INVESTIGATE THE POTENTIAL OF BAMBOO LEAVES FOR THE DEVELOPMENT OF PARTICLE BOARDS FOR INTERIOR APPLICATIONS

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Abstract: This study focuses on the viability of using dried bamboo leaves in addition to other leaf types like date palm and banana to generate sustainability particleboard for interior usage. It analyzes the characteristics of the boards, comparing them to standard practices for things like density, water absorption, and thickness swelling. The goal of the study is to encourage the development of materials by showcasing the potential of leaf-based particle boards as affordable and environmentally beneficial substitutes. The study is to convince stakeholders of the potential of bamboo leaf particle boards and encourage more research and development in this field by raising awareness of the environment and promoting sustainable construction practices in Sri Lanka.

Keywords: *Bamboo, Particle Boards, Bamboo Leaf Products, Plastic Wastage, Bamboo Particle Boards.*

1. Introduction

This study explores the feasibility of utilizing dried bamboo leaves to create sustainable particle boards for interior applications, aiming to address the decline of natural wood resources and advance environmental sustainability. The goal of the project is to create durable, environmentally friendly particle boards by examining several bamboo leaf kinds in Sri Lanka and evaluating the usage of plastic waste as binders. These boards are compared to typical goods and their mechanical properties, environmental effect, and business potential are assessed. The study aims to introduce novel bamboo leaf-based boards through an industrial survey in Sri Lanka. It also sets the groundwork for future research in sustainable material development and encourages eco-conscious interior design practices, offering insightful information to designers, inventors, and industry professionals.

1.2. AIMS AND OBJECTIVE

This project explores creating sustainable particle boards for interior use from bamboo leaves and plastic waste, aiming to develop strong, eco-friendly boards. It examines the varieties of bamboo leaves found in Sri Lanka, how plastic waste is used as a binder, and how their mechanical qualities, commercial potential, and environmental effect are measured.

The objectives supposed to be fulfilled while carrying out this study are:

- To investigate the potential of bamboo leaves for the development of particles boards for interior application.
- To investigate the available plastic waste as the binding agents used in particle boards.
- To investigate the dry particleboards that are currently made from dried leaves.
- To assess the potential market for dry-leave particle boards and analyses the current particle board products in Sri Lanka

2. Literature Review

This chapter explores the many applications and environmental effects of bamboo and particleboards, highlighting their significance for modern building and sustainability projects. Bamboo is a popular alternative to traditional wood in a variety of architectural applications due to its strong structural qualities and quick growth. Certain varieties of bamboo are highly valued in Sri Lanka for their longevity. The conversation also touches on the wide range of items made from bamboo and their advantages for the environment.

The chapter also discusses the chemical composition of bamboo leaves, focusing on their silica content and bioactive qualities, which improve particleboards' strength and resilience and naturally resist bacterial infiltration. In light of Sri Lanka's profusion of bamboo leaves, it investigates the possibility of increasing the manufacturing of particleboard based on bamboo. Addressing the pressing issue of plastic waste in the country, including exacerbated by the COVID-19 pandemic, the chapter proposes utilizing plastic waste as binding agents in particleboard production to mitigate environmental pollution.

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It highlights the constant improvement of materials and production techniques, increasing the usefulness and sustainability of particleboard, by taking a historical look at the development of the material and emphasizing recent advances. In the conclusion the chapter promotes using innovative waste recycling techniques and environmentally friendly materials like bamboo to address environmental issues and advance sustainable building practices (Harish Sakaray,N.V. Vamsi Krishna Togati,I.V. Ramana Reddy, Jan-Feb 2012) (Jayaratne, 2022) (Perera, 2023) (Silva, 2022) (Fernando, 2023) (Irle, M., Barbu, M. C. ,Sernek, M., 2010) (Laufenberg, T. L., Gfeller, B., 2013) (Maloney, 1993) (Suchsland O, Woodson, G. E., 1987) (Youngquist, 1999).

