

The Ubiquitous Role Bamboo Has in Making a More Sustainable World

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It is indisputable that the Earth has been suffering for decades and even centuries. The planet's average surface temperature has increased about 1.62 Fahrenheit since the late 19th century due to the increased greenhouse gas emissions. According to NASA (n.d.), the Greenland and Antarctic ice sheets lost an average of about 413 billion tons per year which consequently increased the sea level about 8 inches in the last century. As natural disasters become more drastic and frequent, an average of 25.3 million people have been displaced each year since 2008 ("Disasters and Climate Change", n.d.). Although climate change has been discussed frequently, more needs to be done to raise awareness and combat the climate crisis. It is important for consumers and businesses to be more conscious of their carbon footprint—bamboo is a solution to reducing that footprint.

Bamboo is a grass plant that has about 1,200 species and occupies about 37 million hectares of the total forest area of the world. It is considered one of the most sustainable resources because it grows rapidly and requires less energy to treat compared to wood (Minke, 2016). An unique aspect of bamboo that makes it stand out from other natural resources is that it can be used for a diverse range of purposes, from culinary uses to architectural uses. The multipurpose, rapid growing bamboo provides a more sustainable substitute to other renewable and nonrenewable resources.

Culinary: *Meat Production*

For example, since antiquity, bamboo has been used for multiple purposes in Yunnan. The province of Yunnan is located in southwest China and has the most abundant bamboo forest in the world with about 250 species. Through conducting interviews with native inhabitants and carrying out field surveys, it is determined that of the 250 species, about 100 are edible and nutritious. In fact, bamboo shoots have many advantageous properties. For example, shoots have a high protein content (up to 15%), contain many vitamins and minerals, and have a low fat content (Yuming et al., 2004).

These advantages make bamboo shoots a suitable substitute for meat protein. It is evident that bamboo shoots do not contain as much protein as meat products as the protein content in beef is around two times the amount in bamboo shoots, however, the recommended dietary allowance is only about 0.8 g of protein per kg per day (Institute of Medicine, 2005). In fact, the National Health and Nutrition Examination Survey found that the average American male and female consume about double the daily recommended intake of protein (Jones, 2012). In addition, producing meat protein such as beef and poultry requires more energy and emits more greenhouse gases such as methane. In fact, a regular diet has a greenhouse gas emissions of

about 3.88 kg CO₂-equivalents per person per day and a diet that consists of plant proteins drastically decreases the greenhouse gas emissions by 49.6 percent (Willits-Smith et al., 2020). Through introducing bamboo shoots into one's diet and reducing meat protein intake, one can reduce their carbon footprint caused by the production of beef and poultry.

Textile: *Fast-Fashion*

In addition to using bamboo for culinary purposes, bamboo is also implemented in the textile/fashion industry as a biodegradable material. Bamboo is known as the “green fiber” because it grows without the use of pesticides and fertilizers, it is in fact a more sustainable fiber than other eco-fibers such as cotton and hemp. Bamboo fabric is lightweight, strong and has great moisture-wicking properties. This makes dyeing bamboo fabric more time and cost efficient than dyeing cotton. Unlike cotton, it does not need to be pretreated with sodium hydroxide to increase the fabric’s luster and dye affinity (Dilek, 2019).

Most importantly, bamboo fibers can help counter the waste and pollution generated by fast-fashion. Fast fashion brands frequently update their clothing products in store in response to the ever changing fashion trends, this consequently leads to a shorter life cycle of garments and more waste. According to a report by the Ellen MacArthur Foundation, the fashion industry will use up a quarter of the world’s annual carbon budget by 2050. Additionally, the industry cuts down 150 million trees annually and a truck of clothes gets sent to a landfill every second (Hopkins, 2018). Bamboo fiber is a solution to the negative environmental impacts of fast-fashion because it is completely biodegradable and the decomposition process does not release any pollutants (Dilek, 2019). Garments made from bamboo fibers are durable, making them last longer and at the end of the garments’ life-cycle, it will not contribute more waste to the Earth. Therefore, it is essential to introduce more eco-friendly fibers into the textile industry in order to raise consumer awareness and create timeless pieces that would last a lifetime.

