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Review Article

Literature Review on the Bamboo as a Sustainable Material for Interiors with Its Potential and Market Assessment

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Abstract

Bamboo is one of the fastest-growing resources which provide wide opportunities as a cheap raw material to many sectors. Many industries are using bamboo as substitute raw material in different forms and while having a wide chain of demand and supply bamboo does not attain social status in many countries and still been considered as a resource for poor class and named as "poor man timber". This study is trying to find out the properties of the bamboo, it's possible availability, optimum development done in the field of construction and interiors and what are the drawbacks the bamboo industry is facing in its development and acceptability globally.
Keywords: Bamboo, Sustainability, Bamboo Construction, Life Cycle Assessment.

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1. Introduction

Bambooone of the most versatile originated resources which are also known as the "gentleman" among other plants, as per the ancient history the species of the bamboo evolved between thirty million years ago. The major research about bamboo species began after 1920 it is being said that the word bamboo is been originated from the Malay word "mambu" the Dutch-named it "Bamboes" and then it got its neo-Latin name "Bambusa". As per the German Botanist Charles Kunth "of all the grasses, bamboo is the largest and the only one that can diversify into the forest." Bamboo is one of the most sustainable resources which is been used for the production of more than 1500 products from a tiny toothpick to constructing a building. Bamboo has always been known as "green gold" and one of the most sustainable and resistant resources than traditional timber. This literature review is focusing on the different use of bamboo from a constructional material in disaster-prone areas to its use in making fabric which considered being soft and tough like cotton. In this review, the positive impact of bamboo is compared from wood and is been summarized by life cycle assessment (LCA) and why its products are been considered as Green Sustainable for Trade (GSFT). This review is also analyzing the Indian bamboo market, the impediments and issues this industry is facing, and legislative measures that need to be taken for its promotion.

2. Literature Review

Bamboo is the perennial grass that is popular for its multipurpose uses from a wide source of food material to building uses. Due to its multiple-use bamboo possess an enormous potential to improve the rural economy and be a sustainable building material. With the gradual advancement of technology people forgetting the scope of bamboo. This Paper review the future and present role of bamboo in the economy of the country.

The potential economic status of the bamboo market needs good research. Many bamboo laboratories are been engaged in bamboo conservation such as Tropical botanical garden and research institute has 48 species while Kerala research institute has 45 species. Many government institutes have introduced modular courses to develop skills in producing bamboo products among the people. Government Legislation is formed for Keeping a mind-frame of harnessing the maximum benefits of bamboo crops, the Indian government is implementing schemes with the mutual support of people. The bamboo has a huge employment potential of employing 10 million people annually. Women are majorly being associated in some craft industries and 68 million tribal populations depend on the exploitation of non-timber forests. India covers 8.96 million hectares' bamboo forests which produce occupies 129 million jobs or even more. In the global market, India contributes only 4.5% while china shares 50% of commercial production which shows that being one of the largest producers of the bamboo the contribution is very low globally [1].

This paper studies the environmental aspects of bamboo as a building material, its social and economic aspects to understand its sustainability. Being one of the cheap and durable materials it has been suitably developed as a modern construction material. Using bamboo in housing projects is a source of income for people who are involved in bamboo cultivation. Traditional construction technology has been transferred from generation to generation and has become an integral part of socio-culture. The revival of such technology and further its development and transferring the updated technology to the people who are already familiar that it is a key to the success of bamboo sustainability.

For economic and social suitability necessities is ecological development. As per the research, it was stated that bamboo construction is required to promote suitability because of its environmental benefits that can improve social-economic standards. Bamboo though has the potential to be a sustainable material but still, this area requires more studies especially when it comes to social context. Bamboo is being considered for its superior seismic property which is being studied both theoretically and practically. However, studies for Bamboo as a building material are still not been widely accepted and require a better understanding of the socio-economic aspects of bamboo-based construction and further studies should focus on the built-in environment and comfort effect of bamboo-based building construction[2].

