Report on the Situation, Potential and Prospect of Bamboo Industry in Rwanda

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Preface

Our age has been one ubiquitously harassed by adverse climate changes that no country or community on this planet could stay intact. Behind the more and more relentless ravages of our national economies, lives and people's safety is the fact that our planet is being tormented by changing weather patterns, rising sea levels, more extreme weather events and unprecedented greenhouse gas emissions. If we stay as unresponsive to them as before, the world's average surface temperature is likely to rise by 3 degrees centigrade within this century. Among the victimized populations, the poorest and the most vulnerable people are the most pathetic ones.

Affordable, scalable solutions are now available to enable countries to leapfrog to cleaner, more resilient economies. Renewable energy and other emission-reducing and adaptation-oriented measures, as embraced by more and more people, represent our faster and faster paces to alleviate and mend the damages. However, climate change is a global challenge disregarding national borders that no low-carbon economy in the real sense could be developed in the developing countries without viable solution based on international coordination.

On the International Day of Forests (21 March), UN chief António Guterres is calling for 2020, which has been referred to as a "nature super year", to be the year that the world turns the tide on deforestation and forestry loss.[1]

While the outrageous degradation of forest on our planet, and the environment as a whole, is precluding our sustainable development, our overconsumption of natural resources are accelerating the biodiversity loss and exacerbating climate changes, according to the UN chief.

Given the unparalleled role that forests play in preserving life on earth and regulating the climate, Mr. Guterres expressed his alarm at the damages being wrought by longstanding droughts in many parts of the world, citing devastating forest fires, from the Canadian Arctic and Siberia to California and Australia.

On top of this, the development large-scale agriculture contributes to further deforestation: even though the annual rate of deforestation has halved over the last 25 years, the areas of forest to be laid bald every year is still huge.

"We must act quickly to reverse this. Safeguarding forests is part of the solution," said Mr. Guterres, urging all governments and businesses and civil society to "take urgent action to halt deforestation and restore degraded forests, so future, generations can enjoy a greener, healthier future".

The Global South-South Development Center Project, jointly initiated by China International Center for Economic and Technical Exchanges and UN Office for South-South Cooperation, aims to make due contribution, at the project level, to benefit more countries and their peoples in the form of international poverty reduction cooperation.

This sector-specific analysis is documented from a small-grant project under China South-South Development Center Project (Global South-South Development Center Project grew out of China South-South Development Center Project). Since its inauguration, the South-South Development Center Project has promoted economic and technical exchanges among developing countries through training, workshops and small-grants projects. To date, under SSDC there have been 21 small-grant projects, involving various thematic areas such as agriculture, forestry, new energy, environmental protection and industrial development. These projects have benefitted more than 30 developing countries. During the implementation of the small-grant projects, parallel funding channeled through PPP have expanded to 1.6 times of the core funds, based on which partners and participating institutions from developing countries, including China, could have accesses to technologies, equipment and facilities, and opportunities to gain knowledge and develop capacity simultaneously. It's literally a "win-win" scenario.

[1] UN News: Turn around deforestation in 2020, the Nature Super Year, says Guterres (https://news.un.org/en/story/2020/03/1059852)

Executive Summery

At the kind invitation of Rwanda Water and Forestry Authority (RWFA), Ministry of Lands and Forestry (MLF) of Rwanda, two Professors from China National Bamboo Research Center (CBRC), as dispatched under the Global South-South Development Center Project (GSSDC), proceeded with a mission in Rwanda from September 4 to 9, 2019 in a bid to investigate the situation, potential and prospective of the local bamboo industry, particularly its contribution to socio-economic development and ecological protection, with a focus on the efforts and achievements made by China Aid Bamboo Project (CABP) in Rwanda from 2009 to 2019.

We visited RWFA, MLF, the Economic and Commercial Counsellor's Office (ECCO), the Chinese Embassy in Rwanda(CER), CABP, etc., paid some field visits to Bamboo Processing Technology Incubator(BPTI), Bamboo Multiplication Technology Incubators (BMTI), bamboo demonstration and pilot plantations, nurseries, etc., which were established through CABP, made in-depth discussions and interviews with all relevant stakeholders on the possible upcoming partnership under the framework of China aid and GSSDC. Through this fact-finding mission it was ascertained that:

1. Gigantic role of bamboo development as a green agro-industry in Rwanda

Bamboo is universally recognized as one of the most important Non-Timber Forestry Products (NTFPs) and "timber for the poor" thanks to its unique advantages: fast growth, short cycle, strong regeneration, large biomass, multiple use, sustainable development. Featuring simple technology, easy operation, low investment, quick return and so on, the green bamboo agro-industry, with its presence in the primary industry (bamboo plantation), the second industry (bamboo processing) and the tertiary industry (marketing and service), has been yielding social, economic and ecological benefits in a harmonious way. Proven to be a novel and prospective alternative option in line with the local social and natural conditions, this industry could help address Rwanda's challenges with an overarching solution, including job creation, import reliance alleviation, soil and water conservation and ecological restoration.

2. It should be recognized as one of the most powerful means to realize SDG 2030

5 SDGs and 10 SDG targets are involved

- SDG1: End poverty in all its forms everywhere;
- SDG2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. SDG targets 2.2, 2.3 and 2.4;
- SDG13: Take urgent action to combat climate change and its impacts. SDG targets 13.2 and 13.3;
- SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainable manage forests, halt and reverse land degradation, SDG targets 15.2; and
- SDG17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development. SDG targets 17.7 (17.7.1) and 17.9 (17.9.1).

3. Based on the 10-year collaborative efforts of China and Rwanda through CABP, the bamboo agro-industry has been prospering from its birth until its takeoff.

Given the Rwanda people's deep-rooted and well-raised awareness of the agro-industry, the bamboo plantations have been contributing a lot to soil and water conservation based on the annual production value of around US $ 1 million and the 2,000 jobs directly and indirectly created, including 80% for women and 20% for young adults.

4. The galaxy of state-of-the-art and practical bamboo technologies, fine bamboo species, compatible experiences, which have been imported from China and transferred to, innovated in and applied to Rwanda, are giving a strong impetus to the bamboo agro-industry development in Rwanda.

4.1 Bamboo cultivation

- The well-selected Chinese bamboo species, which have been brought in from China to Rwanda in line with the scientific site-match principles, boast proven biosecurity and wonderful growth that will they facilitate the establishment of new and high-quality plantations, one of the most important links of the bamboo agro-industry chain as well-recognized in Rwanda thanks to their sustainable supply of high quality bamboo timber and shoots to the down-stream processing sectors;
- Greenhouse nursery equipment and technologies ensure domestication, mass multiplication and large-scale production of imported bamboo species;
- Fast bamboo multiplication technologies which facilitate large-scale production of bamboo seedlings to meet the high demands of bamboo afforestation at low costs and with high qualities;
- The bamboo cultivation technologies such as intensive cultivation, orientated cultivation, and classification management could bring about well-balanced economic and social benefits. Different cultivation technologies and measures are adopted for a variety of purposes: for bamboo timber, for bamboo shoot, for both timber and shoot, for ecological protection. Plantations alongside river banks are set for two categories of indicators, namely soil and water conservation and economic output, through their scientific harvesting and sustainable production; and
- High potential has been manifested in the productions of bamboo shoots as a novel food for Rwanda.

4.2 Bamboo processing

- By machine or by hand, the collection of technologies for bamboo toothpick, curtain/blind, mat, carpet, furniture, weaving and others will enhance their commercial productions at different quality and pricing levels for specifically differentiated markets;
- Methodologies for bamboo supply chain, value-addition, integrated utilization, market-oriented production, etc. are adopted in the bamboo agro-industry;
- To further upgrade the industry of bamboo processing through:
  To improve quality and increase productivity to transform the bamboo production mode from small-scale producers featuring moderate quality to middle-scale ones featuring higher quality; and
  To further incubate and develop bamboo bio-energy, ply-board, paper and shoots as pillar bamboo agro-industries in the future.

5 Technical training, demonstration, service and promotion

5.1 Technical trainings conducted throughout its practicing and pilot production turn out to be highly rewarding;

5.2 The 3-phase promotion campaign initiated by CABP in the first 3 months and the subsequent various activities such as TV report, new media coverage, on-site visit, interview, demonstration and exhibition facilitate the start and fast development of Rwanda's bamboo agro-industry; and

5.3 The on-site technical service and consultation offered by the CABP expert team to farmers, entrepreneurs and businessmen across Rwanda are highly conducive to their development.

6 Sustainable development of incubator

Driven by high demand of people and market and buttressed by the revenues from their pilot production and product sales, sustainable operation and development of incubators funded by CABP has become a reality.

7. It should be acknowledged as one of the most successful models of South-South Cooperation in nature

- Perfect match of supply capacity and demand. With its unparalleled production capacity, China is at the top position of bamboo industry in the world. The huge funds injected into the bamboo sector by the government and private investors since 1980s have yielded enormous socio-economic and environmental benefits. For example, from 1981 to 2016, the annual production value of the bamboo sector was increased from USD 160 million to USD 35 billion, for which over 8 million people were employed. Developed against this background, the galaxy of technologies, expertise, machine manufacturing capacities, management skills, marketing methods and so on thus could serve Rwanda well for its unique characteristics of simple operation, easy learning, transferability, duplicability, massive application and excellent results. Rwanda, as the demand side with abundant bamboo resources but still in a primitive stage of development, is eager to share China's technologies and experience to develop their bamboo resources. In a word, the two sides are each other's perfect match;
- Good coordination and implementation mechanism to ensure the rewarding partnership. MOFCOM, CEW and MLF are government-representing agencies of China and Rwanda to make decisions on project framework, scheme, fund, etc. Through their bilateral friendly consultations which are concluded at least half a year ago before initiation of each project term (each 2 years as a term, totally 5 terms in 10 years), CBRC and RWFA are designated by both governments to implement them;
- Fund guaranteed. A sum of US $ 3.5 million has been earmarked by the Chinese government for the 10-year CABP and some in-kind supporting facilities such as building and land have been well provided by the Rwanda government. All the funds can be available in time;
- A systematic approach. A systematic approach involving technical transfer, social-economy, human resource, management, operation, differentiated marketing and so on are created and optimized;
- Working with a long-term resolution. As a tree has a long life cycle from budding, rooting, flowering to fruiting, it is logical and understandable that only after working assiduously through a long time could the South-South Cooperation, particularly its agriculture and forest projects, score achievements we expect. It is really impossible to achieve all the targets at one stroke. In fact, this project will take 10 years, through which 13 Chinese experts in total will be dispatched to Rwanda, including 5 working there to render regular full-time services;
- Active participation. All the self-motivated stakeholders, whether the government agencies, businessmen, farmers, artisans, etc. of Rwanda or any of the Chinese experts, will make spontaneous efforts under a harmonious partnership; and
- An integration of TCDC, ECDC and ECOCDC.

The project is aimed at enhancing Rwanda economic development and ecological protection by means of bamboo technology transfer. In its nature, it is put under the dual-target of Economic Cooperation among Developing Countries (ECDC) and Ecological Cooperation among Developing Countries (ECODC), therefore the modes of TCDC and ECDC shall be upgraded to ECODC.

List of Abbreviation

ABU	All Bamboo Utilization
BMTI	Bamboo Multiplication Technology Incubator
BPTI	Bamboo Processing Technology Incubator
BSC	Bamboo Supply Chain
BTI	Bamboo Technology Incubator
BVAP	Bamboo Value-Addition Processing
CABP	China aid bamboo project to Rwanda
CBRC	China National Bamboo Research Center
CER	Chinese Embassy in Rwanda
CMBP	Classification Management of Bamboo Plantation
EAC	East Africa Community
ECCO	Economic and Commercial Counsellor's Office, Chinese Embassy in Rwanda
EDPRS	Rwanda's Economic Development and Poverty Reduction Strategy
EBP	Experiment Bamboo Plantation
FAO	Food and Agriculture Organization
GGCR	Green Growth and Climate Resilience Strategy
GSSDC	Global South-South Development Center Project
ICMBP	Intensive Cultivation and Management of Bamboo plantation
IFAD	International Fund for Agriculture Development
INBAR	International Bamboo and Rattan Organization
ITCFST	International Training Center of Forestry Science and Technology (ITCFST), National Forestry and grassland Administration of China
MLF	Ministry of Lands and Forestry of Rwanda
MOFCOM	Ministry of Commence of China
NFGA	National Forestry and Grassland Administration of China
NTFP	Non-timber Forest Product
OBPC	Orientated Bamboo Plantation Cultivation
RBTTDI	Regional Bamboo Technology Transfer and Demonstration Incubator
RWFA	Rwanda Water and Forestry Authority
SDGs	Sustainable Development Goals
ZPG	Zhejiang Provincial Government

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At the kind invitation of Rwanda Water and Forestry Authority (RWFA), Ministry of Lands and Forestry (MLF) of Rwanda, two Professors from China National Bamboo Research Center (CBRC), as dispatched under the Global South-South Development Center Project (GSSDC), proceeded with a mission in Rwanda from September 4 to 9, 2019 in a bid to investigate the situation, potential and prospective of the local bamboo industry, particularly its contribution to socio-economic development and ecological protection, with a focus on the efforts and achievements made by China Aid Bamboo Project (CABP) in Rwanda from 2009 to 2019.

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The detailed reports are provided below.

A. Profile

The Republic of Rwanda is a landlocked country in the East African region, with an area of 26,338 km² and an estimated population of 12 million in 2017. Rwanda has an equatorial climate with a soothing constant annual temperature ranging from 16 to 24°C. And apart from the comparatively “drier” east region with an annual precipitation of 700 to 800mm, the bulk of the country is moistened by the rainfall and mist of 900 to 1400mm in the uplands and mountains of steep topography. Acidic soil is good for bamboo growing. Floods and landslides have higher and higher frequencies of occurrence;

As driven by Rwanda 2020 Vision, Rwanda is economically developing in the fast track in the past decade. As shown in the data from 2014-2019, Rwanda’s GDP rose by around 7%, higher than the world average, to which the biggest contributor was mining, the second biggest was industry, and the third biggest was agriculture including Forestry (Table 1). Rwanda GDP per capita is also increased by a wide margin (Table 2), and the living standard of Rwandans has also improved;

As seen from Fig. 1, the contributions of the timber and non-timber forest industries to the total wealth per capita were only US $ 386 and US $37 respectively, which means that that full economic potential of the abundant forest resources, with bamboo as the primary non-timber ones, has not been unleashed. Its rich bamboo resources are in stark contrast to its weak economic performance;

Currently, Rwanda is still facing the following major challenges during its rapid economic growth are:

- Given its hilly, steep topography and acidic but fertile soil in one of the smallest territories, its population density of 490 people/Km², one of the highest in the world, forces the Rwanda people to adopt a land-intensive cultivation mode with unsustainable land usages that cause deforestation, water erosion and deterioration of the fragile ecology while the agriculture sector dominated by small-scale farming operators employs 68% of the total population;
- Nearly all of the products for their daily use have to be imported with high transportation costs due to its landlocked geography.

