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Grouping of Bamboo Applications, and its Important Impacts on the Environmental and Technological Benefits

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Abstract:

The study groups different bamboo applications, exhibits the correlation between bamboo applications and environmental benefits, investigates the correlation between importance of bamboo applications and technological advantages, and explores bamboo applications' impacts on environmental and technological benefits. Three factors were considered: importance of bamboo applications, environmental and technological benefits. Data analysis was performed on a 156 respondents' sample. This study showed the importance of bamboo applications was significantly related to the environmental benefits versus the technological benefits where no significant differences were discovered. Furthermore, the results indicated the importance of bamboo applications has a positive impact on environmental benefits but not on technological benefits. As a result, consumers have become more focused on environmental benefits of bamboo applications based on their knowledge and experience of the products. Exports are meaningful to the economy which could encourage production of bamboo and seek new channels to sell the excess of production.

Keywords: bamboo applications, environmental benefits, technological benefits

1. Introduction

Nowadays, bamboo is considered one of the oldest tools used to build almost anywhere in the world. The processing of bamboo stems can produce a variety of products ranging from household items to industrial applications and others. Bamboo products may include foods such as skewers, baguettes, craft products, furniture, pulp and paper, toys, flooring, charcoal music, boats, and weapons. According to several sources, most bamboo plants in Asia are relatively common to bridges, scaffolding and dwellings. But it is usually a temporary external structure material. In many more populated areas, some bamboos provide the appropriate material, often cheap, and abundant to meet the important needs of low-cost housing. Germinating bamboo is considered an important source of food and delicacy. Over the past decade, bamboo cultivation has played an important role in environmental aspects, and in social and economic conditions. The technology and innovation of modern processing techniques have transformed bamboo into a series of products that, in many ways, compete with traditional wood products, as well as production costs and product quality. Other benefits are defined as environmental mitigation products such as carbon sequestration, soil stabilization and restoration of degraded lands. This led to a strong desire to grow bamboo around the world (Lobovikov 2003)

In addition to most usual uses, bamboo offers other services, such as: scaffolding skyscrapers and phonograph needles with sliding rules and diesel fuels. In addition, bamboo has a wide range of other advantages, in respect of the environment, considering it can be harvested between 3 and 5 years with 10 to 30% of the biomass (American Bamboo Society, 2014). Nowadays, it has a high rate of exploitation for wood; nonetheless, extracts and various parts of the plant have been used for ointments, for hair and skin, asthma medications, eye drops, potions for lovers, and poison for rivals. Bamboo ash can also be used to polish jewelry and made electric batteries. It is found in bicycles, as airships, windmills, scales, retaining walls, ropes, cables and filaments in the first bulb. In fact, bamboo has many applications beyond first imagination with wide and abundant uses. (Bystriakova, Kapos et al. 2003). Therefore, with the innovation and technology of bamboo and its different applications around the world, we can talk about the globalization of bamboo being another source of income not only for one but also for many other countries since China is the first exporting country of bamboo.

However, compared to other bamboo growing Countries, Haiti is not getting equivalent economic advantage from this resource. The competitiveness of Haiti's bamboo product in the international market does almost not exist. Haiti is vulnerable to natural disasters such as hurricanes, slides, flood, storms, and other disasters such as earthquakes. Considering the different problems, the country faces today, we may consider the benefits of bamboo applications as a form of development for the country on different points. We consider whether the Haitian government is investing and encouraging bamboo planting, the country may export the products to other countries especially in Europe; given bamboo grows more easily in the tropical and subtropical countries. In general, with the development of bamboo in terms of

different points, we can have another source of energy especially for the population living in rural areas of the country. The adoption of bamboo in Haiti can help the country to eradicate the phenomenon of tents, and give the population the means of housing; and finally, we can say the bamboo plantations can reduce erosion, deforestation, and increase reforestation. We can have fewer deaths in natural disasters; and lastly with filtration of drinking water, we can reduce the rate of cholera in Haiti.

