

Bamboo is a Sustainable Healthy Eco-friendly material for Interior Design and Furniture

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Abstract

The contemporary interior design is trying to contribute in protecting the environment, while satisfying the need of the people with a functional and aesthetic interior design and furniture, that can improve health, and standards of living. Bamboo is a rapidly growing grass that has sustainable, renewable, and recyclable properties, also has multiple physical properties as lightweight and high-strength, durability, water, fire, pests, and microbial resistance. One of its important advantages is being cost-effective for its low-cost cultivation, transportation, production, and less time consuming and energy expenditure. The research problem: cutting the natural woods to satisfy the need of interior design and furniture for everyday living, is depleting the natural resources and negatively affecting the environment. Can bamboo, being a sustainable eco-friendly material, be used in interior design and furniture and contribute in protecting the environment by minimizing cutting natural wood and cover its shortage, while keeping the earth green? The aim of the research is to illustrate the role of bamboo, as a sustainable, healthy, eco-friendly environmental material, and its uses in interior design and furniture to help creating a healthy interior environment while keeping the earth green. Results: interior designers must consider using bamboo being a sustainable renewable material to reduce depleting the natural resources and help in protecting the environment. The use of bamboo in the interior design and furniture creates an interior environment close to nature with its natural look, and comfortable ambiance being oxygen inducer and carbon dioxide reducer as well as thermal insulator. This helps in reducing everyday stress and the negative impact of the modern lifestyle on its occupiers' and on the long term it ensures a relaxed and healthy interior environment protecting against psychological and physical illnesses. The different advantages of bamboo encouraged interior designers with the help of new technology to integrate bamboo in the contemporary interior design and furniture to create a healthy and positive environment with diversity of modern designs using an eco-friendly material. The results of the study were applied on a bedroom in a touristic resort.

Keywords:

Bamboo, sustainable, interior design, ecological, environment, ecofriendly.

المخلص :

أدرك المصممون في القرن العشرين أهمية استخدام خامات طبيعية متجدده و صديقة للبيئة في التصميم الداخلي والاثاث المعاصر للمساهمة في حماية البيئة مع تلبية احتياجات الناس وظيفيا وجماليا بالاضافه الى تحسين الصحة ومستوي المعيشة. يعتبر البامبو (الخيزران) خامة صديق للبيئة و سريع النمو وله خصائص الاستدامة،متجدد،قابل لإعادة التدوير وله أيضا خصائص فيزيائية متعددة مثل الوزن الخفيف،القوة،المتانة ومقاومته للماء والنار والآفات والميكروبات. أحد مزايا البامبو

المهمة هي التكلفة المنخفضة لزراعتها ، نقلها وإنتاجها مما يقلل استهلاك الوقت والمال والطاقة. مشكلة البحث: الطلب المستمر على الأخشاب الطبيعية في التصميم الداخلي والأثاث يستنزف الأشجار كموارد طبيعية غير متجددة مما يؤثر سلباً على البيئة. هل يمكن استخدام البامبو في التصميم الداخلي والأثاث باعتباره خامة مستدامة متجددة وصديقة للبيئة وتساهم في حماية البيئة من خلال تقليل قطع الأخشاب الطبيعية وتعويض نقصها مع الحفاظ على البيئة خضراء؟ الهدف من البحث: هو توضيح دور البامبو باعتباره خامة بيئية مستدامة ، صحية وصديقة للبيئة واستخدامه في التصميم الداخلي والأثاث لإيجاد بيئة داخلية صحية بدون اضرار بالبيئة. منهج البحث : يستخدم المنهج التحليلي لدراسة وتوضيح مميزات وفوائد البامبو كمادة بيئية واستخداماته المختلفة في التصميم و المنهج التطبيقي التي سعى الباحث من خلالها لتقديم رؤية تصميمية معاصرة تحمل مضمون بيئي عملي صحي مستغلا خامات بيئية في مجال التصميم الداخلي و الاثاث ومكملات التصميم. النتائج: يجب على المصمم الداخلي التفكير في استخدام البامبو باعتباره خامة متجددة ومستدامة للحد من الأضرار في استخدام الخامات الغير متجددة مما يساعد على حماية البيئة. استخدام البامبو في التصميم الداخلي والأثاث يوجد بيئة داخلية قريبة من الطبيعة بمظهرها الطبيعي وأجواءها المريحة الصحية لكونها محفز للأكسجين ومقلل لثاني أكسيد الكربون وكذلك عازل للحرارة والصوت وهذا يساعد على التقليل من الإجهاد والتوتر اليومي والتأثير السلبي لنمط الحياة الحديثة على شأغليها وعلى المدى الطويل تصيح البيئة الداخلية مريحة صحية وتحمي من الأمراض النفسية والجسدية. شجعت المزايا المختلفة للبامبو واستخدام التكنولوجيا الحديثة المصممين الداخليين على دمج البامبو في التصميم الداخلي والأثاث المعاصر لإيجاد بيئة صحية إيجابية وتصميمات متنوعه مع تحقيق الجانب الوظيفي والجمالي باستخدام خامة طبيعيه وصديقة للبيئة. تم تطبيق نتائج الدراسة على غرفة نوم في منتجع سياحي.

الكلمات الرئيسية

البامبو ، الاستدامة ، تصميم داخلي ، بيئي ، صديق للبيئة

The research problem:

Cutting natural woods to satisfy the need of interior design and furniture for everyday living, is depleting natural resources and negatively affecting the environment. Can bamboo, being a sustainable eco-friendly material, be used in interior design and furniture and contribute in protecting the environment by minimizing cutting natural wood and cover its shortage, while keeping the earth green?

The aim of the research:

The aim of this study is to illustrate the new important role of bamboo as a sustainable, healthy, eco-friendly environmental material, in its usual form or as manufactured, in interior design and furniture to help maintaining a healthy interior environment, while keeping the earth green.

