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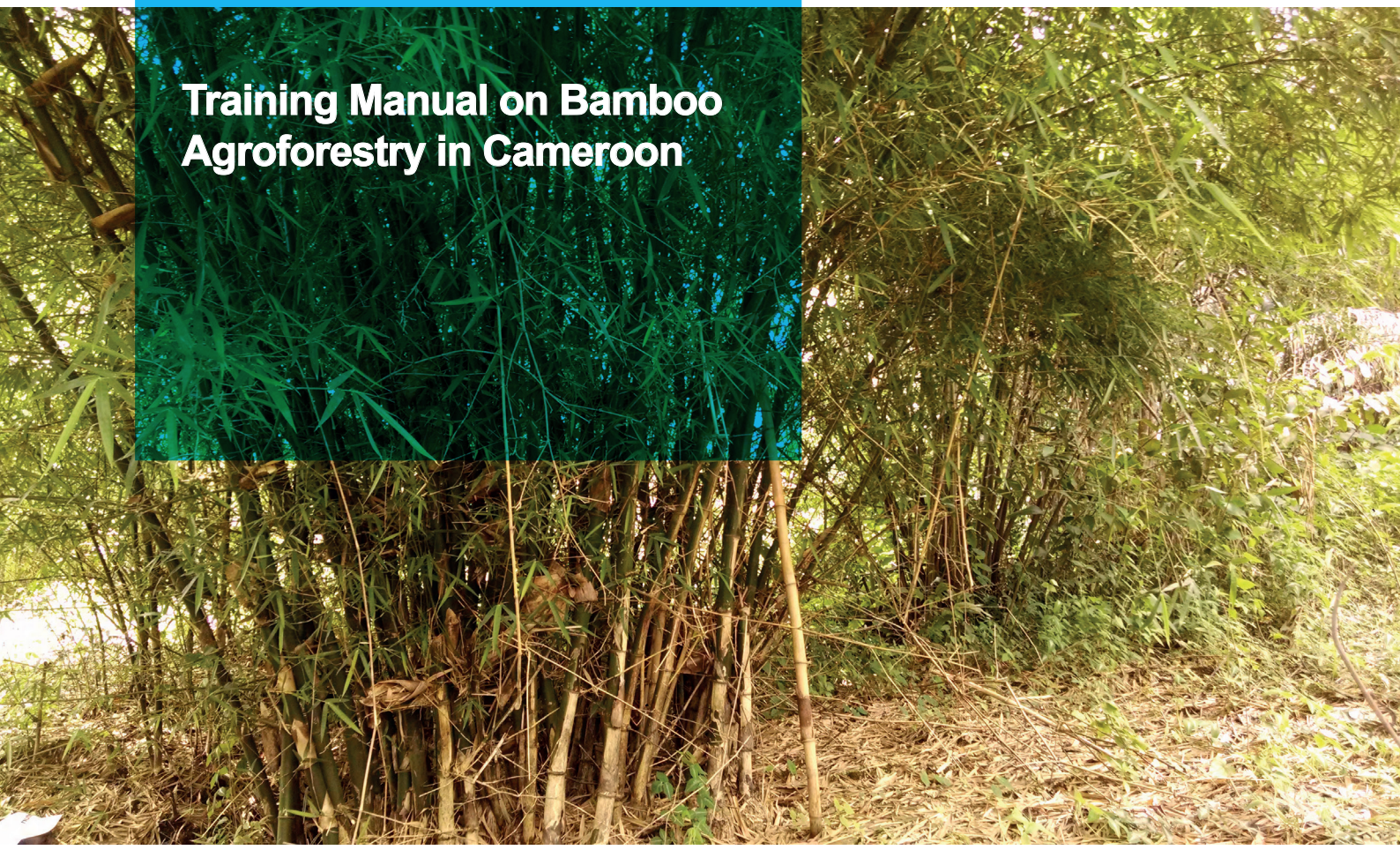
The Inter-Africa Bamboo Smallholder Farmers Livelihood Development Programme (Cameroon, Ghana, Madagascar and Ethiopia)