The paper is discussing how the bamboo which is been known as the most versatile material with various inputs in building material, paper pulp resources, scaffolding, weaving material, basketry, and medicines can be converted into the main raw material for construction. With new industrial applications and modern construction design, it has been demonstrated that bamboo has huge potential. If the combined value of Bamboo is evaluated around the world, it comes 50000 crores annually which is expected to get doubled in the future. The lack of awareness and antiquated legislation inhibited the bamboo-based industrialization. The authors also stating that the biggest impediments towards the bamboo-based sector are irregular and scant supply to the entrepreneurial use. An efficient regulatory institution is essentials for the market to grow sustainably. Transaction cost must be minimal and information availability is maximal with clear focus maintaining forest cover. The bamboo industry is being caught under the antiquated forest laws. Therefore, it is needed that the industrialization of the bamboo sector can provide a huge link to the rural sector. Despite having detailed estimates on the sizes and the market segments of the bamboo-based industry, the appropriateness, and reliability of the market potential along with the availability and method of estimating are circumspect. The process of consultation is needed with the stakeholder, people associated with resources use, including government officials and a representative from the various bamboo based industry. However, the viable entrepreneurial activity of any bamboo-based product will be the market trend to provide the supply and demand linkages and it's only then livelihood benefits will be possible [3].

The paper is focusing on the sustainability aspects (economic, social, and environmental) of bamboo and shifting from industries to cultivation. The higher demand of timber had led to its gradual depletion of the resources which are formulating global warming and to overcome this issue industry are now focusing on the use of substitute resource from nature for the development of economical substructures. With wide uses and fast-growing properties, bamboo is a sustainable alternative to wood. Its wide range of demand and uses add employment and income generation. The social context overviewed how investment in bamboo industries helping in the livelihood of people and its benefits, risk, and threats. The development in bamboo will add to the ecological balance, struggling industries, and mostly up boost the social of life of the related people. The research showed that the planned and scientific approach to cultivation. With a large range of species, the biomass of bamboo is growing with Bamboo strength. The environment supportive resource Bamboo and the products from bamboo crossed the value of 100 million in global trade. It serves as an alternative to soft and hardwood. The weakness of bamboo is availability in techniques for reproducing of bamboo seeds. It is perishable after its harvesting so it requires proper preservation methods. Bamboo is a heterogeneous material and with properties varying among species to species. Bamboo is a highly opportunistic material and can reinstate products with fossil fuels and chemicals. Replacement of all the needs of timber can be catered with the bamboo and can deploy the pressure on the forest ecosystem. The main threat is a demand for a bamboo product which leads to depleting Bamboo resources. The upboost infrastructure act as a barrier for controlling of a flood, and arresting soil from eroding. In Africa however bamboo can't eradicate all the problems of sustainability like (social, economic, and environmental). Switching to bamboo resources will improve stabilization in the development of its economic structure [4].

This paper is showcasing the facts of the potentiality and properties of the Bamboo as the building material and its comparison with the conventional building material available around the world, construction activity consumes a lot of material and monetary resources, so bamboo can be added as the main construction material which can reduce the bills and add profits to the clients, good jobs and returns opportunity to the farmers producing bamboo. The most important and significant aspect of bamboo is that it can reduce the "carbon footprint" as Bamboo is known Natural material with low energy and can menace the global warming. It is a natural sustainable material which requires nature-friendly preservation methods so we can minimize the use of chemical that are harsh for nature. Bamboo can be shaped to any free-flowing form that can add to a meaningful architecture. The author important aspects of this paper are to present the awareness among the people through the academic platform and draw the attention of all the common people and construction stakeholders [5].

The paper concentrates on ascertain several timber products that influence global warming. The two techniques involved were: the quantification of greenhouse gas of several representatives of wood-based product and the integral environment aspects. The products were divided into indoor and outdoor products which are been sub distinguished into convertible pieces of furniture, headboard accessories, and non-convertible wooden wall playground, etc. According to the assessment results; metal, board, and energy are considered the maximum impact of more than 39% to 90%. As per the review, manufacturing of woods based material such as boards and panels are one of the important process combined with energy production in almost all item. The transport of inputs to the factory and metal production is majorly depending on the products and improvement alternatives for each product under assessment to be set out in the short term[6].