Material and methods

This paper used the analytical methodology to illustrate the important properties and advantages of bamboo and its uses being a sustainable eco-friendly healthy material that can be used in interior design and furniture in its usual form or as manufactured, while, protecting the environment. This study also used the applied method on a bedroom of a touristic resort using

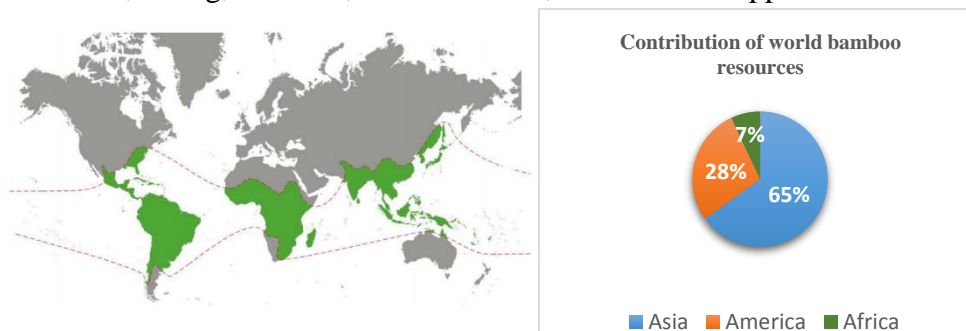
the different type of bamboo in its interior design and furniture to create new modern natural language of design with a healthy comfortable environment. We also combined bamboo with other materials in some of the furniture to offer variable choices with aesthetic looks and modern styles.

Introduction

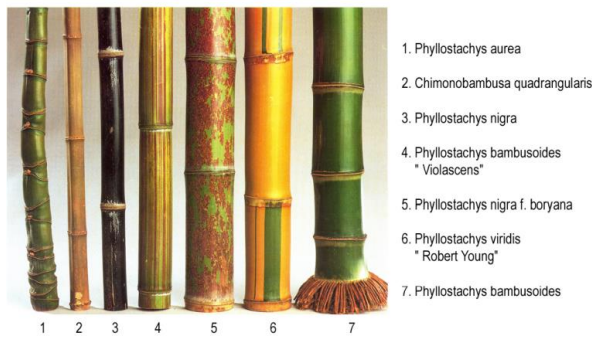
Today interior designers search for stylish and trending interior designs and furniture, while, having a positive impact on the ecosystem and humanity, using environmental and healthy materials to cope with our contemporary lifestyles. Bamboo is an ecofriendly material, and its rate of utilization has recently increased. Bamboo is a fast-growing grass reaching a full height up to 30 m within a year, the culm continues to gain strength reaching its optimal structural properties within 3-5 years. (Xuhe, 2003) Bamboo has the property of being lightweight, high strength which facilitates its transport with low cost. Bamboo can be an alternative material to wood, having several similar properties. Bamboo is a sustainable eco-friendly environmental material with multiple advantages, including being natural antibacterial, water and fire resistant. Moreover, it is a renewable material, easy to be processed and manufactured, producing low pollution and consuming minimal energy. Bamboo offers a comfortable environment through its thermal insulation and continuous oxygen production. Bamboo sheets can be involved in interior design as panels for walling, flooring, ceiling, window curtain and furniture. (Malanit et al. 2011) (Wahab et al. 2009). Bamboo is an ideal natural material with a renewable source, easy recyclable and cost effective, holding a promising wood replacement process and can be considered a potential material for furniture and interior design, however, it is not yet fully used. (Chaowana, 2013)

I. Bamboo:

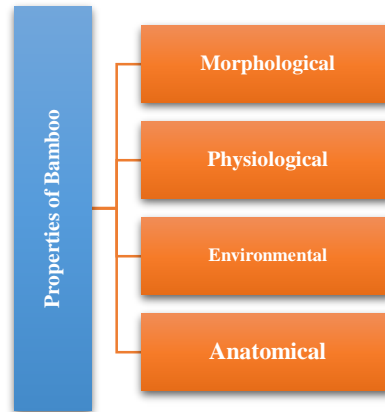
Bamboo is a non-wooden forest plant that originates from the largest grass family. It is one of the semi aquatics plants that grows in humid places and requires large amounts of water therefore it grows in the tropical and subtropical countries as India, China, Indonesia, Japan, in southeast Asia. Also, in Kenya, Tanzania, Nigeria, Ethiopia, and Egypt in Africa. It also grows in Brazil, Chile, Colombia, Ecuador, Mexico in south America except for Europe (Figure1). It grows in Egypt on the edges of canals and water ways under the name Bambusa, Buddha Belly Bamboo and Guadua Angustifolia. Bamboo is a grass with great diversity and utility, that is closely related to trees, in its use and appearance. There are about 1600 species of bamboo in the world, distributed across 111 genera (Figure 2) (Benhua et al. 2016). Bamboo is a highly renewable material, strong, versatile, with a durable, and aesthetic appeal.



(Figure 1) Bamboo distribution worldwide. (Boran,et al . 2013)



(Figure 2) Some species of bamboo genus



(Figure 3) Bamboo properties.

Properties of Bamboo:

- **Morphological:**

The two essential morphological features are rhizome system and culm:(Jiang,2007)

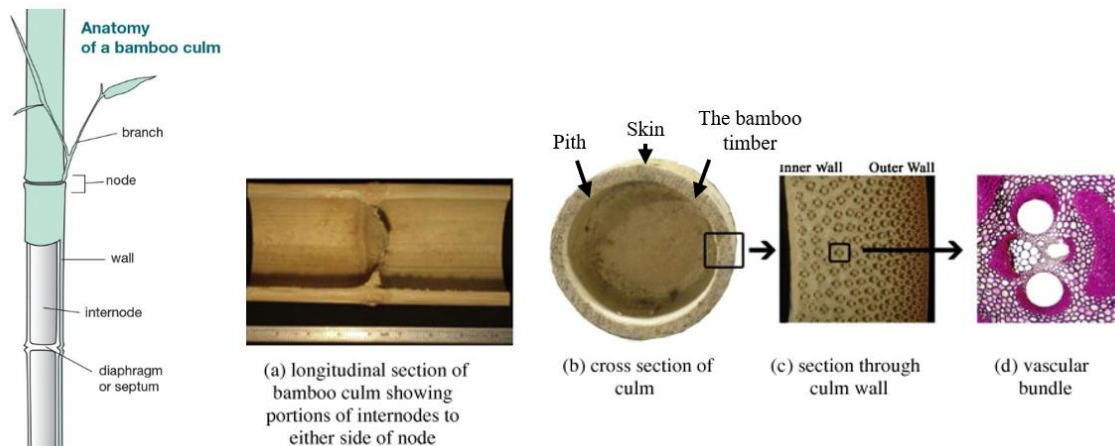
- **The rhizome system** is responsible for the fast growing and resistance to environmental conditions of bamboo. Bamboo is different from the trees regarding growth, bamboo grows from the rhizome, while trees grow mainly from the trunk. Rhizomes prepare all the things needed for the growth of culms.