One of the main motivations for bamboo cultivation is that it could present a more sustainable option to current forestry practices. However, Sustainability is the marriage between economic, social political and ecological systems over an extended time period (Cerling 1992). For a more responsible and 'sustainable' industry for bamboo, we need to know more about the weed invasiveness of different species, and also have better methods to reduce it escaping from cultivation. Over the past few years, bamboo is widely cultivated with exceptional value and most top substitutes for wood. Bamboo can replace wood in many industrial applications; thus, it can also contribute to the economy and restoration of the world forests. From this, to highlight the benefits on the environment, the technology of the related plants, the different applications such as, food cooking, flooring, musical instruments and supplies, construction, plywood, raw materials, purification of drinking water, soil protection, and to emphasize its economic, agricultural, and cultural advantages, by evaluating its benefits that may interest both national and international businessmen to invest their money in bamboo. The specific objectives of this research aim to:

- Group the different applications of bamboo.
- Exhibit the correlation between the importances of bamboo applications versus environmental benefits.
- Investigate the correlation between the importance of bamboo applications versus technological advantages.
- Find the impact of bamboo applications on environmental benefits and technological benefits.

Further more, to encourage the general population to the bamboo plantation and to reinforce public investment for the sustainable development of the country. If most of the countries in Asia, Africa, America were able to increase their economy through the bamboo and why not Haiti.

2. Theoretical Background

2.1. Importance of Bamboo Applications in Haiti

Haiti is a country susceptible to natural disasters because of its geographical position, its level of deforestation, and its experience with the high number of hurricanes every year. Around 20 to 40 million hectares tons of mountain soil are carried away and thousands of hectares remain of their layer. A result of a satellite photography program in 2002 showed that there was only 1.25 million hectares of forest data left in the country. In order to remedy to this situation, the Ministry of Natural Resources and Rural Development (MARNDR) jointly with the financing of the Haitian and Taiwanese governments has set up a project: The Federation Association Native Coffee-farmers (FACN) with farmers' association federation whose main objective is support for the production and marketing of coffee and bamboo (MARNDR). The importance of application bamboo in Haiti is very important, based on the different things we can do with the bamboo; so far all around the world, especially in Asian countries, bamboo is very used. One of the major raw materials being promoted for use in the development of the textile industry is bamboo. Earlier efforts to reforest the country have shown that bamboo was burned in Haiti by the US Agency in Haiti, including marmalade and several parties in the country, the project was to plant 10,000 hectares of bamboo by 2019 to generate 150,000 tons of dry bamboo annually (Ogunwusi 2013). This would lead to an increase of 10,000 jobs, which can be direct or indirect. So, we come with interest in the development and processing of bamboo for the country. And Haiti, we find many applications such as: houses, bamboo beds, chairs and tables

In Bamboo, which is the most common, and with other new applications, the country may have another opportunity to develop national and international markets. We attribute five criteria of importance application for the country as follows:

2.1.1. Profitability

The manufacture of bamboo products leads to high quality that would allow us to fight against food insecurity in different rural areas of the country. As a result, and according to previous research, there is economic, social and cultural importance in bamboo production areas, which makes it possible to rank it second only to agriculture in village production systems (Liese 2005). Compared with other forms of natural resource use, the bamboo sector is highly profitable and requires little capital investment and, as a result, monthly profit margins are relatively high. In addition, the contained harvest of bamboo processing can provide an important economic safety net for puppetry that can lead to a situation of economic recession that makes it possible to talk about its ability to be profitable for the country (Blowfield 1995, Hunter 2003)

2.1.2. Feasibility

Bamboo is considered a versatile group of species with multiple uses for socio-cultural and industrial (Lobovikov, Schoene et al. 2012). Speaking of the feasibility of bamboo for the country we take into account the bamboo products that are considered as alternative materials for production. The American industry in Haiti, whose mission was to plant bamboo across the country, has always been very stable and robust because of its commitment to quality. Therefore, this high quality is at the cost of large quantities of waste largely burned to heat the facilities. And with the recent surge in corporate responsibility for the total life cycle of their products and the push for increased sustainability, bamboo has been

viewed as a viable resource as a partial or full replacement. Prototypes of bamboo chopsticks were made using a technique described as radial lamination to increase the overall stiffness that is crucial for the functionality of a rod and an economic analysis was performed. So it is concluded with the feasibility of its hard-core application of the environment and the technology of bamboo included the global perspective of the use of bamboo as an alternative for the country (Chen, Zhou et al. 2014).

