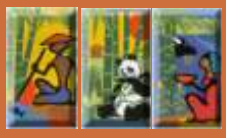
BAMBOO *for* sustainable development

CIBART

A strategic framework for bamboo development in India



CIBART adds value to bamboo

Strategies for sustainable development through bamboo

The transformation of rural agrarian economies includes development that is cleaner, more harmonious and more sustainable. This needs an enabling environment to drive efforts towards livelihoods generation, poverty alleviation and community empowerment; efforts that address ecological concerns.

The Sustainable Development Goals are a big step forward for achieving equitable and environmentally sustainable economic development. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and addresses a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection.

Bamboo is a resource that addresses six of the seventeen Sustainable Development Goals (SDGs) and offers a range of social, economic and ecological benefits. Technological innovations in this field will help unleash the potential of bamboo for creating job opportunities and driving social transformation.

Enabling policy, a regulatory environment and community awareness will collectively play a critical role for success of social enterprises working in the bamboo sector. And, the twin objectives of sustainable development and poverty eradication require close collaboration between the government, civil society organizations, the private sector and local communities. Because, the transformation required now needs to be technologically, economically and socially viable.

The Centre for Indian Bamboo Resource and Technology (CIBART) is a specialized agency on bamboo and the largest group working on bamboo in India that is vertically and horizontally integrated. It was established as a non-governmental organization in 2002 to develop social, economic and

environmental applications of bamboo in all sectors, and especially in rural areas where most of the resource and the poor exist. It has several subsidiary organizations and partners across India, as also several social enterprises and an entity for livelihood finance under its NATIVE banner and is expanding its network overseas. CIBART is also establishing the Bamboo Chamber of Commerce and Industry of India (BCCII), to bring all stakeholders in the sector together through which it will also organize an annual national congress and exhibition on bamboo.

CIBART's expertise and experience in growing spans nursery development, planting material production through seed, vegetative and tissue culture propagation, homestead and block planting, bamboo farming and resource inventory. In processing, CIBART undertakes the establishment and operation of bamboo processing units and treatment plants, skills enhancement programmes, handicraft, furniture, packaging, construction, biomass and charcoal briquettes, and biomass-based power production. CIBART is a leader in technology and applications development due to its deep understanding of the science behind bamboo. Besides, CIBART has data-based policy and strategy development expertise

Policy goals

1. **Facilitate** a coordinated approach to bamboo development: Bring together all relevant ministries to the table through a Bamboo Council hosted by MOA through a Cabinet decision to facilitate coordination among the various departments and ministries involved with bamboo development.

2. **Ensure** (i) a farm-focus for bamboo farming, and (ii) a medium to long-term lease of forest bamboo to tribal community families and other forest dwelling communities: Clear separation of the strategy for farm bamboo and forest bamboo. It is proven in China, Tanzania and elsewhere that farmers who own or have long-term lease title to land produce up to 20 times the productivity of forest bamboo. When forest areas are leased to individual farming families (not collectives like JFMCs), productivity similar goes up - quite the opposite of the fear of foresters that the resource would get wiped out. Tribal families given title to forest land under FRA would likewise have higher productivity if provided similar extension support as farmers with private lands.

3. **Government markets:** All government funded programmes and projects, both central and state, would institute a quota of 25% and above for bamboo furniture, bamboo in construction, and other items where bamboo could be utilized. This is essential to kick-start the bamboo economy. Please see Annex 4. Species specific innovation for products. Bamboo products should be exempted from GST until the both the volume and value markets develop.

Farm bamboo

Quality commercial bamboos in quantity for artisans and businesses

1. Governance

a. A multi-stakeholder coordinating agency for policy decisions and major investments, with participation of stakeholder representatives (for example, CIBART and BCCII) could bring in representation of bamboo farming and processing, and industry concerns to the table for consideration, and provide regular feedback

b. Focus on farmers and FRA beneficiaries, both of whom have titled land.

c. Technical Working Groups set up by the bamboo board and by other key stakeholders as well on a need basis as well.