-**The culm** is the upper part of bamboo which differentiates it from grass and trees. The culm is a naturally straight cylinder formed with nodes and internodes and contains most of the solid material. It is the visible part of bamboo which makes it so unique as a plant. The growth of the culm begins from the buds on the rhizomes.

- **Anatomical:**

The bamboo culm cross section is divided into three parts (Figure4)

The skin: the cortex of the bamboo culm cross section is a Watertight layer which protects bamboo against moisture loss from inside and outside. **The bamboo timber:** between the skin and the pith, with vascular bundles and internal tissues. It is the main structural and functional part of the culm. **The pith:** is the inner of the bamboo cavity. It is a parenchymal tissue, without vascular bundles. (Trujillo and Lopez , 2016)



(Figure 4)Anatomy of bamboo culm. (Gottron et al.2014)

- **Physiological:**

The bamboo culm grows to reach its maximal height in a very short time and build in straight and clear form to support the leaves and transport nutrients so the leaves can expose enough surface area for maximum sunshine and rainfalls needed for the photosynthesis. The rate of its growth is very fast, 40-120 cm per day, it can be harvested in 3-5 years. Bamboo can reach its full height within 2-4 months, around 15-30 meters, a diameter of 5-15 cm and a wall thickness of 10 mm. Before the culms reach their highest points, their branches will not grow. During this time, all the new growing culms only get nutrients from the rhizomes and other older culms. This also demonstrates the special surviving strategy of bamboo: the leaves always have a relatively high position so that they can get better insolation. (Wahab et al. 2009)

- **Environmental impact:**

Bamboo can grow rapidly in absence of pesticides or chemical fertilizers, requires no irrigation, does not need replanting. Bamboo tree produces 35% more oxygen than the stand of trees, isolates carbon dioxide, thus, balancing atmospheric oxygen and carbon dioxide. Bamboo is an excellent soil erosion inhibitor, grows in a wide range of environments and has a lower environment impact, unlike other plants. Bamboo is a non-polluting material with no waste of any part. Unused parts can be recycled back into the earth as fertilizer or can be processed as bamboo charcoal. Bamboo has a natural color, that does not require industrial toxic paints. Therefore, bamboo is a sustainable eco-friendly, healthy material that can substitute natural wood and contributes in protecting the environment and keeping the earth green.



(Figure5) Untreated, section and creative bamboo poles (Schroder, November30, 2014)

II. The advantages of Bamboo:

The bamboo tree is abundantly grown worldwide due to its cheap cost and easy cultivation and usage. Bamboo grows rapidly, unaffected by the climate changes like temperature, humidity or soil and requires no fertilizers or pesticides. Bamboo has a self-renewable property, after harvesting it grows back from its root system without additional planting which saves time and money. (Mera & Xu ,2014) Bamboo is a natural eco-friendly environmental material that produces no wastes. All parts are useful, from the roots, new bamboo grows back and from the culm, furniture and textiles are manufactured. Moreover, any unused part can be recycled to soil fertilizer. Its natural aesthetic color, smooth and clean surface, require no scraping or toxic polishing or painting, which made it natural and non-toxic to the environment. Bamboo protects the environment as it releases 35% more oxygen than the other trees and absorbs large amount of carbon dioxide, thus providing a continuous atmospheric balance. It helps in preserving some of the unrenewable sources, as it grows from renewable source, similarly, it consumes less energy, when compared to other materials (Demelash et al. 2015). Bamboo is highly resistant

to ultraviolet rays; its penetration rate is 0,00006. The natural surface of bamboo is composed of variable sizes oval pores, that absorb large amount of water, thus it is a moisture absorber. The natural surface of bamboo-is highly rich with silicate acid and water, which made it fire resistant. Another property its non-absorbability and non-production of heat, which help maintain a cool environment in the summer. (Xiaofang, 2009) Despite its high flexibility, that facilitates its cutting and folding into infinite sizes and shapes, it is composed of strong fibers, which, provide it with high strength, durability and resilience that protect it from easy splitting. The light weight of bamboo facilitates its displacement, store, and transportation with minimal cost. (Nurdiah ,2016) The bamboo also has an antimicrobial property that protects it from damage by worms or pests during its growth and storage and diminishes the requirement of any pest-control. This property never fades by repeated washing or sun exposure. The antibacterial and antifungal property can be considered a natural antibiotic for patients with low immunity or normal people fearing sickness. (Yang et al.2009) Also, its pesticide-free cultivation property made it a natural component in thousands of natural prescriptions. Bamboo is a cost-effective material, due to its abundant growth in different parts of the world, adaptability in any climate, rapid growth rate, its renewability, recyclability, lightweight, high-strength, flexibility, and its antimicrobial property, which facilitates its mass production, manufacturing and transportation and maintenance, without any sophisticated tools or equipment with low costs and time with no wastes. (Baldawi, 2015)

Comparison between bamboo plant and hardwood plant:

Table 1 shows the advantages of Bamboo, which help in covering the shortage of hardwood faced today and maintain a green earth.

| Bamboo | Hardwood |
|--|---|
| Bamboo produces oxygen during the day, 35% more than hardwood plants, also, it absorbs more carbon dioxide. | Hardwood tree leaves produce oxygen in the morning and carbon dioxide at night. |
| Bamboo is an eco-friendly material as it is an endless renewable grass, thus, cutting it, causes null waste and its recyclability made it sustainable with no impact on the environment. | Cutting hardwood trees, are non-renewable, non-recyclable and sometimes associated huge waste, resulting in a huge damaging impact on the environment which requires long time to repair. |
| The rate of generating bamboo trees is quicker, it takes 3-5 years to reach complete maturity and harvesting. (Lugt et al. 2009) | The rate of hardwood trees takes a long duration of years; for example, oak trees take nearly 50 years to grow. |
| Bamboo offers great quality of hard material and big quantity and easy transportation with lesser cost than hardwood. | Hardwood offers great quality but not big quantity and with higher cost than bamboo. |
| Bamboo is unaffected by the variable environmental conditions such as expansion and contraction. | Hardwood is affected by climate changes. |

| | |
|--|--|
| Bamboo is self-regenerative and renews itself from pre-existing roots of the plants. | Hardwood trees need new planting, I-e wood trees are not self- regenerative. |
| Bamboo is water-and moisture-resistant. | Water and moisture can stain or damage most of hardwood. |
| Bamboo is fire resistant. | Hardwood trees are not fire resistant. |
| The cylindrical shape with its circular cross sections and hollow centers of bamboo provide lightweight and high-strength, which caused it to be easy to handle, transportable and storable. | The Hardwood cross sections are with no hollow centers and provide high-weight and high-strength material, which is not easy to handle or transport. |