2.1 INTRODUCTION TO BAMBOO SPECIE'S IN SRI LANKA

Table 1:-Below table shows the available bamboo specie's in Sri Lanka

Scientific name	Common name	Description
Bambusa bambos	Giant thorny bamboo	Large, thorny bamboo used in construction and for making furniture.
Dendrocalamus giganteus	Giant bamboo	One of the largest bamboo species used for construction and scaffolding.
Bambusa vulgaris	Common bamboo	Widely cultivated used for construction, paper, and as a food source.
Dendrocalamus asper	Rough bamboo	Thick-walled bamboo used for construction, furniture, and handicrafts.
Bambusa balcooa	Balcooa bamboo	Strong and durable used for construction, scaffolding, and paper.
Thyrsostachys oliveri	Thai bamboo	Straight and strong used for construction, furniture, and handicrafts.
Ochlandra stridula	Yellow bamboo	Smaller species used for weaving, mat making, and construction.
Gigantochloa atroviolacea	Black bamboo	Ornamental used for decorative purposes and in furniture making.
Schizostachyum brachycladum	Sacred bamboo	Decorative bamboo used in ceremonies and for ornamental purposes.
Bambusa multiplex	Hedge bamboo	Grown for ornamental purposes and as a natural fence or hedge.

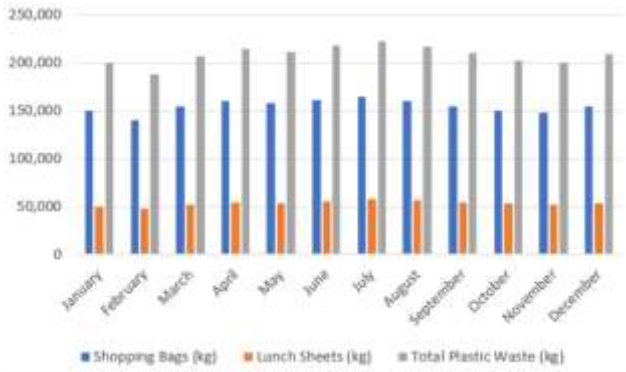
(Department., 2016) (Neela de Zoysa , Upeksha Hettige and K. Vivekanandan, 2003) (A. Swarnamali' and K. Vivekanandan) (Abeywardhane, HMYM, 2019).

2.2 ANALYSIS THE AVAILABILITY OF THE BAMBOO LEAVES FOR THE MASS PRODUCTION IN SRI LANKA

Table 2: below table shows the available bamboo specie's for mass production in Sri Lanka

Bamboo species	Common name	Usage in construction	Citations
Bambusa vulgaris	Common bamboo	Widely used for scaffolding, formwork, and temporary structures	(Silva & Perera, 2016)
Dendrocalamus strictus	Iron bamboo	Preferred for structural elements like columns, beams, and trusses	(Bandara & Pushpa kumara, , 2017)
Dendrocalamus asper	Rough bamboo	Widely used for scaffolding, formwork, and temporary structures	(Silva & Perera, 2016)
Gigantochloa atroviolacea	Black bamboo	Utilized for roofing, flooring, and decorative elements in traditional architecture	(Ranasinghe, 2021)

2.3 DISCUSS MONTHLY PLASTIC WASTAGE IN SRI LANKA



Bar chart 1:-above chart shows Monthly plastic wastage in Sri Lanka

The environmental hazard in Sri Lanka is growing gradually with the use of single-use plastics, mainly shopping bags and lunch sheets. Even though polythene bags of smaller micron sizes were banned in 2017, inefficiency in its enforcement and a lack of proper awareness among the public have made plastic waste a continuous problem. Plastic wastes block the drainage systems, contaminate the waterways, destroy the marine ecosystems to develop overall environmental degradation. Data reveals that monthly plastic waste generation ranges from 188,000 kg in February to 223,000 kg in July, with shopping bags consistently making up the largest portion. Although public awareness campaigns, recycling activity, and related development of biodegradable alternatives have been initiated, problems persist regarding proper plastic waste management (Jayaratne, 2022) (Perera, 2023) (Silva, 2022) (Fernando, 2023).

