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INDUSTRY AWARENESS OF BAMBOO-BASED MATERIALS IN PARTICLEBOARD AND FURNITURE MANUFACTURING: EVIDENCE FROM MALAYSIA

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Abstract:

The rising demand for the forest resources coupled with the rising sustainability and regulatory burdens has increased pressure on the wood-based manufacturing systems in an attempt to find alternatives to wood. It is generally known that bamboo is an eco-friendly alternative to conventional timber because it is fast to replenish and has favourable material characteristics. Although bamboo has good policy backing and much technical research has been done, the industrial utilization of bamboo in the production of particleboard, chipboard and furniture is still minimal, especially where it comes to lack of industry-level awareness and application know-how. This paper examines the awareness of the manufacturers of the bamboo-based materials in the industry in Malaysia. A quantitative survey was carried out in the period of October 2025 and January 2026 making 228 valid responses from the particleboard, chipboard and furniture industry. The industry awareness had been evaluated on four dimensions that were general familiarity with the industry, specific application awareness, benefits awareness and challenges awareness. The descriptive analysis and the correlational

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analysis suggest that the level of knowledge about the benefits of bamboo, in general, and the sustainability-related benefits, in particular, is consistently high, and the overall and technical knowledge levels are relatively low and have a significant difference between the firms. The extent of challenge awareness is moderate and with low dispersion which shows that there is a high level of agreement among the manufacturers. The result of correlation tests proves that familiarity is more associated with the awareness of challenges than the separately assessed benefits. On the whole, the idea of bamboo-based materials in the industry is mostly theoretical and not practical, which also indicates a significant gap in knowledge that prevents the use of this approach by industries and the shift to more sustainable production.

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Keyword:

Bamboo-Based Materials, Industry Awareness, Particleboard and Furniture Manufacturing, Sustainable Materials, Wood-Based Composites, Malaysia

Introduction

The industry of particleboard, chipboard, and furniture manufacturing are also in the forefront of providing key products in the downstream wood-based industry in Malaysia to provide the essential materials to be used both locally and in the production of furniture that is export-oriented. The industry has also proven to be economically relevant even when the world demand has been varying. The particleboard market in Malaysia is expected to record a steady growth during the same period 2025-2029 and the growth rates are projected to grow between -0.97 percentage in 2025 to 10.41 percentage in 2029, whereas the export of the chipboard and particleboard has reached MYR 14.4 million in October 2025 and the previous month stood at 9.2 million (6Wresearch, 2026; CEIC Data, 2026). The trends can be said to be a sign of the volatility of the market as well as the continued relevance of the wood-based panel in the international trade. To reflect this strategic importance, the New Industrial Master Plan 2030 lists the wood, paper, and furniture industry among the priority manufacturing industries, which gives a significant place to sustainability, biomass usage, and being included in the global supply chains.

Nonetheless, the further development of the particleboard and furniture sector is brought skid by the sustainability growing concerns due to the high dependency on traditional raw materials which are made of wood. The timber industry in Malaysia is also in a high demand because it relies on natural forests that have been over-exploited, degraded by climate change, and encroached by other land utilization activities (Durst et al., 2004; Wei and Shi-long, 2010). In spite of the fact that the use of plantation timber is being advanced as a long-term solution to decrease the utilization of tropical hardwoods, the supply remains unstable and the performance

of exports unpredictable, which impacts on the availability and price of material (Iwanaga and Masuda, 2013). With the growing pressure on the environmental sustainability of production in global markets and compliance regulations, manufacturers must re-evaluate their strategy of raw material sourcing to stay profitable in the market and allow them to comply with regulatory requirements (Kuri, 2012; Astari et al., 2019).

In that regard, bamboo has become a sustainable alternative material which can replace both environmental and supply-related issues. Bamboo is also known to possess a short growth cycle, renewability, high strength-to-weight ratio and relatively low input needs, which make it an appealing alternative to traditional timber as a panel product and furniture manufacturing material (Chang, 2015; Arsado, 2012; Supriadi and Trisatya, 2021). Market trends also contribute to this possibility since the market of bamboo-based products in Malaysia was estimated at USD 2.3 billion in 2024 and is expected to expand to USD 4.5 billion by 2033, which demonstrates the compound annual growth rate of 8.2% (Inno Wave Digital, 2025). These features make bamboo a strategically viable material that could contribute to the sustainable manufacturing system and relieve the pressure on the forest resources.