2. Backward linkages

a. Implementation at the farmer level by CIBART (national level NGO) as a nodal technical agency with a network of NGO partners in the states that link with the GPs. MoA and others could take a stake in CIBART and sit on its Board. CIBART will operationalize the Council in its constitution which will include key stakeholders. CIBART has linked up with IFFCO through its subsidiary, IFFDC, that will help expand outreach to 36,000 farmer cooperatives in the country. CIBART is the South-South technical partner to three African countries. CIBART Madagascar has been established. CIBART also organized several workshops in Italy under its BambooBridge programme in partnership with the Italian Bamboo Association. This will provide a comparative context for decision making. Please see Annex 1.

   i. Inventory and networking: Gram Panchayat level inventory of bamboos in homesteads, farm boundaries and block plantings;

enrollment of farmers into a digital information sharing& marketing network. CIBART has done detailed inventory in Assam and Tripura, and to a lesser extent in Nagaland.

ii. Quality parameters relevant to commercial use such as wall thickness, circumference, usable culm/pole length, etc. would be assessed during the inventory in addition to species, numbers, volumes, annual incremental growth

iii. Primary processing: Reviving of government funded CFCs and other processing centres- CIBART has considerable experience and is operating 5 CFCs successfully and on a self-sustaining basis.

iv. Extension network: Building up a GP-level network of local correspondents/agents whose capacity will be built up as extension agents

v. Age and location marking: on all new poles (culms) so that standardization is possible and quality of products, especially industrial, increases and rejects decrease. For example, the same bamboo clone grown on flat land and on hill slopes have different strength qualities.

vi. Prices and farmer to large trader supply chain network

vii. Gram panchayat level depots for sale of bamboo poles at negotiated prices

viii. Since green weight is considerable and much primary processing is best done with green poles, establishment of primary processing centres to produce bamboo commodities at GP or block level that would be supplied to industries in truck-loads for direct end-use without the headache of having to source bamboos. Ordering can be done online or over the phone as with any other commodity.Harvested bamboo culm should be utilized 100% to derive full value.

ix. Both bamboo round poles and bamboo commodities would be treated in district level CFCs/processing centres and made available in depots to buyers and traders. Active marketing would be done.

x. Planting material of commercially useful bamboos in demand would be produced in distributed small tissue culture units and through vegetative propagation at the block and district level. Certification of planting material.

3. Forward linkages

a. Volume markets within the country and export markets would be needed to absorb the annual sustainable harvest of the bamboo grown. Traditional products consume only bamboo in relatively small to medium scale quantities. Large-scale consumption markets are required that could absorb huge quantities of bamboo that would be produced from plantations for landscape restoration, watershed protection and carbon sequestration.

Unlike most biological materials, bamboo is not just one commodity but many commodities. Besides traditional handmade products, appliances and shelter - incense sticks, implements, utensils, baskets and mats, furniture and rural housing - bamboo products now span the traditional and the uber modern, and encompass nearly all sectors with tens of billions of dollars of domestic and global trade. Such industries are power (8000 tons/year for 1 MW); pellets as cooking/heating fuel; charcoal; cellulosic ethanol (100,000 tons/year for 60,000 litres ethanol/day) which can reduce petroleum imports; pulp for paper/kraft paper (>100,000 tons/year); dissolving pulp for Tencel cellulosic textile fibre (250,000 tons/year of bamboo for 60,000 tons/year of dissolving pulp).

High quality charcoal can be produced from biomass gasifiers using bamboo that are already activated. This has a large market.

b. Bamboo Chamber of Commerce & Industries of India (BCCII):CIBART has already developed a constitution for the autonomous non-profit and will float it ASAP.Will take membership in FICCI, CII and ASSOCHAM; establish state chapters and regional areas within states too (e.g.Vidharbha) that will be powered by the local membership.All stakeholders including individuals can become a member of this body which will be self-governing (like FICCI's framework).This will help strengthen the link of bamboo to the Ministry of Commerce, Industries, and MSME and help businesses.

c. CIBART or BCCII will organize an annual Indian Bamboo Congress & Exhibitionto bring together all producers, processers, policy makers and others, with exhibitions, B2B services, technical advisory services in terms of directories of manufacturers of machines, adhesives, and others within the country and abroad.CIBART's CMD has experience in organizing several International Bamboo Congresses from 1991 onwardsin India, China,Thailand, Bali, Costa Rica, and other locations.

d. R&D Centre: CIBART will strengthen its R&D and set up a dedicated R&D centre in the Delhi-NCRregion and undertake time bound tasks and R&D projects to produce pencils, packaging, produce round sticks, organic fibre. Please see Annex 3 for further strategic research needs.

Annex 1

How CIBART and its network can contribute to the National Bamboo Mission (NBM)

1. **Bamboo is a strategic economic and environmental resource:** For countries to combat the negative effects of climate change. Bamboo's benefits for climate change mitigation are (1) Absorbing and storing carbon, (2) Protecting and restoring degraded lands and watersheds, (3) Insulating environments against extremes of weather, (4) Providing low-cost, green housing and infrastructure, (5) Providing a range of biofuels and power, (6) Supplying a renewable, sustainable resource for generating incomes, and (7) Increasing the sustainability, range and season of food sources.

