, mainly due to the expansion of arable lands and pastures and cutting trees for fuelwood. African deforestation is the fastest growing in the world, at a rate far higher than that of the Amazon Rainforest (Jacquemot, 2018). West Africa has lost most of its forests to oil palm, cocoa, and coffee plantations.

In the past 50 years, the forest coverage of the Ivory Coast has decreased from 8 million to 1.5 million hectares, mainly classified as reserves. In Ghana, forest coverage was estimated at 8.8 million hectares in 1900, whereas the current area of dense humid forest is no more than 1.5 million hectares (Jacquemot, 2018). According to Roose (1985), 40 years after the era of large industrial plantations in West Africa, development policies have given priority to the creation of large national parks, the development of anti-erosion bands, and research on adapted cultivation techniques. These measures now have limitations.

2.3. Restoration opportunities and contribution of African countries

2.3.1. *The Bonn Challenge and the New York Declaration on Forests*

The Bonn Challenge, launched in 2011, is a global initiative aimed at restoring 150 million hectares of degraded and deforested land by 2020. Support provided within the framework of the United Nations Climate Summit 2014 and included in the New York Declaration on Forests extended this target to 350 million hectares by 2030. Achieving this target is expected to generate around 170 billion USD per year in net benefit from protecting watersheds and improving agricultural and forestry yields and could sequester up to 1.7 gigatons of carbon dioxide (CO₂) equivalent per year.

Far from constituting a new agreement, the Bonn Challenge is a practical means of achieving the goals of a number of international agreements, including Aichi Target 15 of the Convention on Biological Diversity, the Reducing Emissions from Deforestation and Forest Degradation (REDD+) target of the United Nations Framework Convention on Climate Change, and the Rio + 20 target on land degradation neutrality. It is also a way of guiding national priorities for food, water security, and rural development.

2.3.2. *Africa's commitments*

The African Forest Landscape Restoration Initiative (AFR100), supported by the African Union Development Agency-NEPAD and 32 additional technical partners, involves 30 countries: Benin, Burkina Faso, Burundi, Cameroon, Chad, Central African Republic, Congo, Cote d'Ivoire, the DRC, Ethiopia, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Togo, Uganda and Zimbabwe (Jacquemot, 2018; Mamadou Diakhite (Online)). It responds to the African Union's mandate to restore 100 million hectares of degraded lands by 2030, in accordance with the political declaration approved in October 2015 for the creation of the African Resilient Landscapes Initiative. It complements the African Landscapes Action Plan and the broader Climate Change, Biodiversity, and Land Degradation programme of the African Union. AFR100 contributes to the achievement of national commitments to restoration and sustainable development in the context of the Bonn Challenge and the New York Declaration on Forests, among many other goals. The initiative also contributes directly to Sustainable Development Goals and the Paris Climate Agreement.

AFR100 and all other forest landscape restoration initiatives are based on two basic premises. The first is that restoration will always be country- and community-driven. To achieve these

ambitious restoration targets on such scales, millions of people will need to be involved, using both technical and procedural knowledge, and justify their time and effort to themselves and their peers. Communities, consisting mainly of smallholder farmers, will need to be at the forefront of restoration efforts and share commitments with policy- and decision-makers. The second premise is that individually involving millions of people in landscape restoration through on-the-ground, site-based projects is not practical for any one organization. Although restoration projects and pilot sites are important, they will never reach the scale of implementation required by the task at hand. Working with actors representing organizations inside and outside governments and related ministries who can play a role in advancing landscape restoration is key (Craig and Karangwa, 2014).

AFR100 is committed to accelerating restoration to improve food security, increase resilience and mitigation in the face of climate change, and fight poverty in rural areas. To date, 126 million hectares in 33 countries have been committed to FLR under the AFR100 banner. All of these countries have subscribed to the Bonn Challenge by setting quantified objectives (see figure 1, Appendix 2 and 4). Cameroon is the only Central African country on this list, whereas seven West African countries are represented. Benin and Liberia have committed to contributing to the Bonn Challenge by planting 1.2 million hectares between them (0.2 for Benin and 1 for Liberia). Cameroon, Ghana, and Nigeria have aligned their objectives with the 2030 target of the New York Declaration as follows (in millions of hectares): Cameroon 12.06; Ghana 2; Nigeria 4. Of the 41.56 million hectares that African countries wish to plant by 2030 (Table 1), the contribution of Central and West African countries is at least 19.26 million hectares. In a sample of countries in Central and West Africa, the potential for regenerating forest landscapes is clearly expressed in some (Benin, Cameroon, Ghana, Liberia, and Nigeria), while it does not translate to quantified objectives in others (Senegal, Sierra Leone, and Togo; Table 1). An attempt to locate areas of special opportunity at the national or subnational level should allow us to speculate on the potential contribution of a species like bamboo.

The CAFI, also launched in 2015, aims to help governments in the Central Africa region implement reforms and strengthen investments to respond to challenges that increase the pressure on tropical forests, such as poverty, food insecurity, and climate change. The CAFI is a collaboration between the FAO, the United Nations Development Programme the World Bank, six Central African countries, and a coalition of donors, including France, Germany, Norway, and the United Kingdom. The six participating Central African countries are called

upon to develop investment frameworks to support the sustainable use of their forest resources, in particular through undertaking REDD+ actions (Jacquemot, 2018).

Table 1. Bonn Challenge commitments of INBAR Member States of West and Central Africa

Country	Time frame	Total area committed (million ha)
Benin	By 2020	0.5
Burkina Faso	By 2020	5
Cameroon	By 2030	12.06
Chad	By 2030	1.5
Central African Republic	By 2030	3.5
Congo	By 2030	2
Cote d'Ivoire	By 2030	5
Ghana	By 2030	2
Guinea	By 2030	2
Liberia	By 2030	1
Mali	By 2030	10
Niger	By 2030	3.2
Nigeria	By 2020	4
Senegal	By 2030	2
Sierra Leone	By 2030	0.7
Togo	By 2020	1.4
Total		55.86

In April 2018, the Blue Fund Initiative for the Congo Basin, a project launched by Congo to protect this 220-million-hectare forest massif, was the subject of a memorandum of understanding. It is funded, according to the twelve African countries that created it, on the basis of renewable subsidies of 117.125 million USD each year (Jacquemot, 2018).



Figure 1. Map of African countries committed to AFR100 and those that have undertaken assessments of FLR opportunities (source: Craig and Karangwa, 2014).

2.4. The place of bamboo in FLR in a sample of Central and West African countries

The Great Green Wall, a continental initiative, is one of Africa's responses to continental challenges. It is underpinned by regional cooperation mechanisms as part of a concerted global approach. It unites all the countries involved in the fight against desertification and climate change according to a new approach of integrated development of arid and semi-arid areas often completely deprived or poor (Dia and Niang, 2010). Through reforestation and development activities, the Great Green Wall brings together actions to restore land, conserve

biodiversity, develop agricultural and pastoral systems, and fight poverty through income-generating activities that promote the repopulation of arid zones.