The researchers in this paper are discussing the structural strength of *Dendrocalamusaper* and *Gigantochloa* (bamboo Species) with local traditional wood. He has followed the experimental studies with dry bamboo stripes and oil palm trunk as they are being processed into thin laminates to produce Bamboo oil palm trunk veneer and biocomposites. It has been studied that bamboo furniture is more resistant than traditional wooden furniture. The results also define the strong correlation of bamboo hybrid under screw withdrawal strength but have a weaker mechanical property of the bamboo hybrid due to laminate selection from different inappropriate species. The research aimed to develop wood-like material from a non-wood source to meet the increasing demand for a wood-based products without exploiting forest resources. Further results showed that OPTV composites could be suitable wood alternatives [7].

The paper discusses the environmental behavior of the material in such a way that it can be incorporated directly into a multi-criteria decision problem-solving. The paper discusses the life assessment method tested in parallel and applied to different polymer materials used for packaging. The present review aim was to study the needed to perform analysis when an order process of selecting material and to enhance the environmental performance of the product. To select the product variety of segments, it has to be kept in mind such as cost properties, performance environmental aspects, etc. LCA incorporated environmental aspects that should be used in designing a product. As per designer, obtaining an indication to analyze and evaluate the environmental behavior of material which can be incorporated into the multi-criteria decision. The author supported the paper with simple examples to perform a sensitivity analysis on material selection. Solving the problem of selecting material by using an environmental score [8].

The paper demonstrates a comparison of bamboo and wood. The positive impact of bamboo has been summarized and evaluated by life cycle assessment (LCA). The comparison of bamboo and wood has been detailed and the writers could conclude that product made of bamboo has comparatively less eco-cost than hardwood. Even bamboos that are been imported from Europe have less eco-cost than locally available softwood. The yield of bamboo is high as compared to the other wood. The Bamboo stem is a sustainable solution for local applications. The main hurdle is the transport distance so that local species proves to be a more sustainable solution. Some bamboo products developed and commercially available in Europe are:

- Industrial bamboo in Europe in the form of plywood and SWB (Strand Woven Bamboo).
- Bamboo is an excellent source of biofuel and second grade
- Bamboo products –Mdf Board and Panel Board are good for local use but cannot complete in the European market of soft wood [9].

This paper presents a criterion for selecting material with low environmental impact. The LCA (Life Cycle Assessment) methodology has been applied for wood-based material. In comparison to the wood-based board, the standard particleboard has a lower environmental impact than Standard Fiber Board. The particle board with low formaldehyde is more preferred due to partial replacement of Urea-formaldehyde (UF) resin by Melamine Formaldehyde (MF) resin. An additional process such as cutting and machining is needed to transform the board for making furniture. For surface covering the low-density laminate is preferred than high-density laminate The most impactful stage for raw material is its acquiring time and production which total impact (59.8% and 37.1%). The paper state that from the life cycle perspective, it is important to consider the environmental impact and the entire cycle of the veneer incorporated to the board, additional processes are needed to treat the wood veneer surface [10].

The researcher in this paper aiming for a comprehensive study on the type of materials that uphold on choosing a sustainable material. Studying the chain of Green Sustainable Fair Trade (GSFT) products supply and demand for the developing adequate design. For instance, the desk research of presently available GSFT material was carried. Finally, brief structured interactions with the retailers were carried. The analysis depicted that products of GSFT available at presents like material treatments for ceiling and roof surface including fabrics and window treatments can be sourced from retail outlets. About the Knowledge of ESID Researcher has also elaborated that designers have accepted it but not translated it to processing. The main issues that are been discussed that green-sustainable fair trade product is available for ESID but how this material should be promoted for given sustainable credentials and how designer and public can avail them. The solution is better and complete awareness of sustainability through promotion. The researcher also discusses the difficulties to find out the Provence of the material. By the use of external resources and better material, product selection and comparison can be made effectively. Some solution has also been discussed which need to be improvised such as “Green Shelter” for products, Eco labels which could promote awareness and can become a major remarkable footprint for promoting awareness. Therefore environment sustainability requires a significant change in the value and behavior of interior designers and common sources adaptability [11].

