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Unlocking the Potential of Bamboo: A Comprehensive Review of Its Use in Indoor Flooring

Yaman Sokienah*, Diana Gharaibeh

Department of Design, Faculty of Arts, Yarmouk University, Irbid 21163, Jordan

Corresponding Author Email: Yaman.s@yu.edu.jo

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ABSTRACT

This study focuses on using bamboo as a substitute for indoor flooring, emphasizing its sustainability, economic benefits, and aesthetic potential. This research systematically reviewed existing literature using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to analyze factors influencing the adoption of bamboo flooring materials as an alternative sustainable material. These factors include cost, durability, sustainability, availability, and aesthetics, positioning bamboo floors as a viable sustainable alternative to other flooring materials. A total of 50 studies were reviewed, with 20 meeting the inclusion criteria, showing a noticeable increase in interest in bamboo flooring in recent years. The findings highlighted bamboo floors' cost-effectiveness, visual appeal, and strong durability when properly processed and treated. The chemical and mechanical properties of bamboo contribute to the durability of bamboo flooring, especially after the manufacturing process. However, some issues persist, like high transportation costs, limited market reach, and low awareness in many regions, particularly outside of tropical areas.

1. INTRODUCTION

In recent decades, the focus on green buildings has intensified as a key factor in selecting building materials [1]. This focus extends beyond mere material selection to include a broader consideration of eco-friendly materials and resources that positively impact human health and productivity [2]. On another note, the materials used in construction are a significant criterion for global warming solutions. They also offer opportunities for sustainable living practices. The overarching goal of this focus on sustainability is to ensure that resources are used in a manner that is both responsible and sustainable [3].

Sustainable buildings aim to achieve environmental and economic efficiency in addition to the social efficiency of construction [4]. One of the objectives of sustainable buildings, which help to reduce energy usage and improve the environment [5, 6], is to manage natural resources effectively without depleting them [4, 7].

Because of its exceptional growth rate and sustainability, bamboo has become a popular alternative to hardwood in green construction [8]. Unlike hardwoods, which take over 50 years to mature, bamboo grows rapidly—reaching maturity in just 3 to 5 years after planting, with an initial growth phase as short as 6 months to 2 years [9, 10]. Moreover, its mechanical and physical properties make it a sustainable material, especially during manufacturing [10]. Otherwise, during the transportation of bamboo stems, their ecological advantage is reduced because of low transportation efficiency, even though they are highly environmentally friendly in bamboo-producing countries [10].

Bamboo genera and families have exhibited various properties, for example, resistance, strength, flexibility, and low shrinkage, which make bamboo an adaptable material for interior and exterior applications, such as flooring, walls, ceilings, and more bamboo species influence vertically glued laminated bamboo's physical and mechanical characteristics [11]. Specifically, *Dendrocalamus asper* and *Dendrocalamus giganteus* are suitable for flooring and have a harvest time of 3-4 years, making them more environmentally friendly alternatives to wood [12]. Therefore, bamboo stems must be transformed from hollow cylindrical stems into laminated sheets that can be used as building materials [11].

Additionally, bamboo has water-resistance capabilities compared to hardwood, and it is considered to be anti-bacterial, so it's a great way to use bamboo flooring to improve the building's sustainability [13]. Additional advantages of bamboo flooring are sound insulation, pressure resistance, smoothness, and size stability more than wood flooring [11]. The bamboo fiber enriches the strength, flexibility, and resistance to crushing, also making it more tolerant to large impacts of stress.

Bamboo can be appraised as an alternative to wood, helping to alleviate pressure on forest resources. It can contribute to a 70% reduction in plantation requirements [14]. Wood-based flooring has low embodied energy and carbon emissions, sequestering more carbon than other flooring types, thereby mitigating global warming [3]. Bamboo has proven its efficiency in storing carbon, preventing its release into the atmosphere for the duration of the building's life [15]. It also boasts the highest strength-to-weight ratio compared to steel, concrete, and timber [14]. Furthermore, bamboo is cited as an

excellent source of biofuel due to its high-yield potential [16].

The selection of sustainable materials for green buildings is often based on a Life Cycle Analysis (LCA), aiming for low environmental impact from raw material extraction to on-site installation [17, 18]. Bamboo flooring comes in two types: laminated and scrambler flooring. Both types have environmental impacts during manufacturing. Laminated flooring is considered more environmentally friendly than scrambler flooring, which has a negative environmental impact [18].