Daily Use

Carbon Sequestration

So far, bamboo products are only discussed in terms of being a sustainable substitute in order to minimize the amount of greenhouse gas emissions. Bamboo products can also be discussed in the context of carbon sequestration. Carbon sequestration refers to the storage of carbon in plants, soil, the ocean, etcetera that has the potential to become carbon dioxide (Selin, 2019). While combustion and decomposition releases carbon from plant tissues, which combines with the oxygen in the atmosphere to create carbon dioxide, photosynthesis transfers carbon in the atmosphere to be stored in biomass and soil. Therefore, autotrophs such as bamboos are terrestrial carbon sinks as they retain carbon and prevent it from entering the atmosphere. A study was conducted to determine the role bamboo products play in carbon storage. The study took place in north-east India where bamboo sustains 70% of the rural workforce. The carbon storage of various bamboo products was measured through weighing and analyzing the bamboo

samples collected (Ray et al., 2020). The biomass and carbon stock in bamboo products for different communities are shown in Table 1. The result reveals that each household has between 196 to 517 kg of carbon dioxide in bamboo products annually. To put it into perspective, a gallon of gasoline has 8.887 kg of carbon dioxide and an average U.S. forest sequesters about 770 kg of carbon dioxide annually (“Greenhouse Gases Equivalences”, n.d.). It is impressive to see that a single household can sequester almost the same amount of carbon as an acre of forest. It is important to note that although there is a considerable amount of carbon stock in bamboo products, the maximum longevity of those products is five years because they are not pretreated. In order to make bamboo products a long-term carbon sink, the community should apply post-harvest treatment to the bamboo to minimize deterioration and extend the longevity of the products. In general, preservative treated bamboo can be used to make a diverse range of products such as baskets, containers, brooms, fishing devices, fans, trays and so on in order to retain carbon for a long period of time.

Community	Total number of products prepared per household per annum (number/year)	Biomass stored in bamboo products per household (kg/household)	Carbon stock in bamboo products per household (kg/household)	CO ₂ e stock in bamboo products per household (kg/household)
Fishing	1016 (180)	508 (55)	239 (70)	876 (75)
Khasi and Hmar	1135 (150)	578 (35)	272 (55)	998 (80)
Bengali Hindu	2447 (290)	1100 (30)	517 (75)	1899 (110)
Tea tribes	800 (120)	416 (25)	196 (60)	718 (60)

Table 1. Biomass and carbon stock managed through bamboo products among the different communities in Barak Valley (Ray et al., 2020)

Plastic Pollution

In addition to bamboo products being a carbon sink, they are also a solution to plastic pollution. Although plastic utensils and containers are most convenient to many, if a person gets a cup of coffee and lunch daily, that is already so much plastic waste annually from one person. With only nine percent of plastic that are actually recycled, microplastics end up in the ocean, soil, biota, and even the atmosphere (Rochman & Hoellein, 2020). This waste can easily be avoided if the one uses reusable bamboo products instead. Plastic pollution is a global issue that mainly impacts poorer communities. Remote communities that do not have an established waste management system have to shoulder the impact of the plastic pollution crisis. Plastic waste impacts the health of marine life, which consequently impacts the qualities of fisheries, aquaculture, recreational activities, and tourism. This has an economic consequence with about \$3,300 to \$33,000 loss per ton of marine plastic annually (Phelan et al., 2020).

Plastic pollution is an issue in underserved, remote communities due to the conventional purchase and disposal habits. In the coastal and remote Indonesian communities, the majority of the household goods are sold in single-used plastic sachets. Additionally, many households prefer processed, packaged foods over fresh foods because it is cheaper and more convenient. The result from the surveys conducted shows that 59% of the respondents think plastic waste should be burned, 3.8% think it should be buried, and 13.5% think it should be put in the ocean.