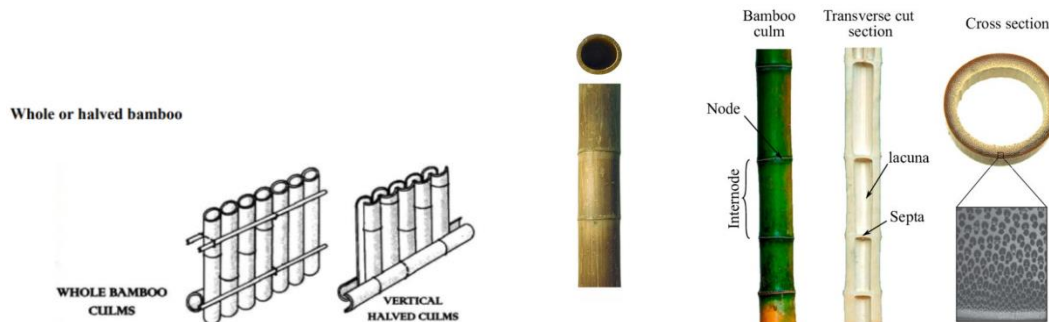


III. The application of different types of bamboo in interior design and furniture according to its advantages:

The application of bamboo as an environmentally sustainable healthy material draws the attention of interior designers. It became popular in most of the world due to the resources needed for interior design and furniture use since natural resources are being depleted and the need to keep the environment green. This study showed the use of four different forms of bamboo in interior design and furniture: Bamboo section (whole or halved bamboo culm), bamboo slices, bamboo strips and ply bamboo.

1- Bamboo section (whole or halved bamboo culm):

One of the most basic processing methods of bamboo is to cut the whole bamboo culm or cut it into sections to be used after bleaching. Using the bamboo sections, in interior design and furniture gives the production some natural elegance, simple appearance, and durable quality. It can be used for designing interior design and furniture like beds, chairs, tables, doors, walls, ceiling, partition, accessories. (figure6 &figure7,8).



(Figure 6) whole bamboo culms, vertical halved culms and cross section .(Gangwar and Schillinger, 2019)

▪ Interior design and furniture:

In indoor partitions:

Using bamboo culm as a whole or halved for partition between rooms or in any interior spaces will make spaces more private and give it a natural and different appearance without building walls. LED light can be added to the partitions to provide a warm and welcoming atmosphere.



(Figure 7) Different ideas using bamboo for interior partition design.

Indoor wall design:

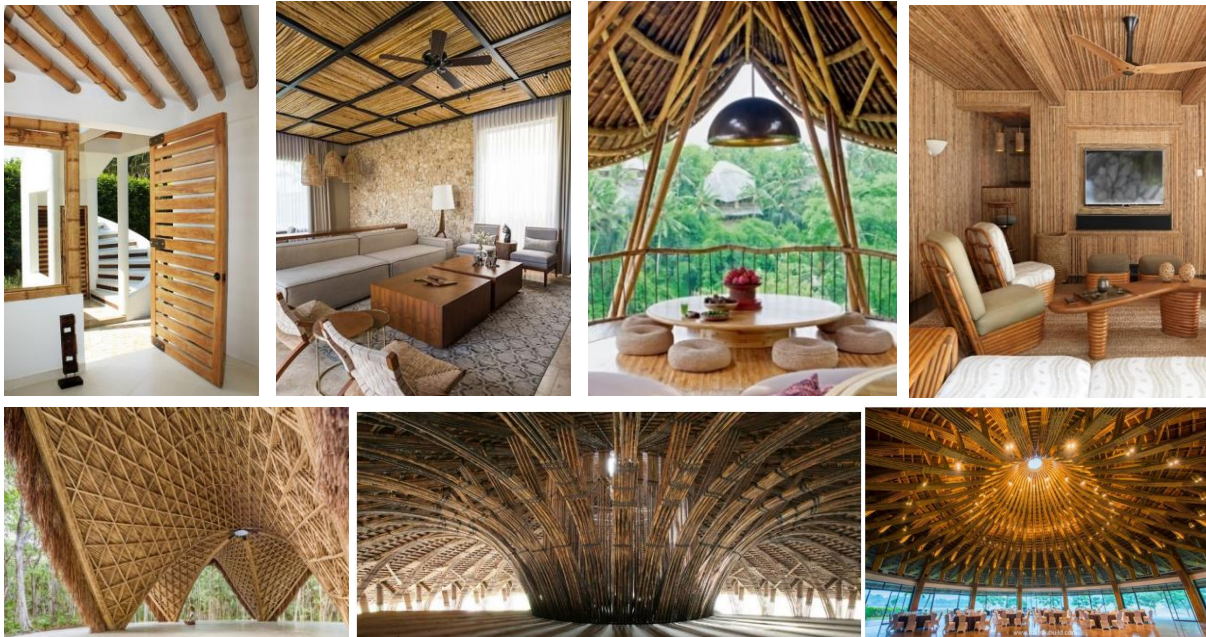
Bamboo culm as whole or halved can be used to cover part or a whole of any existing walls in any interior design. Example using it in workplaces to decrease heat and sound transmission while adding an aesthetic aspect. In bathrooms, bamboo has water, moisture, and fire resistance and antimicrobial properties.(Figure 8)



(Figure 8) Using whole or halved bamboo sheet in interior wall of different spaces.