2.1.3. Acceptability

The benefits of bamboo as a plant are numerous; and we can say that the placement of bamboo is cheaper to plant, they can grow very fast and can be harvested using less fossil fuels. Even when the problems of sustainability and resistance are resolved, the question of acceptability remains (Liese and Tang 2015). A bamboo construction does not need to be "low cost": an inventive design and the use of other locally available materials in the cultural context can make the building desirable rather than simply acceptable. For example, in Central America, there are several regions with a long tradition of bamboo construction, bamboo buildings of all kinds, the price of bamboo consumption ranging from a few hundred dollars to a few million. In Ghana, the shortage of affordable housing is one of the most serious social problems related to the country's economic situation. The backlog of housing is already 420,000 units and is growing every year by 120,000 units (Blowfield 1995). In Haiti, speaking of the bamboo issue is almost irreproachable in the face of the various problems that overcome the country and the key advantages that we can draw with the bamboo and all its application and we can say that with bamboo we take a particular importance by offering an ecological alternative to declining wood products, high-energy materials, petroleum-based plastics and expensive imports to the country.

2.1.4. Availability

Marketing involves developing bamboo to transform the current process of selling bamboo products. The availability of the bamboo refers to the different applications that can be profitable in relation to the number of elements such as functionality, validity and expenses that must be taken into account when choosing a building material (Paudel and Lobovikov 2003). The design of the bamboo can be considered as natural and unique, it is hollow inside and the fibers extend longitudinally. As a result, the mass of material required is less than that of wood with a larger material mass cross section. When considering the bearing mass, it functions as a section of form I. The operation of the bamboo can be related to the requirements of the building. If the bamboo is planting Bamboo growing in a box takes a square shape and can be used to connect objects. It can be folded after being freshly cut and remains in this form after drying. Some bamboo species have the same strength ratio of steel and almost double the compression ratio of concrete. The 1999 earthquake in Colombia was marked by the destruction of all concrete buildings, but bamboo houses remained intact and were not affected by the earthquake. In conclusion we can say that giving importance to the benefits of bamboo applications can be linked with the sustainable development of a country.

2.1.5. Success

Regional bamboo companies may successfully reduce extreme poverty in developing countries according to (Darabant, Rai et al. 2016). Having large economic potential, in terms of success, we can talk about the performance and price of bamboo products that can be combined with other woods, by using the bamboo in the panes and the use of composite materials. Technically speaking bamboo can replace wood, concrete and why not steel in many uses. However, the agricultural sector remains the largest consumer of bamboo products. In addition, bamboo items are still widely used everywhere. Bamboo houses are often found in many types of houses, for example, bamboo houses, traditional houses, which use bamboo stems as a basic building material, and modern prefabricated houses.

2.2 Relationship between the Importance of Bamboo Applications and Environment Benefits

The relationship between the applications of the bamboo to environmental benefits is related to different applications that are beneficial for the environment especially, and by implementing all its applications, they automatically linked to the environment. Bamboo grows very fast and establishes rapidly (Aiyeloja, Oladele et al. 2013) It grows both in the forest and plantation; In plantations where the selective annual harvest of mature culms occurs, bamboo can place on sequestration of carbon, especially if transformation and durability of carbon harvested in sustainable products (Akwade and Akinlabi 2016). Bamboos lock in more carbon when intensively managed. Therefore, the development of bamboo plantations is one of the main ways to reduce environmental impacts and climate change. According to the Environmental Bamboo Foundation (Ogunwusi and Jolaoso 2012) the growth uses of bamboo can provide more oxygen than a tree equivalent. The implications of these aspects are favorable for the reduction of atmospheric carbon dioxide. Using bamboo, which has the fastest growing canopy, bamboo can release about 35% more oxygen than tree equivalents and can sequester up to 12 tons of carbon dioxide annually. Uses of crop materials refer to the carbon potential of sequestration in forest ecosystems. Bamboo is currently used for new applications and new needs have been developed almost everywhere. The bamboo grows very fast is very favorable for the environment taking into account natural areas, it can grow up to 1 meter in 24 hours (Alfonso, 1987). The production of bamboo can be established from scratch in 10 years and individual stubble. The bamboo can be harvested every 3 to 6 years (depending on the species). Advantages of bamboo plantings include lower levels of exposure to external hazards, such as fire, and flexibility to increase management and harvesting practices faster and comparatively with climate change (Lobovikov, Schoene et al., 2012). Investing in bamboo harvesting produces a quick source of income and an important safety record for bamboo producers. In addition, the bamboo can plant on marginal lands can be considered as a major advantage, as well as steep slopes, degraded lands

and thus leaving better land for more demanding crops (Fischer, Lindner et al., 2002). As a result, bamboo can be planted in almost all degraded areas, especially in the eastern part of the country where erosion ravines and groundwater ravages (Ogunwusi and Jolaoso, 2012) and in soils damaged by overgrazing and poor techniques agricultural (Pandey and Shyamasundar 2008). Today bamboo applications are used in almost every day aspect by referring to the current society basing on the protection of the environment, bamboo can evince undoubtedly consistent with the sustainable development of green materials. The industrial production of bamboo products has a substitution impact on the applications of bamboo products. And according to the importance of bamboo and the benefits in the environment, we propose the following hypothesis:

