



12th World Bamboo Congress

Taiwan, 18-22 April, 2024

www.worldbamboo.net



Archaic image disruption of bamboo: Art, design, versatility, industrialisation, sustainability

Debika Biswas *

Ministry of Micro, Small & Medium Enterprises, Government of India, Bamhue, Navi Mumbai, India.

Abstract

This paper delves into the Evolution & rationale for the foundation of *Bamhue Innovations*, in reinventing bamboo with the attempt of sustainable value creation, through its aesthetic innovation, inquisitive exploration into material science and practical execution across combination design in making it globally accessible and useful. This paper entails the panoramic capture of the essence of bamboo travelling across the landscape of history and tradition to future and innovation. It covers the significance of *the growth drivers*, which have been symbiotic to the evolution of the nation's bamboo sector, majorly contributing and conducive towards the formation of a bamboo-focussed brand in India. The presentation covers the exploration of the scope of developmental areas towards transforming and creating *novel bamboo products* in decor, lifestyle, stationery and gifting sectors in conceptualising and crafting unique, innovative and functional products with the vision of *environmental sustainability*. The unique creations around *contemporary art* (Modern & Heritage) and *designs* in Home & Living; each articulating a novel story of its own, are instrumental in the bold and holistic image makeover of bamboo in its functionally accessible form. This paper will also deal with exploring the scope of *industrialisation* of bamboo via mass production and through the variety and versatility of bamboo's material science as a viable sustainable lifestyle alternative at a scale, through employing its diverse forms: Timber, Fabric, Paper in combination designing. This is an attempt at breaking the stereotypical adage and preconceived limitations through experimentation and innovation of bamboo beyond the limits of its visual appearance and beyond the notion of bamboo being limited to timber as a viable sustainable lifestyle alternative.

Keywords Bamhue Innovations; Growth Drivers; Novel Products; Environmental Sustainability; Contemporary; Art

**Corresponding Author: Debika Biswas, Ministry of Micro, Small & Medium Enterprises, Government of India, Bamhue, Navi Mumbai, India.*

1. Introduction

The quest for discovering that one element of nature with high sustainability, material versatility, high replenishment rate and design flexibility didn't take much of the doing by the virtue of Bamboo's pervasive existence in a nation like India with second largest global produce. Author's vision and idea of environmental sustainability germinated finding its base with an in-depth exploration of Bamboo, the emblem of resilience and adaptability, interwoven into the fabric of India's environment, culture, and economy for centuries. Its roots in Indian society extend far beyond its functional use (in its traditional form) of augmenting the daily life of rural India across generations, but also has been central to traditional craftsmanship, where it's been transformed into everything from simple tools to intricate craft pieces, moreover playing a key role in spiritual and cultural rituals, underscoring its deep connection to Indian heritage. In contemporary times, bamboo has emerged as a vanguard in India's shift towards sustainable materials, marking a pivotal transition from its conventional roles to cutting-edge, eco-friendly applications. This shift is not merely a change in usage but represents a broader transformation reflective of India's commitment to eco-conscious practices. This evolution signifies the integration of age-old wisdom with contemporary technological advancements, positioning bamboo as a beacon of innovation in sustainable living. Today, bamboo is more than just a resource; it represents a paradigm shift in India's approach to balancing ecological preservation with economic development. The story of bamboo's metamorphosis in India is a vivid illustration of the country's adaptability and foresight in environmental stewardship, cementing its status as a leader in sustainable practices and green innovation on the global stage.

1.2. Historical Context

In India's rich tapestry, bamboo has been more than a plant with 125 indigenous and 11 exotic species from 23 genera; it's a cultural emblem. Its utility in rural home construction speaks to its robustness and ease of access, an essential aspect of village architecture. Bamboo's influence in the handicraft industry has been profound for centuries across India's diverse landscape; artisans across the states have long harnessed bamboo to create a vast array of items, from utilitarian baskets, toys, decorative objects to elaborate musical instruments, geographically specific to their culture of design. It has been beautiful to explore and find out the ingrained cultural glimpse of elements of form, design and craft in Bamboo, whilst navigating through the states and regions of India. This not only showcases regional artistic diversity but also underlines bamboo's versatility. Economically, bamboo has been a lifeline for numerous communities, anchoring its significant portions of rural economies, in providing sustainable

livelihoods and contributing to socioeconomic development. The cultivation practices of bamboo, varying across India's diverse climatic zones, are a testament to its ecological adaptability. In bamboo dense regions of India such as the Northeast, bamboo is not merely a crop but a vital component of the local ecosystem, cultivated through practices that are sustainable and deeply rooted in traditional ecological knowledge. Knowledge of this rich historical context of bamboo in India is crucial, as it sets the stage for understanding its contemporary relevance and potential. It underscores a deep connection between the land, its people, and this versatile plant, forming a foundation upon which its modern applications and innovations are built. This historical perspective is essential for a comprehensive understanding of bamboo's role in India's past and its promising future.