Training Manual on Bamboo Agroforestry in Cameroon



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PREFACE

Bamboo grows almost everywhere, even on soils with low fertility in tropical, subtropical and mid temperate zones. Bamboo is a multipurpose plant which is currently used in our day to day life and plays direct and indirect roles in the livelihood of people around us. Bamboo influences livelihood directly via its socio-economic potential and indirectly through the role it plays in environmental protection. Bamboo has a great socio-economic impact on the sustainable development of many countries. Nowadays in Africa and particularly in Cameroon, people's experience of bamboo products is still limited to bamboo furniture from handicraft whereas the last 20 years has been a turning point in bamboo industrialized commercial products. Indeed bamboo is now seen as a timber substitute. Its rapid growth cycle and capacity for sustainable harvesting increase the demand for bamboo products. Recent developments have created new employment opportunities in the bamboo Handicraft sector (Bamboo farmers, bamboo collectors, bamboo culm sellers, bamboo culm transporters, bamboo processors, bamboo product sellers). Bamboo has enormous potential for socio-economic development, this gives place to the development of an international bamboo market and trade. It is exported worldwide as raw material, semi-finished and finished products. The bamboo sector can bring extra revenue to African countries via the development of some industries for bamboo processing into varieties of industrialized products. Bamboo is also used in the pharmaceutical domain for the production of drugs and cosmetic products. Bamboo shoots are used in Asia as a vegetable (food). Bamboo positively impacts the environment. It can replace wood and as such reduces pressure on the demand for timber, thereby encouraging forest protection. Again, bamboo contributes in soil protection and has a great capacity to sequestrate carbon through its canopy and litter, thus reducing soil evaporation and erosion, limiting land slides and contributing to the restoration of soil fertility. Bamboo also purifies water and provides a source of energy, it can be used to produce both wood fuel and charcoal for cooking and heating.

I. INTRODUCTION

The demand for natural resources in Cameroon grows daily but the supply endangers its sustainability, especially when the livelihood of millions of local population depend on these resources for medicine, energy and other socio-economic and cultural aspects. Non-Timber Forest Products (NTFPs) have long been an important component of the livelihood of forest-dwelling people by providing shelter, food, and income. At the household level, forests directly provide about 8 million rural-poor Cameroonians with traditional medicines, food, domestic energy and construction materials[1]. Bamboo has long been regarded as one of the neglected Non-Timber Forest Products (NTFPs) in Central Africa[2] , despite its taxonomy, its rapid growing rate, and its vital economic and ecological importance to humans. Bamboos are renewable and are harvested[3], as some species grow a meter per day and attain maturity during five years[4].

In order to promote Bamboo Agroforestry in Cameroon, we need to inform Cameroonians of the importance of Agroforestry (**Module I:** What is Agroforestry) and the potential of bamboo (**Module II:** Why Bamboo). By so doing, we will raise awareness on the integration of Bamboo on cropping lands (Module III: Bamboo Agroforestry system and its productivity), and appreciate its benefits and constraints (**Module IV:** Bamboo Agroforestry Constraints).

Module I is designed to inform Cameroonians of Agroforestry components, farming systems, functions and benefits. Module II and III will illustrate bamboo potential in Agroforestry. **Module IV** is all about the negative aspects of practicing bamboo Agroforestry systems.

1. Main objective of the training manual

The aim of this training manual is to contribute to the knowledge of Cameroonians on bamboo Agroforestry systems.