- H₁: There is a significant relationship between the importance of bamboo applications and the environmental benefits

2.3. The Importance of Bamboo Applications Impact on the Environmental Benefits

Speaking of the importance of bamboo and its impact on the environment we can say that bamboo is an asset for the environment. Bamboo can help us reduce lightness and protect against ultraviolet rays. The problem of deforestation can also be brought down with the planting of the bamboo, and since the damage of the trees is done each, we can also improve the rate of consumption of wood. The development of bamboo can also reduce pollution; its plants reduce up to 35% of carbon dioxide in the climate and provide more oxygen. Bamboo roots can help erode erosion by creating a water barrier. In the most developed countries bamboo is used as an element. Developed countries use bamboo as an element to prevent their crops and villages from washing. The bamboo content of its large amounts of nitrogen helps reduce water pollution. Bamboo can be reconstituted and harvested without detriment without destroying the natural forest (Atanda 2015). Bamboo is considered as a resource renewal: bamboo panels, in particular, panels used in engineering and construction, such as ply bamboo used for paneling, tiling, making paper made by bamboo pulp, briquettes for fuel. Bamboo fibers can also be used to make composite thermoplastic reinforcements used in roofing, etc. These diversities make bamboo beneficial to the environment and easily adaptable. This in that aspect we can conclude to say that the bamboo plays an important role in the environment based on its different applications. Therefore, according to his approaches, we can say is the importance of different applications of bamboo can they have a positive impact on the environment? So, we propose this hypothesis

- H₂: The importance of bamboo applications has a positive impact on the environmental benefits.

2.4. Relationship between the Importance of Bamboo Applications and Technological Benefits

According to several types of research on bamboo technology compared to the different application that are very important, and this improvements in technology innovation and processing equipment highlighted in the research, they have allowed access to more sustainable products based on the application of bamboo on the market (McNeely 1999). The relationship between the importance of applications and the benefits of technology is related to the development of various technological applications of bamboo. Thanks to the bamboo technology farmers have more means of production. Technology transfer is also a process commonly referred to as the transfer of information and skills such as research laboratories (Valera, Fung et al. 1987). The attribution of this new result of the technology is the adoption made by the farmers and their putting into practice and their subsequent emission to other members of the community. With respect to the adoption of bamboo technology, farmers can sometimes distinguish difficulties in putting the recommendation into practice (Valera, Fung et al. 1987). The transformation of bamboo into charcoal could make packaging and transportation sufficiently efficient to make it an industrial activity on an economically favorable scale (McNeely 1999). Bamboo charcoal can replace traditional (tree) charcoal, also reducing deforestation. And with the growth of the current bamboo economy, people have a growing demand for food, health, supplies, the environment, and other needs. Bamboo is therefore considered a natural material to meet market expectations at all levels and with high economic value with different technological applications. In addition, with a high level of the application on technology, consumers can achieve better observation of the importance of applying bamboos with benefits technology. Therefore, we propose the hypothesis as following:

- H₃: There is a significant relationship between the importance of bamboo applications and the technological benefits

2.5. The importance of Bamboo Applications Impact On technological Benefits

Technology development, even when applied in a specific context, is not enough for a considerable sustainability change in the industry scenario. It must be seen as an opportunity of qualification and achievement. For that, it is necessary involving the actors in participation policies. The context complexity demands a real multi-dimensional approach; facilitate greater transparency in the decision-making process and the expression of system operation. Japan is the major nation of bamboo distribution in the world, also is an important country on cultural circle of bamboo in Asia. The bamboo is known as a symbol of Japanese culture with the technology of bamboo product manufacturing applications and thus increases a large number of products with the adoption of technology, including charcoal. By design the development of its products in Japan made with bamboo paves the way for the future in the world of bamboo products. In many western countries, the initial resources of bamboo did not have a great importance, but today with the innovation of the bamboo technology we meet new varieties of bamboo, so the westerners do the development of the bamboo industry with vivacity while taking a strong interest in bamboo. Among the bamboo innovation products, we can talk to products such as mobile bamboos, bicycles, bamboo lamps and bamboo products that are appropriate for the technology. Industrial

design in Western countries is more mature than in China, they are more inclined to environmental elements and designs. They pay more attention to product quality and require a strict manufacturing process, so that makes bamboo products so very delicate. Basing on its approaches we come to say is that the importance of applications has an impact on the technological advantages, we propose the following hypothesis