1.3. Scientific Context (Anatomy, Morphology, Characteristics, Composition) For Choice & Utilisation

The scientific understanding of Bamboo, its make, types, parts, sizes, characteristics etc are significantly inevitable for the author towards its behaviour analysis in holistic utilisation as the primary material of building objects of size, design and medium, from the product building perspective. This sub section covers a typical understanding of Bamboo, the primary raw material, is a diverse group of mostly evergreen perennial flowering plants making up the subfamily Bambusoideae of the grass family Poaceae. As per the anatomy and morphology of bamboo, there are different parts, which need to be understood, starting from the Rhizomes, which constitute the heart, brain and leg of bamboo combined together, spread out and generate the growths that will become new shoots and culms, through Buds. It is for the rhizome growth system, bamboo qualifies as one of the fastest growing plants, registering itself in the Guinness Books of World Records. Nearly 100 genera of bamboo, and more than 1,500 species, are classified into runners and clumpers. Running bamboo has what are called leptomorph or monopodial rhizomes, which grow horizontally away from the main plant, causing it to spread out, sometimes quite aggressively. Whilst, the clumping bamboo has what we call pachymorph or sympodial, staying pretty close together, and will stop spreading once they reach a certain size. Presence and absence of Sulcus groove (Running along the Internodes) identify running and clumping bamboo, respectively. Speaking of the Bamboo roots, it is not to be mistaken as Rhizomes both functionally or physically, wherein the roots, emerging out of the rhizomes, typically function like the food channel. Bamboo shoot is the bud developing out, whilst the Culm Sheath is the bamboo shoot leafing out from the Node anatomically to a specialised branch. Its shape plays a major role in marking a differentiation amongst the species of bamboo. These sheaths peel off and drop for the shoot to graduate into a culm, which will continue to

grow some branches, contributing to the overall height of the plant. The solid ring around the hollow culm is defined as the node or nodal joint, appearing typical to any grass. Moreover, a closer examination of the nodal joint can often be very helpful when it comes to recognizing a bamboo species. However, it is the morphology of bamboo flower, plays the most important role, like any typical flower, towards the classification and determination of the species. Internodes constitute the hollows, in some cases solid spaces in between the nodes, varying in their lengths, based upon the species and the amount of water and direct sunlight a plant gets. The aforesaid comprehension helps in understanding the material of construct with a wider perspective in design and application conceptualisation. Be it, whether the culm sheath to be used as a broad sheet of art or its avoidance in utilisation of any kind of culinary use due to the surfacial deposit of the white powdery substance. Rhizome artefacts have been an age-old form of bamboo craft; boiled and fermented bamboo shoots of many species are widely edible, and so are the processed bamboo leaves, alongside contributing to medical science. In specification to the size and dimension determination of product making, the internodal length, width and make (Hollow or Solid) play a major role, as characteristics by making the right choice of bamboo species. *Bambusa nutans* is used to make a 22 inches tall Bamboo Vase, Lego, a contemporary Bamhue Vase. *Dendrocalamus giganteus* with 7 inches diameter, is being used for crafting a wide wall mask for Bamhue. The choice of bamboo type (Running & Clumping) and species remains crucial for setting the primary base for product development. Furthermore, in exploration of Bamboo's multifaceted and rich qualities, bamboo is characterised as the fastest growing plant with certain species growing 91 centimetres (36 inches) within a 24-hour period. Bamboo's capacity to generate 35% more oxygen as compared to trees and absorb five times more oxygen, compared to pines, ease of cultivation, shorter harvesting time, material versatility, tensile strength higher than steel's, abundance in quantity, had only made the hypothesis stronger in choosing bamboo as the primary material of Sustainability. Yet, the chemical composition of bamboo, composed of Cellulose, lignin and silica, is susceptible to mould and attack by fungi because of its high content of starch and sugar. This continues to be a major durability risk and challenge to mitigate in a sustainable manner for the entire bamboo industry.

1.4. Transition/Drivers to Modern Use

The focus of the paper lies in the reinvention of bamboo in disrupting the archaic image in its traditional form and exploring through the augmenting factors to leverage upon the drivers. In India, the transformation of the bamboo sector represents a significant shift from traditional utility to modern innovation, driven by policy reforms, technological advancements, growing

sustainable mindset, increased bamboo sensitisation, etc. This evolution aligns with India's broader environmental strategies and economic aspirations, showcasing bamboo's potential in sustainable development. These drivers have led to the creation of a developing ecosystem and a conducive environment for the bamboo focussed brands like Bamhue.