Ceiling:

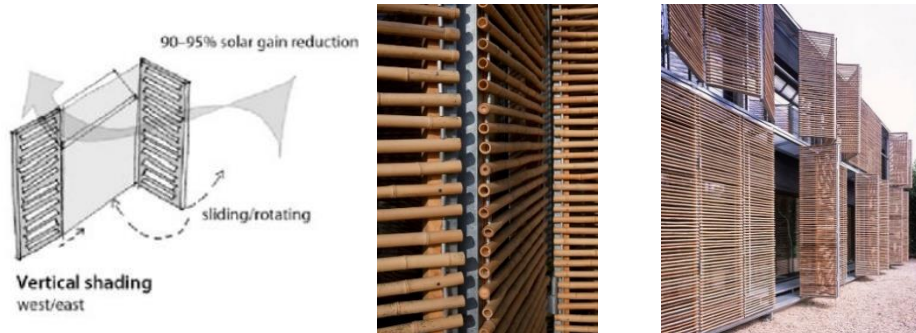
A relaxed and simple design with a natural and aesthetic atmosphere and sound isolation can be created from a ceiling design made of bamboo secondary to its lightweight and different geometrical shapes. (Figure 9)



(Figure 9) Using whole bamboo culm in the ceiling's design in different ways to give a natural and aesthetic atmosphere.

Solar shading device:

The insulating property of the bamboo made its use as cooling shades in rooms in summer, thus preventing overheating. (Figure 10)



(Figure10) Using whole bamboo in traditional shading devices for window .

Indoor furniture design for normal and sick people:

Its natural aesthetic color, smooth and clean surface, requiring no scraping or toxic polishing or painting, made it natural and non-toxic material to be used in indoor environment. The antibacterial and antifungal property of bamboo make it a safe and suitable material to be used for patients with low immunity or normal people fearing sickness.



(Figure11) Using whole or halved bamboo in different furnitures.

Outdoor furniture design:

Bamboo is unaffected by the variable environmental conditions like temperature, humidity and resist pests, water, fire that is why the designer used it in outdoor furniture with diverse looks.



(Figure 12) Using whole bamboo in outdoor furnitures

Lighting units:

The flexibility, durability, decreasing the heat, resistibility to climate changes and the natural look of bamboo encouraged the interior designers to use it in the lighting units indoor or outdoor.



(Figure 13) Whole bamboo culm used in lighting units.

Accessories':

(Figure 14) Using whole or halved bamboo in accessories.

2 -Bamboo slices:

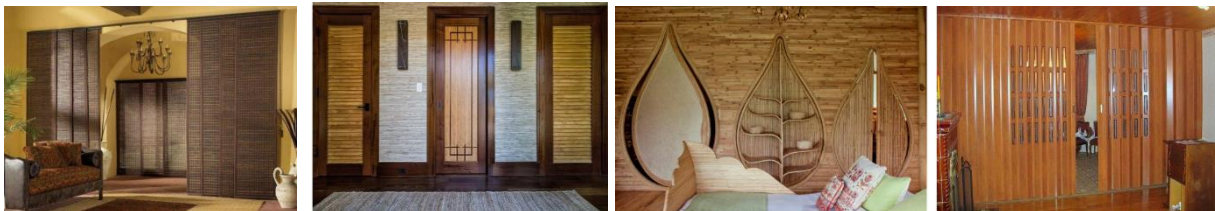
Bamboo slices are made of bamboo with large radius and are cut transversely to make sheet thickness greater than 1 mm. In the interior design, bamboo slices are used in walls, floor, ceiling, window and doors (figure 16,17). In furniture design, bamboo sheets are often used in single chips, and the woven forms in bamboo chairs and tables. A new styling language is now added to the traditional bamboo, from the industrialized bamboo slices, giving the chairs and tables a modern design with the bamboo natural texture. (Figure 15)



(Figure 15) Bamboo slices giving the furniture a modern design with the bamboo natural texture designs.

Doors, windows and curtains out of bamboo:

Using bamboo material in different door designs like sliding, normal, accordion doors can be an alternative material to wood, being unaffected by the variable environmental conditions such as expansion and contraction, while having similar properties



(Figure 16) Using bamboo material in different door designs.



(Figure 17) Bamboo slices in windows and curtains.

3-Bamboo strips (split or flattened Bamboo)

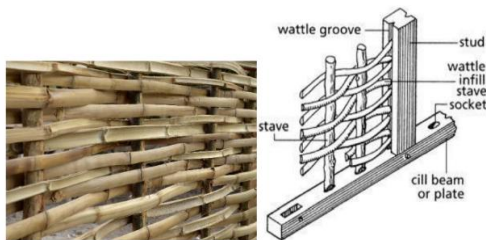
The split bamboo has two sides, a straight and curved sides. It can be cut into pieces for weaving or made flat with two- or three-dimensions furniture products as curtains, seats, and tables. Using different weaving methods create different pattern of bamboo rhythm like wattle and woven bamboo. Wattle bamboo is made of thick panels of bamboo strips that are intertwined around the bearing beam of bamboo.(figure20) The technique of woven bamboo is similar to the wattle one but the strips are densely placed close to each other and does not require external coating.(figure21) In addition to the different pattern and natural texture, the sheets made of bamboo strips are adding strength to the originally strong strips.



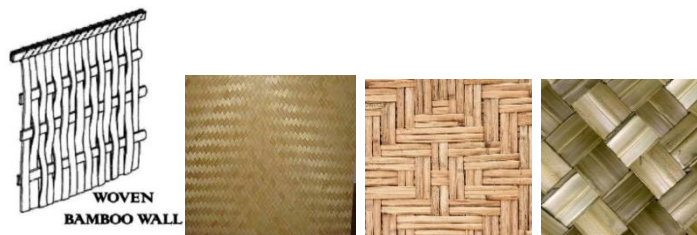
(Figure18) Flattened and split bamboo



(Figure19) bamboo curtain



(Figure20) wattle bamboo



(Figure21) Different woven bamboo

In interior design and furniture:

Using the different weaving methods in interior design and furniture because its lightweight and high strength, unique form, simple, natural color and healthy in the ceiling, wall, lighting units, chair. The seat shell had closed woven methods to bear weight.



(Figure 22) Using woven bamboo in interior wall, ceiling, lighting unit, and furniture.