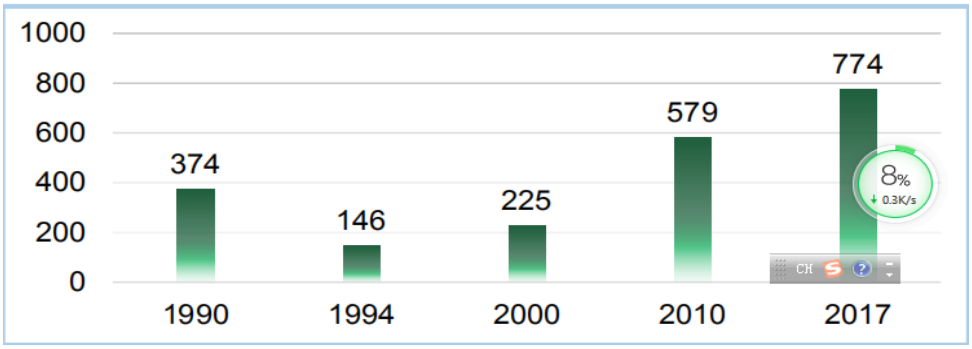
Table 1. Rwanda GDP Growth Rate from 2014 to 2020

(Source: Key Statistics on Rwanda, Oct. 2018)

	2014	2015	2016	2017	2018	2019	2020
GDP	7.6%	8.9%	6.0%	6.1%	7.2%	7.8%	8.0%
AGRICULTURE	7.0%	5.0%	4.0%	7.0%	5.6%	4.5%	4.3%
Food crops	9.0%	4.0%	3.0%	7.0%	7.1%	5.1%	5.1%
INDUSTRY	11.0%	9.0%	7.0%	4.0%	8.3%	13.1%	13.9%
Mining & quarrying	25.0%	-5.0%	10.0%	21.0%	20.1%	31.5%	32.9%
Manufacturing	8.0%	8.0%	7.0%	6.0%	6.1%	7.6%	8.5%
Construction	10.0%	15.0%	5.0%	-3.0%	5.2%	10.1%	8.7%
SERVICES	7.0%	10.0%	7.0%	8.0%	7.6%	7.8%	7.8%

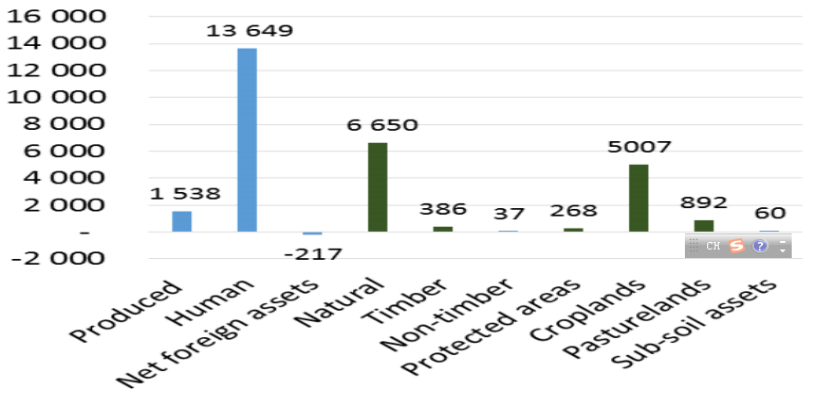
Table 2. Rwanda Change of GDP per capita (US $）

GDP per capita (US $)



(Source: Key Statistics on Rwanda, Oct. 2018)

Fig. 1 Rwanda: Total wealth per capita: US$21 619/capita (2014)
Note that natural capital is sub-divided into its parts



(Source: Lange et al. 2018, World Bank 2018)

B. Forest sector

B.1 Forests' roles in national development

Forests contribute a lot to Rwanda's national development. They provide 86% of the primary energy source whose primary purpose is for domestic cooking. They abound with tourism opportunities whose development generated US$ 294 million in 2013 and might expectably rake in over US$ 600 million by 2020 as the set target. Shielding and nurturing watersheds and downstream wetlands, Rwanda's forests constitute one of the pillars of its agriculture which represents 36% of its GDP, 80% of its employed population and more than 45% of its export revenues. Forest catchments convey a high proportion of the water supplies for domestic, agricultural, industrial, urban and ecological needs in both upstream and downstream areas. One of the key challenges faced by land, forest and water management is how to maximize the wide range of multiple-sectoral forest benefits with no detriment to water resources and the ecosystem as a whole. To address this issue, the government has proposed four pilot projects for conservation of forested water catchments along the rivers of Sebeya, Nyabugogo, Muvumba and Upper Nyabarongo under the mechanism of Payment for Ecosystem Services.

B.2 Status quo of forest and shrub land resources

According to the forest cover survey conducted in 2012 the forest area was 673,516.80 ha, accounting for 28.28% of the total land area, in which the western province houses the biggest share of natural forests (69,733 ha), the southern province of the biggest share of planted forests (109,765 ha) while the eastern province the biggest share of shrub land (258,403 ha). The percentages of the total forest areas by category were as follows: 18% as natural forests (123,538 ha), 39% as shrub-lands (260,569 ha) and 43% as forest plantation (286,811 ha). Of the total plantation forests, eucalyptus forests represented the majority (256,065 ha) while other species were either in monocultures or in mixed forests. Forest stocking of plantations could be as low as 50m³/ha for public plantations and 17m³/ha for private plantations. But according to the district inventory conducted in 2017, the maximum stocking of eucalyptus, as high as 285 m³/ha, or 5 times higher than the rest, is in the western province. The low stockings are mainly attributable to:

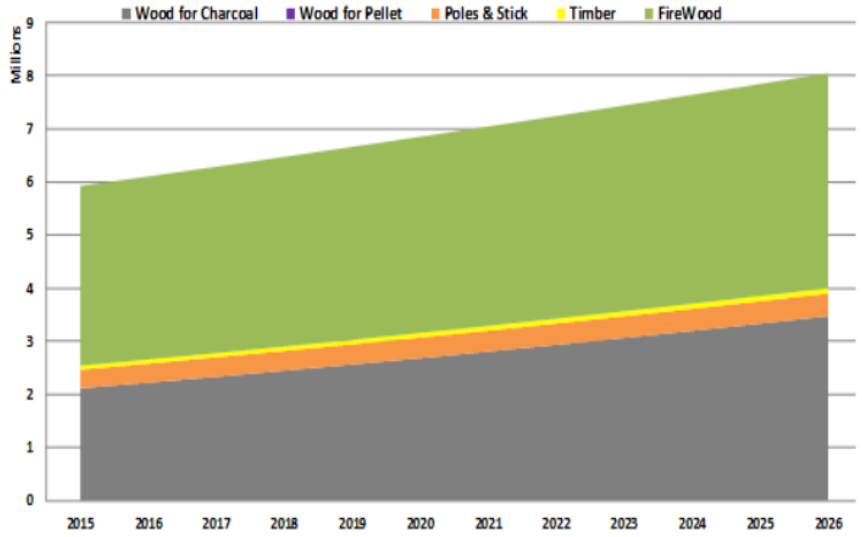
- Poor management without silviculture guidelines, including harvesting method;
- Early harvesting;
- Barely any genetic selection of species or species-site match; and
- Barely any cultivation technologies applied

B.3 Adverse impact of forests on environments

Rwanda features steep topography. Despite the forest cover of almost 30% of its territory, the high population density of 490 people/Km², which is still on the rise, has expanded farming beyond arable land and worsened deforestation. Although tree planting areas are expanding on and within farming landscapes, the degraded genetic quality of the planted timber, narrow range of species choice and unavailability of good silviculture result in low productivity, especially in private plantations. More than 95% of the rural population rely on wood for fuel. There is a relentlessly widening gap between wood supply and demand which has been more than twice of the sustainable supply. Shortage of fuel wood drives public forest degradation while private forests are often seriously overcut; both these factors prejudice future productivity. Due to the lack of high quality management and damages caused by fire, pests and illegal activities, forest service potentials are severely below than what they deserved. Trees and forests fail to deliver their potential values for soil and water conservation. The situation is more exacerbated due to an unsustainable practices in agriculture on steep slopes without implementation of adequate soil conservation measures.

B.4 Wood use

Fig. 2 Total demand projection per type of wood product for a business-as-usual scenario



(Oven-dry tons/year)

(Source: Projection scenario of supply/demand of wood biomass in Rwanda from 2015 to 2026. RNRA-DFNC summary report)

Table 3 Wood consumption for different ends (oven dry tons/year)

Category	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Wood for charcoal	35%	36%	37%	38%	39%	40%	41%	42%	42%	42%	42%	43%
Fire wood	57%	56%	55%	55%	54%	53%	53%	52%	5`%	51%	51%	50%
Wood for pallet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Stick & Pole	6%	6%	6%	6%	6%	6%	6%	6%	5%	5%	5%	5%
Timber	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%

(Source: Projection scenario of supply/demand of wood biomass in Rwanda from 2015 to 2026. RNRA-DFNC summary report)

It can be concluded that:

- The total consumption of wood for charcoal, pallet, fire wood, stick and pole, timber and any other purposes from 2015 to 2018 and the expected one from 2019 to 2026 are both stable, or only subject to infinitesimal inflation;
- The largest share of wood consumption goes to firewood and charcoal which accounts for over 90% of the total, the second largest one goes to stick or pole for construction and the third largest one goes to timber which represents only 1%. This means that the timber utilization in Rwanda is of very low added-value, hence a wide gap between the high demand of timber products driven by the rapid economic development and the low timber processing capacity.

The overarching issues to be tackled for forests include how to maximize the ecological benefits against escalating water and soil erosion, how to earnestly address the increasing demands for people's livelihood with increased living and fuel supply and how to balance the relationship between more wood logging for fuel and forest protection. For these purposes, the following aspects shall be taken into overall account:

- Agroforestry to stabilize farmland, improve soil structure and fertility, and enhance farm production and income generation;

- Rehabilitation of public forests and optimization of private and group tree plantations to improve productivity and delivery of service values; and
- Increasing efficiency along the wood supply chain for narrowing the wood supply gap as early as possible.

C. Bamboo

C.1 Bamboo resources

No survey of bamboo resources on species, distribution or other aspect has been conducted in Rwanda. But we assume there should be around 10 bamboo species, all of which are exotic. In the only 2 primary species, *Bambusa vugaris*, mainly distributed in plains, hills and river bank areas and with an estimated total area of several thousand ha, cannot be processed into valued products for its quite low timber quality, while *Arundinaria alpine*, mainly in the high mountain reserves, grows very densely with at least 25,000 pieces of bamboo plants per ha with an average height and diameter of over 8m and 5cm respectively, or a much bigger diameter in the areas at the altitude of over 2500m above sea level.

Some fine bamboo species have been imported from China by CABP and grown in the form of plantations all over Rwanda to provide good materials for value-added processing.

C.2 Bamboo as Non-timber Forest Product (NTFP)

It is classified as a NTFP, namely, the definition of all goods derived from forests that are tangible and physical objects of biological origin other than timber. Although sometimes it could be recognized as tree since people do not understand what exact differences exist between tree and bamboo. It should be quite different from the traditional NTFPs, like mushroom. Bamboo is one of the most important NTFPs in the world, and would be of far-reaching significance in Rwanda:

- Bamboo is one of the most important NTFPs and the unparalleled one in Rwanda;
- Bamboo can work in two ways and achieve balance between ecological and industrial benefits.

But it could be legislatively confusing in Rwanda at different levels. At the central government, it is a NTFP; but at the district level, it is not deemed a NTFP since it still needs cutting or harvesting permits as trees, and its cutting is banned in the areas 1200m above the sea level.

C.3 Bamboo sector

Before 2009 when CABP was initiated, there were mainly 2 native bamboo species as mentioned above. *B. vugaris* which is of too poor timber quality to be processed into high value products, and *A. alpine* which is not accessible and whose cutting is banned in the reserves, therefore it could be one of the reasons to keep Rwanda bamboo industry at a primitive level.

It was just used for livelihood improvement with low-valued handcrafts, fencing and housing, or low-level commercialization. Bamboo mainly works for environmental conservation by its soil and water erosion control. After CABP was brought into Rwanda with 4 well-selected bamboo species, bamboo processing technologies and expertise, processing equipment /devices, the bamboo industry began growing in a good momentum up to now. The industry is streamlined from plantation establishment to value-added processing with machines, and for marketing, the bamboo supply-chain is taking shape: The primary industry focusing on bamboo pole production is giving way to imported bamboo species from China with better timber quality whose supplies could be processed into different value-added products in the down-stream sectors.

While the processing industry is set to transform bamboo material into market-oriented value-added bamboo products, such as furniture, mat and lamp, the tertiary industry is mainly engaged in marketing of bamboo products. In spite of its low marketing capability, concerted efforts could be made to narrow or even eliminate the discrepancy between the high sale prices and the poor production capacities, hence the further development.

C.4 Bamboo role

Before the implementation of CABP, the bamboo industry in Rwanda was still a primitive one: Bamboo plantations were mainly available in high mountain reserves, which was barely accessible because of the poor transportation system, and their cutting was banned. So, they only worked as an ecological protector. Their distributions in hills and plains were less dense where bamboo can be harvested for handicrafts, fencing, and housing. But after the implementation of CABP, it has made a substantial change and played a great role in addressing all these problems and challenges.

- Begin new bamboo plantations in hills, plains, pasture ranges, river bank areas and soil-eroded areas with well-selected bamboo species from China, or make inter-planting with other tree existing crops with insufficient stockings or coppices, to make a sharp increase of forest coverage and effectively reduce carbon emissions and stop severe soil and water erosions caused by over-logging; and they provide good bamboo timber materials for value-added products to improve livelihood in rural and urban areas;
- Incubating and developing a new value-added bamboo industry of small commercial scale to link bamboo plantations with bamboo product market will provide various kinds of products for daily use to meet higher demands for livelihood in rural areas and to improve living in urban areas since the wood industry in Rwanda, relying on high-cost imports, is still vulnerable;
- Provide a new value-added NTFP by intercropping in the existing farming system, and increase land efficiencies and profitabilities;
- Fill the wide gap between wood charcoal supplies and demands by minimizing forest logging;
- Introduce a new vegetable—bamboo shoots— to the local market; and
- Create more jobs, particularly for women.

In conclusion, bamboo is the most important non-timber forest product of Rwanda. It can not only give strong boost to the economic development but also protect ecology of the country.

C.5 The women and young adults in the bamboo industry

After the CABP was initiated, more jobs in bamboo weaving and furniture making were created. Specifically, over 80% of the lamp weavers were women and about 80% of the furniture makers were women as well. Men or women, all bamboo makers are young people below the age of 25 years old.

C.6 Relevant regulations on bamboo sector

Although the bamboo sector in Rwanda still lags far behind in industry scale and value-added utilization, some regulations on bamboo sector management have been formulated, which would exert positive and negative impact on its development:

- Environmental Impact Assessments. Environmental Organic Law No. 04/2005 of 08/04/2005. It creates the precedent for environmental impact assessments (EIAs). The bamboo development does not need any activities of EIA as required for other trees;
- Import Permits for Plant Material. Introducing, releasing and disseminating a new planting material into / in Rwanda, incl. bamboo, requires a special Import Permit by which RWFA is authorized to manage this sector under the Law Governing Biodiversity in Rwanda No. 70/2013 of 02/09/2013;
- Bamboo Products Licenses. The rules on Licenses are set out in the Law Determining the Management and Utilization of Forests in Rwanda under No. 47bis/2013 of 28/06/2013. Bamboo is currently classified as a NTFP which falls under Forest Products. The sale of bamboo in its harvested places or after being processed into products requires a license issued by the District where the aforesaid business is conducted and indicating the nature of the goods and their origin (Article 56);

- Transport Licenses: The transport of forest products in their harvested places or after they are processed require a license issued by the District in which the forest is located. Such a license must indicate the nature, means of transport, quantity, origin and destination of the products transported (Article 55). The License costs RWF 1000 / ton based on the total vehicle capacity and not on loaded amount and must be paid in the district of origin. If a truck is loaded in 2 districts, then a license must be obtained in each district. This could increase costs, posing a challenge for harvesting natural bamboo because many of the plantations along rivers span more than one district;
- Forest Clearing License: If a forest was cleared for bamboo plantations, a Forest Clearing License would be required to be issued by the Minister (Article 52).