It comes across as a great deal of support towards a blooming bamboo industry, primarily the policy change that catalysed the bamboo industry's growth with the reclassification of bamboo from a 'tree' to a 'grass' under the Indian Forest Act. This reclassification simplified legal and bureaucratic hurdles, encouraging entrepreneurship and investment in the bamboo sector. It marked a decisive step towards commercialization and large-scale cultivation, enabling easier transportation and trade of bamboo products. The government has played a major role be it with revamping of stringent laws or with the promotion of bamboo at a higher and industrialised state. Technological Advancements have played a major role in recent years in redefining bamboo's applications. In India, Bamboo has been a part of rural livelihood in its non-industrialised, untreated, archaic, traditional form with limited technical applications and urban exposure. However, there have been technological innovations with Modern processing techniques that have enhanced its durability, strength, and aesthetic appeal, making it suitable for a wider range of products and industries. Innovations in preservation and treatment methods have extended bamboo's lifespan, boosting its competitiveness with conventional construction materials. Sustainable Development and Environmental Impact has been another driver in the modern use of bamboo, closely knitted to sustainability goals. Bamboo's rapid growth, abundance and carbon sequestration ability adds up to its promotion, making it a critical component in combating climate change. Its use in eco-friendly construction, furniture, and textiles aligns with global trends in sustainable living. The positive Economic Implications for a bamboo heavy nation remain endless, which comes with the foundation of the modern bamboo industry. The demand for sustainable materials in global markets has opened new avenues for bamboo exports. Additionally, the rise of bamboo-based enterprises offers employment opportunities, contributing to rural development and economic diversification. Bamboo's Integration with Modern/contemporary Industries such as construction, textiles, and renewable energy further demonstrates its versatility. In construction, bamboo is being utilised for sustainable housing and infrastructure projects. In the textile industry, bamboo fibres are being used for eco-friendly fabrics, combining sustainability with comfort and style. The energy sector explores bamboo as a renewable resource, producing biomass energy as a cleaner alternative to fossil fuels.

Despite these advancements, the primary challenges remain, starting from lack of high quality skilled manpower, perennial availability of manpower with dependency on other farming activities for livelihood, Lack of advanced R&D, lack of awareness, knowledge & know-how for ecological bamboo development to lack of industrialisation of bamboo. The challenges of transition lies in adapting traditional bamboo craftsmanship to modern industry standards, ensuring sustainable harvesting practices, and competing with synthetic alternatives. As they say, "Necessity is the mother of Invention", and there comes an attempt like Bamhue in paving its way to rediscovering bamboo as a contemporary design and conceptualisation of industrialised products in pursuit of transitioning into the diaspora of innovation and simultaneously mitigating the primary challenges in the long run towards catering to a broader set of beneficiaries of environmental sustainability. Moreover, addressing the aforesaid challenges requires a multi-faceted approach, including policy support, skill development, and public awareness campaigns. The future of bamboo in India hinges on continued innovation, sustainability, and market expansion. Emphasising research and development, fostering international collaborations, and promoting bamboo's ecological and economic benefits are crucial for its growth. This journey reflects a broader narrative of innovation, sustainability, and economic resilience, positioning India as a leader in the global bamboo sector.

1.5. Foundation of Bamhue Innovations

Foundation of Bamhue Innovations lies in the identified market gap of conventional designs and industrialisation of bamboo in its transition and entry to the modern bamboo industry in the urban markets. Focus of this project lies in innovating around the usability of bamboo in its versatility and industrialisation through design, art, aesthetics & technology, weighing the convenience of the end users with a multidimensional approach/projects, penetrating various industries through a green business model and development of rural economy. The quest began with visiting the traditionally existing bamboo crafts across the rural geographies of India, in exploration of the age-old craftsmanship of bamboo, whilst trying to assess the scope of urbanisation of the archaic model of design and operations through innovation.

1.6. Bamboo, As Contemporary Design of Art & Decor

The plethoric omnipresence of bamboo craft has been evident in rural India in its untreated and achromatic form of traditional designs, ranging from the objects of utility and decor. The observation and scope of transformation lies in design transition, creative development and chromatic art implementation put together into the conceptualisation of contemporary bamboo products.

1.6.1. Steps

Observation of the genre and techniques of the Age-Old Craft for future design assessments: As a new entrant in the bamboo industry it was significant to understand the existing age-old designs and genre to comprehend the artisanal capabilities and competencies in assessing their ability to create our perceived designs. These designs include from intricately thin knitted craft of bamboo to solid bamboo craft work. The thinly sliced bamboo ribbons have been used to create objects defying the fixed shape and size of the chosen bamboo species, with multiple techniques of knitting, mimicking the conventional shape of the object, majorly baskets, lamps, boxes, toys etc. however, for the solid bamboo craft where the bamboo poles were directly used and shaped to obtain the required object's shape like pen stand, tubular vases, wall masks with the use of basic carpentry tools.

- **Identification of Decor/Utility Objects in demand**

The next step was to finalise on the list of objects to be designed and curated as the product of Bamhue, to startoff in the decor and the lifestyle segment in alignment with Bamhue's market research and overall market demands. The range of selection included lanterns, Table lamps, hanging lamps, wall masks, Vases, Art Canvas, Penstand, Ashtrays etc

- **Conceptualisation of Design and Art towards innovation of a Contemporary product fitting into the urban landscape:**

The product design was conceptualised keeping in mind the factor of urbanisation in reinventing the bamboo products whilst breaking free from the tag of poor man's timber, where the idea was to create a design matching the modern taste without losing the ancient/vintage charm of the existing product. The element of art was added to complete the contemporary designing alongside hueing it with the complimenting and subtle color and design of art, allotting a contemporary identity to the product.