2. Specific objectives of the training

1. To contribute to the knowledge of Cameroonians on Agroforestry.
2. To contribute to the knowledge of Ca-

1. *Topa, G., Karsenty, A., Megavand, C. and Debroux, L. 2009 Forêts tropicales humides du Cameroun Une décennie de réformes. Dans : Directions du développement Environnement et développement durable. Banque Mondiale, Washington, DC.*
2. *TabotTabot, Ebenezer 2006. Strengthening forward and backward linkages n the Rattan and Bamboo sectors in Africa: the case of South West Region of Cameroon. Article présenté lors de l'atelier international OIBT/ INBAR sur le développement durable du secteur mondial du rotin, Premier atelier de formation sur la normalisation du bambou et du rotin, 23—27 Juillet, Pekin, China.*
3. *Wu, F. Z., Yang, W. Q., K. Y. Wang, N. Wu and Y. J. Lu. 2009. "Effect of stem density on leaf nutrient dynamics and nutrient use efficiency of dwarf bamboo." Pedosphere 19: 496–504.*
4. *Benton, L. T., O. Cronin, J. Frith, Jonkhart and W. Junqi. 2011. Market Potential of Bamboo and Rattan Products. International Network for Bamboo and Rattan Working Paper 63. International Network for Bamboo and Rattan, Beijing, China*

meroonians on bamboo.

3. To inform and engage Cameroonians into bamboo Agroforestry.
4. To inform Cameroonians of the constraints of bamboo Agroforestry.

3. Expected Outcomes

1. The knowledge of Cameroonians on Agroforestry is improved.
2. The knowledge of Cameroonians on bamboo is improved.
3. Cameroonians are informed and engaged into bamboo Agroforestry.
4. Cameroonians are informed of bamboo Agroforestry constraints.

4. Target groups

This training manual targets Cameroonians from bamboo rich regions in Cameroon who will serve as a source of inspiration in their communities during and after the project. This is in a bid to contribute to the valorization of bamboo in Cameroon.

II. METHODOLOGY

The methodology used will be participatory and will involve the participants taking full responsibility. Depending on the module, interactive presentations will be given. Participants will work individually or in groups by answering oral or written questions in workshops designed from their real life experiences, specially oriented to their knowledge on bamboo and their contributions to valorize it. Many activities will be based on participants' experiences using questionnaires and discussions. In some cases, there will be collective reflections (brainstorming session) and comments on possible case studies.

1. Tools needed

Didactic support: printed documents (ToR, training manual, PowerPoint presentation).

Tools: Flip chart, post it, markers, conference paper, digital camera, video projector, laptop, Dictaphone and saw.

2. Content of the training manual

This training is focused on five (5) modules organized as follow:

1. Module I: What is Agroforestry?

- Definition of Agroforestry.
- Agroforestry farming systems, components and functions

2. Module II: Why Bamboo for Agroforestry?

- Bamboo plant.
- Bamboo species.
- Bamboo reproduction methods.

3. Module III: Bamboo Agroforestry systems and their productivity

- Bamboo Agrisilvicultural system.
- Bamboo interstitial canopy cover Systems.
- Bamboo Silvopastoral system.
- Bamboo Agrosylvopastoral system.

4. Module IV : Module V: Contraints of Bamboo Agroforestry systems

- Interaction competition in bamboo agroforestry systems.
- Bamboos are considered as invasive species

5. Module V: Constraints of the Bamboo Agroforestry system

- Interactions competition in bamboo agroforestry system
- Bamboos are considered as invasive species.

3. Evaluation of the training

At the end of the training, evaluation forms will be distributed to participants. This is aimed at evaluating the training organization (strengths and weaknesses), the logistics, the working conditions, the relevance of the modules, the interests of participants in this training, the animation style and participant's suggestions. These evaluation forms will be analyzed and used to improve each module in order to better meet the expectations expressed.

III. MODULE I: WHAT IS AGROFORESTRY?

1. Module I : Qu'est-ce-que l'agroforesterie ?

1. Definition of Agroforestry

- **Agroforestry definition by FAO, 2015**

Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components. Agroforestry can also be defined as a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. In particular, agroforestry is crucial to smallholder farmers and other rural people because it can enhance their food supply, income and health. Agroforestry systems are multifunctional systems that can provide a wide range of economic, sociocultural, and environmental benefits. There are three main types of agroforestry systems:

- **Agrisilvicultural systems** are a combination of crops and trees, such as alley cropping or homegardens.
- **Silvopastoral systems** combine forestry and grazing of domesticated animals on pastures, rangelands or on-farm.
- The three elements, namely trees, animals and crops, can be integrated in what are called **agrosylvopastoral systems** and are illustrated by homegardens involving animals as well as scattered trees on croplands used for grazing after harvests.
- Agroforestry is the collective name for land-use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (crops, pastures) or livestock, in a spatial arrangement, a rotation, or both with the components grown together on the same land. There are usually both ecological and economic interactions between the trees and other components of the system[5].