- H₄: The importance of bamboo applications has a positive impact on the technological benefits

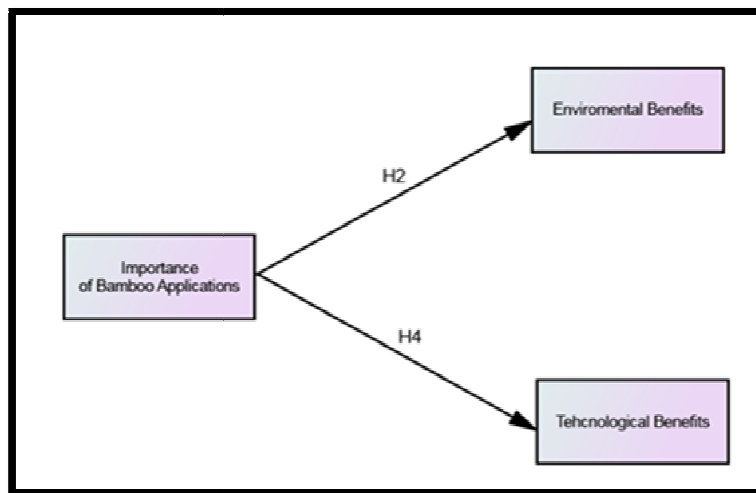


Figure 1: Research Model

3. Research Methodology

This study is based on the experimental research using questionnaires as a tool for data collection among 156 respondents, the importance of the application of bamboo and its environmental and technological benefits. Online surveys were within by Haitian community. The collected data were analyzed with several types of tests such as the correlation matrix and simple regressions. The first quarter was used to group different types of bamboo applications. The SPSS Statistical Package Version 22 was used to analyze the data to support the research findings.

3.1. Measurement

In the study, I presented the independent variable in the model. IA is defined as being the applications that matter most for the country according to the criteria stated in the literature review the second was the environmental benefits, related to environmental issues such as degraded land, soil conservation, and reforestation, finally, the technological benefits meaning the several of bamboo applications resulting from technological transformation and innovations.

In this study, we used questionnaires containing objective questions related to the IA as a function of consumer knowledge. The questionnaire is divided into four sections: section one referred to the respondents' experiences using bamboo (four questions), section two included 20 applications with multiple choices (from A to T, with each letter representing an application, for example A represent: bamboo housing, B represent: bamboo raw materials, C: represent bamboo charcoal, and T: represent bamboo paint brushes) measured on a five-point scale (1= very poor, 5= very good) based on the benefits the respondents had to choose from, section three is about the environmental and technological benefits, with three questions for each advantage; responses were measured on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). Section 4 referred to the personal information such as gender, age and education.

According to previous research, sample size is a set of individual selected from a population and is usually intended to represent the population in a research study (Gravetter and Forzano 2012). The study was conducted through online surveys targeting Haitian people. A total of 173 subject participated in this study during May to July 2018, 17 invalid questionnaires were deleted. The data analyzed consisted of 156 responses, 59% male and 41% female. The age structure was as follows: less than 30 years old represented by 27.60%, 31-40 age groups represented by 58.3% and the remaining 14.1% was between 41 and 50 years old.

4. Result and Analysis

We conducted a two-step analytical procedure to present the results. In the first link we made a group with the applications that were selected more by the respondents. Secondly, the correlation matrix and the simple regression analysis were examined in order to verify the relationship between the importance of bamboo applications versus the environmental and technological advantages, and also the impact of the importance of bamboo applications on environmental and technological benefits.

4.1. Descriptive Analysis

In this study, most of the respondents were between 31 and 40 years old which is about 58.3% of all them, and 61% of them were high education levels. With respect to their experience and knowledge about the importance bamboo applications. The descriptive statistics and its differences in Table 1 indicated there is no difference of the overall

importance applications between gender ($t = 0.152$) among age ($F = 0.663, p = 0.517$) groups and education levels ($F = 0.117, p = 0.890$) Based on these results, there is a high level of consumer perception about the importance of bamboo application for the country.