- **Ethical Sourcing of Bamboo**

The process of product development begins with the selection & sourcing of bamboo species as per design needs, wherein the species selection goes hand in hand with the comprehensive understanding of the size, dimension, parts and subparts of the product. The selection is dependent on the internodal length and diameter of the poles matching the dimension of the product and the availability of the bamboo type and species within the local vicinity.

- **Treatment for Material Durability**

As described previously, bamboo as a natural resource is prone to fungal attacks due to its high sugar content, hence it is prudent that its proper treatment process is carried out to keep a check

on the durability of the finished product. The treatment of bamboo plays a crucial role in provision of durability to the creation of bamboo products, and it is imperative on the bamboo industry to maintain an environmentally sustainable process for the same. Here is the detail of the bamboo treatment process as had been followed during this project execution. Water solution with five percent concentration of boric and borax powder was dissolved in the ratio of 1:1.5 at the temperature of 50 degree Celsius and 65 degree Celsius, respectively, for soaking the bamboo for 5 days, further to be sun/air dried for another 7 days.

- **Prototype Creation**

The design conceptualisation creates the base for the product prototype. For the simplicity of understanding, one of the contemporary designs and creations of Bamhue, has been represented as an example of the process execution. The design conceptualisation and execution of a Bamhued Lantern, a.k.a The Green Dawn will be described as reference. The make of lantern has been divided into three parts, a) the primary structure comprising the body with the top, bottom and side support, measuring 14 inches in length and 6.5 inches in width b) the spindle-shaped glass part of the lantern and c) The saucer shaped bottom cover. *Bambusa nutans* was identified as the selected species of bamboo with available internodal length upto 22 inches for the ease of slicing, peeling and obtaining and knitting with longer bamboo ribbons. The design idea for the lantern was to use the combination of five intricate knitting design patterns to compliment the different parts of the lantern in enrichment and implementation of the traditional design with utmost importance to the structure's sturdiness. Addition of elements like a bamboo circle on the top and the handle, attached with the metal nut and bolt in addressing the functional aspect yet retaining the vintage look of a traditional lantern(Fig.1). Speaking of functionality, a movable brass bracket lamp holder with electrical connection was integrated, attached to a circular cut ply board of one inch diameter for the ease of changing the bulb in conjunction/limitation with the existing shape of the product. The base of the lantern is utilised as a storage space for the electrical wire of 1 metre to be then covered with a knitted bamboo saucer. These functional attachments along with the design modification contribute towards the contemporary creation of an existing, semi-functional, untreated age-old product. Then begins the transition of making the Green Dawn, with the implementation of contemporary art in the form of line art and, in tribute to bamboo, often addressed as the Green Gold. Green Dawn is representative of the sap green line art painting with the touch of gold, portraying the flexibility and colour of bamboo as a material. The lantern once lit is the exact expression of the word Green Gold, where the term Gold has been replaced with 'Dawn' in the

warm mistiness of the effect created by the Bamhued Lantern. For the prototype creation, each part of the lantern is separately created to then get assembled as a whole.



Figure1. Contemporary Design with Functionality & Retention of Vintage Look

- **Training & Development for Artisans and Nurturing Artists**

Training of artisan was mostly around design sensitisation and the treatment process. It involved handholding, trial and error, and required shape formation augmented by the original parts of a typical lantern. Training of a few village women was imparted to execute the abstract artwork making it a contemporary and distinct piece of design.

- **Functional Attribute and Aesthetics:** Addition of the functional aspects like the electrical fitment is then executed by the team of carpenters and electricians in line with the technical build of the product. The aesthetics part involves the neatness of the artistic execution and addition of branding accessories such as the honey wax seal logo of Bamhue, further adding up to the uniqueness of the product.

- **External Durability & Product Lusture**

The product is then coated with the Natural varnish, either in glossy or matt finish depending on the design specifications for lustre and external safeguarding from moisture or wear and tear of the weather.

- **Quality Check & Product Release**

Once all of the aforesaid processes are completed, the product then passes through the quality check procedure of ticking off the design and execution checklist for it to be released in the market.

- **Outputs**

Creation of over twenty product designs in less than one year across Home-décor, Lifestyle & Stationery segments, which involved ideating on marrying art with craft, creating modern

designs to satiate contemporary décor & lifestyle needs, with an earthen handmade, yet technically equipped and durable approach, hand - hued with the fusion of art towards urbanisation of bamboo. The product range included contemporary art pieces of lantern, lamps(Table + Hanging), vases, Wall masks, Art Canvases with ancient & modern art, Pen Stands, Pencil, Pen, Baskets, Boxes, Ash trays, Jewellery, etc.

System & Process Setup was defined towards an automated execution system with a contingency plan to mitigate over dependencies and for achieving an efficient and effective process of operations. Small Treatment units had been set up in each of the artisanal locations along with a well-defined process handbook in the respective regional languages for guidance purposes.