4-Plybamboo:

Bamboo plywood is made of thin layers of bamboo strips in parallel order, glued at high pressure, under high temperature without formaldehyde. It can be pressed either horizontally or vertically for different structures and cut into the required dimensions (Anwar et al.2005). The Ply bamboo is now being used for wall paneling, floor panels, furniture and accessories. (figure 23)

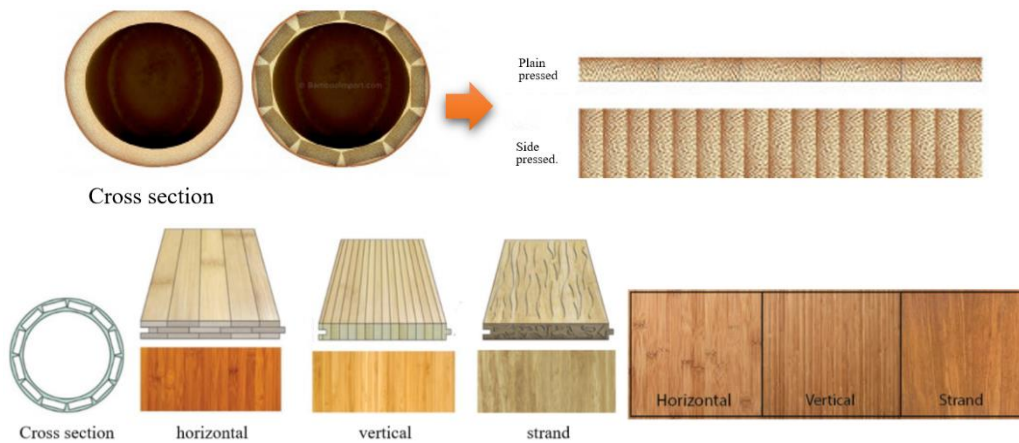
In furniture:



(Figure 23) Vertical bamboo plywood used in different furniture.

In floor covering decoration:

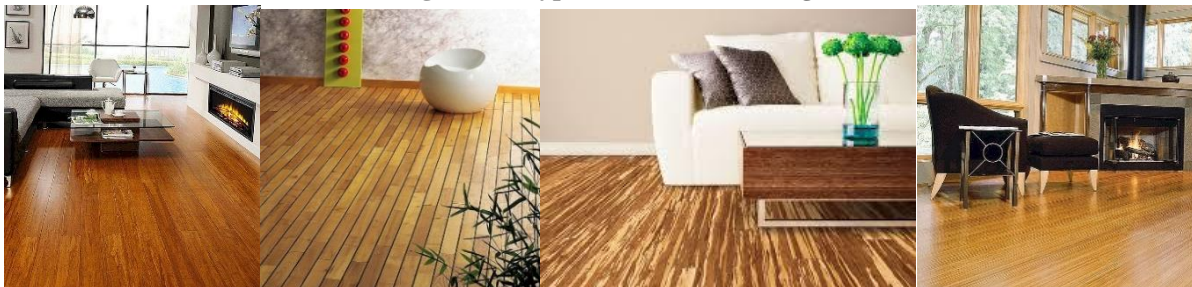
The modern processing technology used the natural advantages of bamboo in flooring, being naturally resistant to water, fire and insects, flexibility and durability, smooth and flat surfaces, it is most of all, eco-friendly, unaffected by environmental conditions such as expansion and contraction, and is being sustainable more than the traditional hardwood floors. Bamboo is not slippery; therefore, it can be used in flooring, especially for elderly and young children. Bamboo as a flooring material is more resistant to scratch marks and its natural warm color made it the first choice for all environment-friendly homeowners instead of the hardwood floorings for the contemporary styled homes. There are three types of bamboo flooring: horizontal, vertical and strand woven. (Figure 24,25,26) (Trujillo and Lopez, 2016)



(Figure 24) Vertical, horizontal and strand bamboo flooring



(Figure 25) Types of bamboo flooring



(Figure26) Using bamboo flooring in the interior design gives a friendly, warm and natural environment and a great alternative to traditionally used hardwoods.

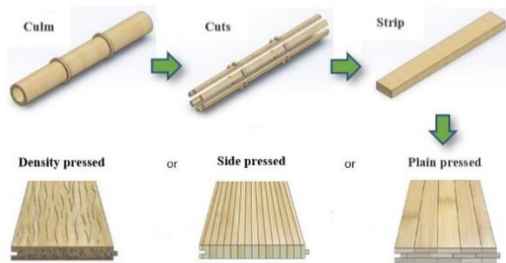
Source; www.Ambientbp.com/blog/11-of-the-most-frequently-asked-questions-about-bamboo-flooring

III. Bamboo board manufacturing process:

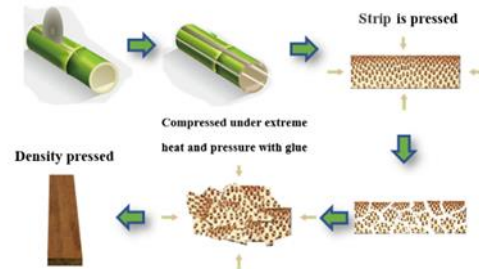
- The bamboo stem is cut in a longitudinal direction and turned into strips, while removing the outer green cover of the plant. The strips are treated against mold and insects by boiling over steam to burn sugars and substances that may cause mold and turn the color of the slices to caramel brown.
- Slides can be connected in different ways to create sheets: (Figure 27)
 - **Plain pressed (The horizontal):** The horizontal is composed of strips of bamboo that are arrayed on their side horizontally and glued together under high pressure, also referred as flat grain, and the resulting sheet has a pattern of small marks from the nodes of the bamboo culm.
 - **Side pressed (The vertical):** The vertical bamboo is composed of strips that are arrayed vertically and glued together under high pressure, also referred to as edge grain, and the resulting sheet has less apparent nodes from the culm.
 - **Density pressed (strand woven):** in this case the strips are pressed before gluing so that slats are transformed into fibers, then glued together, then compressed under extreme heat and

pressure to create a unique grain of linear texture, in addition, the hardness of the product is more than twice the hardness of traditional bamboo. (figure 28)

- **Flexible connection (panda/zen):** in this case the strips are not glued but tied together with corrugated thread for vertical support.



(Figure 27) Slides can be connected in different ways



(Figure 28) Density pressed (strand woven) resulting in a sheet.

IV. New suggested combination of bamboo with other materials in modern interior design and furniture:

Bamboo can be combined with other complementary materials that provide an aesthetic view to the interior design and furniture in addition to the diversity of function in design. This combination brings a new styling language of design that provide a feeling of relaxation from the simple modern design and the practical artistical natural functions of bamboo.