5. *ZNath, S; Das, Rameswar; Chandra, R.; Sinha, A. 2009. Bamboo based agroforestry for marginal lands with special reference to productivity, market trend and economy. Jharkhand News, March. pp. 80- 96..*

- In simple terms, agroforestry is an agro-ecological intensive farming system approach which integrates woody and/or trees species on agricultural production farms (crops and/or livestock) for economic, ecologic and social benefits.

2. Agroforestry farming systems and components

The three main universally used agroforestry systems include: the agrosilvicultural system, the silvopastoral system and the agro-sylvo-pastoral system.

- The agrosilvicultural system consists in associating trees with agricultural crops.
- Under Interstitial Systems as underground Covered Crops, these are crops whose cycle is at most one year.
- The silvopastoral system is trees association with animals for forage, or forage crops (fodder) and animals.
- The agro-sylvo-pastoral system is the association of trees and animals with agricultural crops.

3. Agrosilvicultural system

1. Windbreak farming systemt

Windbreak farming system is the association of trees and crops on a given land unit, where these trees are planted in a linear direction. These trees provide crops with shelter, protects them from heavy winds and wild animals. These trees also improve the soil physical, biological and chemical properties through their roots and leaves, thereby increasing soil fertility. This farming system is also called living fences or hedge farming system.

Photo : Kossipo Hedge *(Entandrophragma candollei) at Bayangam, West Cameroon* ***(source: Lucie TEMGOUE)***

2. Alley cropping farming system

This is a farming system which involves planting crops between managed tree rows. These trees provide crops with input (biofertilizer). This system can be designed to produce fruit, vegetable, and grain crops. It is also called hedge farming system due to its defined strips of rows and the zone it occupies. zone and its occupation.

Photo2 : *Alley croping farming system* ***(source: Lucie TEMGOUE)***

3. Improved tree fallow farming system

Here, woody species are planted and left to grow during fallow. Trees planted in this system improve farming land. These trees fix atmospheric nitrogen, grow rapidly, resist the lack of agricultural care and are easily cleared for farming. The tree's litter and roots help to speed up the process of restoring soil fertility.

4. Under interstitial canopy cover Systems

1. Homegarden farming system

This farming system refers to a planted area with a multistorey combination of several plant and crop species located around a dwelling or homestead. These home gardens provide householders with spices, vegetables, leaves for packing and foodstuff.

Photo 3: *Homegarden farming system (**source: Lucie TEMGOUE**)*

2. Cocoa and tea-based Agroforestry system

In this agroforestry system, woody species and/or trees provide a certain degree of shade essential for the growth of cash crops.

The most common tree and woody species in cocoa and tea plantations are; Canarium schweinfurthii, Albizia sp, Anthocleistha sp, Tetrapleura tetraptera, Dacyodes edulis, and Musa spp.

5. Silvopastoral system

1. Silvopasture/ Pastured forest plantations

This farming system is the combination of trees and livestock on a piece of land. These trees provide timber and fruit. Also, these trees guarantee shelter, shade, and fodder for livestock thus reducing stress on the animals.

2. Sylvo- fishing

Sylvo-fish farming involves associating trees with fish farming. There are several advantages to this association. Indeed, trees planted around fish ponds not only generate forage for herbivorous fish but create and maintain a microclimate favorable to fish growth and production.

Photo: *Silvopasture/ Pastured forest plantations **(source: Lucie TEMGOUE)***

Photo: *Sylvo-fishing (source: Lucie TEMGOUE)*

6. Agro-sylvo-pastoral System

1. Agricultural crops and livestock in natural or artificial forest stands farming system

In this farming system, the pastoral component can be perceived either through forage crops or through the actual presence of domestic animals. These pastures minimize the maintenance of forest plantations and reduce bushfire damage. Animal droppings and urine improve soil fertility. This can also enrich the soil with nitrogen if there are legumes suitable for the symbiotic fixation of atmospheric nitrogen.