Figure 2.
Representation of
workshops/training and
treatment setup facility

Skill Enrichment of Artisans remained as one of the positive outcomes of project Bamhue, which has been instrumental in addressing the nation's challenge of skill gap in bamboo industry. Employment generation opportunity for the underprivileged class of society resulting in rural economic development. Product Appreciation and acceptance amongst the targeted crowd, i.e. the rural population. The popular feedback hovered around the uniqueness and functionality of the product.

- **Learnings**

There exists a gap in understanding the scientific aspect of bamboo with the lack of technical knowledge amongst the artisans around the process and significance of treatment, concept of durability, and addition of requisite functionality to the products for its holistic utilisation with proper finishing. A lack of flexibility to learn new concepts and adaptability to the change and processes were the other stumble blocks, however provision of a clear vision had proved to be of some help during the knowledge transfer.

A perennial issue of Manpower Crisis during the sowing and the harvest seasons, wherein the artisans indulge themselves going back to their regular farming activities for their livelihood. This is indicative of the lack of opportunities in the bamboo sector to completely fulfil the financial needs of the artisans and craftsperson's, leaving a room of improvement for brands like Bamhue towards a strategic manpower intervention. Manpower strategists like the author of this paper with years of experience in human resources management, need to come up with both tactical and long-term manpower planning and growth plans to mitigate this issue.

The Skill and genre of bamboo craft changes with the changing geography hence leaving a vast array of design reinforcements and opportunities for product development. The design genre in the east covers a more intricate element than that of the south and west of India. The element of art and colour is to be seen in the southern part of the country, specifically in Kerala. It is the impact of the existence of a well-established and globally recognised bamboo organisation, Uravu, that the state sees well finished and treated bamboo products with a proper development of the ecosystem, setting inspiration for bamboo entrepreneurship in India.

Optimal utilisation of resources and effective time management become a major learning whilst working with a natural resource like bamboo. Bamboo product making is dependent on the internodal size and dimension of the poles, which increasingly varies from the bottom to top of the pole, leaving behind only a limited part of the bamboo to be utilised for the targeted product development. This has been taken care by putting the leftover internodal pieces to use for smaller product making and storage of the bamboo waste for charcoal making. Time management becomes imperative towards the entire process, especially during the procedure of treatment and drying. A measured approach is significant right from the calculation of age for bamboo harvesting, to calculating the proportions of borax-boric during the treatment process, wherein the solid bamboo treatment is more intensely done over the treatment of bamboo ribbons. Proper drying of the treated bamboo is very important before starting off with the product development phase for durability purposes.

1.7. Industrialisation of Bamboo (Product Manufacturing in Scale & Diversification)

Bamhue's idea of industrialisation of bamboo is rooted in fast tracking the process of manufacturing in lesser time towards the implementation of scalability and attaining a global reach in reinventing bamboo as the primary material and a sustainably viable alternative to product development. Diversification of products in exploring the wide range of mediums that bamboo has to offer appears just like a catalyst in the innovation and development of the bamboo industry.

1.7.1. Product Manufacturing Targeting Time & Scalability

Here the idea of the author is to go beyond the handcrafted and time-consuming approach to a more scalable, cost effective & time efficient manufacturing of viable bamboo products as a sustainable alternative, in quantity, yet retaining the quality and aesthetics of the craft in functionality with integration of technology and machine for production efficiency and effectiveness, whilst promoting eco-consciousness with a larger impact.

1.7.2. Steps

- **Selection of the object to be manufactured in scale**

The thought of environmental sustainability runs parallelly alongside the thought of cutting down the consumption of plastic in cleaning the environment. Bamhue's focus in making bamboo buttons has to do with the same concern of eliminating the over-saturated plastic button market, fair market opportunity for sustainable buttons and at the same time selecting an object as small as a button for the sake of simplicity and conciseness of the experiment. This experiment has been conducted in Bamhue's workshop in Pondicherry, that's in the southern part of India.

- **Choosing the right Bamboo & Creating the base for Button Making**

Ethical sourcing of matured bamboo ageing 3-6 years with lesser amount of starch and sugar from the local farmers for creating bamboo reapers to be used as the base for button making. Bambusa Tulda had been used for its significant involvement in the area of handicrafts and bamboo product making and also for the ease of availability.

- **Treatment for durability**

Flat bamboo reapers are put to the borax- boric treatment for material durability and are dried to be ready for product development

- **Product Prototyping**

It involved understanding of the technicality of the button industry, starting from the terminology to the technology of button making , benchmarking the established players and creating products par quality. The button sizes are measured in the units of Ligne(L- Size Code) based upon its association with the parts and types of clothing. Button designs were created with sizes ranging from 18 Ligne to 40 Ligne with a thickness of 3-4 mm. A few handmade buttons were created and pyrographed as a part of prototyping and cost analysis.

- **Product Development & Finishing**

The first batch of laser cut buttons (Fig.4) was created, followed by the artistic implementation on the buttons with designs through engraving machines, followed by buffing of the buttons. Some of the buttons had been pyrographed as per the market need. The final finishing was done with application of natural varnish coating for adding the lustre to the finished product.