Due to ecological constraints, no African bamboo species is included in the list of local species prioritized for use in this vast programme. Are there any bamboo species in Asia or elsewhere that can be adapted to the Sahelian context and contribute to this initiative? In the following sections, we will examine the situation in some countries included in the study area. In Africa, the International Bamboo and Rattan Organisation (INBAR) provides assistance through campaigns raising awareness of the economic potential of bamboo and partnerships with governments. Several countries in West and Central Africa have set up workshops and organized educational trips to China to gain first-hand experience of the bamboo economy.

2.4.1. Overview of the situation in Cameroon

Cameroon, a forest country without a large forest product deficit, does not have a long history of restoring forest landscapes. However, the country engages in reforestation in its northern, more arid part, where efforts to combat desertification date back several decades (Atyi et al, 2018). In its southern part, there are no considerable experiences and impactful approaches from which a new FLR initiative could draw. Consequently, the use of bamboo for landscape restoration does not have a long past and should draw its resources primarily from external inputs.

Non-agricultural private companies hold that sustainable land management is primarily the responsibility of state and local authorities. However, it is in fact large companies in production sectors that invest the most for their raw material needs. For example, current private reforestation initiatives are located in the western and north-western regions of Cameroon, where the companies in charge of transporting electricity invest heavily in eucalyptus plantations for the production of electricity poles.

Regulations in Cameroon classify bamboo as a non-timber forest product (NTFP). The formulation of the national NTFP development plan takes this classification into account to allow multiple NTFP sectors to effectively deploy the significant economic potential at their disposal. The development of strategies for the forestry and wildlife resources also takes into account the valuation of NTFPs as an important factor for supporting the process of the country's economic emergence by 2035. In 2015, a bamboo inventory was compiled for the

Centre, South, Littoral, and South-West Regions to serve as the basis of a feasibility study for the creation of a pilot bamboo valorization unit.

In Cameroon, several initiatives are underway to reconcile the development of the existing potential and the contribution of exotic bamboo species and to develop promising techniques for the exploitation, transformation, and sustainable use of the resource. If this objective is achieved, many aspects of using bamboo for the regeneration of landscapes will be simplified. An analysis of the integration of bamboo into Cameroon's forest policy is underway (Neba et al, in press).

2.4.2. Overview of the situation in Congo

The Republic of the Congo encompasses 22.5 million hectares of forest, of which approximately 21.8 million are relatively well-preserved dense humid forests. Although the country's population density is still low (10.5 inhabitants per km²), the levels of deforestation and forest and land degradation are high in peri-urban areas. The main direct causes of deforestation and degradation of forest resources are the following (in order of importance): unsustainable practice of agro-industry, slash-and-burn agriculture, unsustainable production and consumption of fuelwood, unsustainable logging practices, coastal erosion, and urban expansion (MEFDD/IUCN, 2016).

The Congo believes that its commitment to the Bonn Challenge will enable it to promote its efforts at the international level and its leadership within Central Africa in terms of conservation, sustainable use, and restoration of degraded or deforested lands, and garner support from partners. A reflection on Congo's formal engagement strategy in the Bonn Challenge helped, among other things, to identify concrete actions and potential partners. Its implementation targets include the establishment of plantations on millions of hectares over the long term to meet its needs in timber, services, energy, and industry, as well as NTFPs. Measures taken to reverse the trend of deforestation and forest degradation in the affected areas include the launch of a major reforestation programme: the National Afforestation and Reforestation Program. The country has incorporated 13 strategic axes in its new forest policy (2015–2025), including one related to afforestation and reforestation. Its National Strategy and Action Plan for Biodiversity, revised in 2015 and running until 2030, includes six strategic lines of intervention prominently featuring the conservation and restoration of forest ecosystems. Other ongoing initiatives include certification, Voluntary Partnership Agreements REDD+, and the Forest Management Program. The North Congo Forestry Program and the Tri-National

Dja-Odzala-Minkébé programme are potential initiatives that can boost the bamboo development. However, the place of bamboo in these initiatives is not clearly defined.

Congo is one of the African countries determined to exploit the potential of bamboo. A partnership agreement has been signed in January 2020 between the Congo National Development Fund and the Congolese Ministry of Forest Economy for the launch of a major bamboo cultivation project worth 152.4 million EUR. There is also talk of setting up an industrial bamboo fund to promote the planning and development of the bamboo industry and establish a research institute specializing in the bamboo economy with the support of private actors and bamboo plantations across the country.

2.4.3. Overview of the situation in the CAR

Faced with ecosystem degradation, the CAR committed to the Land Degradation Neutrality (LDN) programme on February 12, 2016. An estimated two million hectares of land were degraded in 1997, and at an annual deforestation rate of around 0.2%, degraded land amounted to seven million hectares in 2015 (Tchatchou et al, 2015). The CAR has subscribed to international agreements such as the Bonn Challenge, AFR100, and Aichi Target 15, the implementation of which will significantly contribute to the achievement of LDN goals.

2.4.4. Overview of the situation in Ghana

Ghana's land is vulnerable to degradation due to multiple human and natural factors. Human activities associated with the pressures of a growing population, manifested in urbanization, unsustainable agricultural practices, deforestation, overgrazing, mining, and industrial activities, have contributed to land degradation (FAO and INBAR, 2018). Its estimated annual deforestation rate of 2% is one of the highest in the world. Almost 69% of Ghana's land suffers from soil erosion, especially in its northern, north-eastern, and north-western parts. Soil erosion costs between 1.1% and 2.4% of the country's GDP.

The west of the country is home to nearly 400,000 hectares of bamboo growing more or less naturally. Exotic species have been introduced from India (*Bambusa balcooa*) and Ethiopia (*Oxytenanthera abyssinica*). These two species, adapted to dry regions, are useful for producing bioenergy. Bamboo agroforestry offers ample opportunities for ecological health, fallow land, and quality of life improvements, carbon sequestration, and sustainable landscape practices.

In addition to the National Forest Plantation Development Programme, the Ghanaian government launched the Bamboo and Rattan Development Programme (BARADEP) in 2012, in collaboration with the INBAR, the United Nations Industrial Development Organization, and other partners. The objective of this programme was to promote the development of the bamboo and rattan industry as an alternative raw material to wood. The programme promoted awareness of the socio-economic and environmental benefits of bamboo and supported the development of bamboo plantations across the country in collaboration with the Ghana Forestry Commission (GFC), the private sector, and local communities (Nana Afranaa Kwamong, 2018 FAO and INBAR). BARADEP also promotes the processing and use of bamboo for many products, including furniture, craft and construction materials, charcoal, bicycles, and rugs.

In 2004, BARADEP introduced 18 exotic bamboo species into the country and distributed them to institutions and non-governmental organizations (NGOs) for testing and evaluation. Ghana's forest plantation strategy aims to create 625,000 hectares of forest plantations, including 50,000 hectares of bamboo by 2040, planted at an annual rate of 2,000 hectares (Nana Afranaa Kwamong, 2018). Some case studies from Ghana highlight bamboo's potential for restoring degraded lands in various agro-ecological situations.