The mechanical, physical, and structural performance of bamboo-based composites, their applicability to particles boards, and furniture have been reported in a large amount of literature (Arsado, 2012; Dukarska et al., 2025; Supriadi and Trisatya, 2021). However, the implementation of bamboo in the mainstream manufacturing of particleboard, chipboard and furniture in Malaysia has not achieved extensive use in spite of good technical reasons and the positive policy backing. Most projects involving bamboo are still run at pilot or research levels, including the plans described in the bamboo masterplan of the Sarawak Timber Industry Development Corporation, but are not linked to commercial scale manufacturing.

Although bamboo has been widely researched under the material performance and engineering view, its usage in particleboard and furniture production is low in Malaysia. This implies that, technical feasibility is not always enough, and industry level awareness, knowledge and perception may be the determining factor in influencing adoption behaviour. This kind of lack of connection between technical viability and real-world industrial implementation suggests that the performance of materials, in their own right, is insufficient to cause manufacturing transition. The current literature demonstrates that lack of industry awareness, processing compatibility uncertainty, and product safety concern (stability of the supply chain) and the lack of developed industrial ecosystems could be the hindrances to adoption of bamboo-based materials (Iwanaga and Masuda, 2013; Supriadi and Trisatya, 2021). Even though some policy frameworks like the NIMP 2030 encourage the idea of sustainable material substitution, they rely on a number of factors such as how well manufacturers are informed and understand about the practicality of using alternative materials like bamboo.

The fact that the human and organisational aspects of material transition have received little attention, especially the awareness and perception of manufacturers, is a significant gap in the current literature, which has been dominated by engineering and material science approaches (Kuri, 2012; Dukarska et al., 2025; Gayda, 2025). This is a crucial gap because the choice as to whether bamboo is limited to laboratory work or moves forward to general industrial use falls on the manufacturers of particleboard, chipboard and furniture. To this end, awareness forms a preparatory requirement that leads to the later preparedness and adoption behaviour.
The current research is founded on this gap, and the aim is to analyze the awareness level of the manufacturers in the particleboard, chipboard and furniture industries in Malaysia about

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utilizing the bamboo-based materials. The research expects to offer industry-level knowledge on the viability of bamboo use by manufacturers, their perceptions of positive gain, and perceived obstacles to understand the ability of the policy-making process, knowledge dissemination strategies, and the efforts of introducing sustainable material use in the Malaysian wood-based manufacturing sector.

Literature Review

Bamboo as a Sustainable Material

Bamboo is a rapidly growing sustainable material whose biological properties and unique features have attracted growing attention to the material. Bamboo is a grass, not a tree, which has the capacity to grow up to 91 cm per day and thus is one of the fastest-growing renewable resources in the world (Zheng et al., 2023; Madhusudhan et al., 2021). Being more sustainable due to its renewable qualities and high strength- weight ratio, bamboo has become a potential replacement of traditional wood products which are rapidly becoming scarce due to deforestation and environmental degradation (Li et al., 2024; Zheng et al., 2023).

Other than physical characteristics, bamboo has immense environmental advantages. It captures carbon much faster than numerous tree species, and it helps in the reduction of climate change (Zheng et al., 2023). Bamboo plantations also increase the soil stability and biodiversity by offering habitats to many species (Duan et al., 2024). In addition, the processing of bamboo has a relatively low carbon footprint heat, which is partially explained by the use of simplified harvesting procedures and a reduced amount of chemical processing (Shi et al., 2023; Wen-xin et al., 2023). All these features reinforce the fact that bamboo is an eco-friendly raw material.

Bamboo in Panel Products and Furniture Manufacturing

Widespread research has revealed the technical capability of bamboo in the panel products and furniture production. Previous researchers have analyzed the mechanical characteristics of bamboo-based particleboards and composites, and it was found by researchers that bamboo laminas placed into medium-density particleboards can help to increase tensile properties, modulus of rupture, and overall durability more than traditional materials (Barbosa et al., 2014; Zhao et al., 2023). These results suggest that bamboo can be used in structure and functional furniture and panels (Duan et al., 2024; Barbosa et al., 2014).