Figure 3. First Batch of buttons

- **Quality Check & Product Release**

The process of quality check is done through ticking off the design and operations checklist for the final product dispatch.

- **Outputs**

A batch of 1250 buttons with a production time of one minute per unit were created with minimum involvement of manpower and process glitches. All the buttons were sold out to an India-Euro based handloom brand.

Product appreciation and acceptance by the who's who of sustainable clothing in the global market, establishing a market fit.

- **Learnings**

During Bamhue's research, it was found that the button market uses the terminology of natural button, making it sound synonymous to sustainability, which also includes non-sustainable materials like pearl, etc. This in turn opens up the scope for a highly sustainable material like bamboo in the button industry, also paving the way for the industrialisation of bamboo.

Drastic curtailment in cost with the usage of laser & engraving machinery, creating a way forward to scaling and attaining a market friendly cost, unlike in the case of handmade bamboo buttons.

Industrialisation of bamboo negates the existing manpower crisis in the bamboo industry with a machine dependent production line and minimum training requirements with automated processes.

1.8. Product Innovation Across Material Science & Combination Designing

This is an attempt to attain the objective of industrialisation through exploration of bamboo's versatility as paper and fabric with the elements of combination designing across the material science of bamboo and other sustainable materials. Variety remains as significant as scaling, and bamboo being the sustainable epitome of versatility and diversity, just widens the scope and makes it easier in plugging it with our vision of utilising bamboo beyond the scope of wooden material.

1.8.1 Steps

Selection of Object for product innovation across material science and combination designing
The product selection was done keeping in mind the usage of bamboo fabric and paper, alongside the market demands of such objects. Sustainable Laptop Backpack, Drawstring Bag, Comfort Bamboo Chair, Bamboo Folder, Notepad and files were the selected options for the design experimentation.

- **Sourcing of raw material**

The required raw materials such as Bamboo Canvas Fabric of 400 gsm, Bamboo Fabric of 180 gsm, bamboo paper of 110 to 250 gsm was sourced along with the readiness of treated bamboo reaper and accessories towards the usage of combination designing. The sourcing partners were

verified around the required certifications of bamboo content in the respective fabrics and papers.

- **Product Designing**

The prototype designing was executed by the author keeping in mind the elements of combination design. For the simplicity of understanding, the design prototyping of the laptop backpack is presented here. The idea of design conceptualization was to make the people identify the backpack as a bamboo backpack through its visuals(Fig.5). Hence bamboo reapers were used in creating the front section of the backpack for the storage of books, newspaper etc. also giving it a semi-transparent cum opaque look. For the backpack two mediums of bamboo, namely bamboo canvas fabric and bamboo in its wooden form were used. The accessory design included bamboo timber (soft textured wooden bamboo chain holders, bamboo wooden handles, Bamboo Label for branding) , brass adjustment buckle , laptop pad made of jute and cotton.



Figure 4. Reference design of Bamboo Backpack

- **Product Prototyping & Aesthetics**

Product prototyping of the backpack was done in collaboration with a local tailor in alignment with Bamhue's product design and aesthetics standards through proper communication of the sketch and placement of the elements in creation of a contemporary piece of design.

- **Product Development in Scale**

Here, the idea of product manufacturing in scale is by forming Strategic Partnerships with Bag houses, Paper Houses, and Established Bamboo players with high end machinery to execute Bamhue's concept design in the respective production houses, as per the shared modus operandi.

- **Quality Check & Product Release**

The standard quality check procedure is followed on receipt of the finished products through necessary actions and ticking off the design and quality checklist for the market release.

- **Output**

Innovative and novel products were created as an outcome of this exercise. In addition to the Bag pack, Drawstring bag made out of knitted bamboo fabric and accessorised with bamboo timber, bamboo notepad, with the combination of bamboo paper adorned with bamboo branches and a comfort cum meditation chair made out of flat bamboo sticks and woven bamboo canvas fabric were created.

The combination design has itself proven to be an 'aesthetics-enhancer' by the virtue of adding diversity to the vision of the product and seems to be a promising design project and game changer for the bamboo industry.

Receipt of Product appreciation across the social media platforms and incoming purchase queries are evident of the idea validation for market entry and demand generation perspectives.

- **Learnings**

There is an existence of a sustainable ecosystem to venture out of the arena of combination designing with easy availability of sustainable materials like jute, hemp, honey wax etc. This is highly supportive and instrumental towards the growth of industrialising bamboo through combination designing.

The strategic partnership with big players could help small players in the industry to fast track the growth of the bamboo sector with minimum resources through provision of economies of scale and expertise.

2. Materials & Method

2.1. Basic Raw Materials

Bamboo (*Bambusa nutans*, *Bambusa tulda*, *Dendrocalamus giganteus*) is sourced from the locally grown cultivation from farmers in West Bengal and Pondicherry. Bamboo fabric, Bamboo paper, product accessories as previously defined and natural varnishes were primarily used as raw material.