Var.		IA		t value	ENB		t value	Tech B		t value
		Mean	SD		Mean	SD		Mean	SD	
Gender	Female	4.145	0.287	0.152	4.156	0.351	-1.845	4.052	0.326	0.885
	Male	4.137	0.306		4.268	0.387		3.986	0.537	
Age	Under 30	4.121	.3521	F=0.663 p=0.517	4.317	.4597	F=2.067 p=0.130	4.054	0.563	F=2.706 p=0.070
	31-40	4.133	0.266		4.194	0.352		4.044	0.334	
	41-50	4.207	0.309		4.152	0.246		3.803	0.640	
Educ Level	High Sch.	4.143	0.321	F=0.117 p=0.890	4.246	0.370	F=0.631 p=0.533	4.049	0.505	F=0.367 p=0.683
	Bachelor	4.125	0.276		4.239	0.342		3.975	0.480	
	High Edu	4.155	0.293		4.167	0.425		4.008	0.372	

Table 1: Demographic Descriptive and Its Differences (N=156)

Note: IA: Importance of Bamboo Applications,
ENB: Environmental Benefits; Techb: Technological Benefits

Table 2 shows the different frequencies represented by first quarter distribution with 20 applications. Three groups were formed, the first was the high importance (28.4%), the second was the medium importance with 48.5%, and third was the low importance with 23.1%. These findings indicated that high importance group had two applications which are: A-Bamboo housings (15.1%) and F-Bamboo flooring (13.3%). Bamboo Housing applications are those with means that respondents showed greater interest in the construction of bamboo housing follow by bamboo flooring. The medium importance group has 10 applications representing a total of 48%. Group C represented Bamboo charcoal which is one of the technology benefits of the bamboo that the respondents had selected. D represented Bamboo Pup which is the bamboo innovation specifically for the decoration restaurant. The group of the smallest importance had 8 applications in which are G: The Bamboo panels and H: the bamboo crafts.

	Items	Description Items	Frequency	%	Group %	Cuml. %
High Importance	A	Bamboo Housing	94	15.1%	28.4	28.4
	F	Bamboo Flooring	83	13.3%		
Medium Importance	C	Bamboo Charcoal	56	9.0%	48.5	76.9
	D	Bamboo Pub	32	5.1%		
	I	Bamboo Shoots	31	5.0%		
	M	Bamboo Fabrics	31	5.0%		
	B	Bamboo Raw Materials	23	3.7%		
	E	Bamboo Paper	30	4.8%		
	J	Bamboo Furniture	23	3.7%		
	L	Bamboo Fuel	24	3.8%		
	N	Bamboo Clothing	27	4.3%		
	S	Bamboo Bed sheets	24	3.8%		
Low Importance	G	Bamboo Panels	22	3.5%	23.1	100
	H	Bamboo Crafts	19	3.0%		
	K	Bamboo Instruments	19	3.0%		
	O	Bamboo Garden	20	3.2%		
	P	Bamboo Matting	16	2.6%		
	Q	Bamboo Cutting boards	12	1.9%		
	R	Bamboo Blinds	21	3.4%		
	T	Bamboo Paint brushes	17	2.7%		
	20		624	100%	100.0	

Table 2: Grouping of Bamboo Applications
Note: Grouped According to Their Frequencies

Table 3 presents the different applications that have been chosen by consumers. The results showed that bamboo pup (D) referring to the decoration restaurant has a great importance mean value of 4.219 compared to other applications. Although having the highest, that application has not been the most selected by the respondents. Bamboo shoots (I)

represented the comestible applications with an average mean value of 4.355 and has been selected 31 times. For the technological benefits, the application (F) had an average mean value of 4.099 and has been selected 83 times