This paper states the application of bamboo elements and their interaction with interior design. The researcher of this paper briefly analyzes how bamboo can be integrated into contemporary modern design, as it is the fastest acceptable material by designer and has been widely used in environmental protection and green building construction. The paper is also discussing the deficiency in the application of bamboo and the challenges of how to make bamboo a separate design element rather than simply a visually appealing material. In the specific indoor space environment, it is necessary to feel bamboo uses and expand the knowledge to common people so that bamboo can be further broadly elaborated and incorporated in the design culture [12].

The paper aims to discuss the understanding of sustainable design and the obstacles that influence design practices. The paper is discussing the finding that is been obtained from the study performed in 2011. The research is considered significant because it is been sharing the outcome that was documented the first time. The conclusion shows that educations and experience inform designers to understand sustainable designs. Designers understanding the sustainable design values affect their behavior, attitudes, and practice following the constitution and building regulation. It determines that the designers are blocked by barriers in the design such as education, cost, product, materials, and rating tools. The research also speculates on the potential transformation of the practitioner. The client solution was established by the study which includes an improved knowledge of sustainable design, implementation of regulation, knowledge, and uses about sustainable materials and educating the client about the product for its wide acceptability [13].

The paper discusses material for sustainable development. The researcher includes what constitutes sustainable textiles. How can textile have formed out of Bamboo resources used for maintaining of suitability? Observations formulated the answer to some aspects. The difference between the properties of chemically manufactured and mechanically manufactured bamboo textiles and secondly, the property difference in the textile obtained from different species like (*Bambusa and Phyllostachys*). The paper states about cotton and polyester fabric that is commonly used in the textile industry and focus on the species of bamboo used as bio-based renewable resources. The fabric formed from bamboo is more soft and little rough, which is mechanically manufactured. The main constraint of the bamboo textile industry face is its cost. The examined issue relates to sustainability was its moisture-wicking and handling. The research was focusing on two aspects –

- Addressing of Bamboo resource for sustainable textile, its pertinent information, its various manufacturing process, its pros and cons in the industry.

- It addresses the experimental part with discussion and limitation under sustainable bamboo textiles. Bamboo is a sustainable textile material but it evolves some drawbacks in its industry like the issues of necessary chemical treatments and consumption of energy and water which could be addressed by loop fabrication and economic tools [14].

This review discusses the functionality of graded material and the development of new better material. Bamboo construction is studied to understand the principle and design process done by biological material. The ability of bamboo has been broadly discussed and stated that its cell can develop the electrical signal. The paper also discusses and explains that electrical properties play a vital role in designing and transforming selection systems and further it has been found that bamboo has a uniform strength at all positions in radial or transverse direction. The ultimate purpose of the study was to understand the design and process of biological materials and finding the direction of new superior material [15].

The paper examines the methodology and relationship between design and its value; exploring the critical elements in the field of development of new products. The paper is evaluating the design elements of bamboo furniture. The author has prepared prototypes by gathering information from environments and these prototype models have been showcased to visitors in the exhibition conducted in Taiwan. It was found that they were having a different perception of bamboo furniture and its origin. The author further understands by people review that bamboo furniture has not been attractive, people don't find any innovation in design, its aesthetic, sensibility, and usability. The bamboo traditional style will always hold a strong foot on the path of innovation and originality of bamboo furniture. It was observed that designers of bamboo furniture need to possess the knowledge and craftsman technique with new design knowledge and marketing strategy. Bamboo furniture thus cannot be upgraded from handcrafted production. Many research methodologies such as discriminant analysis, multiple regression were used for collecting data from the various questionnaire and results obtained that were stating that it is been affected by biological variable; the relationship between design and value and the designing elements such as style, comfort, modernity, production techniques, and texture are some of the major elements. It was found that a designer should focus on the functional aspects of bamboo furniture before production techniques and other design elements [16].