Bamboo processing has opportunities and challenges as far as economics is concerned. Its economic attractiveness is obstructed in the short term because of the high initial investment needs (specialised equipment), but in the long run, reduced maintenance costs and the possibility to charge premium prices to environmentally friendly products make it more appealing (Zheng and Zhu, 2021; Shi et al., 2023). Also, it is proposed that the mechanical properties of bamboo composites can be dramatically enhanced by optimisation of processing parameters, thus increasing their range of application in both construction and furniture industries (Liu and Zhang, 2013; Wen-xin et al., 2023). Although this has increased technical evidence, there is no even distribution of understanding of such capabilities amongst manufacturers.

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Sustainable Material Adoption Industry Awareness

Awareness is an important factor in the implementation of substitute materials in production systems. The sustainable material sense, in its turn, entails the awareness of manufacturers regarding the characteristics of materials, their possible usage, processing conditions, and perceived advantages and dangers (Wang and Xiong, 2024; Hong, 2012). Unless the awareness is adequate, even technically viable materials might not take root in the industrial practice.

In the past, the body of research shows that a weak state of awareness usually results in defensiveness in decision-making, especially in those industries where the capital investment is very high and the risk of operating is very high like the manufacturing of panel and furniture (Wang & Xiong, 2024). The manufacturers might not be willing to take the risk to utilize new materials without proper information on its performance reliability, cost provisions, or market receptiveness. In turn, the absence of awareness may serve as an invisible obstacle to the spread of sustainable materials, even with the supportive policies and technological preparedness (Xiong et al., 2020; Zheng et al., 2023).

Barriers And Drivers That Affect Knowledge Of Bamboo Adoption

Even though the potential of bamboo as a sustainable material in manufacturing has been well documented, there are various factors that affect the consciousness and perception of its relevance by manufacturers. Technical factors, including the change in bamboo characteristics with the species, age, and moisture content, can cause a lack of certainty about the consistency of the quality and compatibility with the processing (Wang and Xiong, 2024; Cheng et al., 2020; Niu et al., 2024). These ambiguities may adversely influence awareness, especially among manufacturers who would be used to the standardised wood materials.

Economic factors also influence awareness creation. The perceived high prices of bamboo stock, machinery, and unpredictable demand may make manufacturers unwilling to actively seek alternative types based on bamboo (Madhusudhan et al., 2021; Zheng et al., 2023; Zhao et al., 2023). Also, successful large-scale industrial applications are relatively invisible, which supports risk perceptions.

The institutional and policy factors are also involved in creating awareness. The lack of information dissemination, low incentives, and poor involvement of the industry may lead to a low awareness of the long-term benefits of bamboo among manufacturers. According to previous research, there might be a markedly positive correlation between greater support mechanisms of the government and specific awareness programmes and the industry knowledge and trust in bamboo-based materials (Cheng et al., 2020; Zheng et al., 2023).

Altogether, though the sustainability qualities and technical viability of bamboo are properly proven, the knowledge of the particleboard, chipboard, and furniture producers does not seem to be a decisive and thoroughly studied factor in the process of industrial adoption. This highlights the necessity of empirical studies that directly concentrate on awareness in the industry as a preliminary measure to sustainable material transition.

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Methodology

Research Design and Data Collection

This study employed a quantitative research design using a structured questionnaire to assess industry awareness of bamboo-based materials in particleboard, chipboard, and furniture manufacturing. The sample population included manufacturers, who act in the wood-based panel and furniture industry in Malaysia since they form the main decision-makers of the choice of materials and manufacturing methods.

The data were gathered in a period of four months between October 2025 and January 2026. The number of the valid responses received was 228, which was achieved by the distribution of the online surveys and personal contact with the industry participants. Participation was voluntary and the respondents were made aware of the academic interest of the research and this was made confidential and anonymous, so that they can be encouraged to provide honest responses.