	Item	Freq. (%)	Importance		Benefit of EN		Benefit of Tech	
			M	SD	M	SD	M	SD
High Importance (28.4%)	A	94(15.1%)	4.193	0.310	4.235	0.385	4.076	0.410
	F	83(13.3%)	4.158	0.294	4.257	0.392	4.099	0.381
Medium Importance (48.5%)	C	56(9%)	4.197	0.341	4.170	0.345	4.048	0.442
	D	32(5.1%)	4.219	0.280	4.135	0.279	3.875	0.621
	I	31(5.0%)	4.148	0.288	4.355	0.421	4.075	0.410
	M	31(5.0%)	4.122	0.253	4.244	0.371	3.989	0.467
	B	23(3.7%)	4.180	0.436	4.130	0.280	4.000	0.492
	E	30(4.8%)	4.143	0.258	4.244	0.381	3.900	0.393
	J	23(3.7%)	4.151	0.340	4.283	0.487	4.017	0.626
	L	24(3.8%)	4.096	0.235	4.236	0.347	4.014	0.269
	N	27(4.3%)	4.017	0.217	4.222	0.320	4.074	0.406
	S	24(3.8%)	4.075	0.281	4.167	0.341	3.972	0.555
Low Importance (23.1%)	G	22(3.5%)	4.069	0.288	4.182	0.321	3.909	0.546
	H	19(3.0%)	4.097	0.323	4.204	0.346	3.963	0.377
	k	193(0%)	4.082	0.222	4.263	0.466	4.000	0.351
	O	20(3.2%)	4.153	0.329	4.200	0.424	3.833	0.524
	P	16(2.6%)	4.173	0.283	4.271	0.408	3.917	0.602
	Q	12(1.9%)	4.196	0.295	4.139	0.413	3.917	0.474
	R	21(3.4%)	4.002	0.200	4.127	0.247	4.063	0.564
	T	17(2.7%)	4.009	0.330	4.235	0.483	3.980	0.702

Table 3: Grouping of Bamboo Applications

The first quarter distribution was employed to divide the different applications, and a sample of two pictures from each group is presented down below.



Figure 2: Bamboo Applications

The correlation analysis was conducted to verify the equation predicted by the hypotheses H1 and H3 on the relationship between the importance of bamboo applications with the environmental benefits, and the importance of bamboo applications with the technological benefits. Table 4 shows that there is a significant relationship between the importance of bamboo applications and the environmental benefits ($r = 0.179, p < 0.05$) and nosignificant relationship with the technological benefits ($r = -0.029, p = 0.360$). The low technology development in Haiti has the ability to explain the lack of relationship between the importance of bamboo applications and the technology benefits. However, the results also show the existence of a low significant a relationship between IA and ENB explained by the contribution of bamboo in the environment's protection considering Haiti is very vulnerable to environmental hazards. Based on these results, H1 is accepted and H3 is rejected.

		Mean	Std.	IA	ENB	TechB
1	Importance of bamboo Applications (IA)	4.140	0.297	1		
2	Environmental Benefits (ENB)	4.222	0.375	0.179*	1	
3	Technology Benefits (TechB)	4.013	0.462	-0.029	0.298**	1

Table 4: Correlation Matrix

Note: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 5 indicates the importance of bamboo applications had a significant positive impact on environmental benefits ($t = 2.254, p = 0.026, Adj-R^2 = 0.432$), the squared structure coefficients which indicated the amount of variance contribute to the synthetic variable approach 43.2%, therefore the hypothesis H2 was supported. Furthermore, the importance application is not significant on the technological benefits ($t = -0.358, p = 0.721, Adj-R^2 = 0.326$), the importance of bamboo applications can only explain the technological benefits by 32.6 %. Therefore, the hypothesis H4 was not supported. Considering these results, those respondents are more concerned with the country's environmental problems.

	Coefficients	Se	t-value	F	p	Adj-R ²
IA → ENB	0.226	0.010	2.254*	5.029 *	0.026	0.432
IA → TechB	-0.045	0.125	-0.358	0.721	0.721	0.326

Table 5. Comparisons Regression Analysis

Note: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

IA: Importance of Bamboo Applications, ENB: Environmental Benefits; Techb: Technological Benefits