1- Bamboo and Rattan

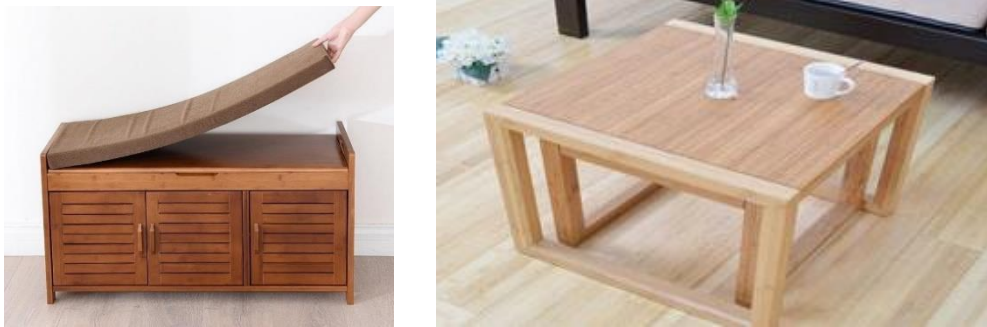
Rattan is like bamboo, a non-wooden forest material. Rattan is a climbing palm found in tropical and subtropical forests. Rattan grows naturally in Asia and west Africa. Rattan trunks are solid and very strong, and its flexibility made it easy to be shaped and bent in the sophisticated designed furniture. (Jiang, 2007) The combination of bamboo and rattan gives an eco-friendly aesthetic design that brings a primitive feeling due to their natural origin and pattern. (Figure 29)



(Figure 29) Combined bamboo and rattan furniture.

2- Bamboo and wood

The combination of bamboo and wood is a new style of interior design and furniture. This combination is complementary in terms of functions and aesthetics and can be integrated in the modern simple design bringing the practical use of the designs with the strength and durability together in an elegant outlook. (Figure 30)



(Figure 30) Bamboo and wood in interior design and furniture.

3- Bamboo and ceramic

Ceramic is a sustainable and eco-friendly material made of soil under high temperature. Ceramic has the properties of high strength, being acid and alkali resistant and cold and heat resistant. Its soft qualities, various colours, rich texture and smooth tactility reflect aesthetic and elegance. However, it is very fragile as it does not resist shock and is prone to worm damage. (Zhou and Dai,2008) The eco-friendly bamboo has a flexibility and high-strength which made it resistant to crushing, environmental changes, as well as pets. Its combination with ceramics will overcome its disadvantages. Embedded ornamental parts of ceramics with its various colours in the bamboo furniture bring an innovative new visual effect. (Figure31)



(Figure31) Ceramics have been combined with bamboo in furniture.

4- Bamboo and steel

The combination of bamboo with other materials like steel, can be considered an innovative design for the interior design and furniture and provided a modern styling furniture at low cost with high strength and lightweight, which made it easier to disassemble and assemble. Bamboo surpasses the tensile strength of steel, counteracts the atmospheric pollution and environmental degradation unlike steel. Moreover, bamboo is an abundantly available material that requires zero to minimal industrial interventions unlike steel and zero waste of materials. This sustainable combination of bamboo with steel can reinforce furniture and provide an aesthetic and practical designs to cope with the contemporary lifestyle.

IV. Application & analysis:

The idea of the proposed design was based on using renewable natural materials in the design and the combination of bamboo with other materials. This idea was applied in the interior design and furniture of bedroom of a touristic resort. It reflected how we can use the advantages of bamboo being sustainable, eco-friendly material to create a healthy, simple, and comfortable indoor environment from the floor, ceiling, furniture, doors, accessories, and lighting units. The

furniture and interior design followed an arched line to create a homogenous environment, emitting positive energy all around. We suggested the use of the different types of bamboo in the design like halved bamboo culm and woven bamboo in the ceiling and using ply bamboo in furniture and floor and the hand-woven bamboo in the pot of plant.



(Figure 32) Plan and section of the room.

Analysis of the proposed design elements:

- **Ceiling:** we proposed two designs for the ceiling of the room using bamboo material, one design used the halved bamboo that partially covered the ceiling showing the unique nodes of bamboo and other design using woven bamboo that covered the whole ceiling. This can change the boring white ceiling into a new artistic, comfortable look. (Figure 33)



(Figure 33) Two designs for the ceiling of the room using bamboo material.

- **Floor:** we used the industrialized bamboo in the design in form of sheets type solid horizontal to cover the whole area of the floor. Its natural color, smooth surface gave the room a comfortable and warm look close to nature. Also, its durability, water and fire resistance, pets and microbial resistance and swelling and shrinkage resistance favored its use in the floor for long time and increasing the room hygiene. The anti-slipping nature of bamboo made it a good choice in the floor especially for elderly people and those with unstable movements. Also, its use with the same color of the ceiling and same material gave a homogenous warm feeling to the inhabitant of the room. (Figure 34)



(Figure 34) The floor made from bamboo with natural color, smooth surface gave the room a comfortable and warm look close to nature.

- **Doors:** the main door, the bathroom door and the door of the built-in cupboard are made of ply bamboo. We used the same natural color of the bamboo used in the whole room and the handles are also made of bamboo. This also created a homogenous natural look of the room with the floor. (Figure 35)



(Figure35) the doors used in the design made from bamboo.

- **Accessories:** Design complements like carpets, lighting units, planting pots, wall plate decoration, are handwoven made of natural sustainable environmental materials like seagrass, bamboo, rattan. All are natural recyclable and renewable material to meet all the needs of the designer in the space to appear as a single integrated design unit. In addition, we used special indoor plants that can renew the room air, thus providing more oxygen and less indoor pollution like snacks and bamboo plants. The plants also created an aesthetic, natural look and the natural green increased the contrast with the natural color of bamboo. Its presence also helped in emitting continuous positive energy in the room. The plant pot was made of handwoven bamboo and legs from natural bamboo to create a natural feeling and keep the pot hygienic and

antimicrobial. We combined the use of natural handwoven bamboo and the rattan in the lightening units beside the bed and the chairs to continue the natural feeling and look of the room. We combined the natural seagrass with the rattan and bamboo in the rounded plates hanged on the walls above the bed and between the doors with its colors to create a contrast with the walls. (Figure 36)



(Figure 36) Design complements like lighting units, planting pots, wall plate decoration.