2.4 REVIEW THE EXISTING DRIED LEAVES PARTICLEBOARD

Dry leaves are already being used all over the world to make particle boards. Inventors have used a different type of leaf, one that has fiber and pith, as row material for producing dry leaf particle boards. To get the ideal balance of pith to fiber, they occasionally blend two unique types of leaves. The binding ingredient is then mixed with the dried leaf particles (by author).

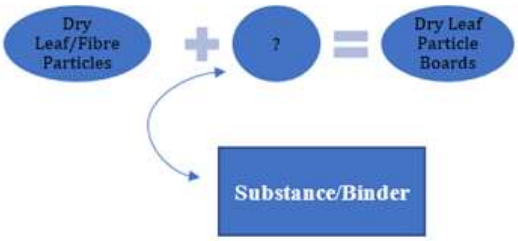
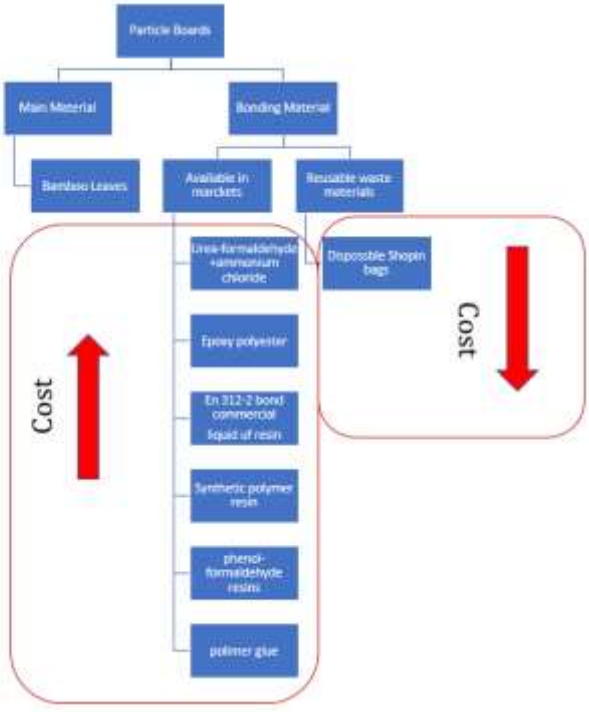


Table 3: this table shows the available particle board in the market

particle board	Leave type	Substance	A. substance	Citations
Palm oil leaves and mahogany leaves	Palm oil leaves (as fiber) Mahogany leaves (as pith)	Uf resin and ammonium chloride	Wastepaper	(Arif Nuryawan,Rahmawaty., 2018)
Dried banana trunks and leaves	Banana leaves	Epoxy polyester		(A Baharin, N. Abdul Fattah, A. Abu Bakar, and Z.M. Ariff., 2016)
Waste tea leaves and wood particles	Tea leaves	En 312-2 bond commercial liquid uf resin	Wood particles or sow dust	(Batiancela, Marvin _Acda, Menandro_Cabangon, Rico, 2014)
Dpl. Particleboard	Date – palm leaves	Synthetic polymer resin and natural polymer		(S.K. Ghosh, L.K. Nayak, A. Day, S.K. Bhattacharyya., 2007)
Weed _soft rush	Weed	Urea-formaldehyde or phenol-		(Hammon, 2018)

2.5 DISCUSS THE BONDING MATERIAL OF THE PARTICLE BOARDS



Flow chart 1: this chart represents the main materials and bonding material of the particle board (By author)

The flow chart presents a comprehensive overview of the materials and costs involved in particle board production. The main material highlighted is bamboo leaves, promoting sustainability. Bonding materials are divided into two Categories. Market-available options and reusable waste materials. Market-available bonding materials include Urea-formaldehyde-ammonium chloride, epoxy polyester, En 312-2 bond commercial liquid urea resin, synthetic polymer resin, phenol-formaldehyde resins, and polymer glue. These are reliable but come with higher costs, as indicated by the upward cost arrow. In contrast, reusable waste materials like disposable shopping bags offer a more cost-effective alternative, denoted by the downward cost arrow. This approach not only reduces expenses but also aligns with eco-friendly practices.