Laminated Bamboo Lumber (LBL) has recently garnered attention from researchers due to its mechanical properties. It can be manufactured in dimensions similar to traditional wood products [19, 20]. Additionally, it can be combined with laterite to create bamboo-reinforced terracrete, offering a robust alternative comparable to concrete slabs [20].

Bamboo laminate is parallel wood in appearance, and is made up of bamboo strips glued together and compressed under cold or hot pressure [21], and this results in a uniform, denser material that can be used in interior spaces [20, 22]. Factors that affect the quality of bamboo culms include their color which can indicate age and diameter and harvesting should not occur in spring or early summer due to the high moisture content [23].

Much research is directed towards achieving sustainability by using plant fibers to bind composite materials, like using biochemical adhesives and resins extracted from plants [24]. This biotechnology has contributed to developing more environmentally friendly binding techniques, including using microorganisms to digest lignocellulosic fibers from agricultural waste. The material is planned for use in interior spaces as thermal insulation panels, acoustic panels, space barriers, and ceiling panels [10, 25].

Advances in bamboo processing technology have expanded its use, with applications in wall and floor decoration [26-28]. However, its use in flooring is still limited due to lack of social awareness and poor transportation infrastructure [29, 30].

Designers prefer to incorporate bamboo into interior design to enhance the atmosphere and introduce cultural and decorative elements [24, 31]. Moreover, the use of bamboo in interiors offers advantages in terms of indoor comfort and energy consumption, making it stand out from other materials [24, 32].

Many people rely on unsustainable or expensive sustainable flooring due to a lack of awareness of alternatives like bamboo flooring material because of misconceptions about this material or prefer traditional material. Additionally, some users may be hesitant due to some less expensive types' quality and durability standards. This review focuses on bamboo as an alternative material for interior flooring, highlighting the key factors that make it a preferred sustainable alternative. While other wood flooring options also contribute to the sustainability of a building, bamboo stands out for its unique advantages. This paper aims to provide an overview of bamboo flooring as a sustainable material, including its species and chemical and mechanical properties, and to investigate the key factors influencing the adoption of bamboo flooring over other alternative materials. To assess the key factors that improve bamboo flooring as a sustainable substitute for conventional flooring materials, as well as its impact on consumer perception, market potential, and economic feasibility.

2. FACTORS AFFECTING THE ADOPTION OF BAMBOO FLOORING MATERIAL

The literature search used two primary databases: Google Scholar and Scopus. The initial keywords were selected based on their frequency in the existing literature on bamboo flooring materials in interior spaces. This phase aimed to identify the most important factors influencing the adoption of bamboo as an alternative to wood flooring in interior design (see Figure 1 for a flowchart of the search strategy).

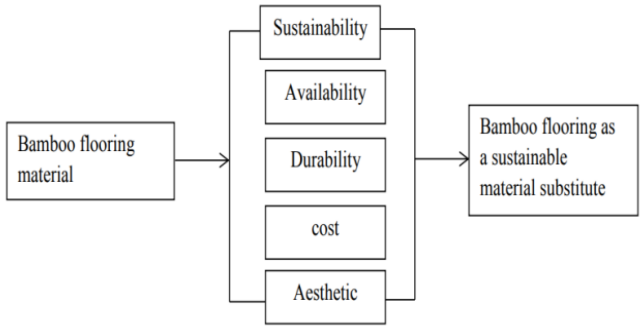

Figure 1. Factors that influence the adoption of bamboo flooring material

This study uses a systematic review methodology using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [33], framework to examine bamboo as a flooring material instead of other traditional flooring options. The review focuses on five key factors that influence the adoption of bamboo flooring: cost, availability, durability, sustainability, and aesthetics, as identified in previous research [34, 35].

The study adopts a structured approach to data analysis, using qualitative thematic analysis guided by pre-defined inclusion and exclusion criteria. We elicited all the peer-reviewed journals from 2012 to 2023 related to bamboo flooring material to capture and identify the key factors that were evaluated by litterateurs. The keywords used to search the relevant articles are "cost, availability, durability, sustainability, and aesthetics" related to bamboo flooring material. The search databases are Google Scholar and Scopus.