In 2014, the GFC signed a public-private partnership (PPP) agreement with EcoPlanet Bamboo. This PPP aimed to establish a commercial bamboo plantation of 2,818 hectares in the North Bandai Hills Forest Reserve to reverse deforestation and provide a long-term sustainable source of bamboo fibre for the production of toilet paper, packaging materials, and textiles. EcoPlanet Bamboo has since established nurseries for three bamboo species: *Oxytenanthera abyssinica*, *Dendrocalamus asper*, and *Bambusa textilis*. The project has created more than 500 local jobs for nursery, planting, and maintenance workers, among others. The introduced bamboos have helped to close pockets of degradation, transforming the entire plant coverage into forest. Positive impacts have been observed for all wildlife. This project is being run in an ecosystem where bush fires destroy young bamboos and retard the growth of adult plants every year. Fortunately, adult bamboos can withstand bush fires thanks to the ability of their rhizomes to regenerate when provided with water. Improving the effectiveness of the project by building firewalls around bamboo stands is proving costly. As a corrective measure, a 'taungya' system is being implemented, whereby community members are allocated land for crops in the form of a firewall. This system provides community members with land to produce food for their households and even for sale. Under the PPP agreement,

EcoPlanet Bamboo is entitled to 80% of the value of the trees, while the remaining 20% is allocated to the GFC, landowners, and marginalized communities. This project is aimed at producing toilet paper for the European and American markets to replace boreal fibres. Many major firms have already made public commitments to shift to such alternative fibres to reduce their ecological footprint linked to deforestation (Rebelo and Buckingham, 2016).

Another case study concerns Ghana's sustainable land and water management programme. It was launched in 2016 with the aim of reducing land degradation and improving biodiversity in the ecological zone of the northern savannah (FAO and INBAR, 2018). This project implemented in twelve districts, brought together the agriculture and forestry governmental services around local communities. Bamboo is planted along watersheds to restore vegetation coverage, reduce soil erosion, and prevent farmers from farming near riverbanks. Community members have been sensitized to the need to protect the river buffer zone. Watershed management committees have been formed, and interested community members have received training and bamboo and other plant seedlings to plant along the river buffer zone. A major challenge is the dry weather in the area, which forces farmers to water the bamboos, especially in their early stages of development. The farmers have pumps to irrigate their farmlands and water the bamboos. The environmental and economic benefits of this project explain its adoption. Monitoring and collection of data on the growth and impact of bamboo should be performed to measure the results of the intervention.

According to Nana Afranaa Kwapong (2018), a third case study is about Ghana Manganese Company, which has been operating a manganese mining concession in an area of 175 km² in the western region since 1916. The company has explored innovative ways to recover stripped soil. In 2013, it signed a partnership agreement with Darlow Enterprise for commercial bamboo plantations on marginal and degraded lands for environmental services, such as renewable energy production, of which bamboo is a good source. After four years, the company expected to produce more than 100 tons of bamboo wood chips per hectare over a period of 50 years. Three bamboo species (*Bambusa vulgaris*, *Bambusa balcooa*, and *Bambusa pervariabilis*) were tested on 10 hectares of land stripped by mining activities. The project created local jobs in nurseries and plantations. Bamboo has now completely colonized the land, turning the site into a forest. The soil's properties have been improved, and soil erosion has been reduced. Avian fauna has grown rich. Although the project did not collect data (such as on carbon, humus, or wildlife) to measure its impact on the environment in the early years, it demonstrated the potential of bamboo for restoring degraded lands. To expand

the Kogyae Strict Nature Reserve to 15,000 hectares in 20 years, it is planned to invest in the restoration of 5,000 hectares of land within 10 years by potential investors under the coordination of the Centre for Research on the Epidemiology of Disasters (CRED) This initiative is a contribution to the Bonn Challenge thanks to bamboo agroforestry, with 1% funding by the government. This CRED project seeks solutions that can be integrated with the values of local communities through the development of community-based green businesses to create economic opportunities, thus improving their livelihoods and making them climate-resilient.

2.4.5. Overview of the situation in Nigeria

In Nigeria, Africa's most populous country, more than 70% of an estimated 180 million people still depend on fuelwood for their energy needs. More than half of the 9.6 million hectares of tropical forest in southern Nigeria have been used to meet the demand for fuelwood in rural and urban areas. Nigeria's second national communication under the United Nations Framework Convention on Climate Change in 2014 estimated that a target of 4.5 million hectares of fuelwood plantations should be set to combat the main cause of deforestation and alleviate the looming fuelwood shortage.

A sustainable forest management project has been initiated to restore over 50,000 hectares of degraded forests and marginal lands in urban and rural areas (Effiom, 2014). It is designed to combat deforestation in the Cross River area by preventing the unsustainable harvest of fuelwood in the Delta and Cross River areas and to limit forest degradation and desertification in Kaduna State. The project was planned with a bottom-up approach of leveraging private sector resources and providing inclusive financial incentives (e.g. start-up loans and corresponding rebate systems) and market mechanisms for supply and demand for energy supported on the market (Effiom, 2014).

Nigeria joined the INBAR in April 2004, with the designated national focal point of the Federal Forestry Department, which reports to the Federal Ministry of Environment. Two major bamboo species grow in Nigeria, *Bambusa vulgaris* and *Oxytenanthera abyssynica*, found along waterways and in rainforests across the country. In 2014, Nigerian exports of bamboo and rattan products exceeded 11 million USD. Bamboo charcoal has been firmly established as the main exported product, with a total value of more than five million USD per year.

2.4.6. Restoration of forest landscapes and contribution of bamboo in other African countries

There are several techniques for integrating trees into agricultural landscapes. One of the most successful and beneficial is assisted natural regeneration (ANR). In Niger, farmers use ANR to regenerate and multiply valuable trees whose roots remain alive in the soil, encouraging tree growth in their fields. These farmers have thus improved about five million hectares of land, in the process producing over 500,000 additional tons of cereals every year (Botoni et al, 2010). Thanks to ANR, large areas of southern Niger are now covered in trees. Farm incomes are on the rise, and food security has been enhanced, even during years of drought. The ANR approach has increased resilience and reduced Niger's dependence on external food aid.

In 2015, the WRI published a report on the steps needed to expand re-greening to wider areas, offering a practical approach to landscape restoration (Reij and Winterbottom, 2015). The report focused on the development of new agroforestry systems through natural regeneration of shrubs and trees, rejuvenation of old agroforestry parks, management of natural regeneration on abandoned croplands and degraded lands, and better management of pastures by pastoralists through the protection and regeneration of trees and shrub sources of fodder for livestock.

There are therefore grounds for optimism about the possibility of large-scale restoration. Indeed, much of the Sahel, centred on Niger and regions of Mali and Burkina Faso, has undergone a remarkable transformation over the past 30 years. Formerly barren landscapes are now home to dense forest trees, helping to improve soil fertility and produce fodder for livestock. Several simple techniques have been applied by Nigerien farmers on a large scale thanks to the empowerment of local communities. Degraded landscapes have been transformed into productive and resilient farmlands through the widespread adoption of agroforestry and related sustainable land management practices (Reij and Winterbottom, 2015).