2.6 CHECKING PARTICLE BOARD RESISTANCE FOR DIFFERENT CONDITIONS

Density Test

Used British Standard BS EN 323 guidelines to conduct density tests on particleboards. Measuring each variety of particleboard's average density was the goal. The formula used for calculating the density

ρ = density , m = mass of each test piece (kg) , v = volume of the test piece (m^3)

$$\rho = \frac{m}{v}$$

The study made sure that particleboard density was measured consistently and reliably by using estab-lished testing protocols. This information is crucial for evaluating the performance attributes and struc-tural soundness of particleboards, supporting researchers and producers in the selection of materials and quality monitoring processes (AA Adediran et al. 2019)

Water Absorption Test

The purpose of the water absorption tests were conducted on the particleboards to assess their water absorption capacity over a specific time frame. The purpose of this was to calculate the amount of water that the particle board could absorb in a certain period of time. By subjecting particleboard to standardized test procedures, the study aimed to assess its resistance to moisture ingress (AA Adediran et al. 2019)

W_A = Water Absorption, W_i = initial weight , W_f = final weight

$$W_A = \frac{W_f - W_i}{W_i}$$

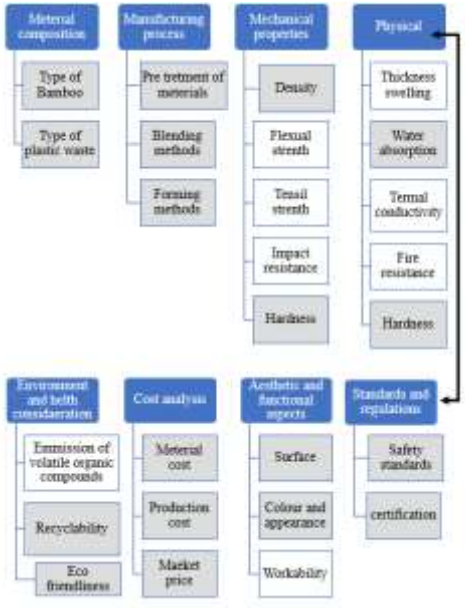
The thickness swelling Test

The thickness swelling test assesses the change in particleboard thickness following sinking in water, in accordance with BS EN 317. This study evaluates the effect of water on the dimensions of the board. Consistent evaluation of particleboard performance when exposed to moisture is ensured via standard testing(AA Adediran et al. 2019)

T_s = thickness swelling, t_1 = initial thickness, t_2 = final thickness

$$T_s = \frac{t_2 - t_1}{t_1} \times 100$$

3. Theoretical framework



key aspects that this research aims to explore and uncover

Flow chart 2: this chart represent the theoretical framework

In order to prove the viability of bamboo as a sustainable material for particle board, this study focuses on specific aspects of bamboo particle board production, such as binding agents, pre-treatment processes, mechanical qualities, and varieties of bamboo leaves. Selected tests were given priority to offer some insight into the possibilities of bam-boo-based boards due to affordability and the exploratory nature of this work. To develop a more comprehensive overview of bamboo particle boards and confirm their suitability as an environmentally friendly substitute for tradi-tional materials, future studies may look further into other factors including long-term durability and environmental resistance.

4. **Methodology**

Research Objective	Methodology Steps	Description
Investigate the potential of bamboo leaves for particle board development	1. Literature Review	Study existing research on bamboo leaves and their potential for particle board development.
	2. Field Research	Assess availability and types of bamboo in Sri Lanka.
	3. Laboratory Testing	Test bamboo leaves for mechanical properties. Samples prepared according to standard protocols, with density measured using BS EN 323 guidelines. Water absorption tests follow ASTM D570 standards to ensure data reliability and industry applicability.
Investigate available plastic waste as binding agents	1. Literature Review	Review research on plastic waste as a binding agent in particle boards.
	2. Experimental Research	Test the integration of plastic waste with bamboo leaves for bonding strength.
	3. Mechanical & Environmental Testing	Perform density, water absorption, and thickness swelling tests. Samples prepared according to BS EN 323 for density, and ASTM D570 for water absorption, ensuring commercial relevance and standardized results.
Investigate dry particle boards made from dried leaves	1. Literature Review	Study production techniques and applications of particle boards made from dried leaves.
	2. Product Analysis	Analyze properties of existing particle boards made from dried leaves.
	3. Mechanical Testing	Conduct density and bending strength tests. Samples prepared following BS EN 323 for density and ASTM D570 for water absorption, ensuring results meet industry benchmarks.
Assess the potential market for dry-leaf particle boards in Sri Lanka	1. Industrial Survey	Survey industry stakeholders to understand demand for eco-friendly particle boards.
	2. Market Analysis	Review existing particle board products and consumer preferences in Sri Lanka.
	3. Feasibility Study	Evaluate economic viability and potential market acceptance for dry-leaf particle boards.