C.7 Where bamboo planting can be developed

According to the Organic Land Law under 05/2005, there are 3 particular land tenure types, as listed below, that provide a good opportunity for bamboo reforestation:

- Buffer zones for bamboo planting such as lakes, rivers and national roadsides shall be termed state land in the public domain. River and lake shores, protected forest lands as they are, shall be allocated concessively for the management of bamboo plantation;
- State-owned forests and unoccupied land that is in the private domain of the state can be used for bamboo plantation;
- Private land with free title: individuals, associations, organizations with free title can plant bamboo and supply to the bamboo bio-economy.

C.8 What favorable frameworks of policies and strategies for the bamboo development

Rwanda Vision 2020, Rwanda's Economic Development and Poverty Reduction Strategy (EDPRS) and the Green Growth and Climate Resilience Strategy (GGCRS) have built a solid framework under which bamboo can be used as a potential tool to help achieve the objectives of each strategy. They also create favorable frameworks for the bamboo developments.

1. Vision 2020 mission aimed at developing Rwanda into a middle-income country by the year 2020 with the following highlights:

- An increase of forest cover from 22.4% in 2012 to 30% by 2020;
- A decrease of the percentage of households using wood as a source of energy from 94% in 2000 to 86.3% in 2012 and then to 50% by 2020;
- An increase of the agricultural land protected against soil erosion from 40% in 2006 to 90% by 2020; and
- Economic restructuring from subsistence agriculture to service and industry.

2. Green Growth and Climate Resilience Strategy

- Limited land but very fertile— expand crop varieties, local sales and manufactured products and exports to increase value addition;
- High population density with most people farming on hillside plots to employ sustainable intensification of small scale farming, resource recovery and re-use;
- Landlocked and limited transport network-- explore import substitution through domestic low-carbon industrial growth; and
- Small but growing manufacturing/ industry sector-- promote sustainable development of industry to address domestic needs.

3. National Policies seeking to take market incentives to manage and enhance the country's forest resources by agro-forestry, wood lots or large-scale plantations:

- Promoting the growth of multi-purpose/ agroforestry trees in all farming systems to have 85% of agricultural land planted with agro-forestry trees; and
- Promoting value-added technologies to wood and NTFPs, including supporting private sector for bamboo value-added processing.

C.9 Bamboo development potential

- Rwanda currently relies on coffee and tea for exports that bamboo products could become the third potential export product;
- Given its land area, Rwanda currently has low productivity, for both forestry and agriculture. The proper development of bamboo as a commercial NTFP could diversify and increase farmers' incomes; and
- Sustainable provision of bamboo charcoal.

D. Impact and achievement of China-aid Bamboo Project to Rwanda

With the strong support from Ministry of Commerce of People's Republic of China (MOFCOM), National Forestry and Grassland Administration (NFGA), the Zhejiang Provincial Government (ZPG), Embassy of the People's Republic of China in the Republic of Rwanda and its Commercial Counselor's Office and the Government of Republic of Rwanda, since 2009, CBRC has been implementing the CABP to enable Rwanda Bamboo Plantation and Processing and Utilization, as funded by the Chinese government. A lot of new concepts and technologies have been brought in, transferred, innovated, incubated, utilized for training and applied in Rwanda from China, which helps Rwanda to establish 2 industry-scale systems of multiple-function-oriented bamboo plantation and high-value and semi-mechanization bamboo processing. All those achievements pioneered in Africa, particularly in Rwanda, contribute a lot to the transformation of Rwanda's bamboo sector from a livelihood-oriented natural bamboo scenario into a commercial industry for people's wellbeing.

1. Multiple-function-oriented bamboo plantation established

- Six well-selected bamboo species set for the production of bamboo timber and bamboo shoots have been introduced from China to Rwanda based on the site-match theory. The are *Dendrocalamus barbatus, Dendrocalamus asper, Thyrsostachys siamensis, Bambusa textilise, Dendrocalamus latiforus and Indocalamus decorus, in which 3 species of Dendrocalamus barbatus, Bambusa textilise and Dendrocalamus latiforus* have been growing fantastically well and have proved to be very suitable for Rwanda site in the areas of up to 300 ha. Demonstration of bamboo plantation for the production of bamboo timber and shoots and for the ecological protection in headwaters of the Nile River and the embankment of the Aikanyam River has been done. Those bamboo plantations have become the primary raw bamboo timber supply source for the value-added bamboo product production, functioned well against soil and water erosion and facilitated urban landscaping. It has changed the bamboo resource situation in Rwanda from the wild and poor bamboo forest into an excellent plantation, enriched and optimized Rwanda's bamboo resource diversity, and laid down a firm foundation for the large-scale bamboo industry development and for greening Rwanda;
- Four modern nurseries, equipped with water spray and light intensity control facilities, have been established with a total ground area of 8,000 ㎡ in 4 provinces. They change the history of bamboo propagation from the outdoor fields to the indoor "greenhouses" and ensure the successful domestication, large-scale multiplication and production of the exotic bamboo offspring. Over 20 local nurseries with a total annual production capacity of 120,000 have correspondingly come into shape with the technical transfers and services offered via CABP;
- 8 main technologies have been transferred, incubated or created. As the major problem solvers and bottleneck removers through bamboo plantation development, they constitute the basis for the bamboo processing industry development; and

Bamboo shoots as edible vegetable are being developed.

Table 4. Eight Major Innovative Technologies

No.	Technology
1	Technology for bamboo offspring propagation

2	Technology for large-scale bamboo afforestation
3	Technology for modern nursery establishment and management
4	Technology for bamboo-oriented cultivation
5	Technology for soil and water loss control by bamboo plantation
6	Technology for bamboo toothpick, curtain and mat via semi-mechanization
7	Technology for bamboo weaving and furniture making
8	Technology for bamboo preservation

2. High-value bamboo processing industry developed via semi-mechanization

- Incubators with value-added bamboo timber processing technologies have been established. Bamboo machineries, devices and tools imported from China to Rwanda are equipped to develop the value-added semi-mechanization bamboo processing industry based on the local market needs:
  ① Bamboo toothpick: a set of pilot production and demonstration line for bamboo toothpick has been set up;
  ②Bamboo curtain/blind, mat and carpet: a set of pilot production and demonstration line for Bamboo curtain/blind, mat and carpet has been set up;
  ③Bamboo furniture; 3 levels of bamboo furniture are produced, or low, middle and high levels for different markets, and totally over 50 kinds of furniture are made;
  ④Bamboo weavings: For decoration and daily-use bamboo weaving products, totally over 40 kinds of products are made.
- The technologies and expertise below provide a strong backup to the bamboo processing, such as bamboo machine operation and maintenance, bamboo tool use and maintenance, bamboo preservation, bamboo product designing, match of bamboo material with its end products, bamboo pole bending with fire, and bamboo product coating /painting.

3. Technical training, service and awareness promotion activities and medium reports are conducted

- Over 110 bamboo technical training workshops in Kigali and other 3 provinces have been launched for around 1400 persons; and
- Bamboo planting in rural and urban areas and bamboo product exhibitions have been conducted with participation of Rwanda high-ranking officials.

D.1 Successful introduction of 4 well-selected bamboo species from China to Rwanda

As shown in Fig. 13 and 14, Rwanda is categorized as the temperate climate with a rich rainfall and a very excellent site for the growth of tropical bamboo or sympodial bamboo. But currently, Rwanda has only around 10 bamboo species dominated by Bambusa vugaris which grows with a tremendous biomass but a bad timber quality and therefore could not qualified for high-valued timber processing.

Fig.3. Geographical distributions of CABP sites in Rwanda

Fig. 4. Rainfall distributions in Rwanda

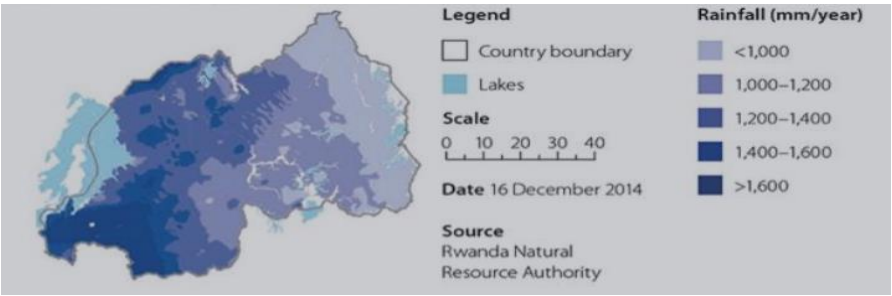
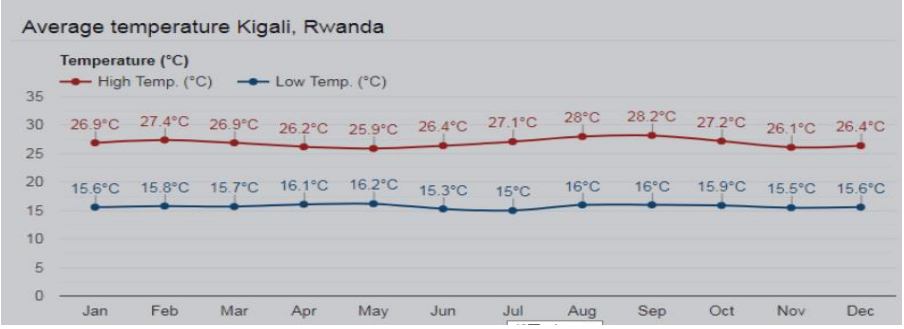


Fig.5. Average temperature in Kigali, Rwanda.



Considering the fact that Rwanda plans to increase its forest coverage in a short time to realize its protection against serious soil and water erosion, and meet high timber demands for people's livelihood, charcoal consumption and construction, some well-selected exotic multi-function bamboo species to Rwanda serve as one of best options to improve and optimize its bamboo resource germplasm and tap its gigantic potential of natural conditions in order to achieve those objects of promoting ecological conservation and increasing timber production through bamboo.

To this end, in 2013, the 6 bamboo species from China as mentioned below were selected and introduced into Rwanda in line with the two criteria: Site-match and end-use. As a result of the 3-year multiply-site field planting experiment, 4 species, or No. 1, 2, 3 and 4 became amazingly successful. They grew well, and had been propagated and produced in huge quantities in the

greenhouse nurseries applying new technologies and planted all over Rwanda with a total area of over 300 ha. Now nearly all bamboo products which are commercially produced in Rwanda are made from the bamboo plantations developed by those bamboo species. In conclusion, they are playing a very important role in the takeoff of the industrial-scale bamboo industry, increase of the forest coverage in the quickest way and cessation of soil and water erosion.

Such bamboo species introduction has been proceeding in strict accordance with the bio-security requirement rules set by the international community, the Chinese and Rwanda governments, i.e. all the bamboo plants were temporarily planted at soil-free nursery beds at the eligible quarantine houses for around half a year, with application of special insecticides every month and inspection by quarantine officers once every three months. Bamboo plants were clearly washed by water and pruned in root, branch and leaves to ensure their health. Additionally, they were padded by internationally-accepted moisture-adsorbing stuff and packed in cardboard boxes and shipped by air from China to Rwanda. It took around 3 days through the journey before arriving in Rwanda. Bamboo plants were planted in greenhouse nurseries in Rwanda as soon as they were released from Kigali airport. Their final survival rates ranged from 56% to 85%.

Table 5. Comparisons between technology, tool and market before and after training offered by CABP

Category	Description	Before training	During training	After training
Bamboo cultivation	Trainees from	Rwanda Bamboo Association, Rwanda Ecology Society and Rwanda Water and Forestry Authority		
	Propagation, planting technology	By big stump, no management	Propagation by 8 methods, large-scale plantation establishment and management	Good at propagation, plantations established and managed
	Market	No	Quality and productivity raised	Good marketing for bamboo seedling
	Farming Tools	Little hoe	How to use greenhouse for multiplication and how to make small-nursery and plantation set up by sterilizing, pruning shears, etc.	Good bamboo seedling and plantation made
	Economic benefits			Bamboo seedling sale at RWF 1000 /seedling
Bamboo weaving, furniture	Trainees from	Rwanda Handicraft Association, Bamboo Association, Ecology Society and Bamboo Furniture Company		
	Technology	All by hand, no preservation	Bamboo selection, splitting, preservation, design, bending, assembling, painting	A good master of how to make 4 kinds of bamboo weaving and 15 kinds of furniture (Bamboo chair, bench, sofa, bed, etc.)
	Tools	No	Machine, handy hand tools	Bamboo quality and productivity much enhanced
	Income	Some people can make some more income through marketing of bamboo lamps and furniture		
Bamboo curtain /blind, mat, carpet, toothpick	Trainees from	Rwanda Handicraft Association, Bamboo Association, Ecology Society and Bamboo Furniture Company		
	Technology	No	Quality and productivity improved by machine and production technology.	A good master of how to produce curtain /blind, carpet, toothpick
	Market	Little	Training on marketing	Good marketing
	Tools	No	Install 2 production lines for bamboo curtain toothpick.	A good combination of semi-mechanical operation and manual operation

Table 6. Detailed description of technologies provided and transferred by CABP

Technology	Description
Bamboo cultivation	1.Nursery management technologies ■land preparation: land cleaning for bamboo cutting and propagation； ■nursery preparation: measures adopted to protect plants from strong sunshine, rainstorm and insects; ■watering：spraying and irrigation. 2. Propagation technologies mother culms selection for mass propagation; ■propagation methods: by branch cutting, node cutting and whole clump etc.; ■preparation for propagation materials: cutting methods for branches and nodes etc.; ■preparation: preservation, moisture-keeping and hormonal treatment; ■nursery preparation: site preparation, soil sterilization, fertilization, ditch for drainage, simple green-house making by plastic clothing; ■Burying in soil, incl. burying depth, location, direction, spacing in row and line; ■management for newly-shooting seedling, water and shade, and fertilization; ■matured seedling management. 3. Set-up of new plantation ■site selection; ■site preparation: land reclaiming, hole making, and base fertilizer applying etc.; ■planting: season selection, planting depth, distance & method, irrigation; ■new plantation management: irrigation, fertilization and weeding; ■matured plantation management: irrigation, fertilization, harvesting and method of leaving shoot to new culms; ■sustainable management for high-yield plantation: bamboo stand density, structure, culm age for harvesting; and ■pest and disease prevention skill, bamboo timber and shoot harvest season, method and tools.
Bamboo Processing	1. Basic knowledge ■preparation and maintenance of tools; ■different tools' function, usage and application; ■function, usage, maintenance and repair of machinery;

	■Anti-insects, anti-mold and dry treatment to materials; and ■classification and processing of raw materials. 2. Processing Technologies 2.1 Bamboo stripping skill ■how to control the size of material cutting and sawing, how to balance material saving with quality guarantee; ■how to cut safely, ■machine cutting skill, how to cut strips in equal width; ■how to use strip-cutting knife: avoid breaking strip and burrs; and ■ how to learn the skill of cutting strip in equal width and equal thickness. 2.2 Weaving process and making of common products ■ how to select and match raw materials to ensure good-looking of final products; ■ how to style or curve bamboo on fire; ■ how to make furniture structure; ■how to install and fasten structure; ■ how to make furniture stable, good-looking; and ■ how to make basic weaving, surface polishing, surface painting. 2.3 Making and styling of quite complex and elegant products ■how to make bamboo products useful and attractive, such as baskets, boxes, mats, and other ornaments etc.; ■ how to style products matching environment; and ■ how to make advanced treatment to the product surface. 2.4 Bamboo toothpick production: ■how to make bamboo cutting as per the final products, ■how to select the blades as per the raw material; ■how to control the size of material cutting and sawing, ■how to balance material saving and quality guarantee; ■how to control the width equally; ■how to make machine cutting skill; and ■how to learn the skill of cutting strip in equal width and equal thickness.