Ethiopia, Ghana, and a many other African countries have initiated policies to support local production and the processing of bamboo by farmers or businesses for supplying domestic and external markets. These initiatives raise reasonable hope that bamboo can become a solid pillar of the green economy, a significant contributor to economic development, poverty reduction, and environmental protection.

In South Africa, intensive chemical agriculture for pineapple production for over a century has caused severe soil depletion. To mitigate the problem, *Bambusa balcooa* domesticated from tissue culture seedlings has been planted on a large scale. The South African case is the first example in the world of large-scale land reclamation where cell culture seedlings are used to compensate for the lack of bamboo planting material. The EcoPlanet Farm project has rehabilitated 485 hectares of severely degraded land, preserved more than 140 hectares of wildlife corridors and natural vegetation, and created some 100 jobs in an area that has greatly suffered from unemployment since the collapse of Southern African pineapple exports to the United States (ECoPlanet Bamboo, 2014).

In Rwanda, the Bamboo Propagation for Soil Conservation and Livelihood Improvement project (Bamboo Project Burera) has made it possible to oversee investment initiatives in the forestry sector, integrate the management of natural resources, and promote stakeholder participation and agroforestry through a collaboration between NGOs, the authorities of Volcanoes National Park, the National Office of Natural Resources, and local administrations and communities (Mukakamari, 2013). With financial support from the Greater Virunga Transboundary Collaboration Program and the Dutch government, this project has promoted the implementation of the National Bamboo Promotion Program with the support of the INBAR. Among its main achievements are a mobilization of actors, an increase in organizational capacities, training (especially in bamboo planting and processing techniques), development of nurseries, production and sale of seedlings, and reforestation of vulnerable places, such as ravines.

2.5. The potential of bamboo in Central and West Africa

2.5.1. *Basic data: botany, ecology, and characterization of production areas*

A re-evaluation of the plants used and how they are used has positioned bamboo, with 1,642 species globally, as one of the most promising (Ben-zhi et al, 2005; FAO and INBAR, 2018; Vorontsova et al, 2017). Bamboos are among flowering plants related to monocots. They belong to the bambusoideae subfamily of the grass family. In Africa, this subfamily comprises six genera, which include four woody (*Sinarundinaria*, *Phyllostachys*, *Bambusa*, and *Oxytenanthera*) and two herbaceous genera (*Guaduelia* and *Puelia*). These grasses, also called 'giant grasses', are included in the category of NTFPs, although from a technological perspective, they have characteristics very similar to those of wood.

The genus *Sinarundinaria* (or *Arundinaria*) is an upright, sympodial branching bamboo found in warm regions of America, Asia, and Africa (Van der Zon, 1992). In Cameroon, it is represented by a single species (*Sinarundinaria alpina* (K. Schumann) Chao & Renvoize). It is a gregarious species whose stems can measure between 2 and 15 m in height and 2 to 5 cm in diameter. It grows in mountains at altitudes of 2,350–2,800 m in humid climates (1,800 to 3,000 mm of rainfall; BFT, 1962). It is confined to the mountains in the west of Cameroon (Bamenda and Dschang) and on the East African plateaus (Rwanda and Kenya). Exploited as construction timber, the species is almost not yet domesticated, although some stands are maintained in Rwanda in an agroforestry system.

The genus *Phyllostachys* is a woody plant of monopodial growth with culms with flattened internodes on one side. The species *Phyllostachys aurea* A. Rivière & C. Rivière, native to China, has been introduced to Cameroon. Individuals have erect culms 5 to 6 m tall with a smaller diameter (2 to 3 cm). It is found in the gardens of large towns in the southern zone (Van der Zon, 1992) as an ornamental plant, sometimes in hedgerows.

The genus *Bambusa* is an upright woody plant growing in large clumps, with many culms and sympodial growth. The type species, *Bambusa arundinacea* (Retz.) Willd., native to tropical Asia, has been introduced into Cameroon. The *Bambusa vulgaris* Wendland species, with culms 12–15 m tall and up to 10 cm in diameter, is found around villages in dense humid forest areas not far from rivers. *Bambusa vulgaris* is found in all the tropical countries of the world, where it is cultivated, among other purposes, for its young shoots consumed as food. In Cameroon, it is found in abundance between Edéa and Campo and in the Guinean-Congolese zone around the Dja Faunal Reserve. The plant is widely used for building houses and making furniture, often in combination with rattan.

The genus *Oxytenanthera* is an erect, tree-like plant with massive or thick-walled culms. It is an African genus from the savannahs with only one species: *Oxytenanthera abyssinica* (A. Richard) Munro. It grows in dense tufts, with culms between 3 and 10 m high and 5 to 10 cm in diameter. This species is found in the forest galleries of wooded savannas and is widespread in tropical Africa. *Oxytenanthera abyssinica* grows in gregarious stands in all tropical countries, at altitudes of 0–2,000 m in areas with rainfall of 700–2,000 mm (BFT, 1962). In Cameroon, it is found in the Sudanese Mountains and on the Adamawa Plateau. Used as construction timber and as an ornamental plant, it is often planted in villages.

Bamboo forests cover nearly 37 million hectares worldwide, representing 3.2% of the world's forest coverage. However, African bamboo forests account for only 7% of all bamboo forests in the world (Lamballe and Vogel, 2014), with the largest areas in Nigeria and Ethiopia. Cameroon has 1.2 million hectares of bamboo forest coverage with four common species: *Bambusa vulgaris*, *Phyllostachys aurea*, *Oxytenanthera abyssinica*, and *Yushania alpina*.

Most of the bamboo harvested for sale comes from natural forests, although plantations have grown significantly in recent years. Of the 30 or so African countries where this woody grass grows naturally, 21 are members of the INBAR. In the African bamboo market, considered underdeveloped by the INBAR, the three main producers are Benin, Burundi, and Ethiopia, followed by Ghana and Nigeria.

Since 1962, *Bambusa vulgaris* was described as the most widespread bamboo species in Africa, covering several hundred hectares in Congo, DRC, and Cote d'Ivoire. It is a species easily domesticated and reproduced by cuttings. Unnatural plantings of *Arundinaria alpina* and *Oxytenanthera abyssinica* are more limited in the same countries. For a subfamily of bambusoideae that numbers more than 1.600 species, it is quite possible that some bamboo species can successfully grow in arid conditions. For example, in South Africa, planting *Bambusa balcooa* in conditions of low rainfall (650–700 mm) has been relatively successful with encouraging survival rates (FAO and INBAR, 2018). *Oxytenanthera abyssinica*, which grows well in comparable climatic conditions, could be tested in programmes such as the Great Green Wall.