After searching the databases, we export a spreadsheet to screen the title and then the abstract of all articles related to the key factors. The inclusion articles are based on the title and abstract that relate to the key factors. If there is a lack of information, then continue to methodology and conclusion, while the exclusion article that is far away from the title or if it's not related to the bamboo flooring and its factors that are adapted from the literature.

2.1 Quality assessment framework

Each selected study was evaluated using the following key criteria:

1) Study design and methodology

The research objectives and hypotheses were clearly formulated, and an appropriate study design (e.g., experimental, observational, or systematic review) was employed.

2) Study design and methodology

An adequate sample size was selected with appropriate

justification, along with a clear description of data collection tools and procedures.

3) Data analysis

Using appropriate statistical tools or qualitative analysis techniques with a clear presentation of data analysis procedures and interpretation of results.

4) Relevance to research focus

Direct alignment with the research objectives related to bamboo flooring adoption, sustainability, and performance.

5) Results and conclusions

Ensure clarity by presenting results with supporting evidence, followed by logical conclusions that align with the findings.

6) Ethics and transparency

The study discloses ethical considerations, including Institutional Review Board (IRB) approval and informed consent, while clearly acknowledging its limitations and potential biases.

2.2 Inclusion and exclusion process

The study selection process followed a structured multi-phase approach:

(1) Initial screening**:** Articles were first screened by title and abstract to assess relevance to the research focus.

(2) Full-text review**:** Eligible articles were then reviewed in full to evaluate their methodological quality and alignment with the study's objectives.

(3) Exclusion**:** Studies that lacked adequate methodological detail, were non-peer-reviewed, or deviated from the study's scope were excluded.

2.3 Inter-rater reliability

To ensure the reliability of the study selection process, two independent reviewers screened the articles using pre-defined inclusion and exclusion criteria. Any discrepancies were resolved through discussion, with a third reviewer acting as an arbitrator when necessary.

2.4 PRISMA flow diagram

An initial set of articles was identified, and through the PRISMA protocol, 50 research papers were extracted for detailed review (See Figure 2 for the PRISMA flow diagram). These papers were further screened using an Excel sheet to categorize the bibliography, resulting in a final selection of 20 research articles that met the study's criteria.

The primary aim of this systematic review is to synthesize existing literature to identify both barriers and opportunities for the effective implementation of bamboo as a flooring material, with a particular focus on its application in architectural interior design.

After applying the inclusion and exclusion criteria, a total of 20 articles were selected for the final review. These articles were published between 2010 and 2022, indicating a growing interest in the topic over the last decade. Most of the studies (n=15) were empirical, while the remaining were reviews (n=3) and case studies (n=2).