5. Results and Discussion

The leaves used to make these particle boards are sourced from these bamboo farms. It is located in Arukwatta village in Padukka area. This land is 100 perches and there are 18 species of bamboo in this land. The owner of this land is Mr Chandana Maithpala. He is a landscape designer, and he works for Urban Development Authority of Sri Lanka (Bamboo Garden Arukwattha, Padukka ., 2024).

5.1. USED BAMBOO LEAVE TYPES FOR EXPERIMENTS

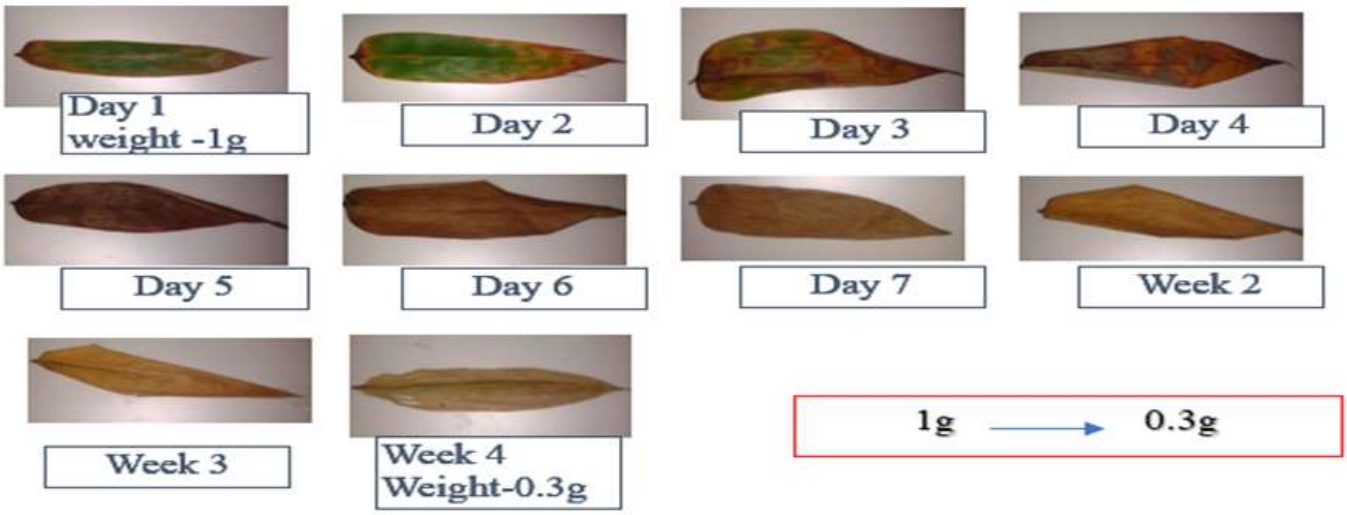
Table 4: Bamboo Leave types for experiments

Bamboo Type	Description	Uses in Experiments	Supporting Research
Wet Bamboo Leaves	Bamboo leaves with high moisture content.	- Study of natural properties (strength, flexibility, biodegradability).	Li, Z., Zhang, X., & Wang, H. (2017). Antioxidant and mechanical properties of bamboo. *International Journal of Material Science*, 12(5), 234–245.
		- Investigation of moisture content and preservation.	