It is interesting to see that although 74.3% of the respondents know that burning plastic has a negative impact on human health such as coughing and difficulty breathing, more than half of them still burn plastic for disposal (Phelan et al., 2020). Poor waste management and lack of knowledge of the negative impact plastic has on the environment leads to excess waste and health concerns. Bamboo utensils and packaging may be an option to resolve plastic pollution in those communities. For example, rather than using single-use plastic sachets, bamboo segments and bamboo leaves can be used as options for food storage and transportation. This is already used in different locations such as Thailand. Thin strips of bamboo are woven together to make baskets called chalom and bamboo segments are cleaned and sealed with dried banana leaves to make a dessert called khao laam as shown in Figure 1 (Grachangnetara, 2019). Recently, there has been studies on how to use bamboo-based biopolymers to produce biodegradable food packaging (Osorio et al., 2020). Ultimately, remote and underserved communities have to pay the social and economic costs of the plastic pollution until they can effectively manage the plastic waste and explore different non-plastic alternatives. Bamboo can be an economically and environmentally sustainable alternative.



Figure 1. Thai dessert khao laam (Grachangnetara, 2019)

Architecture

As mentioned above, bamboo fibers are durable and strong, which also makes them a suitable material for architectural use. Bamboo has a high tensile strength, with the external layer bearing up to 400 MPa—similar to the tensile strength of steel. This also makes bamboo an ideal material for earthquake-resistant structures. For example, in 1991, twenty bamboo houses in Costa Rica survived a magnitude 7.5 earthquake without any structure damage (Minke, 2016).

Reinforcement with Bamboo

Reinforced concrete is commonly used in buildings and bamboo is a more natural, sustainable material compared to the more commonly used steel reinforcement. Steel is costly, takes a lot of energy to manufacture, and is susceptible to corrosion from concrete carbonation and exposure to other concrete elements. An alternative to steel is bamboo because of its tensile strength. Bamboo reinforcement has been tested since 1914 but it was not successful due to the swelling and contracting of raw bamboo and degradation due to fungal and insect infestations (Javadian et al., 2020). However, recent studies have been conducted to design a potential bamboo composite reinforcement system that would overcome the challenges raw bamboo has. In one study, bamboo is boiled and dried in an air-circulated oven to make bundled bamboo fibers. After the fibers are dried, they are saturated with epoxy resin and placed in a hot-press compression molding machine. Figure 2 shows the developed bamboo composite material. Compared to the mean tensile strength of raw bamboo (216-323 MPa), the tensile strength of the

bamboo composite is greater (346 ± 25 MPa). To determine whether the bamboo composite material will still swell and contract like raw bamboo, 10x10x10 mm samples are immersed in water for three months and the weight is measured once a day. The results show that the samples only have a maximum water uptake of about 0.5% of its weight (Javadian et al., 2020). This study makes it evident that bamboo composite material is a sustainable option to design low-cost housing for communities where steel is hard to obtain.

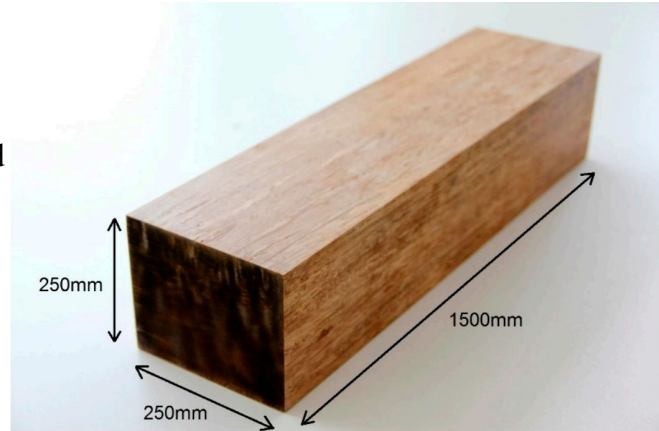


Figure 2. Bamboo composite sample (Javadian et al., 2020)

Flooring

Another sustainable application of bamboo is using it for flooring, which Ambient sets a good example for. An important pro of Ambient bamboo flooring that sets it apart from its competitors is that Ambient voluntarily tests their flooring for off-gassing and complies with the Toxic Substances Control Act. It is essential for the flooring to have minimal off-gassing because indoor pollutants, particularly volatile organic compounds (VOCs), can make the indoor air quality worse than outdoor air quality (Chang et al., 2015). An aspect of bamboo flooring that makes it a better option than wood flooring is that it is more durable. As mentioned earlier, bamboo is a strong material, when woven, the material can withstand loads two to three times greater than the load wood flooring can withhold. Additionally, according to Ambient, their bamboo floorings are water and dent resistant, which extends the length of their life cycle. Compared to hardwood flooring, bamboo and eucalyptus floorings are a more sustainable option due to their rapid growing and durability.