2.2. Tools & Machinery

Creation of the handcrafted products majorly included carpentry tools like handsaw, hacksaw blade, chisel, knife, hammer, marking/measuring tools etc. However, for button making a more advanced laser cutting machinery and buffing machinery were used. For the project of combination design, tailoring and stitching tools and paper binding machines have been used. Art Tools and material include chisel, hammer, pyrography pen, paint brush, acrylic paint.

2.3. Method

“Art and Science have their meeting point in method”-Edward G.Bulwer.Lytton. The essence of Bamhue’s project lies in the above statement reflecting on the idea of reinventing bamboo products in fusion of technology/functionality and craft. The ideation and creation of all products sees the light of the day when the craft gets married to technicality, whilst providing user convenience.

3. Green Economy Business Model & Rural Development

Bamhue’s business operations hovers around creating a green economy business model as evident from the outcome of all three of the aforesaid projects as experimented and executed by the author with the purpose and base of creating a bamboo venture with utmost sensitivity towards integration of sustainability in each of the business operations , be it the sustainable packaging (Fig.6), or the Borax-boric treatment process which is not harmful to the environment, or usage of natural varnishes and linseed oils over petroleum-based varnishes, or be it waste management through utilisation of the leftover bamboo towards creation of smaller products. The future plans include plantation of bamboo for increased oxygen contribution, Carbon dioxide absorption and rehabilitation of degraded industrialised land towards creating a green business model. Working with bamboo boils down to working with the cultivators, preservers, craftspeople, also aligning with the author’s vision of community development and promoting rural economy. Development of rural economy is not only restricted towards the financial support or remuneration, but also in overall training and development of the craftsmen in making them self-sufficient with their skills and competencies in a country like India, where majority of the rural population with majority of the access to bamboo, also the age-old consumers of bamboo remain unaware to maintain the durability of bamboo as building and lifestyle supporting material.



Figure 5. Representation of Sustainable Packaging

4. Way Forward

- **Contemporary Applications**

The current landscape of bamboo usage in India demonstrates a remarkable transition, leveraging its unique properties for innovative and sustainable applications. This shift is reflective of the broader global movement towards eco-friendly materials and practices. There exists plethora of scope for bamboo focussed brands, a few of the industries could act as a catalyst for innovation in the bamboo sector.

- **Construction Industry**

Bamboo's role in the construction industry has been revolutionary. Its lightweight yet robust nature makes it an excellent choice for sustainable building, particularly in earthquake-prone areas. Innovations in bamboo architecture have led to the development of cost-effective, eco-friendly, and resilient housing solutions. These structures not only provide a sustainable alternative to traditional building materials but also showcase bamboo's potential in modern architectural design.

- **Textile Industry**

In the textile sector, bamboo has emerged as a sustainable alternative to conventional fabrics. The development of bamboo fibre, known for its softness and breathability, has been a game-changer in the textile industry. This eco-friendly fabric is increasingly being used for a wide range of clothing and textile products, appealing to environmentally conscious consumers. The use of bamboo in textiles highlights its versatility and aligns with the global trend towards sustainable fashion.

- **Renewable Energy**

Bamboo's application in the energy sector is a testament to its versatility. Bamboo biomass is being explored as a renewable energy source. This sustainable approach to energy production not only provides a cleaner alternative to fossil fuels but also contributes to reducing carbon emissions. Several projects across India are harnessing bamboo's potential in this field, marking a significant step towards sustainable energy solutions.

- **International Collaboration and Global Market Integration**

International collaboration has always been pivotal in the advancement of India's bamboo industry, allowing for a meaningful exchange of technology and expertise. For instance, partnerships with countries excelling in bamboo technology, such as China and Japan, have facilitated the transfer of advanced processing techniques to Indian manufacturers. These

collaborations have enabled the adoption of innovative practices in bamboo cultivation and product development, enhancing the quality and diversity of Indian bamboo products. The integration of the Indian bamboo sector into the global market has been significantly bolstered by these international collaborations. The exchange of knowledge has not only improved production standards but also opened up new markets for Indian bamboo products. This global integration has led to an increased understanding of international quality standards and consumer preferences, which in turn has driven innovation and competitiveness in the Indian bamboo industry. These international partnerships will only exemplify the benefits of cross-cultural and technological exchanges, leading to mutual growth and development, all the more now with China's recent announcement of the 3 year plan to promote bamboo as an alternative to plastic. The importance of global cooperation in promoting sustainable practices and sharing expertise will go on to leverage the potential of the Indian bamboo industry to make a significant impact on the global stage.

- **Innovation and Technological Advancements**

The Indian bamboo industry is witnessing a surge in innovation and technological advancements. Emerging technologies in bamboo processing have significantly improved its structural integrity and versatility. Modern treatment methods have enhanced durability and resistance to pests, making bamboo more suitable for a wider range of applications. In product development, there's a notable shift towards high-value products like engineered bamboo and bamboo composites, which offer superior qualities comparable to conventional materials. These advancements are not confined to traditional uses; they're paving the way for bamboo's inclusion in more sophisticated industries. In construction, for example, engineered bamboo is being explored as an alternative to steel and concrete, especially in sustainable and green building designs. The automotive industry is experimenting with bamboo-based materials for interior paneling, highlighting its lightweight and strong nature. The future prospects for bamboo in various industries are promising. Advancements in genetic research could further enhance its growth rates and quality. Integration of bamboo with 3D printing technology is another area with significant potential, which could revolutionize how bamboo products are designed and manufactured. In summary, the ongoing innovation and technological advancements in bamboo processing and product development are setting the stage for its expanded role in various industries, aligning with global sustainability goals.