5. Discussion and Conclusions

This study examined the issue of innovation on bamboo applications, its impact on technology and the improvement of the environment. The aim was to bring together the different applications of bamboo, to find the correlation between the importance of bamboo applications versus the environmental benefits, also to investigate the correlation between importance bamboo applications versus technological benefits, and finally to indicate the impact of the importance of bamboo applications on both environmental and technological benefits. The results indicated that three groups were formed where bamboo housing and bamboo flooring were the two highest importance of bamboo applications group in Haiti. In addition, the respondents have chosen these applications due to most of the relief on the tents which remained the aftermaths of the earthquakes in 2010 that devastated the country. By listing the various problems that the country faces today, we can consider the beneficial application of bamboo as a form of development for the country on many different points. In addition, the importance of bamboo applications has shown a significant relationship between the environment due to the experience and knowledge of the respondents about bamboo and also the environment problem can reduce with its; but not significant with the technological benefits. Bamboo is one of the building materials currently used by humanity; its stalks are able to produce after processing a quantity of product ranging from domestic applications to industrial applications. The results of this research indicated a positive impact of the bamboo on the environment but not significant on the technology, these results indicated the technology of the country is low; therefore, the development of bamboo applications for the environment can be more quickly for the soil conversation and detestation because this problem is areal challenge for that country. However, when we try to compare our research with others, we do not find too much similarity, but some studies have been done on bamboo, for example in China; the expansions of bamboo resources and industrial production have been a success. Meanwhile, several reports have investigated on how the production of bamboo might expand household incomes and reduce poverty (Bowyer, FERNHOLZ et al. 2014). The bamboo planting has always been used against erosion in reducing runoff in some areas and stabilizing slopes for terraced production and on steep (Bowyer, FERNHOLZ et al. 2014). However, bamboos benefits and environmental costs have been encouraged and accompanied by developing some standards to reforestation (Panda Standard Association 2012). In Nigeria, it has been observed that bamboo plays a crucial role in the environment by reducing light intensity and protecting. Therefore, deforestation's rate is decreased and bamboo planting decreases pollution's rate up to 35% of CO₂ with more O₂ supplying. Its roots combat erosion and create a barrier against slides and flood. Bamboo is considered as a strong water pollution reducer by consuming large amounts of nitrogen. (Kumar, Murti et al. 2015).

This high yielding renewable resource which is the bamboo helps to the manufacturing of bamboo particleboard, medium density fiberboard, and particleboard used in engineering and construction; furthermore, bamboo fibers are

applied to fabricate thermoplastic reinforcement composites for roofs. Governmental organization can play a strong promotional role which would help generate awareness on bamboo products, run a nationalized campaign and help develop product-market linkages. Government can help in establishing more number of bamboo product promotion showrooms such as others benefits. It can also encourage private entrepreneurs to enter bamboo sector as the increase in promotion will help in increasing the awareness among the people about the bamboo use in construction. Further, this will help in increasing the demand of bamboo in construction sector the country could have more benefits, but the development of its different applications also has both advantages and disadvantages. Farmers and consumers can maximize the benefits of the applications, but do not rely on bamboo to avoid the negative aspects of the plant. Thus, bamboo can play an important role in meeting the future human needs of timber used as input for housing and construction, decreasing the level of deforestation and rehabilitating wood-based panel industries. It can be an original wood material with government support and great policy measure; thus, it contributes to minimizing negative soil erosion effects, combats climate change, protects biodiversity, and promotes sustainable development. Furthermore, the bamboo's utilization needs to be encouraged by authorities in construction such as furniture manufacturing, finishing materials, and low-rental housing. However, the development and use of bamboo products must depend on scientific and technological innovation, accelerate industrial restructuring, enhance new technologies and products, establish product applications, and extend the domestic market for bamboo products. The sustainable development importance resides in correlating people, preserving both the environmental and economic development of bamboo products.

6. Limitations and Future Research

The limitations and future research of this study is based on three points. The sample in this study was limited, only the consumers took part in this study according to their experience with the importance of bamboo applications, so future studies could include samples from several parts of the country, and also businessmen. We also recognized that the people interviewed were Haitians on an online survey and this was a limit to the study. However, the contribution of this study is worthy and applicable to countries by putting in place a new economic development structure like Haiti. Other studies will also allow us to compare different uses of bamboo more precisely with those of countries in Asia. Similar future studies should not only be based on consumer perceptions, but also on business people because most we have consumers interest with bamboo applications, businessmen can invest advancement in technology and innovation and encourage more number of manufacturers or manufacturing units to come up. Further, there is a need for market establishment with product testing for quality being a necessity which will ultimately lead to market acceptability. Lastly, the methods that will be recommended for future research will have to explore other important impacts on the application of bamboo and to grasp the changing responses of consumers and businessmen.

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8. Author Contributions

Daphney Francois and Shu-Yi Liaw were responsible for the concept, research design, statistical analysis and writing the manuscript. Daphney Francois distributed the survey.

9. Conflicts of Interest

The authors declare no conflict of interest.

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