Table 7. The list of introduced bamboo species to Rwanda with their growing evaluation

No.	Species	End-use	Results
1	*Bambusa textilise*	For furniture, weaving, paper, for soil and water erosion control and landscaping	Excellent
2	*Dendrocalamus barbatus*	For industrial construction, furniture, board, etc.	Excellent
3	*Dendrocalamus latiforus*	For edible bamboo shoot, paper, etc.	Excellent
4	*Thyrsostachys siamensis*	For furniture, landscaping etc.	Excellent
5	*Indocalamus decorus*	For landscaping, soil and water erosion control, etc.	Good
6	*Dendrocalamus asper*	For industrial construction, furniture, board, etc.	Not good

D.2 Bamboo propagation technology and management

How to make effective reproduction of bamboo seedling is one of the main challenges to plantation expansion in Rwanda. Before the implementation of CABP in Rwanda in 2009, there was no effective bamboo propagation technology except for just transplanting mother stump for afforestation. The stump is usually less than 1.0m high and actually the basal part of mother.

Fig. 6-1. Bamboo seedling washing, pruning, disinfection, temporary planting at the quarantine-qualified greenhouse nursery in China before being shipped out to Rwanda

Fig.6-2. Bamboo arrival at and growth in nurseries

Fig.7.Bmboo domestication and propagation inside greenhouse in Rwanda

Fig. 8. Wonderful growing of introduced bamboo plants in Rwanda (Top: *B. textilis* in 1-, 2-and 3-year. Middle: *D. latiforus* in 1-, 2- and 3-year. Bottom: *D. barbatus* in 1-and 3-year)

Bamboo plantations have the following disadvantages:

- Hard labor is necessary for digging them out from the bamboo stand and transporting them from there to where they will be planted; and
- Limited quantities available which cannot meet the need of afforestation in a large-scale or long-distance manner.

In order to produce a large quantity of qualified bamboo seedlings to supply for large-scale afforestation with presentable quality, at affordable costs and via long-distance shipping, the following 8 bamboo propagation methods are involved in the experiments for the introduced bamboo species (Table 8) in a combination of in outside field and in green-house field:

- By whole bamboo culm burying with stump;
- By whole bamboo culm burying without stump;
- By burying living bamboo culm;
- By aerial branch burying;
- By single and double bamboo culm node cutting;
- By main branch cutting and by auxiliary branch cutting;
- By seed; and
- By laying rhizome

The experiment results proved to be very successful with the shooting rates ranging from 60% to 90% (Table 9). Moreover, all those propagation methods were applied in a mixed way to increase their propagation co-efficiencies and productivities with good qualities and at low costs. For example, for the seedling production of *B. latiforus*, it can be done by a combination of Method

1, 2, 4, 5, 6 and 7, therefore, one bamboo culm can produce at least over 100 seedlings in a production cycle which takes around 3 months.

As far as we know, bamboo propagation methods have been involved in experiments somewhere and somewhat in Africa, but all are in quite small scales, or in an academic way, but never so systematically, or successfully for large-scale production with good quality and at competitive costs.

In a word, it should be a well-acknowledged debut in all African countries if judged from their propagation methods and results:

- Methods: Nearly all bamboo propagation methods have been tried particularly in consideration of Rwanda's social, economic and natural realities and bamboo development needs;
- System: All eight methods were applied in a mixed way depending upon bamboo propagation phases and objectives so as to maximize each method's advantage;
- An integration of method and practice. All methods applied were just oriented toward end-use bamboo afforestation; and
- Results: High multiplication shooting rate in field and large-scale bamboo seedling production are realized with good quality and at affordable costs.

Table 8. The methods, survival rate and species of bamboo propagation

No.	Method	Survival rate	Species applied
1	By burying whole bamboo culm with stump	70%	*D. latiforus,D. barbatus*
2	By burying whole bamboo culm without stump	60%	*D.latiforus,D. barbatus*
3	By burying living bamboo culm	80%	*B.textilise*
4	By burying aerial branch	85%	*D. Latiforus,D. barbatus*
5	By single and double bamboo culm node cutting	75%	*D. latiforus,D.barbaatus, Thyrsostachys siamensis*
6	By main bamboo branch cutting	90%	*D.latiforus,D. barbatus*
7	By auxiliary bamboo branch cutting	90%	*D. latiforus,D. barbatus*
8	By laying rhizome	85%	*Indocalamus decorus*
In fact, the propagation methods from No. 1 to No. 7 are usually mixed together to get high multiplication efficiency.			

Fig. 9. Bamboo propagation methods (From top to bottom: propagation by culm cutting, branch cutting, by burying whole culm with stump and without stump, by burying living bamboo culm, by stump, by aerial branch, and by seed, by rhizome)

D.3 Large-scale afforestation

It is well acknowledged that nearly all the bamboo forests in the African countries are grown that naturally only very few of bamboos are planted in a sporadic way. For example, the overwhelming majority of bamboos in Rwanda are growing in high mountain areas where they are recognized as nature reserves. Only a few of them are planted along river bank area. In this case:

- Not touchable since cutting of those bamboos is banned according to the relevant laws and regulations;
- Not accessible since less roads or no roads available at all; and
- Not valuable species. There are mainly 2 species in Rwanda. One is *A. alpine* in high mountain reserves, whose commercial value use and harvesting are banned; another is *B. vugaris*, but it is not of good timber quality for value-added industrial use.

Sustainable supply of bamboo raw material with good quality and affordable shipping costs should be widely recognized to make it the first precondition for commercial bamboo industry development, or bamboo plantations with quality bamboo species and suitable sites must be established and well managed to provide good, sustainable and affordable bamboo timber to the down-stream bamboo processing industry. Only in such a way could the bamboo industry survive and develop in commercial markets. Bamboo resources in Rwanda should be quite rich if their growing areas are considered. But we found it quite less from the perspectives of (1) value of existing bamboo species, (2) accessibility and cost factor.

China is worldwide recognized as a flagship country in bamboo industrial development. From cultivation to processing, and from integrated use to marketing within over 3 decades, China has successfully established large-scale bamboo plantations through improvement and transformation of the natural moso bamboo forest with focus on the quality timber. Largely

distributed in China, such moso bamboo plantations provide the raw bamboo timber sustainably with top quality for the modern bamboo processing industry.

How to make large-scale bamboo plantations from those bamboo species imported from China is one of the top priorities for Rwanda's bamboo industry development. Considering alternating raining and dry seasons in Rwanda, to plant and manage bamboo is a big challenge.

As shown in experiments through the past several years in Rwanda, it is recommended that bamboo should be planted in raining seasons to ensure its higher survival rate, good growth and lower maintenance costs. The following methods prove to be effective and useful for setting up new bamboo plantations:

- To select 1-2-year-old well-grown bamboo seedlings;
- To keep appropriate amount of soil or clay in bamboo seedling basal parts or root parts to maintain proper moisture;
- To protect bamboo seedling with proper clothing from water loss if trucked through a long distance; and
- To prepare land. Use shallow-planting method. To dig out a 15cm-depth hole with a flat bottom, to place bamboo seedling in the hole, backfill it with the surface soil, to tread it down firmly, to water it thoroughly. Watering again in the next 2-3 days. No bamboo shoots shall be harvested in the first 2 years.

It takes around 3 and 4 years for *B. textiles* and *D. barbetus* to grow into a big stand, e.g. the annual shooting capacity and biomass of *B.textilis* are at least 40% and 30% higher than that in the origin in Guangning County, Guangdong Province, China.

It deserves special attention that watering management shall be maintained in the first 2 years for new plantation, particularly in dry seasons. 2 years later, it can grow well.

Although the new plantation areas are small, it has far-reaching and milestone impacts on bamboo development in Rwanda and Africa as a whole:

- New proper-scale plantations of bamboo species selected in line with the site-match principle and oriented to end uses through a set of technologies of bamboo propagation, planting and management shall be unveiled in Africa;
- Bamboo culms produced from those plantations have already been supplied to the down-stream value-added processing sectors at quite a commercial scale;
- It ushers in a set of new cultivation theories and technologies from China to Rwanda, for instance, Oriented Cultivation (OC): i.e. all the bamboo cultivation method and practicing are used to serve its end use; and
- It has changed bamboo forest cultivation history in Rwanda from the natural, target-free growing with bad quality to artificial and oriented cultivation with high quality.

Fig. 10 *D. barbatus* growing in 3 years

Fig. 11. Bamboo afforestation and management

Fig. 10 shows that D. barbatus has grown through 3 years and can be harvested for use. Fig. 11 on the left shows that bamboos are planted in river bank areas for stopping soil and water erosion participated by 3000 people incl. minister in the 10th International Environmental Protection Week in Rwanda in 2009. Fig. 11 in the middle and on the right show that *B. textiles* has grown through 1, 2 and 3 years respectively.

D.4 Urban bamboo landscaping

It has a very long history for bamboo to be used for landscaping in China since bamboo plant has a unique beauty and many advantages as an urban landscaping plant. Currently it is getting more and more popular in the recent 2 decades with the daily-rising urbanization in Asia and Europe as represented by Germany, France, Italy, the Netherlands, etc.

Kigali, capital of Rwanda, has much lower greening coverage dotted mainly with eucalyptus and some shrubs. With the rapid economic development and urbanization of Rwanda in recent years, greening and landscaping have been a common consensus of Kigali authority and the people. Bamboo landscaping, featuring fast growing, beauty and multiple-functions, is coming up as propelled by the CABP. A 50-ha bamboo garden with a bamboo landscaping belt of 2km long and 50m wide alongside the roadside to the airport at Masaka region, suburb of Kigali where CABP is headquartered, is established, and enjoyed very much by the local people.

Bamboo landscaping by *B.textilise* is also made at the Chinese embassy in Kigali, and also at the headquarters of the Rwanda Ruling Party with over 1500 clumps of bamboo plants.

Usually bamboos unpruned at branch or top are selected and planted in order to keep their beauty and quick formation of bamboo forest. Therefore, it should take whole bamboo clumps with 5 to 20-cm-thick soil balls to help maintain more moisture and keep a higher survival rate. Moreover, it is better to do it in raining seasons. The bamboo plants are always covered with a layer of black plastic clothing during the transportation to prevent water transpiration. They should be planted as soon as they are taken out from land. The size of pits which will be planted with bamboos should be in line with the size of their soil balls to accommodate them. The main management task after planting is to ensure its proper watering of Rwanda's forest coverage of only around 20%. It has much less forest coverage and bio-diversity in urban areas. Therefore, it is recommended to plant bamboo widely in public or private lands.

Fig. 12 Bamboo gardens and bamboo landscaping belts at roadsides and downtown

Fig. 13 Bamboo landscaping at Chinese embassy in Rwanda

Fig. 14 Bamboo landscaping at the headquarters of the Rwanda Ruling Party

D.5 Bamboo shoot

There are over 1250 bamboo species in the world, the overwhelming majorities of which are edible except for a few which could be toxic to human beings. Bamboo, of course, produces two main products: one is bamboo culm or timber which can be processed into different products like wood products, another is bamboo shoot as vegetables.

Bamboo shoot is delicious for its rich nutrients, including protein, ammonia acid, vitamin, folic acid, riboflavin, mental elements, carbohydrate, edible fiber, but little fat, particularly it has its rich edible fiber that improves human internal digestion. Currently countries that enjoy bamboo shoot are mainly distributed in oriental ones such as China, Japan, Korea, Thailand, Vietnam and Indonesia. They are also main producers of bamboo shoot. However western countries like USA, EU and Australia are the main importers of bamboo shoot from the oriental countries. China is the largest producer and exporter of bamboo shoot; its annual export revenue is as high as US $ 300 million.

It is well known that African peoples' food are mainly banana and cassava which are rich in starch, but lack vitamin since they do not get supplement from vegetable and fruits. As analyzed by medicine professionals, such vitamin-less food unbalances nutrition structure, and results in disorder especially for African people. Since bamboo is rich in vitamin, bamboo shoot as a food should rectify such unbalance and benefit eaters.

Table 9. Bamboo shoot nutrition

Kinds	Content	Kinds	Content	Kinds	Content
Energy	19Kcal	Thiamine	0.08mg	Calcium	9mg
Protein	2.6g	Riboflavin	0.08mg	Magnesium	1mg
Fat	0.2g	Niacin	0.6mg	Iron	0.5mg
Carbohydrate	1.8g	Vitanmin C	5mg	manganese	1.14mg
Edible fiber	1.8g	Vitamin E	0.05mg	Zinc	0.33mg
Vitamin A	0mck	Cholesterol	0mg	Copper	0.09mg
Carotene	0.8mck	Potassium	389mg	Phosphorus	64mg
Retinol	92.8mck	Sodium	0.4mg	Selenium	0.04mck
Nutritional data based on 100 gram fresh bamboo shoot samples.					

Table 10. Amino acid analysis of bamboo shoot

Mental element	Content	Amino acid	Content
Tryptophan	0.016	Valine	0.062
Threonine	0.050	Arginine	0.057
Isoleucine	0.051	Histidine	0.025
Leucine	0.082	Alanine	0.072
Lysine	0.079	Aspartic acid	0.249
Methionine	0.017	Glutamic acid	0.145
Cysteine	0.013	Glycine	0.051
Phenylalanine	0.053	Proline	0.129
Tyrosine		Valine	0.062
Nutritional data based on 100 gram samples.			

In fact, a few of African countries, e.g. Eastern part of Uganda, are rich with A. alpine and have a long history of eating bamboo shoot, particularly pickled bamboo shoot. Since fresh bamboo shoot is very prone to ageing and rotting in a few of days after harvesting, to make it into pickled shoot is easier for processing and good for longer preservation.

Fig. 15. Comparison between palm shoot (left) and bamboo shoot (right)

We have cooperated with some partners in Uganda, Mexico, Brazil, Costa Rica and India, where they have rich bamboo resources, but would nearly never know that bamboo shoot can be edible. So you can imagine how difficult it is to make them acceptable it on their dining tables? It is very important to find out a way to promote bamboo shoots as food. In Brazil, Costa Rica, they have a long history of palm shoot production for domestic market and export to USA, and Europe at quite high prices, but currently their production has sharply declined due to insufficient supply of palm shoot material. Considering the facts that bamboo is very similar in taste and process of production to palm and bamboo has much higher yields than palm in shoot production, we think they should like bamboo.