2.5.2. Socio-economic, cultural, and environmental importance of bamboo in Central and West Africa

A study undertaken in the Cote d'Ivoire (Dje et al, 2017) shows that the actors in the bamboo sector are producers (20.8%), wholesale traders (7.6%), carriers (38.8%), shippers (4.8%), and users (13.8%). Financial benefits range from 17.6 USD per load for producers to 330.3 USD per load for wholesalers. The Ivorian state earns 112.4 USD per load on average. The study does not detail the status of the producer or the investment in the production. It is quite possible that this is mainly a harvest in natural formations not planted by the producer

In Senegal, bamboo grows naturally in the eastern regions of Upper and Middle Casamance, in hills or near temporary rivers or marshes. Population growth and high bamboo consumption have led to scarcity or even disappearance of the bamboo (Office de tourisme de Casamance,

2000). *Oxytenanthera abyssinica*, called Vah in Wolof Senegal dialect, is a shrub growing in clumps and sometimes forming dense, impenetrable bushes. In this country, bamboo is used as a stake for certain fetishes. Also, the leaves are used to prevent diabetes, treat rheumatism, and alleviate colic. Young shoots can be eaten at times of food scarcity. They are also eaten by livestock. The seeds replace rice in times of famine. Bamboo is also used for making beds for the circumcisions. Plants multiply quickly and help prevent erosion. Straight rods have light weight and remarkable strength. They are used for the construction of attics and conical roofs of huts. They are also used to make scaffolding, fences, baskets, traps, canes, flutes, and pipes. Twigs are used as wicks for oil lamps. Bamboo is also used in the construction of houses and for protection of market garden areas. Besides its many technical uses, it is also an ornamental plant. Its diverse uses make it one of the most valuable plants in Senegal's vegetation.

Unfortunately, in the eyes of many environmental organizations, good management of this resource is necessary since private and public operators do not always invest in the regeneration and preservation of bamboo (Mansaly, 2015). The long-term average carbon capture and storage of a bamboo development project is static, regardless of the end use of the product. Its high annual carbon sequestration rate makes bamboo forests one of the most efficient types of forest vegetation in this sense (Ben-zhi et al, 2005).

Control measures have been taken in several localities in Senegal for a resource in high demand, particularly in the form of woven panels of 'crintings' (a Wolof term denoting panels braided with bamboo bark) and bamboo stems. In recent years, Senegal has introduced bamboo plantations with more rational exploitation while protecting the places where the plant grows spontaneously.

If we look outside the African context, we can see that in Vietnam, the average annual bamboo yields, without fertilization, are of the order of seven to ten tons of stems per hectare in bamboo plantations in production. Heat treatments, most of which have not yet been tested in Africa, as well as regular maintenance, make it possible to preserve bamboo-based products for more than thirty years (Lamballe & Vogel 2014). In Vietnam, it is found that at the base of dynamic peasant forestry and agroforestry systems, bamboo promotes the development of small industries and rural services that create jobs and income. A similar model should be considered in Central and West Africa, if we manage to change the perception of African

actors, by building on a few pilot examples such as those encountered in Ghana (In Ghana, eco-friendly, fair-trade bikes are made from bamboo).

2.6. Analysis of actors in charge of restoration programmes and the place of bamboo in these programmes

African governments and the private sector have taken various steps to exploit the lucrative bamboo market potential. The African INBAR Member States where bamboo grows naturally are Benin, Burundi, Cameroon, Eritrea, Ethiopia, Ghana, Kenya, Liberia, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Togo, and Uganda (Figure 1). Other countries, such as Angola, Gabon are in the process of being admitted to the organization as members and intend to benefit like the others from support through information on technology transfer, capacity building, and establishing policies for the cultivation of this plant.

At the regional level, the Central African Forests Commission), established by the heads of states of Central Africa in 1999, has the mission to harmonize forest policies among the countries of the Congo Basin. The convergence plan, which is its orientation document, adopted an important focus on the NTFP sector. Bamboo in these countries is classified as a NTFP. In West Africa, the Economic Community of West African States constitutes the framework for making decisions on the same issues of forest policies. The Great Green Wall is one of the flagship programmes in this West African region. It aims at reforestation by relying on the most suitable local species. Due to climatic constraints, the place of bamboo is at the moment not clearly defined in this programme. The situation is markedly different in the forest zone of these two regions and in the forest-savannah ecotone zone. For example, forestry institutions in countries such as Ghana and Nigeria have initiated major bamboo development programmes for both ecological and socio-economic purposes.

At the level of the two regions and at the country level, partner organizations supporting policies and actions on NTFPs are quite numerous, including the Chinese Green Carbon Fund, the European Union, the FAO, the International Fund for Agricultural Development (IFAD), the Society for International Cooperation (GIZ) of Germany, and the International Tropical Timber Organization. Civil society also supports the implementation of forest policies directly or indirectly, both strategically and operationally, in the areas of intervention targeted by these partners.

In Cameroon, for example, the implementation of a national NTFP plan consists of five directions or structures attached to the Ministry of Forestry and Wild: the Forestry Direction, the Direction for the Promotion and Transformation of Forest Products, the National Control Brigade, the Deconcentrated services, and the National Forestry Development Agency. Today, several structures specializing in forestry sectors are operational in Cameroon. The country also benefits from the support of technical and financial partners, such as the Centre for International Forestry Research (CIFOR), the FAO, the International Centre for Research in Agroforestry (ICRAF), the IFAD, the INBAR, the Institute for Research in Agricultural Development and the GIZ, in conducting research and running development or capacity building projects in the forestry sector. Numerous international NGOs and intergovernmental organizations, such as the Netherlands Development Organization (SNV), as well as national civil society, such as Forest and Rural Development (FODER) and Local Materials Promotion Services (MIPROMALO), are mobilized in the development of the NTFP sector, including by promoting PPPs. FLR initiatives are also likely to involve a wide range of stakeholders, including politicians, local communities, government institutions, and private actors.

In each of the other countries of the two regions, a ministry is in charge of forestry issues. However, ministerial departments are often not the only actors involved. Landscape restoration policy also concerns sectors such as agriculture, animal husbandry, town planning, and regional planning. The segmentation of responsibilities and especially the constraints of participatory planning make concrete actions difficult. All these actors are either secondary actors in charge of guiding national policies (government action, promotion of sectors, development of national strategies and programmes) or tertiary actors with technical and financial capacities to support policies, development of sector strategies, and research and development. Primary actors (producers, operators, transporters, artisans), especially in the bamboo sector, are hardly visible. However, the most desired changes lie in building the capacities of primary actors.

Although Cameroon has significant bamboo potential, which is still very poorly developed, it attaches particular importance to the development of forest products. The countries of Central and West Africa have institutions responsible for ensuring the management and protection of forests, monitoring compliance with regulations regarding logging, developing and controlling regeneration and reforestation, compiling inventories, and launching forest management programmes. Institutional reforms of the national forest sectors have reorganized the roles of the various actors by disengaging the state from production functions and encouraging

community and multi-actor intervention approaches. However, weaknesses persist in the development of entrepreneurship within the communities. Therefore, the impact on resources such as bamboo is still not felt.