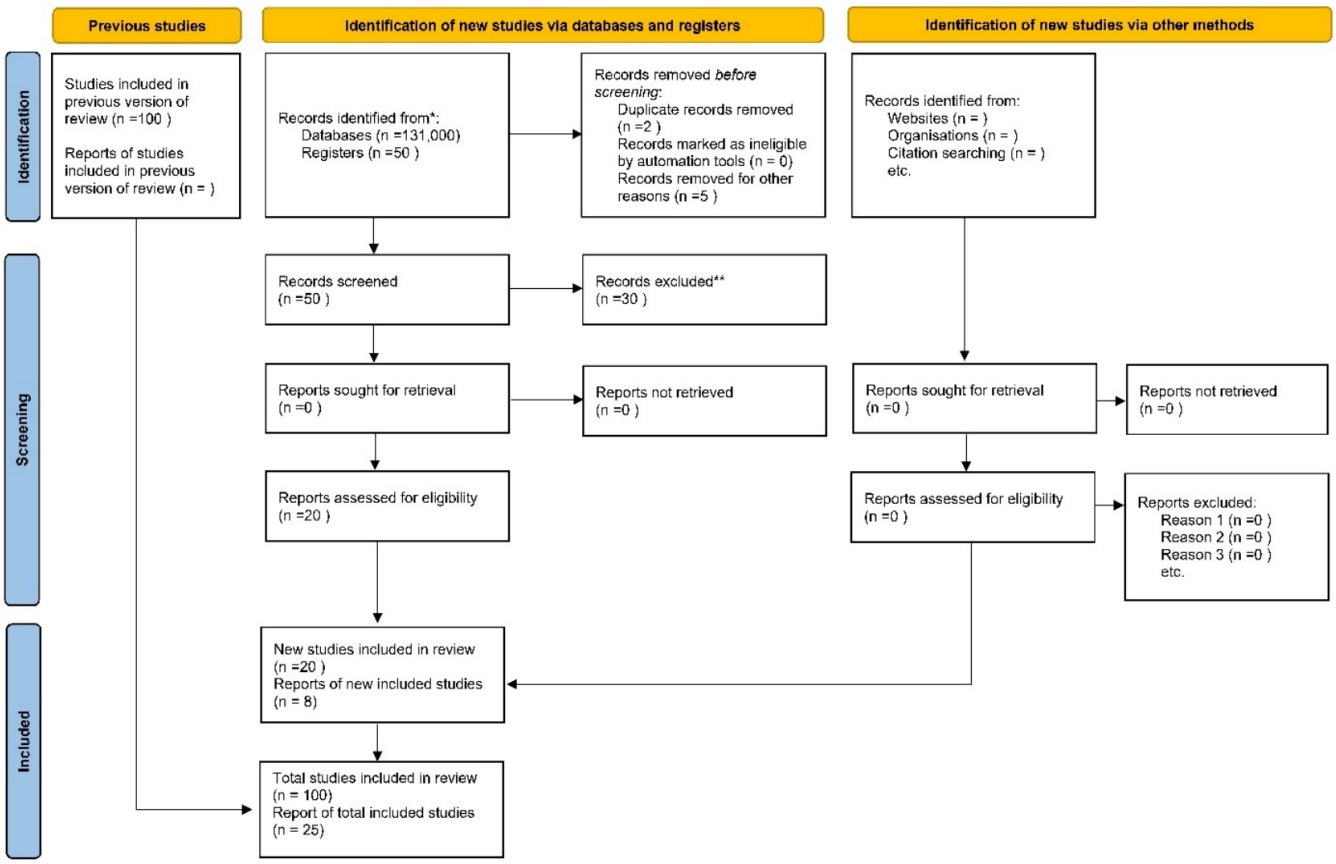

Figure 2. PRISMA 2020 flow diagram

3. SYSTEMATIC REVIEW RESULTS

3.1 Overview of bamboo flooring species

Indoors, laminated and composite bamboo are the most prevalent materials. These are engineered bamboo products crafted from bamboo strips. Bamboo finds various applications indoors, including its use in trusses, partition walls, roofing, ceilings, doors, and windows, which are categorized as permanent installations [36].

Bamboo raw material, particularly those with large culms, is processed into laminated bamboo, suitable for flooring or wall materials. *Dendrocalamus asper* is one such bamboo species, characterized by its large culms that are 7mm thick and 2m high and commonly used in construction [37]. Another species, *Dendrocalamus giganteus*, also known as giant bamboo, can grow up to 24-30m high [37].

A study on *Dendrocalamus giganteus* used as slats on pine panels (EPG) demonstrated that bamboo slats can withstand pressure and are suitable for internal flooring [37]. Life Cycle Analysis (LCA) of bamboo has shown that its use in construction enhances carbon sequestration, thereby mitigating the greenhouse effect [37]. For instance, Yu et al [38] found that the energy reduction in the manufacturing process of bamboo laminates, compared to scrambler flooring, led to a lower environmental impact.

Reducing the use of energy-intensive materials can reduce construction costs, highlighting the economic benefits of sustainable materials [39]. Bamboo is also treated with borax and boric acid to deter insects and retard fires [40]. Its primary constituent, cellulose, contributes to its mechanical properties [39]. However, the high carbohydrate content in bamboo can affect its durability and lifespan [39].

One of the key reasons for choosing bamboo over other hardwoods is its superior carbon dioxide absorption. Unlike hardwoods like oak and walnut, which take over fifty years to mature, bamboo is an environmentally friendly plant that does not require pesticides or fertilizers. Table 1 shows most of the bamboo species used in producing bamboo laminate flooring materials, which are suitable as indoor flooring materials.