Measurement of Awareness Constructs

Four complementary dimensions were operationalised to specify industry awareness; they are general familiarity, specific awareness, benefits awareness, and challenges awareness. General familiarity was valued through a single self-reported measure that evaluated the general familiarity of the respondents with bamboo composites on a five-point Likert scale. Specific awareness measures the awareness about types and uses of bamboo among the respondents by the use of six categorical questions which were coded and averaged to constitute a composite measure. The awareness of benefits was determined on the basis of twenty items determining the perceptions of the benefits of bamboo, such as sustainability, material properties, processing suitability, and market potential, whereas challenges awareness was determined on the basis of sixteen items that concerned supply, processing, cost, and market barriers. Each of the benefit and challenge items was assessed on five-point Likert aggression scales that included strongly disagree, strongly disagree, disagreement, indifferent, difference, strongly agree, and strongly disagree.

Construction of Awareness Indices

The composite awareness indices were developed in order to generalise the various experience dimensions of industry awareness. To facilitate benefits and challenges awareness, the responses of items were averaged to produce composite mean scores of each respondent. General familiarity was treated as a single measure whereas specific awareness was calculated as an average of the corresponding items of the applications. In order to make interpretation and cross-dimensional comparisons, the awareness levels were grouped into low, moderate and high with a set of established cut-off values (low = 1.00-2.33; moderate = 2.34-3.66; high = 3.67-5.00). This method is in line with the exploratory research, which seeks to determine the general awareness but not the causal association.

Data Analysis Techniques

The descriptive and correlation statistical methods were used to analyze the data. The characteristics and the levels of awareness of respondents were summarised using descriptive

statistics, such as means, standard deviations, frequencies, and percentages. The correlation analysis was used to investigate the associations between the general familiarity, specific awareness, benefits awareness, and challenges awareness, which sheds light on the way various dimensions of awareness relate with each other. All the data were analyzed with standard statistical software, and the findings were given on aggregate level to avoid information leakage of the respondents.

Results

Overview of Industry Awareness Patterns

The findings show a subtle trend of awareness amongst the particleboard, chipboard, and furniture manufacturers about the use of bamboo-based composites. In general, the awareness cannot be defined as either high or low but as there exist various aspects of familiarity, benefits, challenges, and technical knowledge with different levels of awareness. As far as the manufacturers are usually aware of the benefits of bamboo, their vision and attitude to the challenges of implementation are narrower.

The overall awareness of bamboo composites is ambivalent. The respondents are nearly balanced in terms of their familiarity level which is low (29.8%), moderate (34.2%), and high (36.0) which shows that there is heterogeneity in the exposure and experience of bamboo materials by the industry. This variety indicates that bamboo is not something new to the manufacturers, but being aware of it is not widespread and is not always progressive.

By contrast, the awareness about the advantages of materials of bamboo content is significantly better and more stable. None of the respondents can be put under low-awareness category under benefits and 59.2-40.8 percentage are respectively under moderate and high-awareness. This high degree of consensus shows that benefits of bamboo, especially its sustainability and environmental benefits are communicated well, and it is very common in the industry.

Awareness of challenges presents a different pattern. A huge percentage of respondents (96.1) are in the moderate awareness category with only a small percentage (3.9) falling in the high awareness category and none in the low awareness category. The absence of variety indicates that the manufacturers have a shared idea of the issues surrounding the adoption of bamboo, they find it as something they know well, faced with these problems as constraints that can be managed instead of something drastic or even banning.

Descriptive Statistics of Awareness Indices

Table 1 represents the descriptive statistics of the compound awareness indices. The general familiarity which is determined by a single self-reported item captures a mean score of 3.03 (SD = 1.06) which shows that there is a moderate level towards familiarity with bamboo composites. Nevertheless, certain knowledge - acquisition of knowledge about certain types of bamboo, its uses, etc. - scores lower mean of 0.66 (SD = 0.34) at a 0-2 scale, which indicates that manufacturers have little technical or detailed knowledge. The awareness of benefits has the highest mean score (M = 3.60, SD = 0.29), which supports the result that the respondents are most aware of the advantages of bamboo compared to other factors. Comparatively, challenges awareness scores an average of 3.24 (SD = 0.26) which is also in the middle range. Interestingly, the standard deviation of challenges awareness is rather low which means that

the respondents are highly unanimous in their perception of the nature and extent of perceived challenges. These findings combined suggest that manufacturers are generally well-informed about bamboo and well-conscious of its advantages, but they do not know the specifics and applications of the material in detail.