3. Barriers to the use of bamboo in landscape restoration

Caught between forestry, horticulture, and agriculture, bamboo cultivation defies attempts at a clear classification. Some international forestry institutions still tend to ignore the role of bamboo, failing to recognize it as an important natural resource (Buckingham, 2014). Although many African stakeholders view it as particularly valuable, others consider it an invasive and unwanted plant. However, if bamboo were given due attention in terms of standards or levels of investment, it could prove to be an essential sustainable commercial crop and play a major role in FLR (Rebelo and Buckingham, 2016). An example of case studies in Africa (EcoPlanet Bamboo, 2014) show that successful restoration at the landscape level offers considerable economic, social, and environmental benefits while overcoming related obstacles.

Numerous events have been organized in Central and West African countries to urge authorities to take action to alter stakeholders' perceptions of bamboo and stimulate its production (INBAR, 2016). When it comes to translating political commitments to implementation on the ground, there are many bottlenecks that could hamper efforts to achieve the stated goals by 2030.

3.1. Barriers related to the level of knowledge and sensitivity

Why have bamboos, with their indisputable multiple uses and possibilities of exploitation, been neglected for so long in African countries? According to various INBAR diagnostics, the main problem is lack of information. Critical policy components, including those related to land tenure and equity, are often restrictive and unfavourable for communities, and measures to encourage communities to undertake FLR actions are sorely lacking. Among the reasons cited, a lack of clear information and obvious evidence of the competitiveness of bamboo species compared to other species is notable. Indeed, the economic benefits of bamboo are not well recognized.

Bamboo is a woody forest product and is industrially valued as such. Nevertheless, it is wrongly classified in several African countries as an NTFP. This hybrid nomenclature is not without consequences for stakeholders' perceptions of initiatives to promote it in Africa. Moreover, there is a certain degree of reluctance to grow bamboo on productive land due to the conception that, once established, bamboo takes over arable land that can no longer easily be used for other purposes. In this case, bamboo is seen as an invasive plant. Furthermore, a lack of knowledge of its exact potential, in terms of both available areas and stubble

properties, limits its valuation in several countries of the study area, as has already been noted in the case of Madagascar (Ramananantoandro et al, 2013).

The success of previous restoration initiatives remains poorly documented or disseminated in most of the studied countries. Most lessons learned remain in researchers' drawers. This limits the chances of success of future restoration projects and optimization of management of resources that are not easy to mobilize. The design of large-scale FLR programmes is relatively recent, which limits the understanding of motivations, real needs, and critical success factors. In many countries in Central and West Africa, information is limited to the policy and regulatory frameworks that govern the bamboo sector. In many countries, regulatory measures fail because they are poorly adapted or implemented, sometimes due to governance issues. In some cases, regulations do not exist at all.

In a context of experimentation on decentralization, as in the case of Cameroon, regional and local authorities have poor knowledge of the specifications of their mandates, and farmers are unaware of their rights and obligations. It is essential for the actors involved to have at least some rudimentary knowledge of the legal aspects of FLR elements.

The involvement of women in the various links of the bamboo sector is poorly documented. If we take for granted the fact that generally women constitute the main actors in the transformation of NTFPs, the finding here is that the transformation of bamboo-based products seems to display an unfavorable configuration for the participation of women. This is an aspect that deserves investigation in order to optimize the contribution of women

3.2. Technical barriers

As forest restoration is expensive, ANR, which has proved its worth in Niger and in neighbouring countries, is one of the cheapest options. However, it does not offer enough leeway in the choice of species. This option only gives desired results with bamboo if the soil in the area has vegetative or edaphic seminal potential constituted of bamboo stumps or rhizomes. Unfortunately, cases of degradation of bamboo stands are poorly documented in Central and West Africa.

Necessary knowledge of species adapted to specific ecological conditions, seed sources and supply methods, and nursery operations is sometimes limited. Restoration practitioners around the world often pay little attention to the selection of suitable planting materials. Many

restoration initiatives have failed due to a lack of knowledge about how to select, plant, and manage the appropriate species. This is also true for bamboo, in which flowering is rare. The development of FLR programmes faces ecological constraints related to the availability of quality seed material. Bamboo's infrequent fruiting makes it necessary to disseminate vegetative production techniques that are still not available to everyone.

3.3. Technological barriers

In more than 30 African countries, there are areas where bamboo grows naturally. The INBAR works with other organizations to enable technology transfer and training of farmers to develop a bamboo value chain between producers and consumers through markets. This is not possible without appropriate national policies, the right technologies, and the investments to support them.

Many African farmers regard bamboo as a harmful, invasive plant that grows too fast, ignoring that rapid growth is its real advantage. Indeed, despite the business opportunities that may arise, some people wishing to have bamboo-based products may face constraints due to the lack of research and technological innovation. However, to be competitive in the country and later for export, bamboo productions must be adapted to international technological, commercial and forestry standards.

Processing techniques are archaic, and recovery of by-products is low. Technological barriers to forestry and processing, low investment in research and development, and a lack of plant material are obstacles to the use of bamboo as a fibre alternative to lumber. Structural weaknesses of technological transformation microenterprises also limit the support of actors in the sector. The problem is further compounded by a significant technological gap and a lack of critical relevant skills.

3.4. Political and regulatory barriers

Regarding national policies and their translation into action plans, a lack of an environment conducive to maximizing bamboo's contribution to the green economy is evident. Implementing sectoral policies remains a daunting task. In most of the countries of Central and West Africa, there is a non-participatory organization of activities in the fields of agriculture, forestry, animal husbandry, fishing, mining, water, environment, and even landuse, and this is not likely to facilitate the integration of sectoral policies and especially of planning and

governance of resources or that of land use. Intersectoral integration is an area on which to work.

Spatial planning is in its infancy in most Central and West African countries, especially in the context of decentralization. Conducting a constructive dialogue between the different stakeholders at regional or local level requires leadership with real decision-making power and appropriate technical and managerial capacities to enforce the decisions taken. We can clearly see that the FLR falls within the approaches that will have more needs in terms of decentralization of power in order to succeed in gaining acceptance for innovations such as the introduction of bamboo into the problem..

The land regulations currently in force are strongly criticized, especially because of their inadequacy regarding local communities' use-of-land rights. This makes their implementation uncertain. Further compounding the issue are the increasing conflicts arising from differences between regulations and traditional practices (MEFDD/IUCN, 2015).

In Cameroon, most landscapes likely to be restored are part of the agro-silvopastoral system. Bush fires constitute a serious problem and a major obstacle to establishing forest plantations. The government still fails to enforce regulations. At the heart of this issue is the uncertainty of land tenure, well known as the main obstacle to investment and sound management (Tunk et al, 2016).