2. **Species and planting material:** Can suitable bamboo species for specific end-uses be identified for planting in the respective agro-climatic regions? Can planting material of these identified species be produced in the many millions that would be needed? How many plants are needed relative to area to be planted? What is the present status of bamboo in the forest and bamboo out of forest?

    a. In each of our states, a market opportunity analysis would need to be undertaken, the area and density to be planted can be computed available land and type, which would give figures for the number of planting material units for each bamboo species.

    b. Seeds followed by macro-proliferation can also scale up planting material quickly. If well organized, vegetative propagation works well for some bamboos.

    c. The fastest scaling up is possible using plant tissue culture. CIBART India has developed a relatively low-cost containerized plant tissue culture unit that has the potential to make tissue culture units

available locally in all districts and blocks. Village nurseries would be established. NBM and other agencies could provide support in establishing micro tissue culture units in various parts of Northern Eastern India and the mainland.

3. **Soil fertility:** Knowing that bamboo is very adaptable and responds according to available inputs, can a low-cost fertilizer be made ubiquitously produced in each member state and made available for local use? Every plant that grows removes minerals from the soil, and so does bamboo. Can the minerals removed by bamboo and trees be returned to the soil so that productivity is restored and maintained?

   a. An innovative biomass fertilizer, a combination of two waste materials, ash and sewage, can be locally produced and mainstreamed. In 1996, an extensive multi-donor funded project in India demonstrated that the combination resulted in a five-fold increase in biomass production from bamboo on degraded lands. Municipalities would be able to put sewage to productive use, and thermal power plants too would be able to utilize the flyash. Both sewage and flyash are pollutants, and hence considerable policy support can be expected for this combination fertilizer. The flyash-sewage sludge could be pelleted which would make handling easier.

   b. A stove-to-field programme could return ash from cooking with firewood or charcoal to areas where bamboo is growing to re-mineralize them.

4. **Fodder and feed:** Bamboo fodder for livestock, and feed for chicken and fish are catching on and it is quite likely that farming bamboo for producing feed and fodder will get mainstreamed. In Ethiopia, during the dry season, cattle typically eat dry bamboo leaves fallen to the ground. Bamboo fodder and feed are being developed further by CIBART.

   a. Bamboo is a grass; its leaves are edible to most animals. Cows, buffaloes, goats, chicken, donkeys, horses, sheep etc. are known to eat bamboo leaves. In India, bamboo leaves are a common fodder in

Uttarakhand and Himachal during winter; this is true in Nepal too. In Benishangul Gumuz, Ethiopia, bamboo leaves are common fodder for donkeys and are even collected by communities and sold in markets as a commodity. INBAR work has shown the positive effect of bamboo leaves on growth of chicken when fed to broilers from an early age. This would contribute to food security.

b. CIBART will contact the National Egg Coordination Committee (NECC) and the Indian Broiler Association and other poultry industry associations to institutionalize micro plantation on all farms and use bamboo leaves and shoots as feed for chicken.

c. Bamboo feed pellets for livestock, chicken and as fish feed: This will involve formulation of pellets for different feeds including the bulking up using bamboo fibre besides leaves. With the large shortage of feed and fodder, bamboo can help bridge the gap while also providing poles and bamboo shoots for other markets.

5. **Bamboo processing centres:** CIBART has a network of self-sustaining bamboo processing centres with backward and forward linkages;its aim is to set up at least one unit/ district in each state, and later expand in each relevant district. Current locations are in Sindudurg district, Maharashtra; Tapi and Navsari districts, Gujarat; Mandi, Himachal Pradesh; Sirohi district, Rajasthan; Bhairabi, Uttar Pradesh; Tripura. Partners have processing centres in Kotdwar, Uttaranchal.

   There are several other processing centres established by different govt. agencies but most of them are defunct/closed that CIBART could revive. CIBART has supported centres in Madagascar, Tanzania and Ethiopia as the South-South technical partner to several countries.

6. **Grassroots inventory:** CIBART has done block and gram panchayat level inventory in Assam and Tripura and to a lesser intensity in Nagaland. These are not just quantitative enumeration but including several quality parameters relevant to artisans, enterprises and industries, with backward

and forward linkages, logistics, traders, pricing, processing centres etc. Includes legal, social conflict, ownership and other aspects as well. Such a comprehensive inventory is the foundation needed for a robust bamboo economy.

7. Environmental applications

a. Rehabilitation of degraded and wastelands lands: Bamboos are very good in making degraded and wastelands productive. Soil organic carbon and water holding capacity increases quite rapidly, pH gets ameliorated, and even sodic soils can be transformed. In Allahabad, the INBAR project the CIBART's CMD developed won the $1 million global prize for sustainable development.

b. Water: The biggest constraint to growth is water. But just 100 mm of rainfall over a hectare is 1 million litres or 100 litres/square metre. Rainfall in arid areas is around 300 mm (3 million litres/ha or 300 litres/sq. m.), and around 800 mm (8 million litres/ha or 800 litres/sq. m.) in semi-arid areas such as Delhi. Commonly, much of this rainfall drains away and little percolates through or becomes available to the top-soil where crops (and bamboo) grow.

    a. Planting suitable bamboos along contours can help conserve this water, with the resultant natural bunding helping hold and conserve the rainwater rather than letting it drain away.

    b. On sloping lands, the planting of suitable bamboo along contours would help in the natural terracing of the land by the deposition and accumulation of silt carried by the flowing water during the rainy seasons.

    c. Enhancing soil moisture retention and microclimate in existing farmlands with bamboo shelterbelts on farmland boundaries. Approximately 1% or less of the net agriculture land is left as crop field boundaries, land in which permanent cover such as bamboo or trees can be planted.

c. Slope stabilization: If not for bamboo (Melocanna baccifera), most of the soil on slopes in the mountainous slopes of Mizoram and Manipur would have got eroded to the Bay of Bengal. This is despite slash and burn agriculture (jhum) that is practiced.

8. **Natural terracing:** Small diameter bamboos that grow in thickets and planted along contours would be able to arrest soil erosion which would then accumulate behind them and lead to the formation of a terrace naturally.

9. **Mainstream bamboo boats:** Bamboo boats are useful for reducing the barrier that water poses to us. Each family in rural areas could be equipped with a boat produced by CIBART. These are useful in daily life for crossing a river or body of water, as floating shops, for tourism, and in the last two years, used in rescuing over 1200 farmer family members in 2016 who were marooned due to recurrent floods especially in the UP terai area. We have also innovated on boats and produced large boats that can carry 25 passengers and more. These boats can be motorized as well. State Disaster Management Agencies to include bamboo boats.

10. **Crates and packaging:** Crates of 100 kg capacity used for storage of apples in cold storage in Himachal Pradesh state, India, 20 kg crates and 20 kg crates were developed by CIBART for Alphonso mangoes, ten of which that could be stacked one above another.

11. **Agarbatties:** CIBART has extensive end-to-end experience in incense sticks production, from bamboo to scented and packaged agarbatties in Tripura.

12. **Household charcoal (HHC):** Household charcoal or HHC is the name given by CIBART to the waste charcoal produced when cooking using firewood by 84% of India's population. About 1000-1200 households (HH) produce 1 ton of HHC and hence with around 10,000-12,000 HH, 10 tons can be produced in a day. This can be pulverized and briquetted and sold as fuel. Considering that 121 million HH in India use firewood, about 121,000 tons of HHC are produced each day. Nearly all of this

goes waste through smoldering of the charcoal to ash, and the charcoal not being aggregated into useful quantities. HHC can also be used as a soil amendment to enhance water-holding capacity and as biochar enriched with microbes, it can enhance soil fertility as well.

13. **NCPP enterprises and rural crowdfunding:** CIBART's innovative enterprise models with equity participation by the NGO, Community, Professionals, in Partnership. 40% equity was from women in a biomass briquetting enterprise.

14. **Flattened bamboo planks and bamboo pencil production:** India is a net importer of pencils from China in a large scale. Suitable wood is in short supply and is even being imported. Bamboo has been tested and found to be a suitable material by the largest pencil producer in India. Bamboo pencils have been produced in India using two methods, cut bamboo and flattened bamboo internodes without cracks; the latter is an innovative technology.

    A special cutter was developed by CIBART that could use handmade slats produced by communities to make individual half-pencil pieces. This needs to be scaled up to its logical end.

15. **Bamboo matchstick production:** INBAR supported IPIRTI with a grant to produce bamboo matchsticks that conformed to the requisite BIS standard. This was accomplished, and a joint patent granted. The constraint to be overcome was production of matchstick splints in the scale of tons/day. Several approaches to produce splints have been developed with input from MIT, a university from the Netherlands, the slicing method, and others. Essentially, the process for agarbatti sticks, toothpicks and round sticks can be used. A method to address free fibres was also developed. This is ready for scaling-up.

16. **Bamboo wafer-board and derivative products such as corrugated roofing sheets:** Wafer-board is a structural panel board. These are highly competitive in cost and much cheaper than mat-board. The vast resources of Dendrocalamus strictus can be utilized for production of

such boards. Production of wafer-board was piloted by RAAU Foundation for Sustainable Development. The board was post-formed into corrugated roofing sheets.

17. Bamboo lath panels: Bamboo laths are round bamboo poles that have been opened to flatten them. These have vertical cracks but there is no loss of fibre strength. Low-cost panels have been produced using such bamboo laths which are later sanded and utilized like any other panel. These have the skin intact or skin removed.

18. **Organic natural textile fibre:** The crude fibre production is originally the traditional knowledge of Kerala that was brought to light by Dr N. Barathi of Growmore Biotech. Melocanna baccifera is a prime candidate for this which can be a game-changer for the NER. The bamboo fibre in the market is viscose (rayon) and is made in a very polluting process. The CIBART CMD, then with INBAR, utilized this organic bamboo fibre for textile. This meant standardization and testing of other bamboo species for fibre production. We have worked with a partner in the Philippines to produce enzyme-treated fibre blended with cotton and with silk that was used to produce textile. An innovative method to produce the needed enzymes in rural areas was developed by IDRC Canada and would be utilized for treating the organic textile fibre produced.

19. **Bamboo briquettes as replacement for coal in thermal power plants:** CIBART has produced biomass briquettes under its social enterprise, NATIVE Briquetters Pvt. Ltd., and partner company, Sakhi Briquetters Pvt. Ltd., that have rural crowdfunding from women and are NCPP enterprises. CIBART also helped set up WODGRA Bamboo & Charcoal in Tanzania. The UP government has partnered with CIBART in using bamboo biomass briquettes to replace coal in its thermal power plants which would have multiple multi-year benefits of (a) large-scale livelihoods for youth, (b) enterprise development, (c) bamboo farming with land rehabilitation, ecological and climate change benefits, (d) renewable energy resource, and (e) pollution reduction.

20. Activated carbon: Research in the Indian Institute of Sciences in Bangalore showed that the surface area measurement of Bambusa balcooa charcoal produced in a biomass gasifier was in the range of 900 (m2/g). Such a value is normally achieved in an activation process using charcoal either using chemical treatment or steam activation process. Investigations suggest that K2O, which comprises 40% of inorganic salts in the ash, had a significant influence in the overall char reactivity in the reduction zone of the gasifier by helping development of micro pores. This was innovated by Dr N.Barathi (Growmore Biotech) & Prof. Dasappa (Indian Institute of Science). CIBART has discussed this with commercial biomass gasifier producers who are very keen to scale this up and fine-tune the process so that output is enhanced.

21. Bamboo commodities:

a. Turned bamboo as a commodity produced in volume - uniformly dimensioned input material for furniture industry. CIBART also supplied turned bamboos to an American company that further made products for the US market. Our companies could equally benefit.

b. Long slivering of bamboo - uniformly dimensioned input material for artisan basketry, mats and other products which would now be of quality. Productivity and income of artisans and tribals would double to treble as validated in Gujarat.

22. Bamboo shoots: Bamboo shoots of Melocanna bacciferaare safe to eat even fresh. Its texture and taste rivals that of asparagus. The huge stocks of Melocanna baccifera in the NER should be leveraged which would also provide considerable employment opportunities. Literally millions of tons of shoots can be sourced which is not possible with any other bamboo species. Melocanna bamboo shoot soup can rival asparagus or mushroom soup, and sold either canned or dehydrated.

Annex 2

Bamboo knowledge and learning management network (KLMN)

Various institutes and companies and government and NGOs are working with bamboo but information remains embedded within them (perhaps globally in spite of various bamboo associations) leading to the creation of knowledge silos. Against this background, CIBART proposes setting up of Bamboo Knowledge & Learning Management Network to strengthen NBM by integrating the scattered knowledge base and appropriating from global case studies and making this available at one platform. It had earlier set up a Bamboo Documentation Centre - can build upon that experience. There will be provisions for information generation and knowledge sharing on multiple dimensions.

Objectives

- Creating a knowledge repository
- Improving knowledge access and transfer
- Enhancing the knowledge environment; and
- Managing knowledge as an asset.

A two-pronged approach: Participatory - for generating trust and ownership and; Analytical - for ensuring the technical adequacy of content, activities and advice (same as participatory stewardship approach).

To achieve the desired objectives a set of seven activities have been proposed which will be undertaken in a phased manner over a five-year time-frame. These include:

1. **Education and training** - to help build capacity of all interested stakeholders. This will result in greater public participation and devising adequate response measures.
2. **Resource development** - to generate content to serve the interests of diverse stakeholders.

3. **Networks and strategic partnerships** - to build functional and effective networks and strategic partnerships that will enable dialogue among stakeholders and initiate activities

4. **Engaging communities and piloting various bamboo projects** - to develop a systematic and effective approach towards Knowledge Management, providing a platform to implement projects that generate key lessons for scaling up

5. **Knowledge portal** - to cater to the needs of user groups thus serving as the first point of entry for policy and decision makers, practitioners and the public.

6. Communication and outreach strategy - to develop a systematic and effective approach for communicating and a framework for delivering key messages to target audiences.

7. Brand management and outreach - to help NBM carve out a unique position for itself

The organizational structure of the Bamboo KLMN will be in the project mode that would foster stability and efficiency, while helping develop collaborations between relevant authorities and stakeholders.

There is a need for a comprehensive monitoring and evaluation framework for the centre. This will provide valuable insights on project performance and allow for any mid-course corrections and timely adjustments that may be required. To ensure regular and stable financial flow, strategies will be developed to increase current financial flows and generate new sources of financing.

It is expected that at the completion of the project duration, the Bamboo KLMN would be an established platform offering a range of bamboo information products and services customized according to diverse stakeholder needs. It would have successfully developed its capacity and demonstrated its relevance as a Knowledge Management Centre providing advisory services and support to drive innovations and actions at the local level.

Annex 3
Strategic research needs for bamboo development

Species-wise R&D

1. Elimination of cracking of round bamboo: Nearly all round bamboo products end up having one or more cracks that diminishes the value, and utility of the product, thereby affecting the market.
2. Flattening of bamboo internodes without cracking (flats) - trials done successfully but need to be standardized. The flats could be used for production of pencils to replace wood (mostly imported now), as input material for sliced veneer, slats for built-up panels, etc.
3. Flattening of the whole culms including both internodes and nodes into bamboo planks. This is needed for production of planks that would enable widespread application in various products including flooring.
4. Developing technology for mechanised straightening of bamboo using microwave and steam heating. Would save time, fossil fuel usage, labour costs, reduce price of products.
5. Study on reducing hardness and prominence at nodes, which would help in better machining properties.
6. Thermal modification of bamboo to reduce warping, moisture content, and promote browning for coffee colour look.
7. Production of organic natural fibre yarn from bamboo - building on a traditional method to produce fibre.
8. Study on production of enzymes in coconuts for enhancing bamboo fibre properties by growing . This would make enzyme production inexpensive.
9. Finger-jointing of internodal bamboo slats and cross-nodal bamboo slats to get longer slats for making laminated panel boards and blocks.
10. Splicing of bamboo slivers to get long lengths.

11. Technologies for enhancing screw-holding capacity in bamboo slats.
12. Wafering of bamboo. Production of wafer board (structural board, 90% of houses in US, Canada and Australia use wafer board). Corrugated roofing sheet production (trial done successfully).
13. Crushed bamboo panel production of different densities including equivalent of strand-woven bamboo panel.
14. Well laid out field trials on enhancing straightness of bamboo by debudding at all lower nodes, and assessment of such straight bamboo through user trials.
15. Agronomic trials for enhancing productivity of bamboo.
16. Fertilization trials using flyash and sewage sludge.
17. Allometric data - soil binding, leaf production, leaf area, leaf fall data, canopy, extent of root spread & depth, water capture & recharge - time-series, correlations
18. Soil data including organic carbon, water holding capacity, soil erosion reduction.
19. Carbon data for above/below ground bamboo parts - time-series.
20. HH level inventory and monitoring system; not typical FSI inventory. More bamboo is coming from private holdings. From homesteads.
21. Effect of bamboo biochar on agricultural crops - bamboo biochar is supposed to be good, and double productivity.
22. Mycorrhizal application and productivity.
23. Bamboo as fodder and feed (common in uplands in the lower Himalayas). For livestock, donkeys, chicken, shrimps, fish.
24. Bamboo habit modification for ease of plucking young leaves needed for feed (broilers), and for enhancing leaf availability at level of large and small ruminants.

Annex 4

Market opportunities: Government and private

Bamboo as wood/poles

Market	Ministry	Product	Cases/Precedents/SSC (South-South Cooperation)
Education	Education	• School desks, library & dormitory furniture • School buildings	• Ghana changed specification from hardwoods to Hardwoods+bamboo • Philippines Presidential Order mandating 25% bamboo school desks in government procurements • School furniture for several schools in Gujarat state, India. • Introduced in Madagascar (SSC) being further replicated within • Several school buildings in Colombia and Ecuador
Construction	Construction, Agriculture	• Earthquake proof structures • Social housing • Polyhouses, greenhouses, sheds	Diverse examples in many countries: • Ecuador - industrial scale modular social housing; Costa Rica - social housing; Colombia - resilience of bamboo housing during an earthquake; Robustness of bamboo structuresin face of torrential floods in Uttarakhand state, India; Social housing in Tripura state, India • Schools designed by using bamboo approved by Nepal government • Building standards: ISO22156, ISO22157-1 & ISO22157-2 have been adopted by National Standards Organizations in Ecuador, Vietnam.
Tourism, Eco-tourism	Tourism, Forestry	• Resorts, cottages, gazebos, boats	Diverse examples in many countries, exposure visits of CIBART Action Research Sites (ARS) to see high-end Philippine designed bamboo resorts
Handicrafts	Industry	• Baskets, mats, carvings, musical instruments, fountains, clocks, toys etc.	Diverse examples of very many products in many countries Incense sticks is a multi-billion dollar industry in India, also China, Vietnam (SSC)

Market	Ministry	Product	Cases/Precedents/SSC (South-South Cooperation)
Furniture	Industry	Diverse home and office furniture	Philippines, India, Tanzania, Ghana, Ethiopia
Apiculture	Agriculture	Warré and Kenya Langstroth bamboo beehive	Ethiopia, India (SSC)
Sericulture	Agriculture	Bamboo baskets to gather mulberry leaves; trays for feeding mulberry leaves feeding to silk larvae; montages for production of cocoons; trays for cocoon storage; baskets for steaming of cocoons; bamboo mats	Commonly used in India; in China mainly as feeding trays
Agriculture, horticulture	Agriculture	Packaging, cases, grain storage	Bamboo packaging and crates used and vegetables in China (major) and India (SSC), Mozambique, Tanzania and several others; Crates used for storage of apples in cold storage in Himachal state, India
Fisheries	Fisheries	Boats & rafts, landing stations, bamboo islands, baskets, drying mats	India, Vietnam for coastal and riverine artisanal fisheries introduced in Ethiopia, Mozambique, Tanzania & Madagascar (SSC)
Fisheries	Fisheries	Cages for fish, seafood	Cambodia, Philippines, China, being introduced in India (SSC)
Transportation	Transport	Boats	Round (coracle) boats common in South India and Vietnam. New models of regular boat sizes developed in India by CIBART that can carry many passengers and goods; unsinkable boats also developed and introduced in Madagascar (SSC) including larger motorized boats
Emergencies		Boats	Rescue by CIBART boats of over 1000 families from flood affected areas & transporting materials for reconstruction in Uttar Pradesh, India

Bamboo as wood/poles

Market	Ministry	Product	Cases/Precedents/SSC (South-South Cooperation)
Coastal erosion			Dense bamboo fencing in intertidal zone in sea naturally recovers land lost to sea & raises land levels by 1m in 3 years! 6 locations in 5 provinces in Thailand,surprisingly robust technology, excellent impact, non-sea applications too. INBAR has shared this with some member states.
Panel	Forestry	Glue-board, mat-board, strand-board, wafer-board, stress-laminated panels, strand-woven boards, crushed bamboo panels	China (major), India (roofing sheets), Vietnam, Colombia, Madagascar, The Philippines, others

Bamboo as fibre

Market	Ministry	Product	Cases/Precedents/SSC (South-South Cooperation)
Pulp, paper	Forestry	Pulp & paper, fluff pulp, dissolving pulp	India, Indonesia, China
Panel boards	Forestry	MDF	China
Textile fibre	Textiles	Viscose fibre	China, India
Bio-ethanol	Petroleum	Cellulosic ethanol	India with Finland (TrC)
Panel boards	Forestry	Particleboard	China (major), India, others

Bamboo as biomass

Market	Ministry	Product	Cases/Precedents/SSC (South-South Cooperation)
Power	Energy	Biomass electricity Activated charcoal	India with Madagascar (SSC)
Solid fuels	Energy Energy	Biomass briquettes Biomass pellets	China (widespread), Vietnam, India China, India, widespread markets, can be exported
Charcoal	Energy	Bamboo charcoal as fuel	China, India and Ethiopia, Madagascar, Tanzania, Mozambique (SSC)
Carbon market	Energy	Charcoal, household charcoal from cooking using firewood; pyrolytic cooking stoves	

Bamboo as leaves (keeps bamboo clumps intact)

Market	Ministry	Product	Cases/Precedents/SSC (South-South Cooperation)
Livestock, donkeys	Agriculture	Fodder	Ethiopia, India, China, Ghana, Madagascar (SSC) and several other countries
Chicken	Agriculture	Feed	Philippines & India with Ethiopia, Madagascar, Tanzania (SSC)
Fish	Fisheries	Feed	India
Shrimps, prawns	Fisheries	Feed	India, Puerto Rico
Medicines	Health	Medicines	China (modern, Chinese medicine), India (Ayurvedic, Unani medicine)
Beverages	Health	Tea (infusion)	Several traditional communities

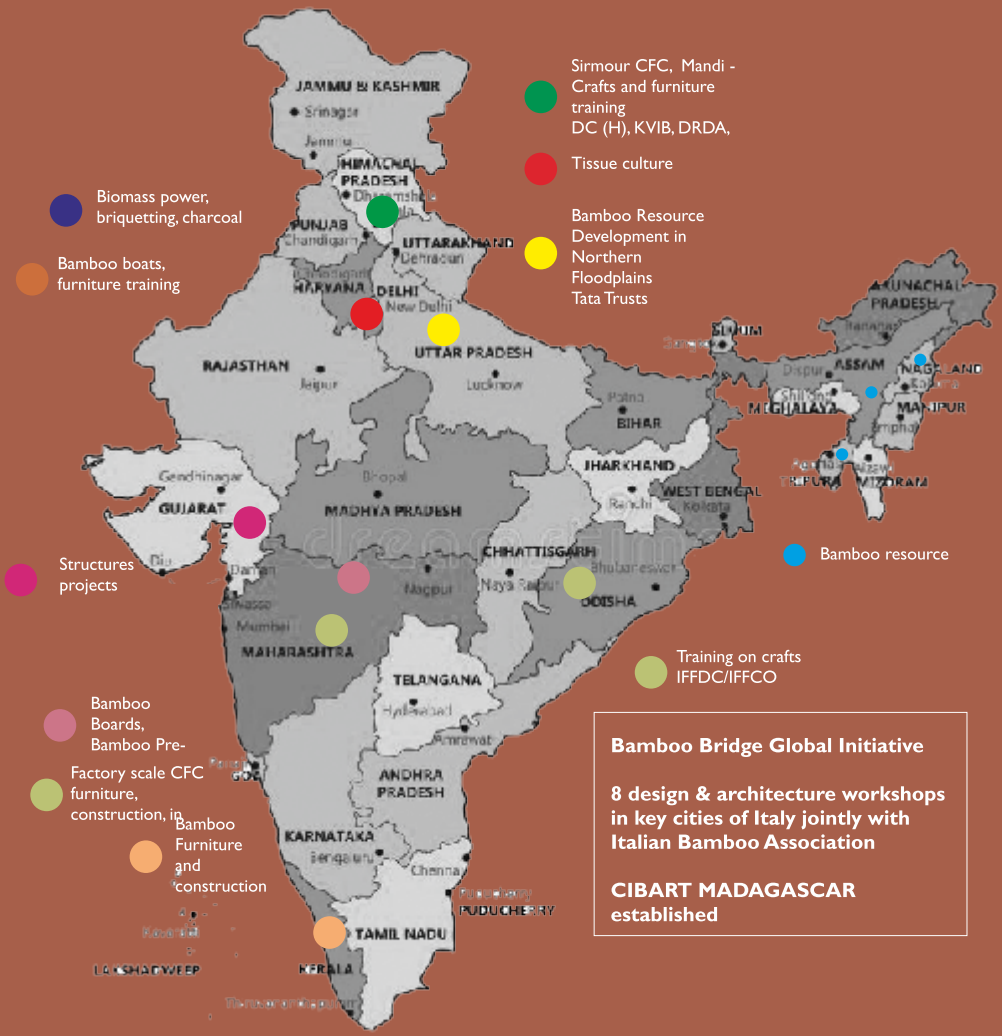
Bamboo as shoots (keeps bamboo clumps intact)

Market	Ministry	Product	Cases/Precedents/SSC (South-South Cooperation)
Shoots	Agriculture	Food	China (major), Japan, SE Asia, India (local), globally a multi-billion dollar industry
Shoots	Agriculture	Ethanol	Bamboo exudate is collected, fermented (bamboo wine) and ethanol is distilled from it).

Live bamboo clumps/plantings

Market	Ministry	Product	Cases/Precedents/SSC (South-South Cooperation)
Public goods	Agriculture Forestry	Rehabilitation of degraded lands & wastelands	India (SSC)
Public goods	Agriculture Forestry	Soil and water conservation	China, India (SSC to Africa)
Public goods	Agriculture Forestry	Watershed protection	China, Ethiopia, India, others
Public goods	Agriculture Forestry	Riverbank protection	Costa Rica, Peurto Rico, Rwanda, the Philippines, Sri Lanka
Carbon market, NDCs	Forestry Agriculture	Carbon sequestration	China, South Africa

Research and development at CIBART



Bamboo Bridge Global Initiative

8 design & architecture workshops in key cities of Italy jointly with Italian Bamboo Association

CIBART MADAGASCAR established

BAMBOO for sustainable development

CIBART

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