In 2017, we worked together with Costa Rica by conducting a 21-day bamboo training program in Costa Rica, funded by the Chinese government. We arranged for the participants to take some fresh bamboo shoots of each 6 species (*Physllostachys flxesua, Dendracalamus asper, Dendracalamus latiforus, Bambusa oldhami, G.angustifolius,*etc.*)* to restaurant, first to taste each shoot to perceive what bamboo shoot is, and then to cook them in Chinese and Costa Rica ways to make overall evaluation, upon which nearly all participants acknowledged that bamboo shoot is excellent and should be marketable in Costa Rica. One 6-year-old kid ate up what is finally left in the plate. Some of them liked the Chinese cuisine, others the Costa Rica one. As a result, some farmers and entrepreneurs are willing to engage in bamboo shoot production.

From 2016-2019 in Brazil we implemented a bamboo project funded by the Chinese government, of which developing bamboo plantation and bamboo shoot processing were the main components. We introduced 4 fine bamboo species for shoot production and machines for bamboo shoot value-added processing in Brazil and made some bamboo plantations dedicated to shoot production by planting new bamboo forests and transforming the existing ones. Bamboo shoots of 3 species (*Dendrcalamus. asper, Phyllostachys aurea, Dendracalamus latiforus)* were produced at small commercial scales and supplied to market. Moreover, bamboo pizzas and canned shoots were also produced.

Fig. 16. Tasting for fresh shoots of 6 main bamboo species, cooking in Chinese and Costa Rica ways, and enjoying them very much, incl. 6-year-old kid

Fig. 17. Bamboo shoot pizza in Brazil

Fig. 18. Canned bamboo shoot production in Brazil

In Uganda, people from the west Uganda have a tradition to eat bamboo shoots, but mainly in form of pickled shoots for the sake of long-term preservation. They eat only one species (*A. alpine*). We are in cooperation with Uganda Industry Research Institute to launch vacuum packing of sliced fresh bamboo shoots for safe preservation.

In Rwanda, 4 main shoot-oriented bamboo species from China were successfully introduced in 2014: *D. barbatus, D. latiforus, D. asper*, and *B. textilis.* The first 3 species come up with shoots in raining seasons, of diameters ranging from 5.0-15.0cm and heights of 15.0-80.0cm which depend upon their harvesting requirements: 15.0-40.0cm for fresh eating, and 40.0-80cm for processing use. Their average yields could be at least 30 t/ha. They taste sweet underground and but little bitter after being dug out; the last one *B. textilis* shoot is 2.0-4.0cm in diameter and 10.0-25.0cm in height, with bitter taste but a spicy flavor and worth being processed into pickled shoots.

Fig. 19 Fresh bamboo shoot (left) presented by Prof. Ding Xingcui (left the third and Hon. Minister of Water and Environment of Uganda Madam Maria);
Pickled bamboo shoots and sliced bamboo shoots in vacuum packagings (right)


Before CABP, the Rwanda people had never eaten bamboo shoots. But after that, people gradually enjoy them very much since Chinese experts trained them on how to manage bamboo plantation for shoot's production, how to harvest them, and how to cook them.

Fig. 20. Bamboo shoot growing and harvesting of *D. barbatus, D. latiforus, D. asper*

Fig. 21. Bamboo shoot cooking by Chinese experts

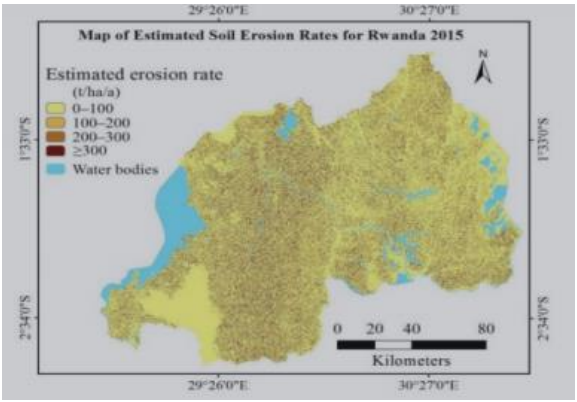
Fig. 22. Rwanda people enjoying delicious bamboo shoots (Rwanda youth, Rwanda beautiful ladies and Chinese expert, Director-general of Rwanda Forestry Authority)


We can draw a conclusion that bamboo shoot is one of the excellent vegetables; the reason why those people are reluctant to eat it is that they knew nothing about it before. Bamboo shoot has a big potential market in Rwanda and should be greatly incubated because its natural conditions of acid soil, rich rainfall and sunlight and its social conditions for intensive farming are suitable for bamboo shoot growing and production. Particularly, its pollution-free condition and geographical uniqueness help to produce organic bamboo shoots and their value-added derivatives.

D.6 Bamboo in soil and water conservation

Forest coverage in Rwanda has fallen sharply from 75% in the last century to 28.28 % now it is still declining year after year. The main reasons behind it are that forests are substantially logged as driven by rigid high needs for fuel charcoal, transformation of forest land into farming land for livelihood and materials, and expanding urbanization, etc. The remaining forests are dominated by the second single-layered ones, and single eucalyptuses and pines which could not function well in soil and water conservation; what's more, not much effort has been made for afforestation. The severe deforestation, of course, brings about sharp deterioration of water and soil conservation, and leads to further escalation of water and soil erosion. The eroded land area accounts for over half of the country's territory. Rwanda homeland security is at high risk. Fig. 23 shows that its annual erosion rate of majority of land in Rwanda has been as high as 100-200 t/ha. Fig. 24 shows over-farming in Rwanda in the over-logged areas.

Fig. 23. Map of estimated soil erosion rates of Rwanda in 2015



(Source: Fidele Karamage, etc., Extent of Cropland and Related Soil Erosion Risk in Rwanda, Sustainability, 2016, 8, 609)

Fig. 24. Over-farming in over-logged areas in Rwanda

How to inhibit such a tendency and restore ecological environment has been one of priorities on Rwanda's sustainable development agenda.

What actions have been taken in Rwanda? Scaling up national afforestation while curbing illegal wood logging, of course. But Rwanda has to face the cold reality that over 80% of its fuel comes from forest cutting, so a new form of alternative bio-energy has to be developed to resolve this problem.

Nothing but bamboo in the plant kingdom might be recognized as one of the best plants to function against soil and water erosion and provide bio-energy:

- Bamboo works as a gigantic umbrella toshield against soil and water loss.
  Bamboo grown in Rwanda is categorized into two classes, one is the clumping represented by *B. vugaris, D. latiforus, B.textilis, D. barbatus* and the other is the mixed one represented by *A. alpine*, those clumping and mixed bamboos grow together as a cluster which forms as many as several hundreds of culms as high as 30m, occupies a ground area of up to 25 ㎡ and a canopy area of 100 ㎡. In a word, it looks like a huge umbrella in air, without interconnected networks unground, therefore it has a great capacity in the function of water holding and soil fixing.
- Bamboo acts as a big buffer against direct rain impact on the ground which is one of main contributors to soil erosion. The big bamboo canopy acts as the first buffer against rain, and the bamboo leaves and humus covering the ground act as the second buffer as bamboos shed a lot of leaves onto the ground during dry seasons and comes up with new ones in raining seasons. Fallen bamboo leaves are further decomposed and accumulated into thick humus to improve the poor soil and increase the water-holding capacity.
- Bamboo should be well acknowledged as the fastest growing plant on earth, and feature short life cycle, renewability and sustainability. Therefore, it can meet Rwanda's demand in just 3 to 4 years.

According to the INBAR research on heavy soil erosion and flooding in Chishui, China since 2001, various programs have been launched to restore unproductive land with bamboo. By 2018, Chishui local bamboo forests have increased from around 50,000 ha to 87,000 ha, the highest forest density in China. Research shows that its afforestation effort has contributed a lot to soil erosion reduction and water resources conservation. The average water runoff for bamboo plantations is 25 per cent less and the average soil erosion quantity is 80 per cent less than that of sweet potato farming lands. One 13,000-ha. bamboo plantation in Chishui was shown to reduce over 350,000 tons of soil erosion that used to flow into the Chishui River and conserve some 6,000 cubic meters of water resources per hectare annually.

Fig. 26 shows that Anji County, Zhejiang province, China which is well recognized as China's First Bamboo Home, 4 decades ago, had outrageous soil and water erosion due to over-logging,

but now it has boasted green mountains and lucid water. It would not have happened without bamboo plantation.

According to the governing laws, plantation is allowed along the river banks for protecting banks and for the livelihood of local people. Therefore, a lot of bamboos have been planted in Rwanda, particularly in river bank areas. The program was initiated by CABP and has achieved wonderful results. Fig.26 Rwanda News makes a special report on bamboo planting efforts and activities.

Fig.25. A big canopy and thick ground layer of bamboo leaves

Fig.26. A bamboo sea grown in China showing “green mountain and lucid water”

Before CABP, bamboos had been planted along river banks, but only sporadic plantations of the species *B.vugalis* with environmental value but not much commercial utilization value. After the China-aid project, such bamboo planting efforts have the following features:

- To be aimed at benefiting soil and water conservation;
- To use those bamboo species imported from China for planting, and to achieve double targets: one is soil and water conservation, another is to get some economic benefits for local farmers through the utilization of bamboos; and
- To make systematic, well-planned and large-scale planting.

Bamboo planting for soil and water conservation in Rwanda is of great significance since Rwanda is one of the main sources of the Nile River.

Fig. 27. On Rwanda Environment Day, 2010 (several ministers and governors of Rwanda joined hands to plant bamboos on river banks for soil erosion prevention with over 3,000 people attending this event (up), Rwanda News reporting (down)

Kamanzi launches Environment Week

BY PAUL NTAMBARA
SOUTHERN PROVINCE

GISAGARA — The Natural Resources Minister, Stanislas Kamanzi on Saturday launched the National Environment Week by planting thousands of bamboo trees on the Akanyaru River bank.

The launch that coincided with the monthly community work attracted thousands of local residents and workers from different public and private institutions that included the World Food Programme, Rwanda Development Board and the Rwanda Environment Management Authority.

They planted bamboo trees on an 8 Km stretch on the banks of the Akanyaru River that borders Rwanda and Burundi.

Addressing residents of Mukindo Sector after the tree planting exercise, Kamanzi called for more efforts to prevent soil erosion which he said is a threat to the well-being of the Akanyaru River.

"There is need for massive tree planting on the river banks. Tree planting should also be undertaken along steep slopes and other areas neighbouring the river," he said.

The Minister called for the intensification of the planting of bamboo trees to cover the 80 km stretch along the river during the Environment Week.

He decried poor land use and poor farming methods in the district and urged residents to cut down unproductive banana plantations that are grown in most parts of the district, and called for proper land use by residents by settling in communal settlements (Imidugudu).

Tian Xinli, the vice team leader, China Aid Bamboo project in Rwanda, blamed soil erosion for the pollution of the Akanyaru waters, but said planting bamboo trees will protect the river.

"We have registered success in similar projects in Uganda and Mexico. In a period of three years, the Akanyaru River water ecosystem erosion should have been partly addressed," said Tian, adding that, apart from protecting the environment, residents will gain from the bamboo trees due to its enormous uses. At the occasion, Governor, Fidele Ndayisaba urged area residents to embrace family planning in order to produce children they can provide for.

The Environment Week will be concluded with the celebration of the International Environment Day that falls on June 5.

WFP workers during the tree planting exercise on the banks of the Akanyaru River on Saturday (Photo / P. Ntambara)

Fig. 28. Before bamboo planting (left) and after bamboo planting (right) along river banks for soil and water conservation

So far, the total area of new bamboo plantation using introduced bamboo species has been around 300 ha. Alongside river bank regions, they can not only work for soil and water conservation, but also be managed and harvested for processing.

D.7 Bamboo handicrafts

Bamboo handicrafts have a history of over 5000 years in China, but quite short and low-valued in Rwanda due to the following factors:

- Only 2 main bamboo species available in Rwanda which are not much suitable for bamboo weaving;
- Low awareness and insufficient skills, tools and designing capacities;
- Poor bamboo preservation technologies and expertise since bamboo is vulnerable to insect and fungus; and
- No market

It is thanks to CABP that the bamboo handicraft sector is booming and becoming one of the main income sources for rural people, particularly for women:

- Excellent bamboo handicraft materials supplied by 2 main imported species: *D. barbatus* which could be 8-9cm in diameter and has a good physical property for furniture making, *B.textils* which has very long internodes and high malleability for weaving;
- Provision of a set of technologies and expertise for bamboo weaving, furniture-making;
- Provision of a set of tools to increase handicraft productivity and improve quality; and
- Provision of good designing tailored to Rwanda market.

D 7.1 Bamboo weaving

In fact, the long history of grass weaving in Rwanda has been quite popular in the market with a chance of export, but it is limited to a small scale due to:

- Barely satisfying solution of its preservation technologies; and
- All are hand-made.

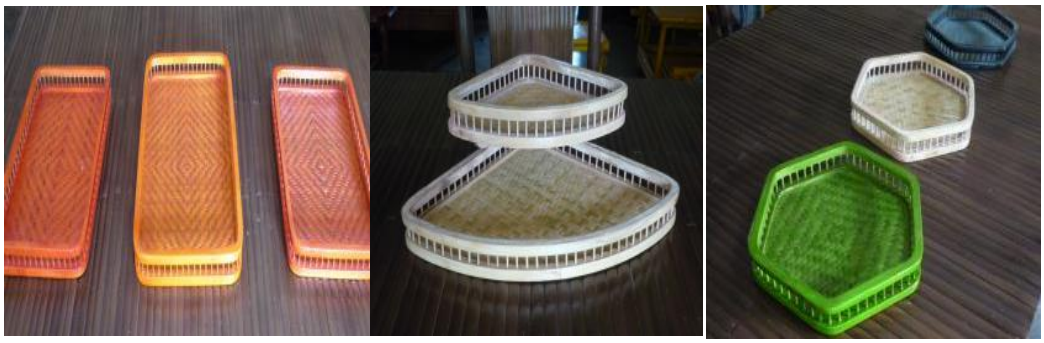
Bamboo weaving, as a novel product, has been brought in and booming from scratch by the help of the CABP, and realized its transformation from the traditional grass weaving to somewhat modern bamboo weaving which are characterized by:

- Production, productivity and quality improvement;
- Multiple designing to meet different market needs;
- Wide applicability of tools;
- Provision of a solution to bamboo preservation; and
- Wide range of products from low to high, from decoration to practical use.

So far, a bamboo handicraft group has been founded whose business is mainly distributed in Kigali. By producing over 50 kinds of bamboo weaving products, they offer around 200 jobs and increase income for rural people, particularly for women. One of its biggest advantages is to enable working homes with some simple tools whenever they have spare time, therefore it can complement their work on other aspects.

Fig.29. Ordinary bamboo weaving utensils for daily life

Fig.30. Premium bamboo weaving products



D 7.2 Bamboo furniture

In the recent decade, Rwanda's economic development has entered into a fast track which of course generates a high market demand for furniture. On the one hand, the domestic furniture production capacity is too low to meet such a demand; and on the other hand, it has to be dependent on import which means too high prices. In this context, market potential and opportunities have to be found for bamboo furniture, but the previous Rwanda bamboo furniture was not so satisfactory since its dominant bamboo species of B. vugaris is of too poor quality to be qualified for furniture making and vulnerable to insect and fungus. But significant changes in bamboo furniture have taken place after CABP's implementation. CABP helped producing excellent bamboo materials of D.barbatus and B.textilis and providing China's technologies, expertise and machines for furniture making. Now, there are over 40 kinds of furniture ranging from low to high qualities to cater to different market needs. The bamboo furniture making has become one of the pillar industries of Rwanda and plays a very important role in its rural social and economic development. The former Prime Minister once visited the CABP's bamboo furniture making workshop and lavished praises on it.