Table 1. Bamboo species for laminated flooring material

Bamboo species	Culms Size	High	Diameter	Use	References
Dendrocalamus asper	Large	2 m	15-30 cm	Construction	[11]
Dendrocalamus giganteus	Large	24-30 m	25-35 cm	slats on pine panels, internal flooring	[11]
Dendrocalamus sericeus	large	20-30 m	10-15 cm	Construction and furniture	[11]
Gigantochloa levis	Large	15-20 m	5-10 cm	Construction	[11]
Guadua angustifolia	Large	15-30 m	10-12 cm	Furniture and crafts	[41, 42]
Phyllostachys aurea	Large	6-9 m	2.5-5 cm	Crafts and furniture, construction	[43]

3.2 Types of bamboo flooring

Laminate bamboo panel flooring is gaining traction in interior design as a substitute for hardwood. There are three primary types of bamboo flooring: engineered, solid, and strand woven. Engineered bamboo is designed for straight edges [44], while solid bamboo is made from Moso bamboo, known for its hardness [44]. Strand-woven bamboo is created by compressing glue-coated bamboo strips into a lumber-like shape [45].

3.3 Advantages and disadvantages of bamboo flooring

Bamboo offers several advantages, including rapid growth, renewability, and environmental friendliness. However, untreated bamboo is susceptible to fungi and insect attacks, requiring preservation [46]. Elevating bamboo floors from the ground surface can prevent rot and insect exposure [46].

Eucalyptus its renewability and durability flooring compete with bamboo. In addition, eucalyptus has a higher market demand due to increased awareness and lower greenhouse gas emissions during transportation [47, 48].

3.4 Mechanical and chemical bamboo flooring properties

To take advantage of the mechanical and chemical properties of bamboo flooring, it is important to note that bamboo should be harvested for use as a flooring material when it reaches maturity, usually between two and six years old. Within this age range, bamboo is suitable for flooring and construction because it retains optimum strength. After 6 years, bamboo gradually begins to lose strength, and this deterioration continues until it is over 12 years old or more [49]. The mechanical properties of bamboo are related to the direction of growth of its fibers, which provides greater strength along the fibers due to the high tensile strength. In addition, high moisture content affects the tensile, compressive, and shear properties of bamboo [50].

The strength of different bamboo species is correlated with their chemical composition. For example, higher lignin content increases tensile strength. Additionally, the tensile strength of bamboo internodes is associated with the ratio of alpha-cellulose to holocellulose in the internode [51, 52].

The production of bamboo laminated flooring consumes less energy compared to materials such as cement and steel. However, the adhesive used in the manufacturing process can negatively affect the ozone layer due to the acid release from urea-formaldehyde resins [24, 42]. The amount of adhesive used in bamboo laminate production also affects the flooring material's mechanical properties.

When comparing bamboo to wood and steel, they found that the tensile strength of bamboo was close to that of wood with 10% higher compression, while the tensile strength of bamboo was about 2-3 times greater than that of steel. The tensile strength and tensile modulus of bamboo laminates were also found to be higher when dried than when wet [19, 53].

The strength of bamboo laminated sheets compared to strong Indonesian wood depends on the manufacturing process, specifically the layer composition and the bamboo species used, which affect the material's mechanical and physical properties [11, 49, 54]. Table 2 explains the comparison of Indonesian wood strength with laminated

bamboo species and finds that *Dendrocalamus asper* is classified as the harder strength class I in contrast to Indonesian wood strength, while *Dendrocalamus giganteus*, *Gigantochloa levis* class II, *Dendrocalamus latiflorus*, and *Guadua angustifolia* class III [11, 55].

Table 2. The strength of bamboo laminated sheets compared to strong Indonesian wood (kgf/cm²)

Bamboo Species (GLBL)	Indonesian Wood Strength Class	Strength Number /kgf/cm²	References
D. asper	class I	> 1100 kgf/cm²	[11]
D. giganteus, G. levis	class II	835 kgf/cm²	[11]
D. latifloru	class III	500-725 kgf/cm²	[19, 56]
G. angustifolia	class III	485 kgf/cm²	[55, 6]

Notes: kgf/cm² is kilogram-force per square centimeter.

3.5 Bamboo flooring life-cycle assessment

Wood flooring is considered a sustainable material due to its ability to sequester carbon. The choice of wood species for flooring is determined by its life cycle and environmental impact, which extends from the extraction of the material to the end of its useful life [57]. The life cycle assessment of wood can be divided into five main stages: species growth, material extraction or harvesting, manufacturing, transportation, and end-of-life [58].