In Cameroon, the management of NTFPs, which include bamboo, is governed by Law 94/01 of 20 January 1994, regulating forests, fauna, and fisheries. The law specifies the modalities of access to the resources, in particular those related to rights of use granted to populations bordering forests and exploitation by special permits. The exercise of the right to use NTFPs allows beneficiaries to harvest limited quantities to meet domestic needs and prohibits the marketing of products without special permits, to which only holders of forestry profession accreditation are entitled. Obtaining such accreditation is itself a cumbersome and costly procedure that is inaccessible at least to the average citizen. The resulting informal trade is also very costly because the operator is subject to heavy parafiscal burdens and corrupt practices. Recorded harassment accounts for around 35% of traders' turnover (Tieguhong, 2010). These limitations of the forest code are not favourable to the disadvantaged social strata and make it impossible to effectively fight poverty. A national NTFP development plan does not pay special attention to bamboo.

Political, security, or even health risks in certain countries of Central and West Africa, such as Burkina Faso, Cameroon, the CAR, Chad, Mali, and Nigeria, pose obstacles to the mobilization of financial resources for the implementation of programmes in the field. These risks do not favour arguments for raising the necessary funds to support restoration efforts and encourage project development.

3.5. Financial and marketing barriers

In several Central and West African countries, the challenges of commercial development of bamboo are numerous. Administrations within governments are slow to translate regulations into incentives. Moreover, prior financial investments by the public and private sectors to support the key links of the bamboo sector are insufficient. Additionally, in a still young FLR sector, financial institutions may be reluctant to provide financing.

Financing forest regeneration is a risky activity, especially for businesses and farmers, who prioritize profitability. In productive areas, mostly private or community actors invest more readily in FLR because they expect direct financial benefits from the production of goods and services. The situation is markedly different in arid zones, where the level of land degradation has progressed to irreversible levels, as in the “hardé lands” of northern Cameroon (IRA/ORSTOM/CIRAD, 1993). To make FLR profitable through direct production, it is necessary to mobilize beyond the funds provided by institutions such as the World Bank, encouraging investments from public funds of countries or other actors such as private sector. Under these conditions, carbon storage and biodiversity conservation become challenges to which only public actors can respond by organizing interventions for the improvement of local communities’ livelihoods and well-being.

Bamboo offers decisive advantages for the development of a green economy. However, what would arouse more interest among the population is the prospect of income for households. The lack of funding and the absence of national policies and strategies to develop bamboo cultivation, exploitation, and processing are also slowing progress.

Restoration efforts are often focused on seedling production in nurseries and on planting operations. The subsequent monitoring and maintenance actions, which are equally important, also require funds to lead to self-regenerating ecosystems. Significant amounts of atmospheric CO₂ are absorbed and transformed into woody biomass between the fourth and

eighth year of bamboo growth, which is also the time when financial needs are greatest. The required long-term capital can sometimes be difficult to mobilize.

Central and West African countries do not export significant quantities of bamboo products. This is due to their limited capacity to manufacture products according to international standards. In addition, their domestic markets remain underdeveloped.

3.6. Barriers related to governance and land management

The model of rural development in Africa, subject to land constraints, does not always lend itself to massive industrial plantations. Smallholder initiatives are more practical and less expensive. The investment efforts that characterize these small farms respond to short- or mid-term needs (such as food security, anti-erosion control, and fertility, water, fodder, and fuelwood management) and can serve as important entry points.

There are, however, many other reasons for which models of small individual or family farms may not reach the scale required to achieve restoration at the landscape level, such as differences in individual visions, means, topographical position, or distance from roads. Not all stakeholders share the same views on models or expected outcomes of restoration initiatives. Agroforestry practices, which have made progress in certain regions, remain an area that requires investments to build the capacities of stakeholders. Investments are also necessary to tackle issues related to climate change.

The Congo Basin forests and other forest ecosystems in West Africa are sources of a wealth of NTFPs. Although the modes of access to NTFPs are generally defined by customary rights that conflict with forest laws of most countries, it is becoming increasingly urgent to take into account NTFPs in forest management objectives. Bamboo is not considered a valuable NTFP because it lies in the grey area between timber and NTFPs. Consumers often regard it as timber, whereas policy makers consider it an NTFP. Despite its classification as an NTFP, most studies on NTFPs in Central Africa (Musau, 2016; Ramananantoandro et al., 2013; Tchatat and Ndoye, 2006) do not focus on its uses.

The lack of clarity on tenure regimes and their application in many West and Central African countries and insecure property rights are additional limiting factors. Improvements in legislation and policies can facilitate restoration initiatives.

4. Conclusions and recommendations

4.1. Synthesis and conclusion

Land degradation, which occurs in various ways in almost every country in the world, does not spare the countries of Central and West Africa. It is manifested in the deterioration of the physicochemical properties of soil and loss of surface water and biodiversity. The losses of organic production lead to increasing pressure on land resources and regression of wooded areas, threatening significant segments of a growing population with impoverishment.

The Bonn Challenge and the New York Declaration on Forests stand out as a consensual path to achieving the targets of corrective actions. FLR, the process of recovering the ecological functionality of land and improving human well-being in deforested areas or degraded forest landscapes, is a long-term process. It deals with 'forests', seeking to increase the number and health of trees in an area. It also deals with 'landscapes', aiming to integrate watersheds in their entirety, and even considering countries where various land uses overlap. Finally, it deals with 'restoration', attempting to restore the biological productivity of degraded areas for the benefit of humankind and the planet.

FLR initiatives in Central and West Africa must simultaneously target various sectors (agriculture, animal husbandry, forestry, town development), taking the form of mosaic restoration. Although it is a complex process, examples of successful restoration exist around the world. One example is South Korea, where restoration efforts increased forest coverage from 35% in 1960 to 64% in 2000 (Buckingham, 2015).

In the two regions studied, ecosystems that can easily accommodate bamboo are those in the Congo Basin or in areas with a similar climate. On the other hand, the dry savannahs of the Sahelian strip are areas where bamboos would have difficulty growing naturally.

Due to its many desirable properties, bamboo is an increasingly attractive product, especially in markets of developed countries (Lamballe and Vogel, 2014). Its durability and hardness, comparable to those of oak, combined with its rapid growth cycle and its many uses, make it a potential substitute for wood. Its properties also make it an ideal plant for restoring degraded land. By leveraging special species such as bamboo, FLR could produce more tangible outcomes, creating jobs and incomes and contributing to carbon sequestration.

Despite their diverse uses, bamboos in Africa are still little used and engage relatively few actors compared to Asian countries such as China or India. There is no evidence that this low use is due to the technological qualities of the main species adapted to African natural formations. A lack of local tradition and mastery of processing technologies for bamboo-based products are more important factors.

To implement FLR programmes on an appropriate scale, it is necessary to work with actors representing institutions and organizations inside and outside of governments who can play a role in the process. Therefore, we must rely on institutions capable of bringing together government actors, NGOs, and other civil society actors, including representatives of local communities and indigenous peoples. Successful FLR must be a forward-looking and dynamic approach, focused on strengthening the resilience of landscapes and creating possibilities to adjust and optimize ecosystem goods and services as society's needs change and new challenges arise.