Fig.31. Bamboo lamp weaving as one of main income sources for rural people, particularly for women

Fig. 32. Bamboo furniture making

Fig. 33 Ordinary bamboo furniture

Fig. 34 Premium bamboo furniture

D 8. Semi-mechanized bamboo processing

Bamboo is characterized by uneven physical property and its hollowness makes it impossible to stay consistent in timber property and processing. Wood timber processing could be automatic in some developed countries, but bamboo processing is still unique.

China is world-widely reputed as a “Kingdom of Bamboo”, but its bamboo timber processing is still dominated by the mixed mode of hand plus machine which is called semi-mechanization.

In Rwanda, before CABP, there was no single bamboo exclusively processed by machine, but only some simple bamboo handcrafts made by hand. After CABP, bamboo processing machines and tools with the corresponding technologies and expertise were brought into Rwanda and hence a profound revolution. They developed a semi-mechanization mode, namely machine plus hand, to replace the exclusive hand making. The present main products could be categorized into 3 lines: Bamboo toothpick, Bamboo curtain /mat/carpet and Bamboo furniture.

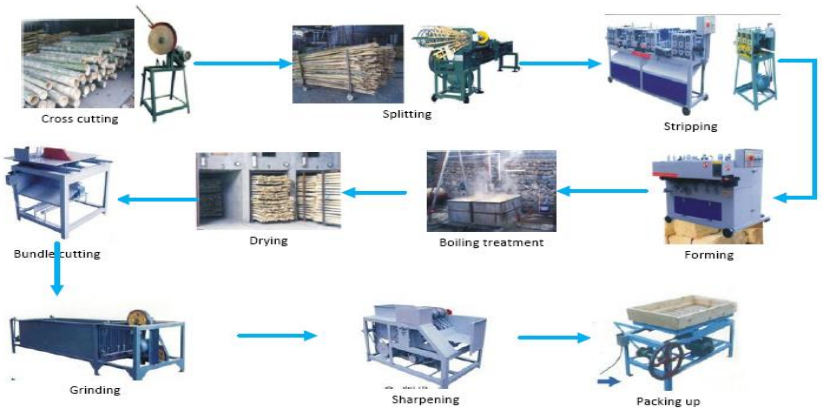
D 8.1 Toothpick production

Toothpick is small, useful, and acts as one of the daily utensils. But it is almost entirely imported from China and Vietnam, through which the expensive transportation will generate exorbitant costs.

CABP has built up a set of production lines for toothpick with machines and production technologies. It has started its pilot productions, but it still faces some big challenges:

As it is widely known that the 2 main bamboo species in Rwanda, *B.vugaris* and *A.alpine*, are not suitable for toothpick production, the former is too poor physically to be eligible for sufficiently strong toothpicks, the latter has too thin bamboo walls and protruded nodes to be produced into qualified toothpicks. The 2 imported bamboo species, i.e. *D. barbatus* and *B. textile*, have good timber quality for solving the problem. Bamboo toothpicks have been successfully produced by using bamboo poles supplied from the plantation sites, but it faces another big challenge from the imported toothpicks. Toothpicks imported from China or Vietnam are not only excellent in quality, but also at lower prices. The Rwanda-made toothpicks are still of much lower quality than the imported ones and their prices are also much higher due to their small-scale production. So Rwanda toothpick sector has to make painstaking efforts to improve their quality and lower their prices to compete against the imported ones for survival. Of course, it will be predictably a long way. In fact, it should be a common challenge that most of the products made in Rwanda are not equal to imported products due to its too weak industry capacity.

Fig. 35. Processing technology flow of bamboo toothpick processing by machine



But the far-reaching significance to Rwanda is that the industry has taken off and made a big stride to the realization of Rwanda-made bamboo products as stipulated in the Rwanda Mission aimed at alleviating import dependency.

Fig. 36. Toothpick production by machine and products

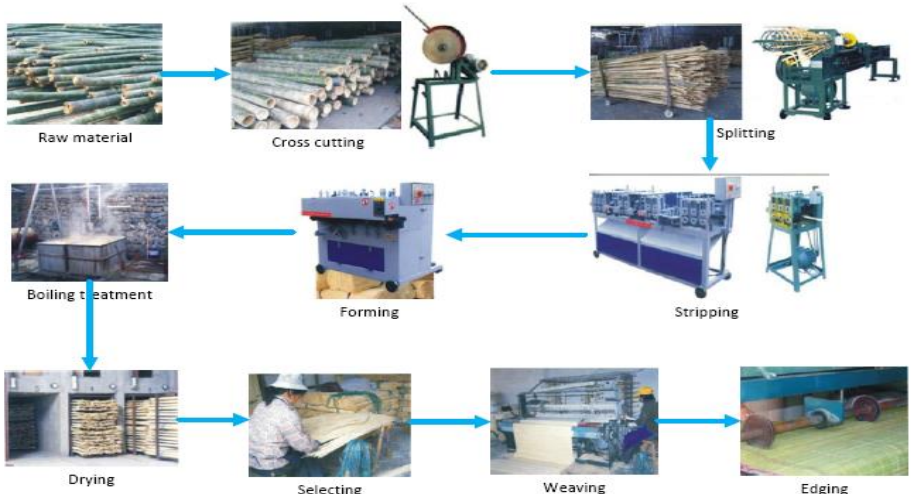
D 8.2 For curtain, mat and carpet production

Rwanda features strong sunlight, particularly in dry seasons, therefore curtains to shield direct sunlight are necessary for people in Rwanda. Unfortunately, no curtain has been commonly used by the local people. Weaved bamboo curtains are so beautiful and practical and have been popular in 50-plus countries, incl. China, for almost 2 decades.

Considering its huge potential market, CABP has brought in a set of machines together with relevant technologies from China and initiated pilot productions which turn out to be a great success. They can also produce so many other different products such as bamboo carpet, cushion and sketch pad in China. Together with the dying technology, those products look much more colorful and attractive. We do believe that the market potential is encouraging because those products are widely accepted and suitable for Rwanda.

Fig. 37. Bamboo curtain, mat and carpet processing

Fig. 38. Processing technology flow of bamboo curtain, mat and carpet



D.9 On-site training

From 2009 to 2019, CABP has conducted over 90 training workshops attended by around 1400 participants, including 890 women and 510 men.

- Bamboo propagation. A complete set of practical technologies and practicing for 8 common bamboo propagation methods in field and greenhouses;
- Bamboo plantation establishment. For the commercial bamboo plantations aimed at producing both timber and shoots; ecological protection, soil and water conservation, urban landscaping, and agro-forest;
- Cultivation technologies. Intensive, oriented and ecological cultivation technologies for bamboo plantations from initial planting to mature plantation management;
- Bamboo weaving. For 3 levels of quality: high, middle and low. From selection and preparations of bamboo materials to final products, use of tools and machines, designing, practical weaving;
- Bamboo furniture. For indoor and outdoor use of coated and natural furniture, 3 quality levels: high, middle and low. Designing. By hand, or by machine and tool;
- Bamboo curtain/mat/carpet. A complete production (training during practicing, machine operation, and tool use);
- Bamboo toothpick. A complete production (training during practicing, machine operation and tool use); and

- Bamboo machinery. Machine operation, training on maintenance.

Training methods:

- By on-site training at Kigali incubators, in the field and at nurseries;
- Training during practicing; and
- Training together with technical services.

Fig.39-1 Bamboo planting trainings

Fig. 39-2 Bamboo toothpick processing training

Fig.39-3 Bamboo weaving training

Fig. 39-4 Bamboo furniture making training

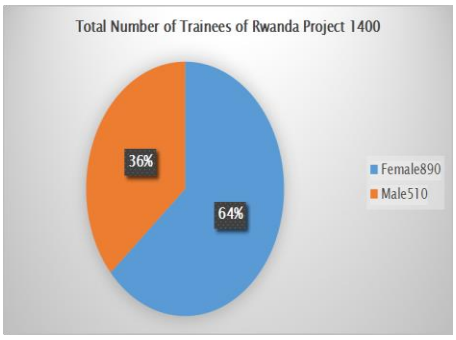
Fig. 39-5 Training from bamboo planting, management, shoot harvesting to shoot cooking for the youth

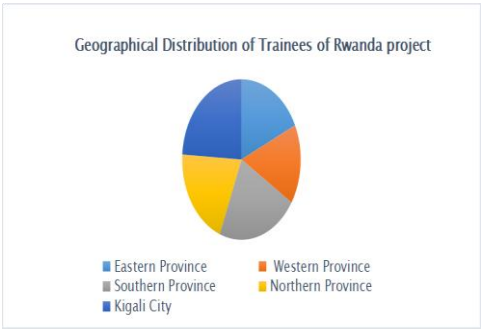
Fig.39-6 Bamboo trainings, certificate awarded by Minister of MWF and Governor of Zhejiang Province of China

3. Training duration

1-3 weeks until they become good masters

Fig. 40 Geographical distribution and gender composition of CABP trainees





D.10 Establishment and operation of Bamboo Technology Incubator

Bamboo Technology Incubator is composed of BPTI and BMTI.

D 10.1 BPTI

Fig. 41 3-phase development process of CABP incubators

BPTI was initially situated at Cabuye, suburb of Kigali, with quite poor facilities (Fig.41 left), and later renovated (middle), and finally moved into Masaka, suburb of Kigali, and Industry Development Park where the development so far is considerable. All those infrastructure improvements have led to much better work conditions. US $ 650,000 was invested in this project by the Rwanda government. It took around 6 years to develop to this level.

BPTI is mainly set for technical transfer, R&D, pilot production, training, exhibition and technical service for bamboo value-added processing. The existing main products are as follows:

- Bamboo toothpick;
- Bamboo curtain, mat, carpet;
- Bamboo furniture; and
- Bamboo weaving.

Meanwhile, various bamboo products made at BPTI are also for sale. Revenues from such sales are invested in BPTI's operation. Types and designs of bamboo products are correspondingly adjusted as per market's feedback which definitely contributes to product's improvement.

D 10.2 BMTI

BMTI is actually a green-house nursery equipped with water sprays and sunlight shielding, 4 BMTIs in total, each having a ground area of around 2,000 m^2 and is distributed in Kigali, East Prince, South Province and West Province. They mainly serve as bases for:

- Large-scale bamboo plant production;
- Domestication of imported bamboo species at BMTI for a few months;
- R& D of practical propagation technologies; and
- Training.

Fig. 42 Rulindo, Nyandongu, Kanombe, Huye and Muhazi greenhouse nurseries in Kigali, East, South and West provinces as BMTIs

Fig.43 Bamboo nurseries developed by farmers across Rwanda technically assisted by CABP

D 10.3 Experiment Bamboo Plantation (EBP)

EBPs are set up all over Rwanda, mainly in Kigali, South, East and North provinces. They are used for further observation on the aspects like what are grown under them in Rwanda, what special cultivation technologies should be taken, what performance indices shall be adopted for bamboo site-match. In a word, it looks like a pilot production in factory for further large-scale planting. So far, the total areas have been around 300 ha., mainly in river bank areas, hills, plains, etc.

Fig.44 Bamboo planting at EBP sites

D.11 Social, economic and ecological benefits

D 11.1 Social benefits

It could be imagined how difficult it is to face and overcome those difficulties in establishing and developing a new industry in Africa. One has to face the challenges such as people's awareness, technology, labor, finance and market, particularly those negative ones for the bamboo industry. Moreover, people involved in the bio-security and bamboo industry are from rural area with poor education background. But the bamboo industry in Rwanda has been growing from scratch to be a matured one by focusing on scale integration of the plantation (primary industry), bamboo value-added processing (secondary industry) and marketing (tertiary industry) over the last 10 years. The joint efforts of and good cooperation between China and Rwanda are the main reasons behind the following successes.

- It creates a new bamboo industry as alternative industry which provides a solution to the problem and challenge Rwanda is facing. It has created jobs and generated more incomes for rural people, lowered product import dependency, addressed the enormous insufficiency of fuel charcoal supply. As a result, the land surface is covered with bamboo plantations and people have been empowered to engage in sectors from bamboo processing to bamboo product marketing. 10 bamboo micro-industries, over 30 bamboo micro-nurseries and around 2000 jobs, directly and indirectly, have been created, in which over 80% are for the women and over 90% for the young people. The Rwanda bamboo industry should be developed sustainably this way, the set of advanced and practical bamboo technologies, the set of bamboo processing machines and imported fine bamboo genetic resources have been provided for this industry. The main technologies applied to the development of the bamboo industry in Rwanda are Intensive Cultivation and Management of Bamboo Plantation (ICMBP), Oriented Bamboo Cultivation (OBC), Classification Management of Bamboo Plantation (CMBP) for the Production of timber, shoot and both timber and shoot, Bamboo Supply Chain (BSC), Bamboo Value-Added Processing (BVAP) as well as All Bamboo Utilization (ABU). Besides, introducing bamboo shoot as a new nutrition-balanced food is another rewarding effort.

Fig. 45. Mr. Mico Oscar Nzeyimana won YouthConnekt Award conferred by Rwanda government and UNDP for his bamboo achievements.

Mr. Mico Oscar Nzeyimana, a 24-year-old guy, participated in the 3-week-long Technical Training Workshop conducted in Kigali by CABP in 2018, ranked first in the west province and fourth in Rwanda in the competition of Rwanda Youth Entrepreneurship for Self-reliance held by Rwanda government and UNDP in later 2018 for and won a Connekt Award and bonus of US $ 1,000 for his successful creation and operation of a bamboo micro-enterprise which employs over 20 local persons and for his wonderful bamboo product designs.

Around 40 micro-enterprises on bamboo processing have been created and made a lot of contributions to job generation, particularly for the women and youth.

Fig. 46 Some micro-enterprises on bamboo business in Rwanda incubated by CABP

- People are fully persuaded and have recognized that the bamboo sector should be a prospective and green alternative agro-industry benefiting people in both the rural and urban areas, and are willing to pursue it after witnessing the achievements of CABP during the last 10 years;
- It is encouraged to increase Rwanda industrial capacities and reduce dependency of imported products. The majority of products in Rwanda have to rely on import for its quite weak industry capacity. For example, all the pieces of wood and plastic furniture are imported at exorbitant costs. Bamboo furniture can partially replace them and be made in Rwanda;
- Having far-reaching impacts on Rwanda forest development. Forest in Rwanda is still in the extensive management stage, tree seedlings have not been selected in scientific breeding methods, and management is not much guided scientifically. Over 95 percent of the wood is just used for fuel or charcoal, but not processed into valued products. A package of advanced technologies and methodologies which are originally applied to bamboo, which can be also suitable for forests generally, have not been applied yet. For example, the bamboo match-site selection method is fully applicable to natural site conditions and plant genetic performance. The technologies of ICMBP, OBPC, BVAP, ABU and so on are invaluable for forest plantation and greenhouse nursery and are very useful for vegetable and fruit farming as well.