Dehydrated Bamboo Leaves	Bamboo leaves with low moisture content (dried).	- Study of drying and preservation techniques. - Chemical composition analysis post-moisture loss.	Zhang, Y., Li, J., & Huang, J. (2014). Dehydration and its effect on bamboo leaf composition. *Wood Science and Technology Journal*, 47(3), 203–214.
Bamboo Leaf Ash	Ash produced by burning dried bamboo leaves, rich in minerals like silica and calcium.	- Development of bio-cements and eco-friendly construction materials. - Use as a natural fertilizer in soil.	Ranganathan, V., & Ganesh, N. (2019). The role of bamboo leaf ash in bio-based material development. *Journal of Green Materials*, 7(2), 123–133.
Chopped Bamboo	Small, chopped pieces of bamboo, often used in composite materials.	- Study of mechanical properties (strength, durability). - Development of bamboo composites for sustainable products.	Kollmann, F., et al. (2012). Chopped bamboo as a material for composite fabrication. *Journal of Engineering Materials*, 28(6), 415–426.
Dry Bamboo	Bamboo with no moisture content, ideal for studying material behavior in construction.	- Investigation of structural integrity. - Use in building materials and furniture.	Rahman, M. M., et al. (2015). Dry bamboo in structural applications. *Construction and Building Materials Journal*, 48, 359–368.
Dry Bamboo Leaf Powder	Fine powder made from dried bamboo leaves.	- Use in bioplastics or composite material research. - Investigation of additives for enhancing material properties like strength and elasticity.	Zhang, H., et al. (2018). Bamboo leaf powder as an additive in bioplastics and textiles. *Sustainable Materials Journal*, 9(4), 215–223.

5.1.1. Bamboo leaves durability observation

Over a duration of four weeks, the weight and durability of bamboo leaves was tracked in this experiment. The weight decreased from 1 gram to 0.3 grams, and when moisture was lost, there was noticeable drying and swelling. These results are consistent with those of Zhang et al. (2014), who studied the structural stability of bamboo under environmental circumstances, and Li et al. (2017), who studied variations in bamboo's moisture content. Since bamboo leaves are the main ingredient in product manufacturing, it is important to understand the dehydration process. We can determine how many raw bamboo leaves are required to manufacture the necessary material for eco-friendly products by calculating the moisture loss (Li et al., 2017; Zhang et al., 2014).



Flow chart 3: this chart shows the bamboo leaves durability observation

5.2 PROCESS OF MANUFACTURING DRY BAMBOO LEAVES PARTICLE BOARDS

The first step of producing bamboo particle boards using recycled plastic is gathering disposable plas-tics, including shopping bags, which, when melted, transform into binders. Because it increases durabil-ity and reduces environmental impact, research supports the use of waste plastics in particle boards (Yong, 2020). To create a mixture, plastics are shredded, melted, and mixed with chopped, dry bamboo fibers. In order to produce dense, smooth sheets with increased

strength and water resistance, this blend is compressed under high pressure in a hydraulic machine (Bajpai, 2018). After that, the boards are allowed to dry so that the plastic can cool and permanently bind the bamboo particles. This process uses bamboo's flexibility and strength to create robust, environmentally friendly boards that cut down on plastic waste (Ghosh, 2021).

Flow chart 4: this chart shows the process of manufacturing dry bamboo leaves particle boards

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6. Experiments

Table 5: Experiments table

Test No.	Sun Dried Bamboo Leaves (g)	Disposable Shopping Bags (g)	Size/Thickness (mm)	Weight (g)	Result	Material Ratio
Test 01	100	200	160x160x10	250	Failed	1:02
Test 02	50	100	160x160x5	100	Failed	1:02
Test 03	75	150	160x160x10	150	Success	1:02
Test 04	200	200	160x160x10	320	Success	1:01
Test 05	150	300	160x160x10	320	Success	1:01
Test 06	400	200	200x200x10	320	Success	2:01
Test 07	250	250	160x160x20	400	Success	1:02

Figure 1: testing 1 experiment process

6.1 SCALED MATERIAL REQUIREMENTS FOR PRODUCING AN 8' X 4' PARTICLE BOARD SHEET

Table 6: bellow table shows the Material Requirements for Producing an 8' x 4' Particle Board Sheet