The paper discusses the chemical and mechanical composition of bamboo and its use in the construction and furniture industry. Bamboo has some positive features like mechanical strength and availability in much tropical and sub-tropical area which confers it to become a renewable substitute for wood. Many wood processing companies are now been considering bamboo as a sustainable alternative for wood for constriction purposes and furniture design. Bamboo has been called a green eco-friendly material for interiors as a natural material is been getting depleted and thus this can be used both in external structure and interior to make a long-lasting competitive product with long life [17].

The paper discusses how the joinery system plays a vital role in building structures. The paper also showcases why bamboo is not widely accepted and what are the factors that seriously hinder the development of bamboo construction. Categories of raw bamboo joints are described and explained in the form of bolt joints. Some experimental studies have also been carried out on joinery strength of bamboo which shows that there is a specific question mark on the bearing capacity, stiffness, durability, and construction. Hence, a definite development is required for easy operation and workability with raw bamboo joints. The paper also draws the attention and states that serious studies and experiments are needed to establish the proper and result oriented bamboo design system. Being a sustainable and green material, bamboo is still behind timber because of its non-standard, inefficient, and non-stable joinery system [18].

The paper is discussing being worldwide sustainable building material for architecture why still its utility is being limited to the furniture industry and it's still been outseen as outcast materials because of its appearance. bamboo is thus being considered for its traditional design. Due to continuous development in the creative design and modern technology the bamboo uses was not been explored further. The study is focusing on Indonesia and refining the use of bamboo furniture in the disaster area. The study intends to show how bamboo can be used in these areas as a higher value of the product. The use of bamboo for the resource in modulating furniture needs thorough investigation, bamboo a sustainable perennial grass which venerable because of its confined breeding, and because of its short term of planting it became the captive roots of Indonesia. Bamboo has various types of species in its roots and the government need to encourage the use of bamboo in construction processes for economically weaker grades and furniture making in disaster and remote area [19].

This paper discusses the important species of bamboo in India and its contribution impact on rural development. Its basic use as raw material for various applications, such resources are widely available in moist and deciduous forests.

As per (FSI 2003) total forest area is 67.7 million ha, from which bamboo acquires 11.4 million ha. The country has 16.7% of the total forest area from which 3.4 % (329 million hectares) is in India. Having one of the largest resources of bamboo in the world, India contributes just 4% of the global market. This leads to lower productivity in comparison to other bamboo producing countries such as China, Malaysia, and Japan whose contribution is 80%. Bamboo is a versatile gift of nature that has a variety of benefits. Bamboo is one of the major sources of raw materials for various industries such as bamboo mat boards, veneer, corrugated sheets, etc. Bamboo craft is one of the old industries and has been put to use for various applications from construction to household utilities. Bamboo was known as "poor man timber", "friend of people", and the cradle to coffin timber. It is a fast-growing plant and matures early. This is the only plant, once been planted keeps on shooting and maturing every year. The major challenges it faces are in the cultivation of bamboo including lack of a mechanism in harvesting, appropriate storage, transportation, awareness in conservation. These challenges should be addressed for the bamboo sector to serve as an eco-friendly source of goods and services and livelihood to millions of people in India [20].