The life cycle of bamboo flooring is examined from "cradle to gate". Its environmental impact is measured by the total carbon footprint emissions over its life cycle, and this is compared to other wood flooring materials to assess its suitability as an alternative [59]. It's important to note that carbon sequestration during the life cycle alone cannot determine the CO_2 life cycle of bamboo. This can only be ascertained if the bamboo is used at the end of its life for energy production through burning or heating and if it is subsequently replanted [60].

Study [61] compared the environmental impact of cross-laminated timber and laminated veneer bamboo through benchmark testing. They found that laminated veneer bamboo is marginally more favorable in terms of global warming, with a difference of 331 kg CO_2 eq (bamboo = 43.183 kg CO_2 eq, CLT = 43.514 kg CO_2 eq). Most of the carbon emissions occurred during manufacturing; however, waste bamboo was used for heat and electricity generation, making it a viable substitute material. Additionally, the environmental cost of transportation depends on the weight-volume ratio and varies depending on whether the transportation is domestic or international. The life cycle assessment indicates that bamboo has a smaller carbon footprint than other timbers due to its lower weight and volume [62].

A recent research initiative aims to develop Laminated Bamboo Lumber (LBL) resembling mass timber composites like laminated wood, glued laminated wood, and veneer wood. To create 'smart bamboo, suitable for walls, floors, and roofs while minimizing environmental impact, it is essential to gather data on various bamboo species [63].

3.6 Bamboo flooring technology transfer challenges

Despite its benefits, bamboo faces challenges in technology transfer to industrial levels [64]. Barriers include trade restrictions, lack of standards, and certification processes. Legal frameworks need to be enhanced to improve bamboo's security and durability in construction [65].

In 2020, bamboo flooring exports constituted 3.3% of total bamboo production, while assembled flooring panels made up 1.7% [30]. The high cost has deterred customers [66], but new markets like panel and veneer are emerging. The growing eco-consciousness in the United States predicts a rising demand for bamboo.

3.7 Factors influencing the adoption of indoor bamboo flooring

Five factors can significantly impact the selection of bamboo as an alternative indoor flooring material: sustainability, durability, availability, cost, and aesthetics. These factors were identified through a literature review as key considerations in the choice of flooring material for interior spaces [34, 35, 67].

In Table 3, the literature highlights the cost of bamboo flooring as a variable that affects its selection as a substitute material for interior space. While the low cost of bamboo flooring makes it an attractive option over other types of wood flooring, the high importation costs could limit its adoption in regions where the material is not locally available.

Table 3. Bamboo flooring substitute/Cost factor

Literature	Cost Factor	Research Result of Bamboo Flooring Substitute Costs
[68]		The variable most affects the selection of bamboo flooring.
[68]	$4-8 per sq. ft.	Bamboo in construction is much low than high-quality wood.
[35]		Using bamboo flooring instead of parquet, the cost increase percentage is reduced.
[35]		Consumers prefer bamboo flooring because of its low cost.
[69]		The cost of importing bamboo floors is high.
[69]		The cost of bamboo comes from high-quality bamboo (bamboo flooring is less costly than LBL).

Notes: The empty space means there's no specific cost announced in the literature.

In Table 4, the literature delineates the primary substances that enhance and diminish the durability of bamboo flooring material in interior space. Carbohydrates are the main component in bamboo, and they attract fungi and insects. To mitigate this, the bamboo can be soaked in water or heated at elevated temperatures to reduce its starch content, making it less susceptible to fungi and insect infestation. Following the drying process, the bamboo is treated with varnish to enhance its resistance. Additionally, during the manufacturing process, the bamboo flooring is coated with aluminum oxide and

polyurethane to minimize leakage and scratching, thereby augmenting its overall durability.

Table 4. Bamboo flooring substitute/durability factor

Literature	Durability Factor	Research Result of Bamboo Flooring Substitute Durability
[70]	Soak in water for 3-4 week or heated 150°C	Low starch content increases the bamboo flooring's durability.
[71]	Painted with varnish Ratio: 2 ingredient to 1 water	Resistance to termites and fungi increases bamboo flooring durability.
[72]	Aluminum oxide and polyurethane	A sealer layer and scratch-resistant improve bamboo flooring durability.

Notes: The durability of bamboo flooring makes it preferable to other floor materials.