Fig. 47. Appreciation Letter to CABP by Workforce Development Authority of Rwanda

WORKFORCE DEVELOPMENT AUTHORITY – WDA

Empowering people with employable skills and entrepreneurship capacity

P. O. BOX 2707
Tel: (+250) 25511336
E-mail: info@wda.gov.rw
Website: www.wda.gov.rw

Date: 08/05/2017

Ref No: WDA/06.69/17

Team Leader
China Aid Bamboo Project Team in Rwanda,
China National Bamboo Research Center.
KG 141 ST4, Kimironko Sector
Kigali-Rwanda

Dear Sir,

RE: Appreciation for the good job done at Masaka Business Incubation Centre

In view of the excellent results achieved by the Chinese Government Aid Rwanda Bamboo cultivation, processing and utilization projects (Phase IV, 2015.2-2017.2), I am pleased to extend my appreciation towards China Aid Bamboo Project Team for the hard work in providing bamboo crafts technology to Rwandans.

Through bamboo furniture, weaving and machine trainings offered by your project team, Rwandans were equipped with relevant skills that lead to the development of the country. Workforce Development Authority appreciates the professionalism shown in handling bamboo crafts. With this positive attitude, customers have started developing their trust especially in Bamboo Furniture.

Workforce Development Authority always avails itself of this opportunity to renew to the China Aide Bamboo Project Team, the assurance of its highest consideration.

Jerome GASANA
Director General
Workforce Development Authority.

Cc:
- Minister of State/TVET

D 11.2 Economic benefits

The total all-chain bamboo production value in Rwanda in 2019, directly and indirectly, is estimated to be around US $ 1 million, in which around 30 bamboo nurseries employ over 400 persons annually producing 120,000 bamboo seedlings with an annual output value of US $ 264,000. Bamboo furniture and weaving have much higher profits. Table 11 shows the details analysis for production costs and profits of bamboo products and demonstrates how profitable they are. Bamboo curtain/mat/carpet has much bigger markets. We do believe that bamboo production value should be raised to a large extent in the coming years.

D 11.3 Ecological benefits

- Huge capacities for water conservation and against soil and water erosion. A huge A. alpine forest which grows fantastically in high mountain areas works as a cap of the mountain to play an amazing water protection and adjustment role: water absorbing and holding in raining seasons, and water releasing during dry seasons. New bamboo plantations alongside river bank areas demonstrate how effective they are against soil and water erosion;
- Bamboo bio-energy can be used as an alternative to the fuel wood and charcoal in shortage. This will definitely help to reduce large forest logging which is in the predominant contributor to ecological destruction;
- Bamboo helps to rapidly increase forest coverage and boost ecological restoration. Bringing the role of bamboo agro-forest model into full play with other trees and crops is highly beneficial.

Fig. 48. Bidding documents for purchasing bamboo plants for national afforestation

THE REPUBLIC OF RWANDA

MINISTRY OF FORESTRY AND MINES

NATIONAL FORESTRY AUTHORITY

Tender document

Title of the Tender:	Supplying and planting bamboo seedlings
Tender Reference :	N°..../ NAFA OF ..../..../2010
Procurement Method:	National open tender
Funding :	National Forestry Authority
Governing law:	Rwanda
Method of management:	
Date of Issue:	.../.../2010
Dead line for the submission:	..../..../ 2010

D.12 Publicity and promotion

Given that bamboo is less popular and people have less knowledge on it, we try to apply all the methods available to promote bamboo in Rwanda. We try showcasing the status quo of the bamboo industry, its potential and future prospective via TV, Newspaper, Interviews, Exhibition, On-the-site, Visiting, Demonstration, Training, etc., all of whose results are satisfying.

D 12.1 3-Step promotion

Knowing Rwanda has little knowledge on Bamboo, we started CABP in 2009 adopting the 3-phase method to upgrade awareness of the people and all stakeholders to make them cooperative and supportive in the first 3 months:

- Month 1: We, 5 Chinese experts led by Prof. Ding Xingcui, spent most of the time on intensive surveys of bamboo and interviews with relevant stakeholders, all those efforts having laid down a solid foundation for formulating the CABP strategy and action plan.
  Bamboo resources and natural site conditions. Our expert team made a nationwide tour to all bamboo-growing areas, including climbing to the highest mountain in North Province classified as natural reserves by the Rwanda government where the most important natural A. alpine forest is grown and the higher it is, the denser the bamboo forest gets. It is said by the guide, an officer from MLF, that no officer or expert had been in this mountain before. Our survey on natural conditions including topography, soil, rainfall, temperature and other aspects provides detailed information for what kinds of bamboo species should be selected and imported as per the site-match principle and for the investigation on which bamboo cultivation methods are applicable, incl. propagation. Through those activities, we got first-hand data on bamboo resources, cultivation situation, etc.
  Bamboo use and market. We visited furniture workshops/shops, supermarkets, hotels, restaurants, offices, nurseries and farms, and surveyed the existing uses of bamboo and figured out the potential use of it in future. This helped us to plan the interventions to be carried out.
- Month 2: Collected and prepared as many bamboo product samples as possible by using Rwanda bamboo materials to show people how what a role bamboo can play in Rwanda.

Fig. 49. Field surveys on bamboo resources in Rwanda by CABP expert team

Fig. 50. Field surveys on what bamboo can be used for in Rwanda by CABP expert team

It took almost 1 month to select, cut and ship bamboo poles to the CABP site, for the corresponding treatment, designing and making. Products were classified into low, middle and high ranks for specific differentiated sectors of markets as shown in Fig. 29, 30, 33, 34, etc. Totally there were around 60 kinds of products.

Bamboo furniture. Bamboo chair, sofa, table, etc.

Bamboo weavings.

- Month 3: Create awareness among people, embark on publicity of the industry and launch strategic planning on how bamboo can be used in Rwanda.

  Bamboo product exhibition. Different stakeholders were invited to the CABP site to look over all the bamboo products. They were Minister of MLF, Chinese Ambassador to Rwanda, government officers from Rwanda and Chinese embassy in Rwanda, businessmen, artists, farmers, etc. They were deeply convinced that bamboo business has huge potential in Rwanda. All the invitees appreciated the innovative and wonderful efforts that the Chinese expert team made.

  Presentation. Prof. Ding Xingcui was invited by the Minister of MLF to make a presentation on the future of bamboo in Rwanda for all the officers of MLF. The presentation was aimed at showcasing different strategies and plans concerning forestry, environment and social development, and formulating a plan on how the bamboo industry can achieve the development goals. The Minister praised the presentation and said that it could be a milestone to guide Rwanda bamboo development towards success, and committed a total support to CABP. Then the Minister and Prof. Ding Xingcui took an interview with Rwanda TV and Rwanda News jointly for a fantastic publicity of bamboo in Rwanda.

Table 11. Break-down analysis for bamboo product making in Rwanda (Currency: RWF)

Product Name	Picture	Bamboo pole needed (Piece)	Bamboo pole costs	Auxiliary material costs	Coal & power costs	Labor costs	Total costs	Sale price	Profits
Double-seat Sofa		10 x big	20000	6300	500	2 persons 1 day	26800	50000	23200
Double-seat Sofa		2 x big,8x small	12000	6000	1500	3 persons 2 days	19500	60000	40500
Deck Chair		4x big, 5x small	13000	4900	1000	2 persons 1 day	18900	30000	11100
Round Chair		3x big,6 x small	12000	3800	1000	3 persons, 2 days	16800	30000	13200
Sofa		4x big, 4x small	12000	3900	500	2 persons 1 day	16400	25000	8600
Deck Chair		5x big, 2x small	12000	4000	500	2 persons 2 days	16500	40000	23500
Three-seat Sofa		10x big, 4x small	24000	6800	500	3persons 2 days	31300	70000	38700
Lamp		0.5x big	1000	1000	0	1person half a day	2000	3000	1000
Vase		3x big	6000	2000	0	1 person, 5 days	8000	20000	12000

Note: Big bamboo pole: *D. barbatus*, Small bamboo pole: *B.textilis*

D 12.2 Bamboo culture exhibition

From Oct. 1 to 5, 2009, a special China Bamboo Culture Exhibition was held at the Chinese embassy to Rwanda with an aim of supporting CABP through the promotion of bamboo culture in Rwanda. It exhibited various bamboo products which were specially shipped to Rwanda from China or made by CABP team in Rwanda. On the spot, bamboo ware weaving performance was also conducted. Over 200 Rwanda officials and entrepreneurs were invited to be present at this event. It greatly enhanced awareness among Rwanda people of the potential of bamboo development in Rwanda.

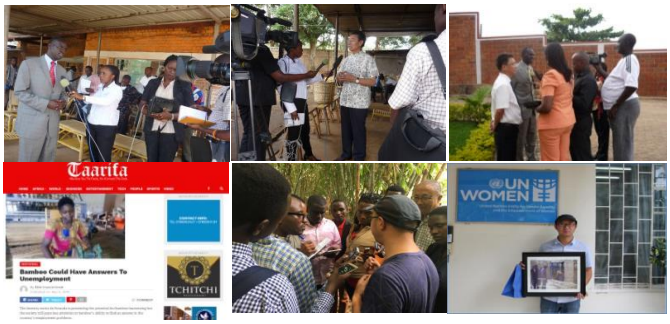
Fig. 51. Chinese bamboo culture exhibition held at Chinese Embassy to Rwanda in 2009

D 12.3 Publicity for the Global Women Summit

CABP was selected by Ministry of Commence, P.R China as a sole successful case of China aid projects to developing countries for its wonderful contribution to women in Development in Rwanda and publicized globally for the Global Women Summit on Sept. 27, 2015 in New York which was co-chaired by President Xi Jinping when he was present there to celebrate the glorious 70th Anniversary of the founding of the United Nations. It has been involved in news coverage by multiple media such as newspaper and TV in Rwanda and in China, and the report headlines include *Rwanda turns to bamboo for packaging material* in The New Times as a Rwanda main media (https://www.newtimes.co.rw/news/rwanda-turns-bamboo-packaging- material), "*Bamboo Could Have Answers to Unemployment*" in Rwanda Taarifa, *Kamanzi launches Environment Week* in Rwanda Newsline.

Fig.52 Special report on CABP in CCTV 13

Fig. 53. Minister of RWFA, Counselor of China Embassy in Rwanda interviewed by Rwanda Media



D 12.4 Exposition events

Around 300 people from Rwanda and other countries and international communities, including Hon. Mr. Anastase Murekezi, Ex-prime Minister of Rwanda, Hon. Mr. Pierre Damien Habumuremyi, Ex-prime Minister of Rwanda, 3 ministers of MLF, 4 governors from China and Rwanda, Ms. Elissa Golberg, Assistant Minister of Foreigner Affair of Canada, over 30 Director-generals from China, Rwanda , EAC member countries, and FAO, International Fund for Agriculture Development (IFAD), International Network for Bamboo and Rattan (INBAR), have visited CABP sites.

CABP has been present at over 10 different exhibitions with awards, including Made-in Rwanda Expo, Agriculture Products Expo for EAC Member Countries, in which CABP ranked 3rd in the Made-in Expo.

All those events have helped enhance awareness of how bamboo sector has great potential as a new alternative to forest and agriculture for people and communities from Rwanda and EAC member countries.

Fig. 54 A lot of high-ranking officials visiting CABP sites

Fig. 55 CABP team experts and awards at local exhibitions

D 12.5 Bamboo R. & D and Demonstration Base in Rwanda conferred

On September 7, 2019, “Zhejiang Rwanda Framework Cooperation Development and Capacity Building Achievement Exhibition" hosted by the Zhejiang Provincial Government and organized by the Department of Science and Technology of Zhejiang Province and CBRC was held in Kigali, the capital of Rwanda. Mr. Yuan Jiajun, Governor of Zhejiang Province, and Madam Clare Akamanzi, Minister of Rwanda Development Board jointly inaugurated Bamboo R. & D and Demonstration Base in Rwanda and issued certificate to 20 participants of Rwanda's Bamboo Technology Training Workshop organized by CBRC. The event further promoted the bamboo industry developments in Rwanda and cooperation of bamboo business between China and Rwanda.

Attendants include Mr. Paula Ingabire, Minister of Information and Communication Technology and Innovation of Rwanda, Mr. James Kimonyo, Ambassador of Rwanda to China, Mr. Rao Hongwei, Chinese ambassador to Rwanda, Gao Yingzhong, Director-general of the Department of Science and Technology of Zhejiang Province, Xu Yuning, Director-general of Department of Finance of Zhejiang Province, Mr. Sheng Qiuping, Director-general of Department of Commerce of Zhejiang Province, Mr. Wang Jiaxin, Counselor of Economic and Commercial Consulate Office, Chinese Embassy in Rwanda, Mr. Wang Yukui, Deputy Director-general of CBRC and Prof. Ding Xingcui, Director of International Training Center for Forestry Science and Technology of National Forestry & Grassland Administration of China.

Fig.56 Zhejiang-Rwanda Framework Cooperation Development and Capacity Building Achievement Exhibition

E What is next: Plan and action

Based on the 10-year painstaking cooperative efforts of the government of China and Rwanda, the Rwanda bamboo industry has developed from scratch and fortunately taken off with a lot of achievements. However, it has to be acknowledged that it is still in a baby stage since the scattering of small-scale cottage businesses, instead of any large-scale ones, could not produce any pillar products, so its contribution to the economy of Rwanda is still understandably small. What is next? More concerted efforts shall be made to transform its huge resource potential into real economic and ecological benefits, particularly the following ones, by taking into account the two aspects:

- Specific social, economic and ecological conditions of Rwanda; and
- Bamboo industry development patterns.

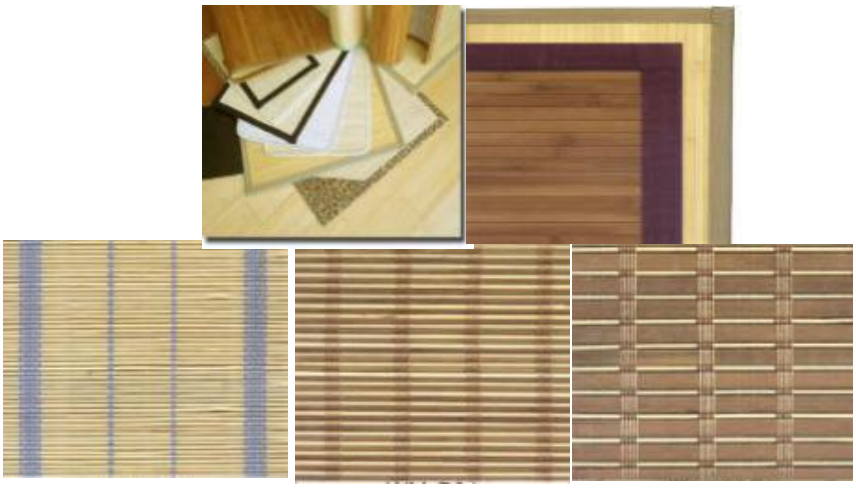
To develop more plantations for ecological protection against soil and water erosion and for rendering more bamboo materials to the down-stream processing sector since severe shortage of high-quality raw bamboo supplies is one of the bottlenecks to hinder its bamboo industry development.

- Which bamboo species to be planted. The imported bamboo species from China are highly recommended;
- Where bamboo will be planted. Bamboo planting in river buffer zones is encouraged where bamboo can have double functions: One is to improve soil and water conservation, the other is to produce bamboo timber and shoots for further processing by sustainable management. In the under-stocking forests and coppicing forests, bamboo can improve forest restoration and increase land use; and in agro-forest with other crops around settlements, bamboo can be used as fuel; and in urban areas, bamboo can be used for landscaping;
- How to plant bamboos. Bamboo planting should motivate all the stakeholders in the Public and Private Partnership (PPP) mode. The government should include the mode in its Rwanda afforestation plan under the regular budget. And on the Tree Planting Day, favorable policies shall be implemented to encourage private investors.