Test	Sun-Dried Bamboo Leaves (g per sample)	Disposable Shopping Bags (g per sample)	Sample Size (mm)	Thickness (mm)	Scaling Factor (to reach 8' x 4')	Total Bamboo Leaves (g)	Total Disposable Bags (g)
Test 03	75g	150g	160 x 160	10	116	8,700g	17,400g
Test 04	200g	200g	160 x 160	10	116	23,200g	23,200g
Test 05	150g	300g	160 x 160	10	116	17,400g	34,800g
Test 06	400g	200g	200 x 200	10	62	24,800g	12,400g
Test 07	250g	250g	160 x 160	20	116	29,000g	29,000g

6.2. COST CALCULATION.

Table 6: bellow table shows the cost calculation for Producing an 8' x 4' Particle Board Sheet

Test	Total Bamboo Leaves (Kg)	Total Disposable Bags (Kg)	Material Cost (Bamboo leave)	Material Cost (Plastic)	Total Material Cost	Operational Costs(Transport +Electricity+labour)	Total Cost per Board
Test 03	8.70	17.40	Rs. 217.50	Rs. 1,044.00	Rs. 1,261.50	Rs. 450.00	Rs. 2,973.00
Test 04	23.20	23.20	Rs. 580.00	Rs. 1,392.00	Rs. 1,972.00	Rs. 450.00	Rs. 4,394.00
Test 05	17.40	34.80	Rs. 435.00	Rs. 2,088.00	Rs. 2,523.00	Rs. 450.00	Rs. 5,496.00
Test 06	24.80	12.40	Rs. 620.00	Rs. 744.00	Rs. 1,364.00	Rs. 450.00	Rs. 3,178.00
Test 07	29.00	29.00	Rs. 725.00	Rs. 1,740.00	Rs. 2,465.00	Rs. 450.00	Rs. 5,380.00

Economies of scale allow material and operational cost reductions in mass production. While simplified processes and continuous machinery operation reduce labor, electricity, and transportation expenses, buying bamboo leaves and disposable bags in bulk may reduce costs per unit. Buying 1,000 kg of bamboo leaves, for instance, could reduce the cost per 50 kg bag from Rs. 25 to ap-proximately Rs. 20–22. Disposable bags may also drop in price from Rs. 60 to Rs. 50–55 for a 50 kg bag. Additionally, operational costs decrease, with labor and utilities expenditures per board going from Rs. 450 to Rs. 350.

7. Conclusion

This chapter analyzes the methods and results of experiments using bamboo leaves to make environmentally friendly particle boards. It starts with a summary of the bamboo gathering location in Arukwatta village, Padukka, which is overseen by Mr. Chandana Maithpala. From there, it evaluates the appropriateness and durability of several bamboo leaf kinds for the manufacturing of particle board. Fungi problems and inadequate drying hampered the first attempts with varying material amounts and polymer binders. Later experiments, on the other hand, using disposable shopping bags as binders had positive results, with the best material ratios and thicknesses producing strong particle boards.

The chapter also explores home plastic usage research conducted in Sri Lanka, which reveals noteworthy trends in participants' plastic consumption and disposal, indicating room for improvement in recycling and reuse approaches. A thorough investigation on the histories, plantation sizes, and widely farmed species of Sri Lankan bamboo farmers, particularly around Kandy, reveals a concentration of expert farmers near riverbanks.

The effectiveness of employing bamboo leaves for sustainable particle board manufacture is highlighted in the end of the chapter, highlighting bamboo's potential as an environmentally harmless substitute for conventional materials. It emphasizes how important it is to cut the amount of plastic waste and provides methods to merge polling results with testing results for reaching well-informed decisions.

8. Recommendations

In conclusion, the study suggest that future studies include comprehensive mechanical testing to evaluate the materials' strength, compression, impact, and tensile qualities in light of the study's findings. These experiments are essential for

comprehending how materials, such sun-dried bamboo leaves and single-use shopping bags, behave and perform under different load conditions. These tests will provide important information on their energy absorption, load-bearing capability, and durability, all of which are critical for selecting the best materials and guaranteeing their performance in future uses.

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