- **Balancing Tradition with Modernity**

In the Indian bamboo industry, balancing traditional practices with modern innovation is crucial. The preservation of traditional bamboo crafts is vital, not only for cultural heritage but also for maintaining biodiversity and ecological knowledge inherent in these practices. These traditional methods, honed over centuries, offer insights into sustainable harvesting and usage, which are invaluable in today's context of environmental consciousness.

Simultaneously, integrating this traditional knowledge with modern technological advancements presents a unique opportunity. By combining age-old wisdom with new techniques, the industry can innovate sustainably. For instance, traditional weaving methods can be adapted for contemporary design aesthetics, while modern engineering can enhance the structural applications of bamboo in construction. This balance ensures that the industry remains grounded in its cultural roots while evolving to meet current and future demands. It's a synergistic approach where tradition informs innovation, leading to sustainable growth and helping maintain the bamboo industry's relevance in the modern world.

- **Challenges and Opportunities**

The Indian bamboo industry's challenges are multifaceted. Environmental sustainability is a prime concern, especially with issues like overharvesting and habitat destruction threatening the ecological balance. In the market, bamboo faces stiff competition from more affordable synthetic materials, impacting its commercial viability. For traditional bamboo artisans, adapting to new market demands and mastering modern design and production techniques is a significant hurdle, necessitating targeted skill development initiatives.

On the opportunity front, the Indian government's proactive measures to promote bamboo use – through subsidies, policy reforms, and support programs – are vital catalysts for industry growth. Furthermore, international collaborations are crucial, offering opportunities for technology transfer, skill enhancement, and market expansion. These collaborative efforts not only enhance the global footprint of Indian bamboo products but also contribute to knowledge sharing and sustainable practices. This dynamic interplay of challenges and opportunities underscores the potential of bamboo as a driver of rural development, environmental sustainability, and economic growth in India.

Conclusion

The transformation of the bamboo industry in India is a striking example of how traditional resources can be reinvented for modern purposes. Historically, bamboo played a fundamental role in everyday life and culture. Today, it has emerged as a symbol of innovation and sustainability, pivotal in India's pursuit of a greener future. This journey of bamboo mirrors India's broader shift towards sustainable development, integrating traditional knowledge with cutting-edge technology. The increasing use of bamboo in various industries, from construction to textiles, exemplifies its versatility and economic potential. These developments are not only environmentally significant but also economically beneficial, creating new job opportunities, especially in rural areas. The Indian bamboo industry's evolution is also a testament to the adaptability and resilience of the Indian spirit. Embracing change while maintaining a connection to cultural roots, the industry exemplifies a balanced approach to progress. Looking ahead, the continued focus on sustainable cultivation practices, technological advancements, and market expansion is vital. This will ensure bamboo's role not only in India's economy but also in its ecological preservation. In the global context, India's innovative approach to bamboo utilization positions it as a leader in sustainable practices. By demonstrating how traditional materials can be transformed into valuable resources for sustainable development, India sets a precedent for other nations. The future vision for the bamboo industry in India encompasses a holistic approach to sustainability. This includes further research and development in bamboo technology, expanding international collaborations, and enhancing the global market presence of Indian bamboo products. Ensuring the industry's growth is environmentally sustainable and socially inclusive will be crucial. In conclusion, the evolution of bamboo in India is more than just the story of a plant; it's a narrative of a nation's journey towards sustainable and innovative development. The bamboo industry, with its blend of tradition and modernity, continues to be a key player in shaping a sustainable future for India and serves as a model for global ecological and economic strategies.

Acknowledgements

The author is grateful to having learnt through experiences being offered by all the stakeholders involved in this project, mostly at the grass root level, specifically in providing a perspective and finding a solution towards mitigating the challenges and limitations of bamboo towards the growth of the industry.

Conflict of Interest

It is hereby confirmed that the manuscript has been read and approved by the named author and there is no conflict of interest. All regulations of our company including intellectual property rights have been followed and there are no impediments to publication.

References

Maria Farrugia; Sai Goutham., 2022. Traditional Methods for Treating Bamboo. Bamboo U, Badung, Bali, Indonesia.

National Bamboo Mission; Department of Agriculture, Cooperation & Farmers Welfare; Niti Aayog; Invest India., 2021. National Consultation on Opportunities and Challenges for Bamboo in India. Concept Note. India. 2, 5, 9, 20, 29, 56.

Fred Hornaday., 2023. Morphology: 9 Parts of the bamboo plant. Bambubatu, San Luis, California