In Table 5, the aesthetic factor emerges as a significant determinant in the selection of indoor flooring material. Attributes such as beauty, luster, softness, elegance, and natural gloss are identified as the principal aesthetic characteristics that make bamboo flooring appealing to consumers. These aesthetic qualities position bamboo as a preferred substitute over other flooring options and serve as the most influential factor following cost in shaping consumer preferences.

Table 5. Bamboo flooring substitute / Aesthetic factor

Literature	Aesthetic Factor	Research Result of Bamboo Flooring Substitute Aesthetics
[68]	Floor finish	Aesthetic has the most variable effect on flooring material selection.
[73]	Beauty/ Luster/ Softness	Natural luster and maintenance natural gloss.
[74]	Smooth texture/ Straight/ Elegant tone	Bamboo is considered a qualitative decoration material when used in flooring.
[75]	Softness/ Elegance/ Natural gloss	Bamboo flooring led to demand in Europe, Japan, and the North American market.

Notes: The empty space means there's no specific aesthetic announced in the literature.

In Table 6, the literature elucidates the role of bamboo flooring's carbon footprint and manufacturing process in its sustainability as an alternative material. Environmental load and carbon emissions are frequently cited as key factors in assessing the sustainability of bamboo flooring. A reduction in these emissions and environmental impacts throughout the manufacturing and lifecycle stages of the material indicates its enhanced sustainability compared to other options.

In Table 7, the final factor influencing the selection of bamboo flooring for interior space as a substitute is the material's availability. The literature indicates that most of the trade for bamboo and rattan is localized. However, the global trade for these materials is estimated to be around USD 60 billion annually. This figure may be imprecise due to the categorization of bamboo and rattan within the broader wood sector [1]. Additionally, a well-defined market is essential for the analysis and promotion of bamboo products, and the success of marketing strategies directly correlates with increased product demand. It is also noteworthy that Chinese companies currently dominate the bamboo flooring market.

Table 6. Bamboo flooring substitute/Sustainability factor

Literature	Sustainability Factor	Research Result of Bamboo Flooring Substitute Sustainability
[76]	Carbon footprint	Bamboo material is used as a substitute to reduce carbon emissions.
[76]	Carbon loss	Bamboo flooring loses carbon significantly (11.4%) higher than engineered wood products.
[77]	Carbon emission /carbon stocks	The carbon footprint for product 1 m^3 bamboo flooring is 14.89kg CO_2 equivalent. Negative carbon emission or sequesters carbon for at least 20 years.
[77]	Carbon dioxide	Bamboo can absorb large amounts of CO_2 and release O_2.
[38]	Environmental loads	Bamboo scrimber flooring manufacturing hurts the environment compared to laminate flooring.

Notes: The empty space means there's no specific announcement in the literature.

Table 7. Bamboo flooring substitute/Availability factor

Literature	Availability Factor	Research Result Bamboo Flooring Substitute Availability
[79]	60 billion USD per year	The majority of the trade is local for bamboo and rattan.
[1]	40.000 m^3 engendered bamboo per year	Western markets such as EU and USA.
[79]		A market is required for the analysis and marketing of bamboo products.
[79]	95% of bamboo flooring consumed	Bamboo floors consumed in EU coming from China.

Notes: The empty space means there's no specific announcement in the literature.

4. DISCUSSION

Overall, the selection of bamboo flooring as a sustainable material for interior space is influenced by various factors, including its comparison with other types of wooden floors, which are also considered sustainable. However, when choosing between bamboo and other wooden floors, it is crucial to consider which wood species are suitable substitutes.

Cost: Ten out of the 20 studies highlighted that bamboo flooring is generally more cost-effective than traditional hardwood flooring. However, three studies noted that the initial installation cost could be higher due to the specialized skills required.

Availability: Bamboo is abundantly available, particularly in tropical regions, as confirmed by numerous studies. However, four studies highlighted that its availability may be limited in non-tropical countries, which affects its adoption rate.

Durability: Fourteen studies have highlighted the durability of bamboo flooring in interior spaces, noting that it often

outperforms traditional hardwood flooring. However, two studies have raised concerns about its sensitivity to moisture and recommended further investigation, particularly during the manufacturing process.

Sustainability: Sustainability emerged as the most discussed factor, appearing in 18 out of 20 studies. Bamboo flooring has received worldwide acclaim for being environmentally friendly, primarily due to its rapid growth rate, which far outperforms hardwood trees.