▪ **Furniture:** The use of bamboo in furniture units in the room as an environmentally friendly, healthy, strong, and low-cost material, with a new innovation and technological and simple vision to achieve contemporary designs to cope with the current period instead of the traditional ones. The furniture used in this room was mainly designed from bamboo like commodes, bed, small table, wall mirror. In those designs we used the ply bamboo vertical type to create a smooth, clean, natural, healthy, and simple design. (Figure37) The other design combined the bamboo with other materials like rattan and steel in the chairs and dressing table. (Figure38)

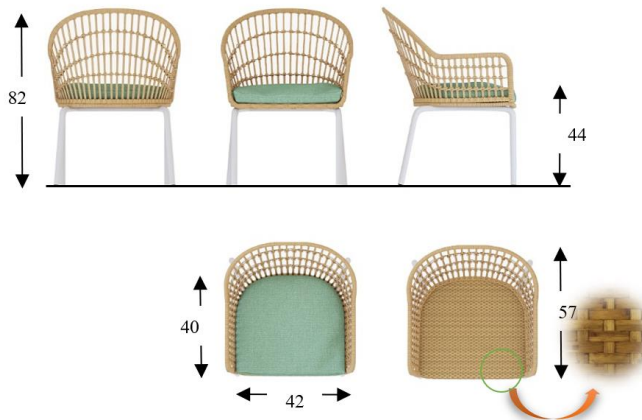


(Figure 37) The furniture mainly used the ply bamboo vertical type to create a smooth, clean, natural, healthy, and simple design.

Application of the new combination of bamboo with steel in the design of chairs and dressing tables provided a modern styling furniture at low cost with high strength and lightweight. Bamboo surpasses the tensile strength of steel, counteracts the atmospheric pollution and environmental degradation unlike steel. Moreover, bamboo is abundantly available material that requires zero to minimal industrial interventions unlike steel. This combination can overcome some of the steel disadvantages while providing an aesthetic and practical designs to cope with the contemporary lifestyle.

The chair: we combined in the design of the chair bamboo, rattan with steel. The frame of the chair was made of steel. The handwoven bamboo and rattan covered the sitting upper part of the chair to give it the rounded shape of the backrest and armrest. The seat shell had a closed woven to bear weight and the backrest was designed to create an airy, simple, and different look. This design is with high strength and lightweight and easy to disassemble and install (Figure 38)

Suggested design for chair



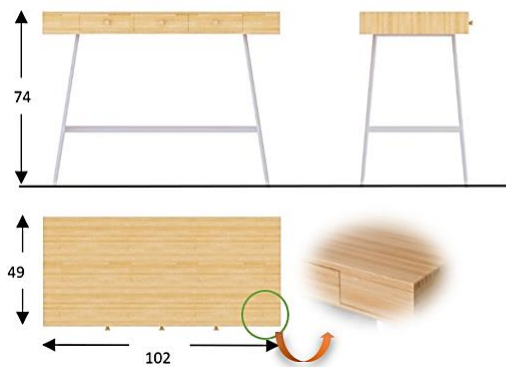
Different view for the real chair.



(Figure 38) The combination of the chair bamboo, rattan with steel in the design.

The dressing table: we combined bamboo and steel in its design. The tabletop was made of ply bamboo, vertical type, to minimize the appearance of the nodes from the culm to create a smooth, clean, natural, healthy and simple design. The table legs were made of white coated steel to bear weights and give different functions as well as matches with the white coated legs of the chairs, thus gives an aesthetic and practical look. (Figure 39)

Suggested design for dressing table



A view of the real design



(Figure 39) Bamboo and steel in furniture.

Results:

- 1-As the indoor environment directly influences the health of its occupants, interior designers must consider using sustainable eco-friendly materials as bamboo in their designs that promote a good interior environmental quality and human comfort.
- 2- Interior designers must contribute to protect the environment by minimizing cutting trees, that require decades for harvesting, by using sustainable renewable materials like bamboo in their designs, to cover its shortage and cope with the everyday human demands in interior design and furniture.
- 3- Bamboo emits more oxygen and absorbs carbon dioxide from the surrounding environment and create a healthy and well-ventilated interior environment close to nature with comfortable

ambiance. This helps in reducing everyday stress and the negative impact of the modern lifestyle on the occupiers of the space.

4-The different advantages of bamboo being: flexible, durable, resistible to climate changes , natural look like variable lengths, distanced nodes, and smooth natural color durable, light weight and high strength, also resistant to water, fire, pests, microbes, swelling and shrinking and ultraviolet, as well as decrease heat and sound transmission, easy to handle, transport and storage, and easy cultivated in any climate and rapidly harvested with low-cost transportation, encouraged interior designers to use it as competitive material to the hardwood with keeping the environment green and safe material in the interior design and furniture like wall panels, floor, ceiling decorations, home accessories, in the kitchens and bathrooms and in all types of furniture in different climates.

5- The new technology changed the traditional bamboo into an industrialized material, that can be well integrated in the interior designs and furniture to create modern simple designs to adapt with the contemporary lifestyles.

6- The combination of bamboo with other materials can be considered an innovative design for interior design and furniture, on one hand it can reinforce furniture in a modernized and aesthetic look, on the other hand reducing the damage to the natural environment.

7- The interior designer must consider the concept of “energy conservation, healthy and environmental protection” in the interior design and furniture, while creating a stylish, functional, and aesthetic design.

Conclusion:

Bamboo is distinguished by its multiple functional, practical, and healthy advantages beside being a sustainable and ecologically beneficial material, which make it a suitable material for interior design and furniture. Bamboo is a cost-effective and rapid harvesting material that can replace or complement hardwood, thus, minimizing deforestation and help in keeping the earth green. Bamboo has positive impact on the human health and the environment and its use in the interior environment offers a long-term relaxed environment and protects against stress-diseases development. The diversity in the natural colors and shapes of bamboo provided a wide range of creativity in the interior designs and furniture. The technology changed the traditional bamboo material into industrialized bamboo, an issue that will encourage interior designers to integrate bamboo in a wide variety of modern designs.

Recommendations:

This paper recommends reimplantation of bamboo in Egypt, being a neglected agriculture, having multiple advantages on the individual, economic, health and the community levels.

We also recommend the implementation of a policy by the government that supports bamboo cultivation to contribute in protecting the environment with minimal soil erosion and climate changes, thus, creating a healthier environment by 2030.

We also advise interior designers to use bamboo for being a sustainable, eco-friendly, renewable material, that possesses some of the advantages of hardwood to use it in interior design and furniture to cover the shortage in hardwood and minimize wood cutting.

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