To further scale up the bamboo processing industry as a bridge between bamboo plantations and the market and as an engine for meeting people's demands, and to drive the bamboo plantation development by purchasing raw bamboo materials from it.

- To improve quality and raise productivity of bamboo furniture, weaving, curtain /blind and mat for the upgrading of productions from small-scale and moderate-quality ones to middle-scale and higher-quality ones;

Fig. 57. Bamboo curtain/blind, mat, carpet



- To further incubate and develop bamboo bio-energy, boards, paper and shoots which could be pillar industries;
- Bamboo bio-energy as charcoal /fuel wood;

  Over 90% of Rwanda forests are mainly used for fuel wood and charcoal. Rwanda Vision 2030 includes the target of lowering the dependence degree of wood as a fuel from the present 90% to 50%. In fact, there are no other alternatives except electricity and gas which are of exorbitant prices for the majority of people. Bamboos can be one of the best alternative sources of bio-energy thanks to their enormous biomass, fast growth, high caloric value and advantage in combustion. Bamboo poles can be used like wood sticks for direct use. Bamboos can be carbonized into charcoal in kilns, and then further processed into briquettes which would be easier for shipping and use. At present the bamboo charcoal price is rather high due to limited bamboo supplies, but we are sure it would be more competitive than wood with the increasing of bamboo forest;

Fig. 58. Bamboo charcoal and briquette production

- Bamboo boards and corrugated roofing;

  At present, with the fast economic development in Africa, incl. Rwanda, various infrastructures such as houses, high ways and other construction projects are being developed in full swing, of which concrete boards are indispensable materials. Bamboo concrete boards are much better than wood and steel ones which were commonly used before. Africa imports bamboo boards from China to meet such a high demand. To manufacture bamboo concrete boards locally represents a high-potential market not only for Rwanda, but also for exporting to other African countries nearby. Now we are discussing with one of the Rwanda's companies on setting up a factory to produce bamboo concrete boards, which will be inaugurated in 2021 as planned. Meanwhile, bamboos can also be processed into corrugated boards with the same production technology and facilities. Bamboo corrugated boards can replace wide metal roofing

with some unique advantages which has been widely used in Rwanda. It also has a huge market potential in Africa.

Fig. 59. Bamboo boards for concrete boards and corrugated roofing

- Bamboo paper making;
  Africa's paper consumptions are being hiked up, but they still rely on paper imports at high costs. Bamboo, with long-fiber and as one of high-biomass plants, is one of the excellent plants for paper making. With the increasing of bamboo plantations, bamboo paper making could be considered as a source of the future products, but it will take a long time since its present bamboo supplies cannot afford the huge bamboo consumptions.

Fig. 60. Bamboo used for paper making

- Bamboo shoots;
  The development of bamboo shoots as a novel food to Africans should be encouraged, particularly under the Rwanda conditions, where the organic bamboo shoot production environment is favorable. Their makers can not only present supplies to the local market for complementing African food with nutrients, but also export the products to the USA or other countries.

To abolish and revise some policies and regulations applicable to bamboo

Bamboo, as a NTFP, is absolutely different from trees. The more abundant its growth is, the more scientific its cutting shall be. Therefore, any policies and regulations which have governed bamboos like trees would be deemed hindering the bamboo industry development and should be abolished and revised, including Bamboo Products Licenses, Transport Licenses of Bamboo Products and Bamboo Forest Clearing License.

To grow it into an EAC Regional Bamboo Technology Transfer and Demonstration Incubator.

East Africa Community (EAC), composed of Kenya, Uganda, Tanzania, the Sudan, Burundi and Rwanda, is on the fast track of integration. All of them, except for the Sudan, have similarities in social, economic and ecological conditions, particularly in the bamboo sector which has rich and untapped bamboo resources. Eager to develop the resources, these countries face the big challenges of insufficient technologies, equipment and experiences. Therefore, for their development of the bamboo sector, it is of high significance and feasibility to share the technologies and experiences which Rwanda has accumulated through the 10-year efforts made via the CABP.

The EAC Regional Bamboo Technology Transfer and Demonstration Incubator (RBTTDI) can be further developed through a multilateral cooperation mechanism participated in by China, EAC member countries and other international organizations. Its main mission is to promote regional bamboo development for enhancing its economic and social growth and environmental protection.

F Thinking and lessons

F.1 Aid project identification and decision should be based on full consultations between donor and recipient countries

The consultations shall be based on comprehensive and objective investigations of the society, economy, market, culture and environment of recipient countries and in a bid to get all-around, salient and measurable achievements for all relevant stakeholders.

Specific recipient countries expect the corresponding specifics under the project, which will provide a right solution to the challenges on job creation, livelihood, ecology and import reliance. The expected aims and targets would be missed should no fact-finding and down-to-earth survey be conducted for identifications with and decisions on the project.

F.2 Methodologies applicable to the project should be in conformity with the local conditions and characteristics

Methodologies applicable to the project should be in conformity with the local conditions and characteristics of natural resources, market, culture, customs, etc. Each process of the industry, from product R&D, technical transfer, personnel training, pilot production, production cost and quality control, marketing to people's awareness promotion through modern media, exhibition, shall be considered in an all-around way with an aim of bringing about tangible benefits as soon as possible to motivate more people of all stakeholders for participating in the project in a more cooperative manner.

F.3 Focus on universal and key problems of project technologies and machines

During the transfer of project technologies and machines from donor countries to recipient countries, those universal and key problems precluding the further development of the industry in the recipient country shall be focused on, with a view to modifying and optimizing them for easier operation, effective duplication and result orientation, adapting them to both the industry development level and social, economic, human conditions and applying them in an industrial scale through experiment, R&D and training.

F.4 Experts should have good theoretical knowledge and rich practical experiences

Experts who will be dispatched by the donor country to the recipient country should be well-versed in their theoretical knowledge, have rich practical experiences, work in a self-motivated, devoted and assiduous way, can be able to work together harmoniously with the local people at different levels, overcome serious problems in work and life and can stay in the recipient country during the project implementation. The capabilities, qualifications and attitudes of the experts are major fate-deciding factors of the project.

F.5 Training methods should be result-oriented.

Sufficient technical training in various forms under the aid project shall be provided for the local people, especially for those poorly-educated or even illiterate ones from the rural areas. The training can be conducted whether in a concentrated manner on the project sites or in a sporadic and well-tailored manner at farmer housholds or in workshops. The training forms include exclusive training, practicing-pilot production and others with adjustable schedules based on the learning ways of trainees, the quality of the products made by them and the sale feedback their products generate on the market.

F.6 The short-term output and the long-term strategy of the project shall be appropriately considered.

Given the long-term nature of the forestry project, it is quite difficult to achieve any salient result in a short time. In this context, we have to be fully aware that it is imperative to formulate a long-term strategy for it. But we have to yield some tangible output in the first place to encourage all the stakeholders to make more efforts, or they might waver in the partnership or be reluctant to make earnest input after waiting fruitlessly for long.

F.7 Impact of commodity import on industry development of developing countries should be fully considered.

Impact of commodity import on survival and growth of industry in developing countries against the background of globalization and free trade has to be fully considered. For example, a few toothpick-making micro-enterprises in Rwanda as aided by CABP could not survive owing to impact of a great deal of imported goods from China. On the one hand, compared with the imported ones from China which feature higher quality and lower prices based on their well-optimized, upgraded and large-scale production lines as a result of three-decade commercialization, the products of Rwanda in their initial production stage feature lower quality and higher prices; on the other hand, although the international logistics costs are high for global trade, they do not affect toothpicks much for their small-sized, compact, one-dimension features or large amounts loaded in each container. How Rwanda toothpicks compete against the Chinese ones is unimaginable.

But it is markedly different in the bamboo furniture industry. Owing to their big sizes and small amounts loaded in each container, the unit costs of imported products will be sharply increased due to the high international shipping costs. So the bamboo furniture industry in Rwanda can be immune from import impact and develop well.

G Conclusions

G.1 Gigantic role of bamboo development in Rwanda as a green agro-industry

Bamboo is world-widely recognized as one of the most important Non-Timber Forestry Products (NTFPs), and “timber for the poor” thanks to its unique advantages: Fast growth, short cycle, strong regeneration, big biomass, multiple uses and sustainable development. As a green bamboo agro-industry integrated harmoniously with social, economic and ecological benefits and combined with the primrary industry -bamboo plantation, the secondary industry-bamboo processing and the tertiary industry -marketing and service, the bamboo agro-industry featuring simple technology, easy operation, low investment, quick return and other aspects proves to be fully in conformity with Rwanda social and natural conditions and acts as a novel and prospective alternative option to Rwanda for providing an overarching solution to the challenges that Rwanda is facing: Job creation, import reliance alleviation, soil and water conservation and ecological restoration.

G.2 It should be recognized as one of the most successful means to realize SDG 2030.

5 SDGs and 10 SDG targets are involved

- SDG1: End poverty in all its forms everywhere;

- SDG2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. SDG targets 2.2, 2.3 and 2.4;
- SDG13: Take urgent action to combat climate change and its impacts. SDG targets 13.2 and 13.3;
- SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainable manage forests, halt and reverse land degradation, SDG targets 15.2; and
- SDG17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development. SDG targets 17.7 (17.7.1) and 17.9 (17.9.1).

G.3 Based on the 10-year efforts and through the partnership between China and Rwanda through CABP, the bamboo agro-industry has been created from scratch, taken off and operated well

The people's awareness on how bamboo functions in Rwanda has been raised and becomes deep-rooted. With an annual production value of around US $ 1 million, the bamboo agro-industry creates 2000 jobs directly and indirectly, in which over 80 % are for the women, and over 90% for the youth. It turns out that the bamboo plantations have contributed a lot to soil and water conservation.

G.4 A set of state-of-the-art and practical bamboo technologies, fine bamboo species, compatible experiences have been brought in, transferred to, innovated in and applied to Rwanda from China, which plays a very important role in the takeoff of the Rwanda bamboo agro-industry.

G 4.1 Bamboo cultivation

- The well-selected Chinese bamboo species, which have been brought in from China to Rwanda in line with the scientific site-match principles, boast proven biosecurity and wonderful growth that will they facilitate the establishment of new and high-quality plantations, one of the most important links of the bamboo agro-industry chain as well-recognized in Rwanda thanks to their sustainable supply of high quality bamboo timber and shoots to the down-stream processing sectors;
- Greenhouse nursery equipment and technologies ensure domestication, mass multiplication and large-scale production of imported bamboo species;
- Fast bamboo multiplication technologies which facilitate large-scale production of bamboo seedlings to meet the high demands of bamboo afforestation at low costs and with high qualities;
- The bamboo cultivation technologies such as intensive cultivation, orientated cultivation, and classification management could bring about well-balanced economic and social benefits. Different cultivation technologies and measures are adopted for a variety of purposes: for bamboo timber, for bamboo shoot, for both timber and shoot, for ecological protection. Plantations alongside river banks are set for two categories of indicators, namely soil and water conservation and economic output, through their scientific harvesting and sustainable production; and
- High potential has been manifested in the productions of bamboo shoots as a novel food for Rwanda

G 4.2 Bamboo processing

- By machine or by hand, the collection of technologies for bamboo toothpick, curtain/blind, mat, carpet, furniture, weaving and others will enhance their commercial productions at different quality and pricing levels for specifically differentiated markets;
- Methodologies for bamboo supply chain, value-addition, integrated utilization, market-oriented production, etc. are adopted in the bamboo agro-industry;
- To further upgrade the industry of bamboo processing through:

To improve quality and increase productivity to transform the bamboo production mode from small-scale producers featuring moderate quality to middle-scale ones featuring higher quality; and

To further incubate and develop bamboo bio-energy, ply-board, paper and shoots as pillar bamboo agro-industries in the future

G.5 Technical training, demonstration, service and promotion

G 5.1 Technical trainings conducted throughout its practicing and pilot production turn out to be highly rewarding;

G 5.2 The 3-phase promotion campaign initiated by CABP in the first 3 months and the subsequent various activities such as TV report, new media coverage, on-site visit, interview, demonstration and exhibition facilitate the start and fast development of Rwanda's bamboo agro-industry; and

G 5.3 The on-site technical service and consultation offered by the CABP expert team to farmers, entrepreneurs and businessmen across Rwanda are highly conducive to their development.

G.6 Sustainable development of incubator

Driven by high demand of people and market and buttressed by the revenues from their pilot production and product sales, sustainable operation and development of incubators funded by CABP has become a reality.

G.7 It should be acknowledged as one of most successful models of South-South Cooperation in nature

- Perfect match of supply capacity and demand. With its unparalleled production capacity, China is at the top position of bamboo industry in the world. The huge funds injected into the bamboo sector by the government and private investors since 1980s have yielded enormous socio-economic and environmental benefits. For example, from 1981 to 2016, the annual production value of the bamboo sector was increased from USD 160 million to USD 35 billion, for which over 8 million people were employed. Developed against this background, the galaxy of technologies, expertise, machine manufacturing capacities, management skills, marketing methods and so on thus could serve Rwanda well for its unique characteristics of simple operation, easy learning, transferability, duplicability, massive application and excellent results. Rwanda, as the demand side with abundant bamboo resources but still in a primitive stage of development, is eager to share China's technologies and experience to develop their bamboo resources. In a word, the two sides are each other's perfect match;

  Good coordination and implementation mechanism to ensure the rewarding partnership. MOFCOM, CEW and MLF are government-representing agencies of China and Rwanda to make decisions on project framework, scheme, fund, etc. Through their bilateral friendly consultations which are concluded at least half a year ago before initiation of each project term (each 2 years as a term, totally 5 terms in 10 years), CBRC and RWFA are designated by both governments to implement them;
- Fund guaranteed. A sum of US $ 3.5 million has been earmarked by the Chinese government for the 10-year CABP and some in-kind supporting facilities such as building and land have been well provided by the Rwanda government. All the funds can be available in time;
- A systematic approach. A systematic approach involving technical transfer, social-economy, human resource, management, operation, differentiated marketing and so on are created and optimized;

- ; Working with a long-term resolution. As a tree has a long life cycle from budding, rooting, flowering to fruiting, it is logical and understandable that only after working assiduously through a long time could the South-South Cooperation, particularly its agriculture and forest projects, score achievements we expect. It really is impossible to achieve all the targets at one stroke. In fact, it would have been impossible to get it if 5 Chinese experts were not working full-time in Rwanda for 10 consecutive years;
- Good cooperation. The Chinese government provided over US $ 3.5 million along with technologies, machineries and 13 experts who would work dedicatedly in Rwanda for 10 years, while the Rwanda government provided land, buildings, management, and supporting logistics services. All stakeholders from China and Rwanda, including the two governments, Chinese experts and Rwanda people, always worked in a harmonious and self-motivated way under a close partnership;
- Active participation. All the self-motivated stakeholders, whether the government agencies, businessmen, farmers, artisans, etc. of Rwanda or any of the Chinese experts, will make spontaneous efforts under a harmonious partnership; and
- An integration of TCDC, ECDC and ECOCDC

The project is aimed at enhancing Rwanda economic development and ecological protection by means of bamboo technology transfer. In its nature, it is put under the dual-target of Economic Cooperation among Developing Countries (ECDC) and Ecological Cooperation among Developing Countries (ECODC), therefore the modes of TCDC and ECDC shall be upgraded to ECODC.

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Sustainable Development Goals: