BRU

Bamboo & Rattan Update

INBAR

Sharing the latest news and activities from the bamboo and rattan sectors

SUSTAINABLE CONSUMPTION & PRODUCTION WITH BAMBOO

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Cover Image
Bamboo is used as the main building material for the Panyaden Secondary School Sports Hall in Chiang Mai, Thailand, designed by Chiang Mai Life Architects. Credit: Marcus Roselieb, Alberto Cosi

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B R U

EDITORIAL

Welcome to the first issue of the* Bamboo and Rattan Update *for 2025, which details bamboo and rattan's contribution to responsible consumption and production.

2025 marks the beginning of Volume 6 of the Bamboo and Rattan Update. This year, we will be continuing to focus on the United Nations Sustainable Development Goals (UN SDGs), as bamboo can directly contribute to at least eight of them. Superseding the Millennium Development Goals, the 17 SDGs act as key markers for global progress across a wide range of activity areas, from eradicating poverty and safeguarding the natural environment to ensuring all people enjoy peace, prosperity and good health by 2030.

One of the main pathways for contributing to these achievements is by reaching a sustainable equilibrium with life on earth through the sustainable utilization of natural resources. To that end, SDG 12: Responsible Consumption and Production aims to promote sustainable practices by encouraging efficient use of resources, reducing waste and minimizing the environmental impact of consumption and production. The goal also emphasizes reducing food waste, improving recycling systems and helping companies adopt sustainable practices. Ultimately, SDG 12 strives to decouple economic growth from environmental degradation to foster a greener future for people and planet.

Bamboo can play a key role in contributing to the achievement of this goal. The plant resource offers a fast-growing, renewable, biodegradable and eco-friendly alternative to traditional materials like plastic, steel and cement. Its rapid regrowth and minimal need for pesticides or fertilizers make it a sustainable material for construction, textiles and numerous products. Furthermore, bamboo cultivation benefits soil health and carbon sequestration, while strengthening the livelihoods of the farmers, processors and middlemen who work with the plant. The bamboo sector can be a powerful driver of sustainable production, waste reduction and green consumption.

The first article in BRU 6-1 highlights community practices in Ethiopia. Home to 67% of Africa's bamboo, the country is building a sustainable industry with its 1 million hectares of bamboo. Local communities are using smart harvesting techniques like rotating crops and controlled burning to boost yields and protect wildlife. Through field schools and cultural events, farmers are sharing their skills, driving growth and creating jobs. Despite challenges like deforestation and limited women's participation, the bamboo sector is demonstrating its capability to boost Ethiopia's sustainable development.

What is the true potential of bamboo for effecting positive environmental changes and sequestering carbon in a largely unexplored region like Europe? The second article investigates this very claim. Locally grown bamboo could help Europe reduce its carbon footprint by offering a sustainable alternative to traditional building materials. The construction industry, responsible for nearly 40% of global CO_2 emissions, could significantly benefit from bamboo's fast growth and carbon-storing properties. Unlike concrete or steel, bamboo absorbs more CO_2 during growth than it emits during production, making it a climate-friendly option—especially when grown in Europe, reducing the environmental impact of long-distance transportation. Some companies are already planting bamboo in European countries, with promising results. Life Cycle Assessments have validated the lower carbon footprint of European-grown bamboo. To fully harness its potential, the industry must overcome barriers such as the lack of building codes and limited experience with bamboo construction. Expanding its use in temporary structures could demonstrate its value and promote wider adoption, helping Europe move toward its carbon neutrality goals by 2050.

New technologies can also play a role in global sustainability, argue the authors of the third article. A new bamboo-based activated carbon filter is now offering an innovative, cost-effective solution for reducing car emissions, especially from older diesel vehicles. These filters are capable of capturing around 80% of pollutants, significantly improving air quality. These filters are faster and more efficient than traditional ones while also delivering a 5–7% cost advantage. The filter also promotes sustainability by extending the life of older vehicles, reducing waste and supporting upcycling through its related platform. These novel products and more contribute to clean transportation, bringing an eco-friendlier future into the present day.

The final article takes a holistic view of bamboo's potential across a range of sectors, drawing lessons from China's experiences. Bamboo's versatility spans multiple sectors, offering both economic and environmental benefits. However, industries face common challenges like outdated production practices, limited technological innovation and weak consumer acceptance. To promote sustainable bamboo development, green production standards, sustainable adhesives and technological advances are urgently needed. Certification systems, consumer education and innovative branding can all help bamboo secure greater recognition and consumer confidence as a high-quality, sustainable material. Given effective policy frameworks and market support, bamboo has the potential to be a major player in the global economy.

THE EDITORS

A GROWING COMMUNITY OF PRACTICE IN ETHIOPIA

Community members sharing knowledge and practices on bamboo harvesting and management.

Ethiopia's bamboo community blends tradition and science to enhance sustainable harvesting, raise incomes and cultivate a thriving bamboo economy.

Ethiopia possesses a substantial area of Africa's bamboo resources, representing 67% of Africa's total bamboo resources. It grows in the forests and on the land of smallholder farmers. Bamboo in Ethiopia is utilized for various purposes, ranging from household needs to commercial applications, including the production of value-added products that cater to local, regional and international markets. It offers rural communities diverse livelihoods and contributes to the national gross domestic product while advancing progress on achieving Sustainable Development Goal 12: Sustainable Consumption and Production.

Effective harvesting and management practices are essential for obtaining high-quality bamboo materials and achieving sustainable yields from forests and farms. Additionally, enhancing the resilience of multiple supply chains helps establish robust business ecosystems.

Bamboo farming and participatory forest management communities have developed effective strategies to sustain bamboo farms across various *Woredas* (districts) and *Kebeles* (wards). Their goal is to empower local communities to manage their bamboo resources in both forests and farms, ensuring long-term viability. This effort has improved local livelihoods and supported wildlife conservation. By combining traditional knowledge with proven practices, the community effectively manages bamboo planting and harvesting in homesteads and farmlands through techniques such as rotational harvesting,

controlled burning, and selective harvesting for fuel, construction materials and other uses.

Bamboo harvesting: A community's practices

Knowledge and practices related to bamboo harvesting in Ethiopian society have been spread through religious institutions, particularly the church, and also through the established Farmers Field School platform. Potential bamboo growers are assembled from various *Woredas* or *Kebeles*, where the Extension Officers or Community Leaders (known as *Yehager Shemagele*, *Garo* or *Aba Geda* in the local languages/dialects) conducted on-site demonstrations. Local folk songs and cultural dances are also utilized as instruments to mobilize farmers in order to spread knowledge and techniques about bamboo harvesting and management. Participatory tools and procedures have been employed to showcase the methods of harvesting and management practices. The Ethiopian bamboo community has implemented the Community of Practice mechanism as follows below:

Kebele or *Woreda* elders instruct the youth and farmers to refrain from harvesting bamboo before the onset of the rainy season, as well as on Sundays and during full moons. Additionally, the community prohibits the harvesting of bamboo in the afternoon or dusk. According to the village elders, bamboo has the highest starch content during this period and is prone to attacks by borers.

Bamboo harvesting equipment

Typically, the Ethiopian community use machetes with handles of restricted dimensions. This type of tool is advantageous to exert maximum force while conserving energy, making them particularly suitable for women. Before visiting the bamboo plantation, the elders recommended sharpening the machetes with sand. These blades minimize damage to the already-present culm within the clump. In the present day, contemporary bamboo growers or cooperatives also employ hand-operated portable chainsaws to harvest bamboo culms. It minimizes the time and effort required,

Age	Culm Appearance	Utility	Harvesting
0–30 days	Nearly 90 percent water and soft.	Food for humans and animals as bamboo shoots.	20–30%
0–1 year	Culms are immature. Starch and moisture content high.	Production of ropes and handicrafts items.	10–15%
2–3 years	Starch content high, susceptible to decay and insect attack. Moisture content high.	Basketry, mats, rhizome-based planting materials and non-structural applications.	20–25%
4–5 years	Starch content comparatively lower. Susceptible to decay and insect attack. Moisture content comparatively lower.	Furniture product, constructions and high-end industrial products.	25–30%
6 years+	Moisture content lowest. Leaf volume reduces, physiological activity decline, culm quality diminished.	Structural applications, industrial products, charcoal and pulp.	30–40%

Community people using local tools to harvest bamboo.

as well as labor expenses. In addition, the farmers employ efficient harvesting techniques, utilizing horse-shoe or tunnel methods to easily access the interior of the clump for harvesting the bamboo culms or poles.

Extraction and transportation

Harvesting bamboo from the forest generally entails felling fully-grown bamboo stems and transporting them to a processing facility called a common processing center linked to a multi-supply chain. The procedure may differ based on the particular application of the bamboo, be it construction, furniture-making or other sectors. The farmers employ physical labor or mules to transport bamboo from the plantation sites, utilizing sisal rope for binding or bamboo slivers. Sometimes, a tractor or motorbike is employed to tow the bamboo and transport it to the market.

Spreading knowledge

Spreading information from the Community of Practice benefits both bamboo growers and small and medium enterprises (SMEs). Bamboo farmers have noted a one-centimeter rise in culm diameter, along with a 15–20% increase in biomass. The acquired expertise is disseminated to fellow farmers to expand their operations and to SMEs for obtaining high-quality raw materials for commercial purposes.

Farmers found it feasible to control culm size and emphasized the importance of managing clump and culm density. The peer-groups learning approach is extensively embraced in *Kebeles* for the purposes of disseminating, scaling up and conserving the on-farm bamboo resources.

In conclusion

Notable challenges still exist for introducing sustainable harvesting and management practices of bamboo in Ethiopia. These include deforestation, excessive extraction, the growth of agriculture-focused endeavors and cultural obstacles that impede women's involvement, such as gender-differentiated roles and lack of women in decision-maker positions. Initiatives are currently underway to bolster and advance the management of on-farm bamboo resources and practices by engaging local communities in participatory scientific harvesting, knowledge sharing and income-generating activities. These efforts can have a great impact not only on Ethiopia's bamboo sector but also on the country's broader sustainable development prospects.

SELIM REZA
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FEATURED ARTICLE

REDUCING EUROPE'S FOOTPRINT WITH LOCALLY GROWN BAMBOO

One of the few examples of the structural use of bamboo stem in a permanent structure in Europe. This private home was designed by architect Sven Mouton in Ghent, Belgium. Credit: Sven Mouton

Bamboo can be a low-carbon alternative to traditional building materials.

The European Union is set to become carbon neutral by 2050 and has established a separate strategy focusing on a circular bio-economy. Sustainable Consumption and Production (Sustainable Development Goal 12) is a key element in these strategies to reach the set climate and circularity targets.

The building industry has a key role to play in meeting these targets as it consumes about 44% of raw materials worldwide and is responsible for 37% of global CO_2 emissions. Of these emissions, about two-thirds are related to operational energy use and one-third is caused by the production of building materials, most notably concrete/cement and metals. With increasingly energy-efficient buildings coming online, the embodied carbon aspect could increase to 50% by 2050. As the material footprint in high-income countries is 10 times higher than low-income countries, it makes sense to focus on bio-based alternatives to emissions-intensive non-renewable building materials in Western markets like Europe.

Bamboo and timber could be part of the solution. When grown and harvested in sustainably managed forests, bamboo and timber store more CO_2 during growth than they emit during production. We know this also holds

true for engineered bamboo products such as laminated bamboo and strand-woven bamboo as elucidated in INBAR's Technical Report on "The Environmental Impact of Industrial Bamboo Products." Furthermore, bamboo has the benefit of faster growth compared to timber, and if stored in durable products in the built environment, also a larger carbon storage potential when substituting for fossil building materials, for more information see INBAR Working Paper "Carbon Sequestration and Carbon Emissions Reduction through Bamboo Forests and Products."

The bamboo stem is an incredibly efficient building material; with its hollow tubular form and strongest fibers at the outside, it is one of the few building materials that can be grown, harvested and used in its natural form as structural element in buildings. However, despite its potential, because of the lack of building codes and experience working with the alternative material, uptake in Western markets as a construction material has been slow. In addition, sea transportation from the tropical and subtropical countries where most giant bamboos grow to Europe has a negative impact on financial costs and environment. For example, when grown and used in China, the carbon footprint of the bamboo stem is only 0.19 kg CO_2 / kg stem, but if it is transported and used in Netherlands, this ramps up to 1.45 kg CO_2 / kg stem, significantly higher.

European bamboo – part of the solution?

Whereas China is the largest bamboo exporter worldwide (USD 2.7 billion), Europe is the largest importer of bamboo products (over USD 1.1 billion). Given the increasing pressure on container pricing for sea transport, possible future import restrictions and the environmental impact of sea transport, large-scale bamboo planting on poor agricultural land and developing a bamboo industry in Europe could be viable solutions going forward.

In recent years, bamboo has been planted for industrial purposes in several countries across Europe. While most of the several thousand hectares of European bamboo plantations are still relatively young (less than 10 years old); several are already producing stems that can be used in many different applications, from food, biochar, pulp to more durable, value added applications such as fibers for composites, insulation and as building materials.

One of the pioneering companies in this field has been BambooLogic, which has currently planted bamboo in seven European countries, including Portugal, Italy, France, Belgium, Greece and the Netherlands. For example, in 2018 ten hectares of the Moso (*Phyllostachus Edulis*) species were planted in Vidigueira, Portugal. Currently, this plantation is reaching maturity and yielding stems up to 8 meters tall, which may be used for structural purposes.

To better understanding of the carbon footprint of the bamboo stems from Portugal, based on their application in the Netherlands, BambooLogic commissioned environmental consultancy Agrodome to perform a Lifecycle Assessment (LCA) to measure the environmental impact, including carbon footprint, for the production of European-grown bamboo stems, including transport to the Netherlands. The results are presented in an Environmental Product Declaration (EPD), which is a standard format to present the environmental data resulting from a LCA study.

The carbon footprint of European-grown bamboo stems compared to alternatives

The third-party verified and publicly available EPD revealed that bamboo stems from Portugal have a negative carbon footprint in the production phase of -253 kg CO_2 per m^3 of 10-cm diameter bamboo stems. This negative number is caused by the storage of biogenic carbon, that is, the carbon stored in the bamboo during growth through the photosynthesis process. This carbon is released again when the bamboo is burned or landfilled at the end of its life, highlighting the necessity to look for more circular solutions such as reuse of the bamboo, potentially as fibers in particle board (cascading) among others. For more information see the INBAR Policy Synthesis Report 6, "Bamboo in the Circular Economy."

Besides the real-life Portugal scenario, the EPD also modeled a scenario in which the bamboo was grown in Belgium, where the planted bamboo is expected to be ready for harvesting within a

Figure 5. Top 10 exporters of bamboo commodities in 2022 (USD million)

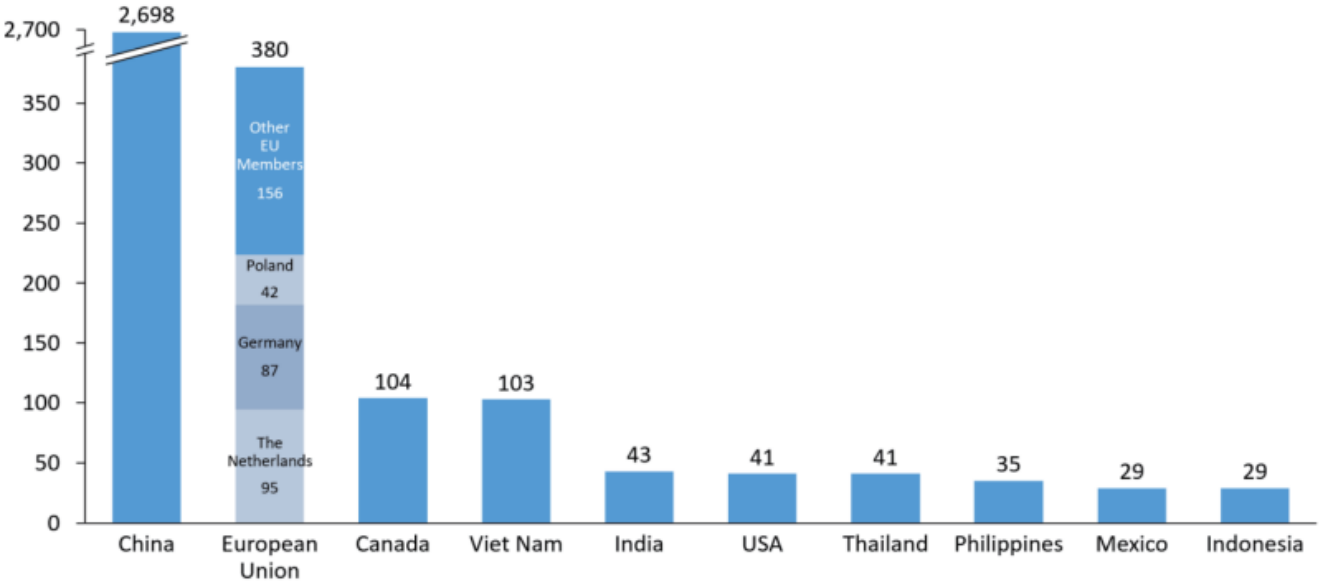
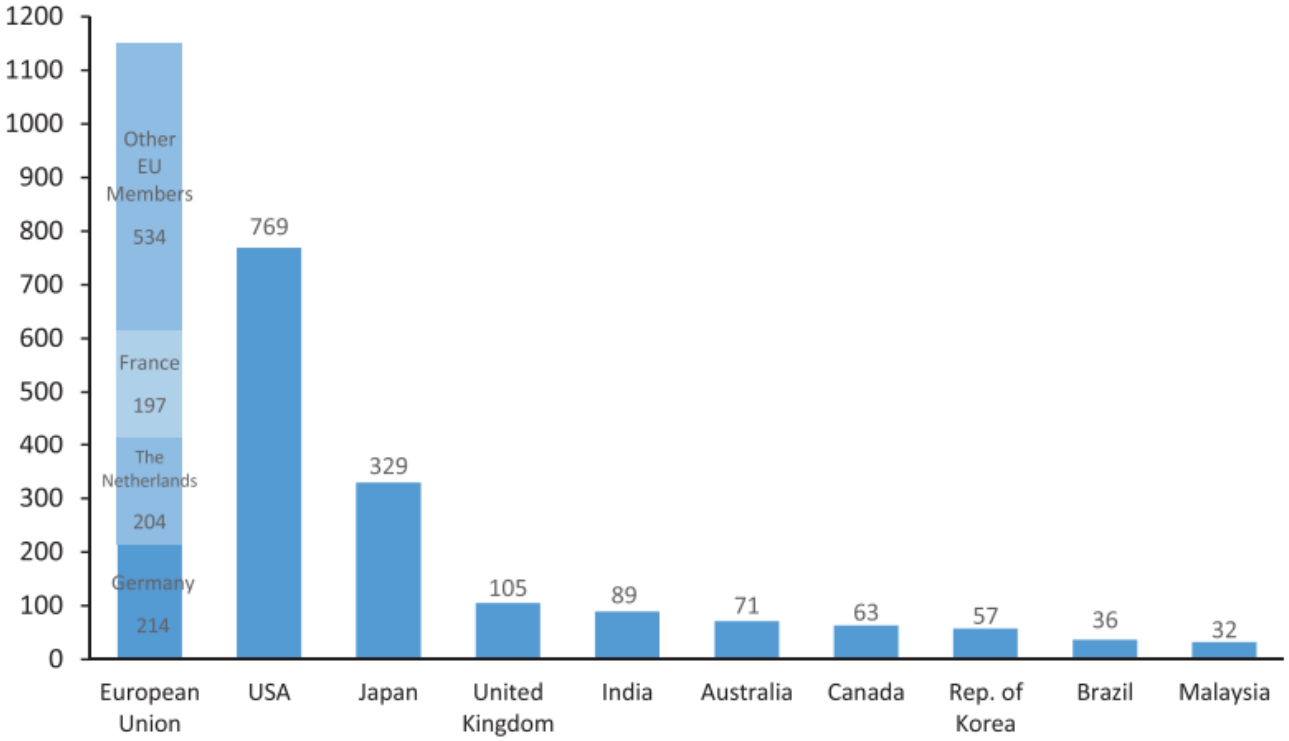
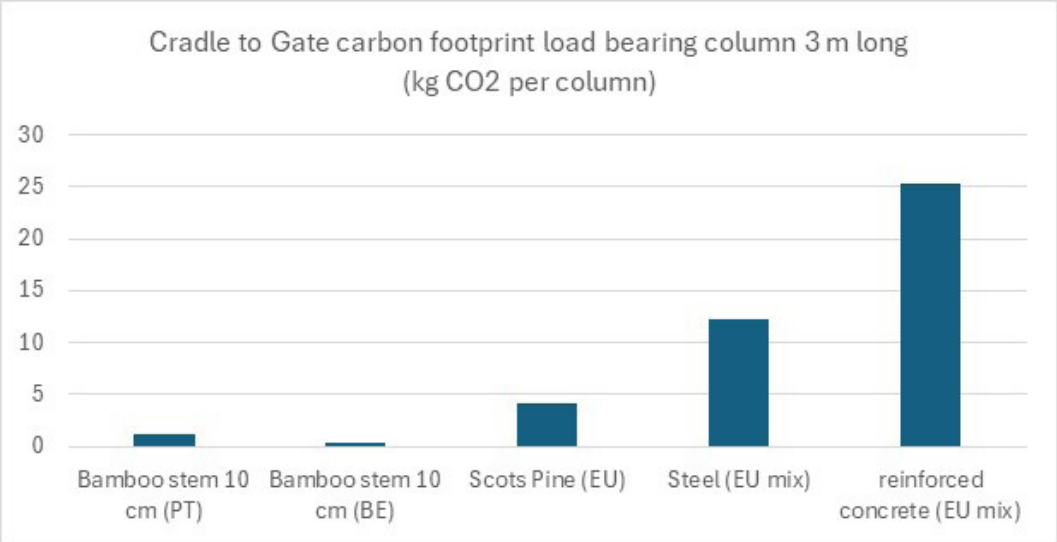


Figure 7. Top 10 importers of bamboo commodities in 2022 (USD million)



Source: (Data compiled from UN Comtrade database)

Import and export figures of bamboo products in 2022.



Carbon footprint during production of a load bearing column in several material alternatives. Bamboo values for Portugal and Belgium from EPD BambooLogic, material alternatives based on Idemat database 2024.

couple of years. Because of its close proximity to the Netherlands, the carbon footprint score is even better, at -283.6 kg CO_2 per m^3.

For a fair comparison with other structural materials, these numbers should be "translated" to a real-life load-bearing application in which all material alternatives have to fulfill the same structural requirements. For this so-called functional unit, a load-bearing column 3 meter long, excluding connectors, with a load-bearing capacity of 13.73 kN, was chosen following material dimensions taken from the PhD thesis of Belgian architect Sven Mouton, "Evaluation Framework for Sustainable, Innovative, Low-Cost Building Prototypes with Bamboo." For this application, the following relevant alternative materials where chosen: Sustainably sourced European Scots pine, steel and reinforced concrete. The carbon footprint data for the production of these materials were taken from the publicly available Idemat LCA database of Delft University of Technology based on the average European market mix.

The results are shown in the graph above, and reveal that for this particular application, bamboo has the lowest carbon footprint during its production phase. It should be noted that the lifespan is not taken into account in this comparison, which could be lower for bamboo compared to the alternatives in a so-called cradle-to-grave assessment.

If the biogenic carbon content would also be taken into account, the bamboo columns are CO_2 negative; -7.6 kg CO_2 for the Portuguese stem and -8.6 kg CO_2 for the Belgium stem. Because of the higher weight (solid beam) and thus higher biogenic carbon storage, the Scots pine column in that case would have a negative carbon footprint of -30.9 kg CO_2.

Looking ahead

The results show that bamboo stem is a very promising material to mitigate climate change in the built environment, but also that the transport distance has a large impact on the final result, highlighting the importance of local sourcing. The EPD also showed that the means of transportation is also a pivotal factor in the carbon footprint. If, for example, bamboo is transported from Portugal by sea vessel instead of by truck, the carbon footprint may be reduced by up to seven times!

Given the strong environmental performance of bamboo stems in all scenarios, it is recommended to increase the uptake of this material and focus on overcoming barriers to its implementation in

Bamboo plantation in Vidigueira, Portugal by BambooLogic, planted in 2018. Interestingly, the biodiversity of the bamboo plantation is far higher compared to the neighboring plantations with a significant higher amount of flora and fauna; for more information, see the thesis of Mona Stöhr for the University of Erfurt, "Biodiversity in the Bamboo Plantation Vidigueira." Credit: BambooLogic

Europe, such as the lack of building codes and knowledge on using this promising structural material. As a first step, an increasing use in temporary structures such as pavilions and festival tents, which require fewer permits and testing, could showcase its potential, increase local acceptance and improve public perception.

In this assessment, the carbon stored in the soil and ecosystem of the bamboo plantation itself is not taken into account. If the baseline scenario uses poor abandoned land, the total carbon benefit after replanting with (giant) bamboo for use in durable products could be substantial. This additional carbon stored in BambooLogic's bamboo reforestation projects is sold on the voluntary carbon market following independent third-party verified Open Natural Carbon Removal Accounting protocol.

For additional reading, please see: https://www.inbar.int/bru-6-1/

PABLO VAN DER LUGT
Dr. Pablo van der Lugt is a renowned bamboo and timber expert attached to Delft University of Technology. He is the author of the international best sellers *Booming Bamboo* and *Tomorrow's Timber*.

CARGREENTECH: BAMBOO FILTERS FOR CLEANER VEHICLES

Bamboo tech is showing up in a big way for its potential to steer sustainable practices in the auto industry.

Passenger vehicles emit approximately 4.6 metric tons of CO_2 annually. On a larger scale, highway vehicles contribute significantly to carbon emissions, with 1.5 billion tons of CO_2 released each year. In addition to the challenges of controlling emissions, older vehicle models that are widely used in developing nations also contribute significantly to air pollution.

One of the major obstacles in addressing this issue is the cost of catalytic converter repairs and replacements. The raw materials used, including ceramic cores and precious metal catalysts like platinum, palladium and rhodium, make the process quite expensive. Repairs can cost anywhere from USD 300 to USD 2500, and replacing the catalytic converter can be as high as USD 2000 for the part alone. Moreover, these filters have shown limited absorbency of greenhouse gases.

Our team, consisting of Mst. Fahmida Sultana Naznin (Computer Science and Engineering), Tasmiah Afrin (Electrical and Electronic Engineering), and Ishmam Tasin (Industrial and Production Engineering), all from Bangladesh University of Engineering and Technology, embarked on this project to tackle the dual challenge of high catalytic converter costs and environmental impact under the mentorship of Md. Toufiqur Rahman Shuvo (Lecturer, Bangladesh University of Textiles) and Nusrat Subah Shakhawat (Doctoral student, Federation University Australia). Motivated by the need for affordable, effective solutions for older vehicles in developing nations, we developed a bamboo-based carbon filter to provide a sustainable and cost-efficient alternative.

Preparation of activated carbon from bamboo

We chose bamboo for activated carbon production due to its exceptional qualities and performance. Its low ash content ensures a purer, more effective carbon product. The activated carbon made from bamboo has an expansive surface area (976 m^2 per gram via steam activation at 600-800°C), which means it has many tiny pores. This structure allows it to effectively trap and store carbon dioxide, with an impressive capacity to hold 3.4 millimoles of CO_2 per gram.

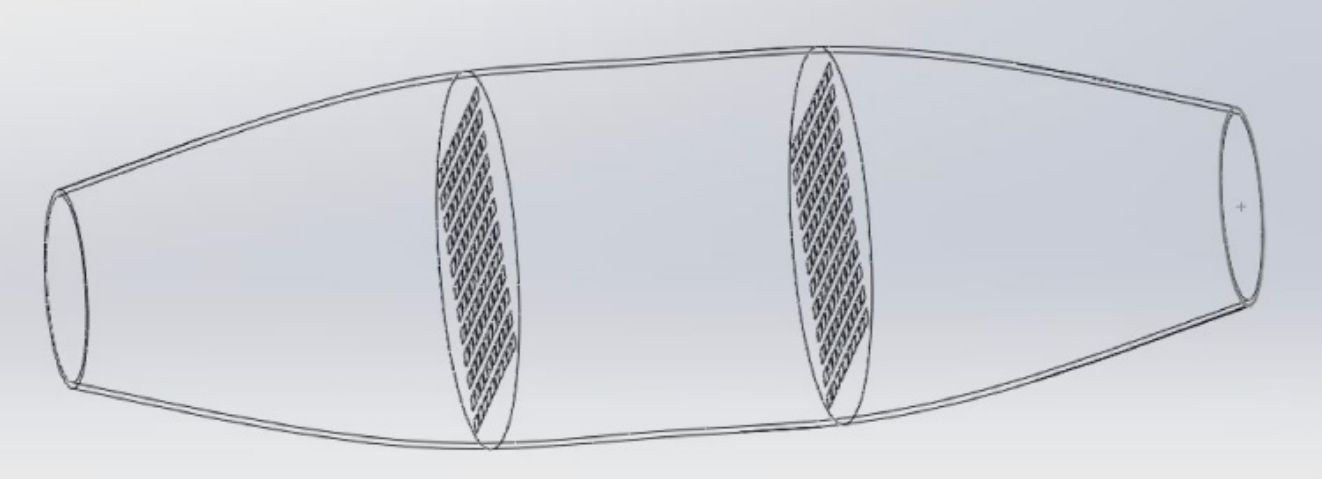
These attributes make bamboo an ideal, sustainable material for high-performance activated carbon, offering superior efficiency and environmental benefits compared to traditional sources.

We first used tropical bamboo to create activated carbon. The bamboo was cut into smaller pieces, then heated in a nitrogen-filled reactor. It was then treated in two ways: Physical activation with steam and chemical activation with phosphoric acid. In both methods, the material was heated before being cooled. The produced activated carbon was washed and dried. The key properties we analyzed included the availability of raw material, high specific surface area, strong mechanical resistance and fast adsorption speed.

Design process of bamboo carbon filter

Before we even initiated the project, we conducted an in-depth analysis of the current catalytic converter systems and their limitations, particularly focusing on diesel engines that emit more particulate matter than gasoline engines. We recognized that traditional catalytic converters often fail to capture small particulate matter effectively, creating the need for additional diesel particulate filters.

Our project aimed to enhance the efficiency of catalytic converters in diesel engines, which



Cross-sectional view of bamboo carbon filter. Credit: Ishmam Tasnim

release more particulate matter than gasoline engines. Due to their small size, these particles often bypass traditional catalytic converters. To address this, diesel particulate filters are typically installed after the converter. Our team developed a modified air filter system for the incoming air, incorporating activated carbon granules and metallic mesh within absorption chambers. This design forces gases through double or multiple chambers, effectively trapping pollutants. Our prototype is not only more aerodynamic but also lighter than current carbon filter designs, offering improved performance and efficiency.

A comprehensive transport management system for reducing auto emissions

CarGreenTech is an innovative platform designed to reduce auto emissions and extend the life cycle of older diesel vehicles. Central to this initiative is a modified bamboo carbon filter that significantly reduces harmful emissions. The platform includes a transport management system and a web app, allowing owners of older diesel cars to easily purchase and install replacement filters. Alternatively, through the CarGreenTech platform, users can buy older cars, equip them with new filters and resell them—providing an efficient and straightforward upcycling solution.

The platform's unique selling proposition lies in its ability to transform older vehicles into more climate-positive assets. By integrating enhanced bamboo carbon filters, CarGreenTech significantly reduces the environmental impact of car exhaust gases. This all-in-one solution not only extends the life of aging vehicles but also promotes sustainable practices in the automotive industry. Through both B2B and B2C channels, CarGreenTech offers a comprehensive approach to making existing vehicles eco-friendlier, thereby contributing to a cleaner and healthier environment.

Overall impact of the system

CarGreenTech's innovative activated bamboo carbon filters significantly improve environmental and economic efficiency in vehicle exhaust systems. They can efficiently remove about 80% of pollutants in exhaust gases from diesel engines. They feature an impressive absorption speed, performing 10% faster than conventional filters, which enables rapid and effective removal of pollutants. They can also offer a 5% to 7% cost efficiency improvement over existing options, making them a cost-effective solution for capturing carbon emissions. This results in immediate improvements in air quality and contributes to reduced carbon emissions.

The platform not only extends the life cycle of older vehicles by an average of three years but also promotes sustainable transportation by offering climate points and discounts. The platform's commitment to sustainability is aligned with several Sustainable Development Goals (SDGs). Specifically, it makes notable contributions to SDG 12: Responsible Consumption and Production. By offering a solution that enhances

What The App Does

CarGreenTech system overview. Credit: Ishmam Tasnim

the efficiency of existing vehicles, CarGreenTech encourages the responsible use of resources and reduces waste through the upcycling of older cars. This approach directly supports the goals of reducing waste generation, improving resource efficiency, and promoting sustainable practices across industries.

In addition, CarGreenTech's innovations contribute to other SDGs, such as decent work and economic growth (SDG 8) by creating new job opportunities, industry innovation and infrastructure (SDG 9) through the development of advanced technologies, sustainable cities and communities (SDG 11) by improving urban air quality and climate action (SDG 13) by addressing auto emissions. Each of these contributions underscores the platform's role in advancing a more sustainable and eco-friendly future.

As CarGreenTech progresses, several challenges may arise. One potential obstacle is the scalability of bamboo carbon production and the supply chain needed to meet growing demand. Additionally, ensuring the long-term durability and effectiveness of bamboo-based filters in diverse environmental conditions requires ongoing research and development. To address these issues, CarGreenTech should invest in expanding its production capabilities and conducting extensive field testing. Collaborating with researchers and industry experts will be crucial to refining the technology. Emphasizing continuous innovation and adaptability will ensure the platform remains at the forefront of sustainable automotive solutions and continues to contribute effectively to global environmental goals.

CarGreenTech offers an innovative solution for reducing auto emissions and promoting sustainable transportation. By utilizing bamboo-based activated carbon filters, the platform effectively captures pollutants, enhancing air quality and extending the life cycle of older vehicles. The initiative not only addresses the environmental challenges posed by outdated diesel engines but also provides a cost-efficient alternative to traditional catalytic converters, especially in developing countries. CarGreenTech's comprehensive approach aligns with global sustainability goals, making it a vital contributor to a cleaner and more sustainable future.

FAHMIDA SULTANA NAZNIN

Fahmida Sultana Naznin is a researcher specializing in Computer Vision, NLP, and Bioinformatics

FEATURED ARTICLE

SUSTAINABLE PATHWAYS FOR THE BAMBOO INDUSTRY

A diverse range of bamboo products. Credit: Feng Pengfei

The process of upgrading traditional industries can significantly benefit from deeper integration with eco-friendly bamboo.

Amid global climate change and resource constraints, "Responsible Consumption and Production" has emerged as a core issue in achieving the Sustainable Development Goals (SDGs). The bamboo industry, offering both ecological and economic value, aligns closely with sustainable development due to its renewable, low-carbon and eco-friendly characteristics. With the richest bamboo resources in the world, China has a long history of utilizing bamboo for a diverse range of products. However, it still faces challenges in environmental standards, technological innovation and market expansion.

The key to achieving responsible development in the bamboo industry lies in improving resource utilization efficiency during production and encouraging green choices among consumers.

Advantages of the bamboo industry for sustainable development

Renewable and low-carbon

Bamboo matures quickly (3–5 years) and naturally regenerates through its rhizomes after harvesting, giving it far superior sequestration capacity compared to typical timber. Compared to timber, bamboo production does not require large-scale deforestation, resulting in less damage to the ecosystem. Furthermore, the carbon emissions of bamboo products throughout their entire lifecycle (from planting, processing to disposal) are significantly lower

than those of plastic and metal products, making bamboo an ideal material for a low-carbon economy.

Cultural inheritance and versatility

Bamboo culture is deeply rooted in traditional Chinese philosophy and lifestyle, which imbues bamboo products with unique cultural value. From bamboo architecture and furniture to bamboo fiber textiles, the application of bamboo has expanded from practical tools into high-value-added areas. For example, the development of innovative products such as bamboo-based composite materials and bamboo charcoal materials not only enhances resource utilization but also conforms to the pursuit of a green lifestyle by modern consumers.

Industrial poverty alleviation and rural economy

Bamboo resources are widely distributed in mountainous and rural areas. The industrial chain, spanning planting, processing and sales, creates numerous employment opportunities for rural communities. By promoting sustainable bamboo forest management techniques, farmers can increase their income while protecting the environment and contributing to rural revitalization.

Current challenges in responsible production

Disconnect between environmental standards and production practices

While bamboo is inherently eco-friendly, pollution issues can still arise during processing. For example, harmful substances such as formaldehyde in traditional bamboo-wood adhesives would not qualify some bamboo products to meet environmental standards. While formaldehyde-free adhesives and other eco-friendly materials have been developed, their adoption remains limited among small and medium-sized enterprises due to cost and poor technological diffusion.

Insufficient technological innovation and added value

The bamboo industry has long focused on low-value products such as bamboo mats and chopsticks, which has limited its competitiveness in high-end markets. Inadequate investment in technological research and development has resulted in inefficient use of bamboo resources. Emerging sectors, such as industrial-grade bamboo fiber and bamboo-based composites, have yet to achieve large-scale production.

Market limitation and consumer bias

Internationally, bamboo product exports from China are overly dependent on traditional markets in Europe and the US, with insufficient expansion into emerging markets. Domestically, consumers still perceive bamboo products as cheap alternatives and lack recognition of bamboo's environmental value. Additionally, low brand recognition of bamboo products makes it difficult to compete with wooden products.

Inadequate policy support and industry chain coordination

The bamboo industry spans multiple sectors, including forestry, manufacturing and environmental protection, yet policy support remains uneven. There is also a lack of effective integration across resource cultivation, technological research and market promotion. For example, the bamboo forest certification system is still not widely adopted, making it difficult to meet international market demands for sustainable supply chains.

Strategies for promoting responsible production

Driving green transformation through technological innovation

Green production standards for bamboo products can be established by promoting eco-friendly materials, such as formaldehyde-free adhesives and water-based coatings. Enterprises can be supported in upgrading production lines to reduce energy consumption and waste emissions. Cooperation between industries, universities and research institutes in areas like bamboo-based composite materials and bamboo fiber textiles can be enhanced to encourage the application of bamboo in industrial sectors such as construction, automotive and aerospace.

In Hunan, China, one company has developed a microwave softening technology for bamboo in collaboration with a university, which improves bamboo fiber extraction efficiency by 40% and reduces costs by 15%. These collaborations

demonstrate that technological breakthroughs must align closely with market demand. In addition, environmental protection could no longer be an unprofitable venture through the promotion of clean processes such as water-based coatings and biomass fuels.

Policy guidance and industry collaboration

Drawing on international forest certification experiences (such as the Forest Stewardship Council), China can establish sustainable bamboo forest management certification standards to improve transparency across the industry chain. Forestry, environmental protection and business sector resources can be integrated to offer bamboo enterprises technical training, market information sharing and export facilitation services.

The absence of a bamboo forest certification system has caused bamboo enterprises in Zhejiang to lose out on European orders. In recent years, Zhejiang has piloted a "bamboo forest carbon sequestration trading" scheme to quantify and monetize ecological value. This has allowed farmers to increase their income by an average of 200 yuan per mu (1 mu is approximately 0.0667 hectares; 1 yuan is approximately USD 0.14) of bamboo forest annually. Wide adoption of this ecological compensation model would help resolve the conflict between resource conservation and economic growth.

Corporate social responsibility and brand building

Leading enterprises can be encouraged to take the initiative in establishing a full lifecycle management system from bamboo forest planting to product recycling to ensure resource traceability. Bamboo products' aesthetic value should be strengthened through innovative design concepts, creating a high-end brand image. Additionally, e-commerce platforms should be used to expand the consumer base among younger consumers.

Consumer education and market expansion

The environmental benefits of bamboo products should be promoted through public service advertisements, social media and other channels to encourage consumers to shift from being "price-sensitive" to "value-oriented." Bamboo-based daily goods and building materials can be promoted in regions such as Southeast Asia and Africa.

Trendy national brands with Chinese designs highlighting bamboo elements can be explored to activate the domestic demand potential. In Chengdu, Sichuan, a cultural brand has combined bamboo weaving with intangible cultural heritage techniques, offering a bamboo lamp set priced over a thousand yuan, which sold out immediately upon release. This illustrates that consumers are not unwilling to pay for green products but rather are looking for items with deeper emotional or cultural resonance. The popularity of the Bamboo as a Substitute for Plastic Initiative on social media further confirms that the younger generation is redefining bamboo elements in trendy Chinese designs.

Going forward

The sustainable development of the bamboo industry is a systemic process that transforms ecological resources into economic value and social benefits. Within the framework of SDG 12, the bamboo industry represents not only the future of upgrading traditional industries but is also a key driver of the green economy.

In the author's view, the transformation of the bamboo industry requires not only policy and capital support but also a revolution in thinking to redefine bamboo from a "mountain plant" to a "carrier of green technology." When every bamboo stalk embodies ecological protection, technological innovation and cultural confidence, responsible consumption and production will truly take root. With the increasing global emphasis on sustainable development, bamboo is expected to become an increasingly relevant material that can even replace plastic and steel. China's transformative experiences in the bamboo industry can serve as a reference for developing countries and promote the joint development of global green supply chains.

FENG PENGFEI

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Collating the latest international news and activities around bamboo and rattan sectors development

Field work investigating the carbon sequestration capacity of bamboo forests. Credit: World Meteorological Organization

Bamboo, a sustainable construction material, has massive potential

Despite being the world's largest bamboo producer, India still imports high-quality bamboo from China while not being among the top ten exporters. Bamboo-based, pre-engineered construction techniques were used in major projects in India, including the Kempegowda International Airport's Terminal II in Bengaluru, where factory-built bamboo components are assembled on-site. India's bamboo industry urgently needs value-added bamboo products and improved marketing strategies to boost its overall growth.

To strengthen bamboo craftsmanship, the Andhra Pradesh State Forest Department plans to collaborate with the private sector to train tribal artisans in creating value-added bamboo products. Currently, 100 tribal bamboo artisans have been announced as being trained, with some even receiving advanced training in Maharashtra. The Forest Department is also engaging artisans and officials in discussions about current bamboo farming practices and their future potential. This initiative aims to enhance bamboo cultivation, promote sustainable construction practices and improve the livelihoods of local bamboo farmers and artisans.

Source: The Hindu, 19 March

How Chinese engineers used bamboo in the world's longest sea bridge

Recently, Chinese scientists have been developing advanced bamboo-based materials for large-scale infrastructure in a display of China's commitment to sustainable construction. Engineered bamboo composite panels have been used on the scenic platforms of the Hong Kong-Zhuhai-Macau Bridge, the world's longest sea crossing. Even after six years of exposure to harsh conditions, including

typhoons and seawater, the bamboo panels have remained strong and durable.

Beyond the sea bridge, Chinese engineers have contributed to other major international projects using bamboo technology. Collaborating with Hangzhou-based Dasuo Technology, researchers created the world's largest curved bamboo ceiling at Madrid-Barajas International Airport, covering 240,000 square meters. These innovations, and more, showcase bamboo's potential as a low-carbon, durable alternative for modern construction and position China at the forefront of sustainable architecture.

Source: South China Morning Post, 18 February

Unleashing bamboo: A nature-based solution to plastics

Bamboo is emerging as a viable nature-based solution to combat plastic pollution, thanks to its versatility, rapid growth and sustainability. As global plastic production continues to surge—reaching 460 million tonnes in 2019—bamboo offers an eco-friendly alternative for single-use plastics such as straws, cutlery and food packaging, which account for 30–50% of all plastic waste. China, with its 7.5 million hectares of bamboo forests, leads the way in bamboo innovation, creating plastic substitutes like phone cases, wind turbine blades and structural components. The Bamboo as a Substitute for Plastic (BASP) Initiative, launched by INBAR and the Chinese government in 2022, aims to leverage bamboo to contribute to the achievement of the UN Sustainable Development Goals. The initiative's Global Action Plan was launched in 2023, and currently scoping studies are underway in six representative countries around the world, investigating the feasibility of upgrading the bamboo plastic substitute industries.

However, there are still major challenges to scale up bamboo production. Bamboo products still face misclassification issues under outdated trade codes, limiting their market competitiveness. Additionally, bamboo producers face financial and regulatory burdens, as bamboo is treated like timber under deforestation regulations despite being a fast-growing grass. To overcome these hurdles, international coordination is essential. Governments must introduce supportive policies, such as tax incentives and streamlined trade procedures, while public campaigns can raise consumer awareness of bamboo's benefits. With proper management systems, bamboo cultivation can flourish without harming biodiversity, offering a sustainable alternative to plastics and fostering economic growth in bamboo-rich regions.

Source: Dialogue Earth, 21 February

Utilization of atmospheric measurements to establish the carbon sequestration capacity of bamboo forests

The four-year pilot project in Anji County, China aims to accurately measure the carbon sequestration capacity of bamboo forests using the Integrated Global Greenhouse Gas Information System approach. By combining atmospheric measurements with inverse modeling, the project provides a more precise assessment of CO_2 fluxes compared to traditional emission inventories. Bamboo forests are highly effective carbon sinks due to their rapid growth and sustainable harvesting practices. However, current Intergovernmental Panel on Climate Change (IPCC) guidelines approximate bamboo with trees, failing to capture its unique carbon dynamics. This initiative seeks to refine carbon accounting methodologies and contribute to improved IPCC guidance specific to bamboo forests.

So far, the project has established 30 sampling plots, built two observation towers and initiated atmospheric measurements. The collected data, including carbon dioxide, carbon monoxide, synthetic organic chemicals and radiocarbon fluxes, are being used to validate and enhance carbon stock inventories. The project also held a workshop to share the methodology with outside institutions. Expected outcomes include a more accurate characterization of bamboo forest carbon uptake, refined IPCC reporting guidelines and improved carbon accounting capacity for INBAR Member States.

Source: World Meteorological Organization, 8 January

INBAR commissions research, conducts project work and raises awareness about bamboo and rattan across its 51 Member States.

Biocentric restoration practices with bamboo underway in the Amazon.

The world unveils first ISO standard for BASP products

On 22 January, the International Organization for Standardization (ISO) released the world's first ISO standard for Bamboo as a Substitute for Plastic (BASP) products: ISO 16830:2025 Specification of Bamboo Drinking Straws. This landmark standard, developed by the ISO Technical Committee on Bamboo and Rattan (ISO/TC 296), outlines the requirements for bamboo straws, marking a major step in promoting sustainable alternatives to single-use plastic. With over 70% of disposable plastic products polluting the environment, bamboo offers a renewable, biodegradable and eco-friendly replacement. Leveraging its rapid growth and versatility, bamboo straws—produced through techniques like drilling bamboo sticks or rolling bamboo veneers—hold significant market potential and can help reduce global plastic pollution.

The standard specifies criteria for the production, testing, packaging, and labeling of bamboo drinking straws. Its development involved collaboration between the International Center for Bamboo and Rattan, Chinese companies like Anhui Hongye Group and China Long Bamboo Technology Group, and over ten institutions, including Central South University of Forestry and Technology. Researchers and experts from ISO/TC 296 member countries also contributed, with guidance from the Secretariat of ISO/TC 296 and support from regulatory bodies. This milestone highlights the growing momentum behind bamboo-based products as viable, eco-friendly alternatives to plastic, paving the way for greater sustainability in consumer goods.

Biocentric restoration: An Indigenous-led approach for ecosystem recovery and resilience

Since 2018, the Food and Agriculture Organization (FAO) and Indigenous Peoples' organizations have collaborated to develop a biocentric restoration approach that integrates Indigenous knowledge with innovative practices to safeguard ecosystems

and biodiversity. Central to this initiative is the concept of "schools of life"—intergenerational, gender-inclusive spaces where elders transmit ancestral wisdom to youth, fostering ecological stewardship. In 2022, FAO and INBAR launched the Indigenous Biocentric Restoration Project in Ecuador's Amazonian Indigenous Territories, engaging four Kichwa communities in Napo province. The project promoted bamboo, locally known as *wamag*, as a key resource for ecosystem recovery, with 55.59 hectares undergoing restoration, the reintroduction of 156 native species, and the establishment of four nurseries and schools of life. The initiative also reintroduced bamboo as part of the traditional Kichwa diet, highlighting its cultural and nutritional significance.

The success of the pilot project has laid the foundation for broader adoption of biocentric restoration practices. The initiative entered its second phase recently, expanding restoration efforts, increasing Indigenous community involvement, and identifying ecologically and spiritually valuable species. This model, driven by Indigenous leadership, not only restores degraded ecosystems but also protects Indigenous Peoples' collective rights and cultural heritage. By blending traditional wisdom with collaborative innovation, the FAO-INBAR partnership offers a scalable solution for biodiversity conservation, ecosystem resilience, and Indigenous empowerment, inspiring similar initiatives across Ecuador and beyond.

Celebrating International Day for Women and Girls in Science in Ghana

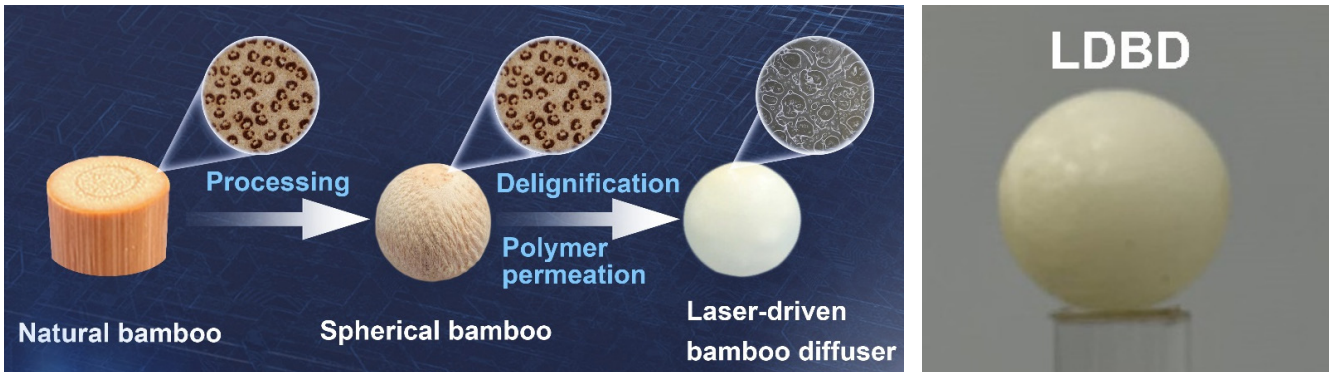
On 11 February, INBAR's West Africa Regional Office (WARO), in collaboration with UNESCO and the Ghana Education Service (GES), celebrated the 10th Anniversary of the International Day for Women and Girls in Science in Mamfe, Ghana. The event, themed, "Imagine a world with more women in Science," highlighted the critical role of women and girls in science and technology. The celebration aimed to inspire young girls to pursue careers in Science, Technology, Engineering, and Mathematics, and recognize the contributions of women in these fields. The Ministry of Education in Ghana used this platform to empower youth, especially girls, to explore opportunities in scientific disciplines, including those related to bamboo innovation.

During the celebration, the GES acknowledged INBAR WARO's efforts in promoting bamboo research and development in Ghana, emphasizing the potential for young girls and women to pursue careers in this field. The event concluded with the presentation of bamboo weaving products to the girls at Dzorwulu Special School for the Intellectually Challenged, alongside bamboo plaques awarded to the event's honorees. These plaques were created by Genuine Bamboo Craft, a Ghanaian youth company focused on sustainable bamboo products.

Inauguration of the Multipurpose Bamboo Center

The inauguration of the Multipurpose Bamboo Center in Bonke District, South Ethiopia, took place on 8 February, marking a key milestone in a pilot project supported by the Spanish Agency for International Development Cooperation. Launched by INBAR, the initiative aims to promote a circular economy and climate change resilience through the development of a bamboo supply chain in Ethiopia. The center, built using locally sourced bamboo, provides a workspace for cooperatives to produce value-added bamboo products, and serves as a bamboo depot for the surrounding areas. The project involved active participation from the local community, especially youth, who received training in bamboo house construction.

During the launch event, Biruk Kebede, Acting Director for INBAR's East Africa Regional Office, emphasized the success of the initiative and the empowerment of local youth through skill-sharing in bamboo construction. Gizatie Gijie, Director General of the Environment Protection and Development Bureau, expressed his appreciation for the project's contribution to the effective utilization of the region's bamboo resources. He assured ongoing support to ensure the sustainability of the center and its expansion to neighboring districts. The center plays a pivotal role in cultivating the next generation of bamboo professionals, further advancing Ethiopia's bamboo industry.



Schematic of the fabrication and directional illumination of the laser-driven bamboo diffuser composite material. Credit: Zhang et al. (2024)

Bamboo breakthrough: Pioneering directional laser illumination technology

Laser illumination, known for its powerful brightness, precision, and intelligent control, is emerging as a game-changer in next-generation lighting technology. It is widely used in areas such as aircraft landing lights, underwater searchlights, deep-sea exploration and optical communication. These lighting systems typically combine LEDs with specialized optical components, like diffraction gratings and lens arrays, which allow for adjustable beam angles and light polarization. However, despite advances in nano-optical design, these devices still face challenges, including low energy efficiency, limited brightness and cumbersome manufacturing processes.

With the growing global demand for green energy and sustainable materials, bamboo has emerged as an ideal alternative to traditional materials due to its renewable and biodegradable properties. In recent years, scientists have explored the potential of bamboo and integrated it into modern technology in novel ways, from architectural structures to optical devices. A research team from the Chinese Academy of Forestry has recently developed a laser-driven bamboo diffuser composite material to successfully convert blue laser light into directional white light illumination, offering an innovative solution for next-generation lighting technology.

Traditional directional lighting devices, which combine LEDs with complex optical components such as lens arrays, often struggle with low efficiency and complicated manufacturing processes. Inspired by the natural structure of bamboo, the research team took a different approach. They infused fluorescent materials and resin into bamboo pores after removing the lignin, the substance that gives bamboo its rigidity. By aligning the bamboo fibers in a specific direction, they created a "bamboo-based laser light source." On a microscopic level, the material behaves like an optical microcavity, reducing light loss while significantly improving light transmission along the fiber's direction. As the light bounces and scatters through the bamboo, it produces an elliptical beam in the perpendicular direction, resulting in highly directional laser illumination.

Tests revealed that the bamboo-based material directs light more efficiently, creating a concentrated and consistent beam as it travels. This improves light transmission efficiency by about 40% compared to traditional devices, while also making the manufacturing process simpler and more cost-effective. The natural porous structure of bamboo evenly diffuse the light, reducing the risk of performance issues caused by errors in artificial nano-optical components. This breakthrough not only adds to bamboo's long-standing legacy—from its early use in light bulb filaments to modern construction materials—but also introduces a sustainable, high-performance option for directional lighting in areas like deep-sea exploration and optical communication.

Summary of article published by Zhang et al. in *Advanced Functional Materials* (2024).

EVENTS

21-23 January
Expert Group Meeting on Strengthening the Engagement of Regional and Subregional entities in the work of the United Nations Forum on Forests (UNFF)
Bangkok, Thailand

27-29 January 2025
Ministerial Conference on the Deployment of Payments for Environmental Services (PES)
Democratic Republic of the Congo

8 February
Multipurpose Bamboo Center in Bonke District
Ethiopia

3-5 March
Marine-based Products and Services Expo
Geneva, Switzerland

7 March
Graduation of the third cycle of the Workshop School of Sustainable Bamboo Construction in Manabi
Ecuador

8 March 2025
International Women's Day

17 March - 15 September
INBAR International Photo Competition 2025
Global

21 March
International Day of Forests

22 March
World Water Day

For more information, please see INBAR's event page: https://www.inbar.int/events/.

The Multipurpose Bamboo Center opens in Ethiopia as part of the Bamboo Supply Chain Development Project.

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