Aesthetics: Nine studies examined the aesthetic appeal of bamboo flooring, with seven studies emphasizing its modern, elegant appearance as a primary benefit.

4.1 Barriers to adoption

The most common barriers cited to bamboo flooring adoption were lack of awareness (n = 12), initial installation costs (n = 8), and limited availability in some areas (n = 4).

Cost: While bamboo flooring is generally seen as cost-effective compared to hardwood alternatives, studies identified high initial installation costs as a significant barrier. However, this concern can be mitigated through public incentives and educational initiatives that highlight bamboo's long-term cost benefits.

Availability: Bamboo's abundant availability in tropical regions facilitates its adoption; however, four studies noted that limited market reach outside these areas poses a challenge. Expanding global trade networks and improving supply chain efficiency present key opportunities to address this issue.

Durability: While bamboo durability is widely recognized, concerns about its susceptibility to moisture were identified in two studies. Six studies have recommended enhancing bamboo's moisture resistance during manufacturing as a viable solution.

4.2 Opportunities for implementation

Ten studies indicated that increased public awareness and government incentives would significantly enhance the adoption of bamboo flooring. In addition, six studies recommended further research to improve the moisture resistance of bamboo flooring.

5. CONCLUSION

Although bamboo is often highlighted for its eco-friendly properties, the availability of high-quality bamboo flooring material and its availability on global markets can involve significant challenges that affect its use as an alternative flooring material.

This review study presents bamboo flooring as an alternative material, focusing on key factors influencing its adoption. A literature review identified five main factors: cost, availability, durability, sustainability, and aesthetics, each affecting the others in various ways.

The trend towards sustainable green buildings and the search for alternative sustainable materials encourage architectural designers to find alternative materials, the specifications of which include bamboo, to improve the internal environment of buildings. Environmental impacts throughout the manufacturing and lifecycle stages of the bamboo flooring material indicate its enhanced sustainability compared to other options.

Bamboo flooring particularly appeals to individuals interested in environmentally friendly, low-cost-effective materials; otherwise, it needs specialized skills for the manufacturing process that may increase the material price.

Additionally, bamboo flooring offers aesthetic value and can even resemble expensive hardwood options, as beauty, luster, softness, elegance, and natural gloss are identified as the principal aesthetic characteristics that make bamboo flooring appealing to consumers. Focusing on flooring durability is highly demanded, specifically resistance to pressure and moisture. Bamboo flooring material durability can be enhanced during manufacturing due to its mechanical and chemical properties.

However, the availability of bamboo may impact its adoption in certain areas, which through the high demand and manufacturing skills could reduce it in the market and let the customers face limited style or quality material options. emphasizing the need for market analysis, considering awareness, promoting bamboo flooring products, and developing bamboo material manufacturing skills.

6. FUTURE RESEARCH

This study analyzed data from 50 scholarly articles, focusing on five specific factors that influence the adoption of bamboo, particularly in the context of interior flooring. Given the limited existing research on this specific application of bamboo, further studies would be beneficial. Future research could delve deeper into each of these factors individually to gain a more nuanced understanding of the factors influencing the adoption of bamboo flooring.

In light of the key findings, the following recommendations are proposed:

- Given the increasing adoption of sustainable building materials in green construction to mitigate environmental impact, it is advisable to explore other eco-friendly materials. This would contribute to the promotion of a more sustainable lifestyle.
- A targeted study focusing on Middle Eastern countries could prove beneficial. Such research would bolster the local economy for sustainable materials and facilitate the introduction and sale of bamboo-based products in the region.
- To boost sales and consumer adoption, an experimental methodology to assess bamboo flooring in residential settings could be effective. This would involve analyzing user experiences and emotional responses, broadening consumer awareness and understanding of bamboo as a viable material.
- Enhancing the understanding of consumer behavior is crucial for marketers and manufacturers to increase sales and achieve long-term success effectively.
- An innovative approach to bamboo flooring manufacturing should leverage AI-driven optimization and advanced production techniques to enhance sustainability, efficiency, and quality. through AI-optimized bamboo flooring manufacturing for sustainable growth. Also used AI-driven growth and harvesting analysis. AI-powered robotics can streamline cutting, treating, and assembling bamboo planks, reducing material waste. AI models can also optimize supply chain logistics, minimizing transportation costs and emissions.

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