2. Trees and livestock in agricultural plantations

Here, tree leaves, fruits, and herbaceous forage species constitute the fodder consumed by animals allowed in such a fallow. The soil is in return fertilized by animal feces. This double improvement in fertility will undoubtedly increase the subsequent agricultural production of the improved tree-fallow.

3. The agro-sylvo-fishing association

Apart from trees, agricultural crops and animals especially pigs and poultry may be associated with fish farming. Here leaves of woody plants (Calliandra calothyrsus, Leucaena leucocephala), and some agricultural crops such as sweet potato (Ipomea batatas) are used as fodder. As for pig excrement and poultry droppings, they contribute to the fertilization of ponds. The mud taken from the bottom of these ponds after emptying is rich in organic matter and mineral elements. This mud can be used as fertilizer for agricultural crops located around fish ponds.

4. The entomo-sylvo-fishing association

This is the association of fish farming with sylvo-sericulture. This association is widespread in the Pearl River Delta in China. The silkworm consumes the leaves of the mulberry trees planted around the ponds. As for the fish in the ponds, they feed on the excrement of the silkworm.

IV. MODULE II: WHY BAMBOO FOR AGROFORESTRY?

1. Bamboo plant

Bamboo is not a tree, it belongs to the grass family that is why all bamboo plants have similar biological features as grasses especially the nodes found on bamboo culms. Bamboo is actually a giant grass belonging to the family Poaceae (Gramineae) and from the tribe Bambuseae of the subfamily Bambosoideae[6]. Bamboo is recorded to be the fastest-growing land plant on the earth since culms of some species of four years can reach 40 m in height and 30 cm in diameter[7]. Furthermore, bamboo has an extremely wide range distribution with a great variety of habitats. In addition, bamboo is an adaptable plant, some species being deciduous, others are evergreen, and especially, some species seem to be able to change their habit when necessary[8].

2. Bamboo species

It is estimated that about 1600 bamboo species globally, consisting of 75-107 genera worldwide[9].The following 10 bamboo species are recorded as the best bamboo species in the world and have a high priority for large scale cultivation depending on the objective and end use of the crop: Bambusa textilis, Bambusa tulda, Cephalostachyum pergracile, Gigantochloa apus, Gigantochloa levis, Gigantochloa pseudoarundinacea, Guadua angustifoliaMelocanna baccifera, Ochlandra sp, Phyllostachys edulis, Thyrsostachys siamensis[10].

3. Bamboo reproduction methods

Even though most bamboo resources grow naturally, great attention has been paid to domesticate bamboo given the opportunities it offers to the poor rural population. However, not all farmers have knowledge of bamboo cultivation. Although there are few cultivation practices and trade (national and international) of bamboo in Africa and Cameroon in particular, many bamboo products are still used domestically in this part of the world and can be very significant in both household and local economies. Bamboo can be propagated using two reproductive methods, through seeds and by vegetative propagation methods.

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6. *Zhu, S., Ma, N., Fu, M.1994. Compendium of Chinese Bamboo: 8-9. China forestry publishing house, Beijing.*
7. *Rao, A.N., Rao, R.V., Williams, J.T., (Eds.).1998. Priority Species of Bamboo and Rattan. IPGRI/INBAR.*
8. *McNeely, J.A.1995. Bamboo, Biodiversity and Conservation in Asia. In: In: Rao V.R., Ramanuja Rao I.V. (Eds.), Bamboo, People & The Environment. Proceedings of the 5th International Bamboo Workshop and the 4th International Bamboo Congress, Ubud, Bali, Indonesia 19-22 June 1995. Vol. 2: Biodiversity and Genetic Conservation. INBAR. Weeds of Hawaii's Pastures and Natural Areas; an identification and management guide. Manoa, Hawaii, USA: College of Tropical Agriculture and Human Resources, University of Hawaii.*
9. *INBAR 2019. A manual for bamboo forest biomass and carbon stock asssessment*
10. *INBAR. 2000. The Tropical tree crops and their uses. International Network Research.*

Seed propagation methods are rarely used because of the irregular flowering of most of the bamboos (can take up to about 100 years). Again, bamboo seeds have poor viability (between one and six months) and the non-availability of seeds during the year makes this propagation method very unreliable. The vegetative propagation method makes use of the vegetative parts of bamboo plants such as rhizomes, culms, and branches. Therefore, vegetative propagation is the most popular and effective of the methods.