Sustainable Companies Today

It is delightful to see so many current and emerging sustainable companies that acknowledge their responsibility in minimizing society's carbon footprint. It is important for companies to not just use the word "sustainability" for public relations and branding but also to make sure to hold their company accountable to being a sustainable brand. This is something that Ambient is doing a good job at currently. Ambient pays attention to how their bamboo is sourced as they comply with the Lacey Act which makes sure their raw materials are legally sourced and cause minimal damage to the environment.

Another exemplary company that can be a model for any sustainable company is Patagonia. Patagonia is an apparel and gear company that uses their resources and platform to combat the environmental stresses. What sets Patagonia apart from most sustainable companies is that they voluntarily admit the flaws of their company and take action in making a change. For example,

they understand that their fleece products contribute to the microfiber pollution so they commissioned a research project to investigate the quantitative impact their products have on the environment. They took further actions such as reaching out to their colleagues and competitors to initiate more discussions on microplastic pollution, discussing with appliances manufacturers to develop more effective filters, and supporting nonprofit organizations to spread awareness about microplastic pollution (Patagonia, 2018).

Although bamboo can be used for endless, diverse uses, it is the companies' responsibility to make the products as green as possible. Figure 3 shows the difference between green and non-green bamboo products. For example, Ambient takes great care into ensuring that they source their bamboo with minimal harm to the ecosystems and making their products last longer. Potential next steps are designing eco-friendly packaging, studying other pre and post treatments to extend the life cycle of the bamboo products, and supporting and working with low-resource communities. Since antiquity, bamboo is a sustainable material that has diverse uses depending on the species and age. It is a renewable alternative to meat protein, synthetic fabrics, plastic household goods and packaging, and nonrenewable construction materials. Bamboo is an essential raw material to combat the climate crisis and climate injustice, this makes it not only environmentally sustainable but also socially and economically sustainable.

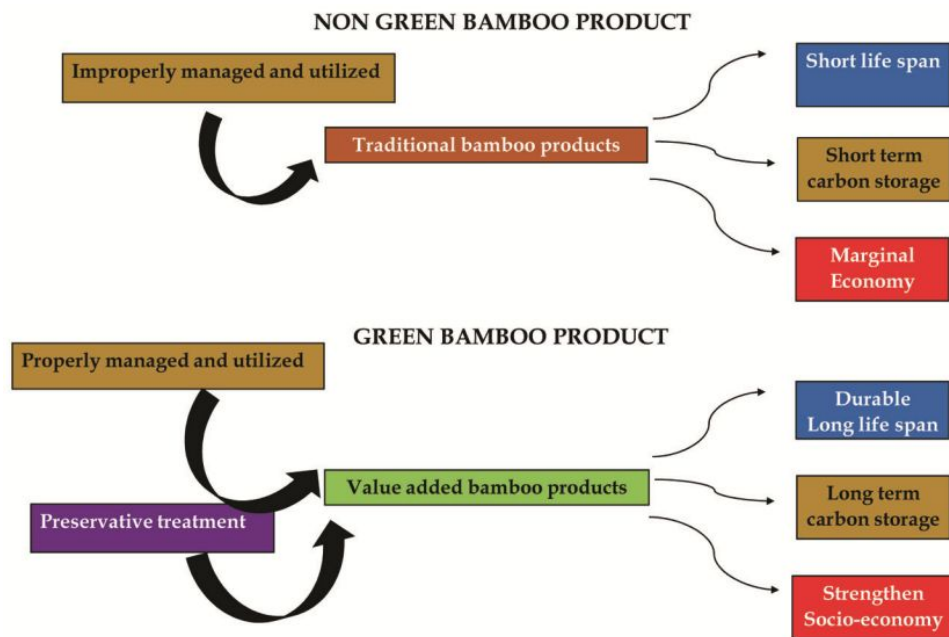


Figure 3. Conceptual diagram of green and non-green bamboo products (Ray et al., 2020)

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