The paper is discussing the Bamboo and its current state. India is the largest Bamboo producer and has a vast knowledge of bamboo and with best bamboo artisans and craftsmen. Bamboo usage for the building is one of the old traditions in India. Due to various climatic conditions, we have different species of bamboo available. The paper is stating various typologies of Bamboo building in India and its evolution with a change in time, influences by the new interests, research, and developments in materials. The hindrance in the acceptability of the bamboo as a preferred material in modern architecture and also the strength that can make India the major contributor to the bamboo building sector in the future. The traditional bamboo architecture acceptability in India Problems, Issues, and Acceptability of contemporary bamboo architecture and the major limitation the bamboo faces in the various aspects is also discussed:

i. Material limitation –elevating bamboo to a level where it can be a structurally stable and durable material, susceptibility towards the fire is another major limiting factor in the usage. Working with the round shape bamboo its jointing is another cumbersome jobs and with its reducing diameter bamboo along the length it adds to its drawback and the most common reason for the failure of bamboo is its splitting on the longitudinal direction. Bamboo can be used conveniently used as reinforcement for small size building but the managing of large spans is difficult with bamboo and very long length can lead to the tapering of the structure. Its hygroscopic nature bamboo use is a deterrent.

ii. Academic, Research, and Development issues- not including bamboo to the architectural curriculum as mainstream material and lack of awareness about its sustainability. Reformation of bamboo is low and the research and the innovation in alternative materials hardly been implied. Standardization, testing and field testing of bamboo can lead to the broader acceptability

iii. Legal and financial policy – inclusion in SSR and NBC, special policy, laws, and relaxation to the bamboo building is needed. Finances schemes for bamboo buildings like cheap loans, subsidies, forming social agencies, and Housing standards schemes should be formulated.

iv. Social Issues- Affordability is prime reasons to opt for permanent solutions whereas substandard houses can be more demanding in terms of maintenance, energy efficiency, time, and money. Social acceptability and standards evolving needs majorly.

v. Execution Issues - Material Availability, skill development, Prefabrication, raising standards for Bamboo, treatment of bamboo, elaborate expensive and non-reliable testing method and backward linkage is unavailability.

Disusing the "how to promote Bamboo" and stating a statement that if the bamboo building technology is made convenient to handle and promoted with standards, codes, and bye-laws it could go along way in creating the gateway all the alternative material and technologies [21].

The researcher focuses majorly on the application of natural landscape (bamboo) to modern interior design. The research summarized that landscape should match modern interior space. The researcher analyzes the application of natural resources. The interior landscape should not be kept for just viewing or decoration purpose but should be linked with Green building, essentially the combination of design and nature. Design and ecology are the trends and integral parts of the natural landscape and ecological building of the natural environment [22].

The paper is discussing and examines the potential of bamboo as a source of income and better livelihood for the rural sector. It was being observed that bamboo is widely available global resources and its various uses from a small toothpick to the construction of houses. Being one of the great profit deals for businesses from which rural people with proper adequate skills and market value chains can cut the poverty trap. By involving rural communities in Bamboo cultivation, management, and marketing generation good amount of income and profit can be generated. Bamboo processing for income generation is largely undeveloped and it's primarily limited to the handicraft and other household processing only. Hence countries should continue to develop some administrative strategies to guide and enabling business climate. While depending upon the natural resources, household plantation of bamboo should be encouraged and focused more which would reduce the scarcity of natural resources as well, like add to the long way to improve rural livelihood The current understanding about the bamboo resources and its value chain is still limited and had certain loopholes of resourceful data and development in various countries and these gaps can only be bridged by the government policies involvement of stakeholders and social acceptability[23].

Conclusion:

From the above literature review, we analyzed that bamboo is one of the most ecofriendly available resources. It has wide usage from building construction to fabric making and plays a vital role in boosting the economy of many countries. We also traced from the above literature review that many researchers have proved that bamboo has a good tensile strength like steel as well it can replace traditional timber many Life cycle assessment tests made to prove their theory, some Asian counties a have accepted the bamboo and have developed themselves as major bamboo producers and developers globally but in some countries like

India who is also a huge bamboo producer globally didn't have a well-developed bamboo industry, the artisan and cultivators are still suffering because of inadequate legislative policies, resources, and facilities it was seen that there is a huge gap in the development chain of the bamboo resources.

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