V. MODULE III : BAMBOO AGROFORESTRY

Bamboo species should be chosen according to the area, soil type, climatic condition and ecological zone. The most common bamboo species found in Cameroon are; Bambusa vulgaris (clumping or sympodial bamboo species), Yushina alpine and Phyllostachys aurea (both non-clumping or monopodial bamboo species). Intercropping with bamboos, however, can be done for a maximum of four years after bamboo planting, after which there is huge competition for the resources[11].

Bamboo Agrisilviculture system

This farming system consists in associating bamboo with agricultural crops.

1. Bamboo Agrisilviculture system

This farming system consists in associating bamboo with agricultural crops.

1. Bamboo windbreak farming system

Bamboo windbreak farming system is the association of bamboo and crops on a piece of land. In this farming system, bamboo should be planted in a linear form to provide crops with shelter and protect crops from speedy and heavy winds, and equally from wild animals. Three bamboo species can be used, but the most suitable bamboo for this farming system are the non-clumping bamboo species such as Yushina alpine and Phyllostachys aurea. For example, in Cooch Behar, Dinajpur, Haldibari, Mayanaguri and Jalpaiguri areas in India, the clumps of B. balcooa, B. bambos and B. nutans have been cultivated in close spacing in one to two rows along the north western sides of rice fields as windbreaks against the dry and cold wind blowing from Nepal and Bihar[12].

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11. *INBAR. 2000. The Tropical tree crops and their uses. International Network Research.*
12. *Tewari, S. et al. 1993. "Bamboo Based Agroforestry Systems." 24. Retrieved (http://www.frienvis.nic.in/WriteReadData/UserFiles/file/Content-Page/Books/Bamboo/Bamboo-Based-Agroforestry.pdf).*

2. Bamboo Alley cropping farming system

This is a farming system where crops like maize, beans and fungi are grown in corridors between managed bamboo rows. These bamboos are used as input, it can be pruned 3 to 4 times a year at 50 cm above the ground to be added to the soil as bio-fertilizer. The width of the corridors depends on the slope of the ground. It varies from 2m to 4m. It is 2m in steep terrain, 3m in gently sloping terrain, and 4m in flat terrain. As for the bamboo planting distance, it is between 50 cm and 100 cm. On sloping land, bamboo alley cropping will control soil erosion favouring water infiltration and retaining soil minerals, thereby improving soil quality or fertility. The bamboo species suitable to use for intercropping in this system is Phyllostachys aurea.

3. Bamboo improved fallow farming system

Bamboo improved fallow farming system consists in planting bamboo on a given land unit inorder to improve the soil fertility of the land, given that bamboo is a fast growing species with high biomass production and abundant litter fall and accumulation. This helps in maintaining and improving physical and bio-chemical soil properties. Nutrient availability in bamboo litter are N, Ca, K, Mg and P[13], therefore bamboo litter greatly influence soil fertility and could be used as a bio fertilizer in this farming system. Bamboo in this system will also reduce soil erosion especially the one caused by run-off thereby favouring water infiltration and retaining soil minerals. Bambusa vulgaris, Yushina alpine and Phyllostachys aurea are suitable for this farming system.

2. Bamboo interstitial canopy cover system

This farming system consists in associating bamboo with agricultural cash crops.

1. Bamboo in homegarden farming system

In Cameroon, we mostly observe the clump forming bamboo species in homegardens mixed with other cash and food crops. Bamboo species found in such system is usually Bambusa vulgaris and mostly in natural stand. These homegardens provide foodstuff and bamboo is often used as firewood for cooking and warming.