Ethiopia, Ghana, and a few other African countries have initiated policies to support local production and processing of bamboo by farmers or businesses to supply domestic and external markets. A look at these initiatives in regions with high natural potential, like Central and West Africa, arouses hope that bamboo can become an important pillar of the green economy. Based on this observation, with the support of organizations like the INBAR, sound recommendations could help make bamboo a significant contributor to economic development, poverty reduction, FLR, and nature protection.

4.2. Recommendations

Considering the constraints linked to the use of bamboo in FLR in Central and West Africa, in this section, we put forward a set of recommendations.

4.2.1. *Research and awareness*

- Further research should be conducted, and technical documents should be produced to improve knowledge of site-species matching, the economic value of different bamboo species, the establishment of bamboo nurseries and plantations, and sustainable management of bamboo forests.
- Key basic studies should be conducted on bamboo species (ecology, use, values), planting technics and technological processing.

- Sensitization campaigns should be organised to raise awareness about the benefits that can be derived from the bamboo sector in contributing to Bonn challenge and New York declaration as well as bamboo industry as driver to encourage the restoration of degraded lands;
- Develop and popularize successful models for FLR (Restoration Opportunities Assessment Methodology, mosaics)

Biology, ecology, and socio-economics studies on the management of local and introduced species of bamboo should be conducted. Emphasis should be placed on compiling an inventory of newly introduced species and assessing technical knowledge regarding plantations and technological knowledge regarding potential processed products.

It is important to mobilize resources to conduct technical studies on the ecology and silviculture of bamboo species adapted to the climatic and pedological conditions of arid zones and current and potential markets, among other areas. Research into bamboo species adapted to climatic and edaphic aridity conditions (Floret and Pontanier, 1984) could be a means of bringing bamboo cultivation closer to communities with the longest tradition of FLR actions. Research on management issues, such as the establishment of information mechanisms related to bamboo management regulations and innovative financing mechanisms, should also be considered. Where planting is necessary, research on the choice of germplasm should aim to maximize genetic diversity while building resilience and promoting sustainable livelihoods. It is also important to launch awareness campaigns emphasizing the benefits that can be derived from bamboo plantations, raw products and their prices, and processed products with their strengths and weaknesses.

- Conduct field studies to document how bamboo value chains contribute to strengthening the role of women, youth, and disabled people in livelihood improvement.

Data on the involvement of women, youth, and disabled people in the various links of the bamboo industry (nurseries, sustainable plantation management, and manufacture of goods such as durable products, charcoal, briquettes, and food) is lacking. It is important to intensify activities aimed at improving women-centred livelihoods in nurseries, plantations, management, and aspects of artisanal processing.

4.2.2. Capacity building

- It is essential to develop farmers' skills in growing and maintaining bamboo crops, supporting the seed supply, and forming partnerships with private enterprises to transform the raw material and increase its added value.
- Build capacity using trainings, funding, technical assistance and technological transfers to promote bamboo sector development projects

A mechanism should be developed to highlight and strengthen the connection between bamboo plantation and forest maintenance projects and processing units. This mechanism should emphasize training and focus on the creation of individual or community-based business and job opportunities.

The specific capacity-building needs must integrate issues of training and technology transfer and exchanges of expertise to fully benefit from the Asian experience. To guarantee the creation of added value locally, the integration of new links into the existent bamboo sector, particularly the development of small processing or production units focusing on simple and commonly used products, must be encouraged. These small units could then grow and constitute important poles of development of large industrial units, as in Asian countries. These processing units must maximize the utilization rate of simple organs such as stems and minimize waste. In relation to advances in new popularizable technologies, bamboo sectors should be able to evolve rapidly, with the desire to develop small-scale businesses near large production basins. Reference nurseries for projects at different scales (from simple propagation by cuttings to tissue culture, including the import of seeds) should be created.

4.2.3. Policy and regulations

- To promote FLR, each country should create a reliable policy environment conducive to good governance, responsible regulation, and robust mechanisms for conflict resolution between stakeholders. Moreover, legal frameworks should promote harmonization by reconciling national laws with traditional local practices.
- Support the Establishment of a governance support programme (political orientation, control and regulation, conflict management), improve the legal and institutional frameworks (revision of existing laws with provisions for the bamboo sector; support for decentralization), and develop a financing mechanism for bamboo plantations using funds from various sources including from processing units.

Political authorities and other target groups must be made aware of the socio-economic value of bamboo and its importance in the provision of environmental services. They should be sensitized about its rapid growth potential which also makes it a tool for FLR. National laws on forests, planning, and the environment must be revised to better incorporate aspects likely to promote the development of the bamboo sector and encourage investments.

Local coordination mechanisms should be put in place under the auspices of existing regional or local entities. These mechanisms must promote the enforcement of regulations and the achievement of consensus on managerial deliberations. To take into account the increasing level of decentralization in countries such as Cameroon, municipalities should be made essential partners in guiding bamboo development initiatives.

4.2.4. Improving governance and funding

- Governments, the private sector, and donors should intensify their efforts to mobilize funding for the promotion of actions that can boost the contribution of bamboo to FLR. Diverse funding from governments and international financial institutions, including through qualified technical partners, should be pursued. The capacities of actors should be enhanced on how to get access to carbon finance to provide funds during the first years preceding the production phase.
- Establish platforms to reinforce local participation (planning, decision-making, monitoring) and to strengthen regional coordination mechanisms.
- Coordinate efforts to mobilize funding for the promotion of actions to increase the contribution of bamboo to FLR, and provide support for the mobilization of different types of funds for the industrial development of bamboo plantations, research, and transfer of technology.
- Train on how to get access to carbon finance and support the establishment of incentive mechanisms for funding the development of the bamboo sector especially on degraded lands

To ensure the long-term sustainability of landscape restoration, it is important to balance the supply of public goods and services with private benefits. To that end, it is essential to encourage PPPs.

To promote regional communication and collaboration, coordination mechanisms should serve as platforms for exchanging information and expertise on bamboo species. To better

integrate real needs and local know-how, it is also essential to encourage local participation in project planning, as well as in decision-making.

The issue of incentive through subsidies is important. It can be more relevant to establish a link between this question and the questions of rights to land, especially in conditions of advanced degradation.

4.2.5. Involvement of international organizations

International organizations such as the CIFOR, the ICRAF, the INBAR, and the International Union for Conservation of Nature (IUCN) should be encouraged to mobilize resources, build capacity, and conduct technical studies to bring bamboo cultivation closer to communities and consolidate FLR efforts across sectors, departments, and levels (from individual farmers to governments).

International organizations should establish appropriate channels for awareness campaigns emphasizing the benefits that can be derived from bamboo. Organizations such as the INBAR are better positioned to integrate issues of training and technology transfer into capacity building packages and reinforce exchanges of expertise, especially to fully benefit from the Asian experience.

Other organizations, such as the World Bank, should support financial investments to ensure cooperation between the public and private sectors in bamboo enterprises and reduce the risk entailed in financing forest regeneration on degraded lands.

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