2. Bamboos in cash crop (coffee, tea and cocoa) farming system

In this farming system, bamboo provides shade for cash crops (coffee, tea and cocoa). Also, bamboo planting spacing will depend on the cash crop to be associated to bamboo. In the bamboo cocoa farming system, bamboo should be planted at 12m X 12m spacing to enable the cocoa plants to grow well and avoid competition. In bamboo coffee farming system, bamboo should be planted at 10m X 10m spacing. Tewari et al. (1993) reported that bamboos are often planted at a spacing of 6 m x 4 m and tea plants at 2 m x 0.5 m in bamboo tea farming systems.

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13. *Banik, R.L.; Tewari, S.; Kaushal, R. 2008.Bamboo in homestead and agroforestry system of India. In: Kundu, S.S.; Dagar, J.C.; Chaturvedi, O.P. and Sirohi, S.K. Eds. Environment, agroforestry, and livestock management. Lucknow, International Book Distributing. pp. 351-365.*

3. Bamboo Silvopastoral system

This farming system consists in associating bamboo with animals that feed both on bamboo leaves (bamboo as forage) and crops.

1. Bamboo pastured plantations farming system

It is the combination of bamboo and livestock on a piece of land. These bamboos will provide shelter, shade, and fodder for livestock such as cattle and goat which feed on Phyllostachys aurea leaves.

2. Bamboo Sylvo- Fishing farming system

It is the association of bamboo with fish ponds on a unit area. Bamboos are found or planted around the fish ponds to serve as forage for herbivorous fish. Bamboo also creates, improves and maintains a microclimate condition around fish ponds favourable for fish development. The appropriate bamboo species to be used in this system is Bambusa vulgaris.

4. Bamboo Agro-sylvo-pastoral system

This farming system consists of bamboo and animals with agricultural crops.

1. Bamboo, crops and fishing farming system

Bamboo, crops and fishing farming system is the association of bamboo, crops and fish ponds on a piece of land. Bamboo here can be in a natural stand or be planted to guarantee a favourable microclimate condition around fish ponds. Bamboo species such as Bambusa vulgaris are suitable for this farming system. Animals like pigs and poultry may be associated in order to use their excrement in the fish ponds to favour fish growth. When cleaning the ponds the mud taken from the bottom is rich in organic matter and minerals which can be used as fertilizer for agricultural crops located around fish ponds.

2. Agricultural crops and livestock in natural or artificial bamboo stands farming system

Agricultural crops and livestock in natural or artificial bamboo stand farming system is the association of crops (both cash and food crops), animals on the bamboo natural or artificial stand. Bambusa vulgaris is suitable for this farming system. In natural stands of Bambusa vulgaris often observed in Cameroon, spacings are from 4m x 4m to 8m x 8m. In the case of establishing the farming system, intercropping bamboo requires to be planted at interspaces from 8m x 8m to 12m x 12m. As tree species, bamboo needs this interspacing in order to reduce the effect of competition when growing. The space between these Bambusa vulgaris clumps should be used for cash or food crops (tea, maize and beans) production.

Tewari et al. (1993) reported that the yield of all intercrops was higher in wider spacing (12 m × 10 m) as compared to closer spacing (10 m × 10 m) which is attributed to the fact that wider distance between two bamboo plants results into better utilization of sunlight, space, moisture and nutrients by the intercrops with minimum competition among them and between agricultural crops[14].

14. *Toledo-Bruno, AG et al. 2017. "Ecology of Litterfall Production of Giant Bamboo DendrocalamusAsper in a Watershed Area." 3(4):363–72.*

VI. Module IV: Bamboo Agroforestry system constraints

1. Interactions competition in bamboo agroforestry system

In bamboo agroforestry systems, as in other agroforestry systems there is both underground and aboveground competitions. Bamboo as a woody species has a high length density root. This makes them competitive for water and minerals found in the soil when growing in association with crops. Furthermore, bamboo is the fastest growing species on the earth, having a dense canopy which develops within less time (3-6years) compared to trees, thus usually competes with intercrops for light. To reduce this competition interspace bamboo should be applied.

2. Bamboos are considered as invasive species

Bamboos are often considered as invasive species, this is when these bamboos are not well managed. If frequently harvested and pruned this will control bamboo spreading speed.

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