Table 1: Descriptive Statistics of Bamboo Awareness Measures

Index Name	Description	Mean Score	Std. Dev.	Min	Max	Interpretation
General Familiarity	Self-reported level of familiarity with bamboo composites (1 item).	**3.03**	1.06	1.0	5.0	**Moderate**
Specific Awareness	Knowledge of specific bamboo types/applications (Mean of 6 items, Scale 0-2).	**0.66**	0.34	0.0	2.0	**Low-Mod**
Benefits Awareness	Composite score of 20 benefit items (e.g., Sustainability, Cost).	**3.60**	0.29	2.9	4.2	**High-Mod**
Challenges Awareness	Composite score of 16 challenge items (e.g., Supply, Processing).	**3.24**	0.26	2.5	4.2	**Moderate**

Note:

- **High Mean (Benefits):** Respondents are generally more aware of the *pros* (3.60) than the *cons* (3.24).
- **Low Std. Dev (Challenges):** The standard deviation for challenges (0.26) is very low, indicating that most companies have a very similar perception of the difficulties involved.

Classification of Respondents by Awareness Level

Additional knowledge of industry awareness is achieved by categorization of the respondents to low, moderate, and high awareness levels based on a set cut- off value (low = 1.00-2.33; moderate = 2.34-3.66; high = 3.67-5.00) as shown in Table 2. This categorization makes it possible to have a more subtle understanding of the level of awareness distribution in various dimensions.

General familiarity with bamboo composites is comparatively well-balanced in the three categories as indicated in Table 2 with 29.8 percent of the respondents recording low familiarity, 34.2 percent moderate familiarity, and 36.0 percent high familiarity. This uniform distribution reiterates the non-homogenous nature of the exposure to bamboo materials in the industry, implying that even though a significant portion of manufacturers is quite familiar with bamboo, there is still an equally significant number of manufacturers in the early awareness stage.

There is a much different trend in the case of benefits awareness. According to Table 2, it is evident that all respondents do not belong to the low-awareness group, as 59.2% of them are characterized by a moderate level of awareness and understand the benefits of bamboo products well (40.8%). The lack of low awareness entirely implies that positive bamboo-related descriptions (especially its sustainability, renewability, and environmental friendliness) have been spread throughout the industry and have successfully permeated the general perception of the benefits of bamboo.

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Conversely, the moderate level of awareness is the highest in connection with the challenges related to the use of bamboo. According to Table 2, 96.1% of the people respondents are moderately aware of challenges and only 3.9% are highly aware and none are lowly aware. The reason behind this small share is that there is a common industry perception about the issues like supply chain stability, processing needs, and cost concerns. These predicaments are broadly recognized but tend to be seen as normal running of business and not drastic or restrictive obstacles.

In general, the trends in Table 2 emphasize an enclosed awareness situation in the industry. The manufacturers show definite awareness of the advantages and difficulties of bamboo-based materials, but it is not that profound and technical, application-specific. Although the case of bamboo as a concept is well-known, the insight into fulfilling all levels of understanding to commit to a large-scale industrial process also seems to be insufficient.

Table 2: Awareness Level Classification of Respondent Firms

Level	General Familiarity (B1)	Benefits Awareness (B2)	Challenges Awareness (B3)
Low	29.8%	**0.0%**	0.0%
Moderate	34.2%	59.2%	**96.1%**
High	36.0%	**40.8%**	3.9%
Total	100%	100%	100%

Correlation Analysis Between Awareness Dimensions

The correlation analysis was performed to discuss correlations among the various awareness indices. Table 3 presents strong positive correlation is found between general familiarity and specific awareness (r = 0.59), which shows that the respondents having higher familiarity with bamboo are more likely to have knowledge on specific applications of bamboo. This association gives the self-reported familiarity measure credibility, implying that it represents the real knowledge and not the surface knowledge. There is a weak relationship between general familiarity and benefits awareness (r = 0.18), which means that mere knowledge about bamboo does not significantly affect the view of benefits. Conversely, the general familiarity is moderately and positively correlated with the challenge awareness (r = 0.35), revealing the fact that more people are exposed to bamboo, the more aware they are regarding the practical and operational issues of the bamboo. It is worth noting that the correlation of benefits awareness and challenges awareness is very low (r = 0.06). This autonomy implies that manufacturers do not regard benefits and challenges as the two ends of the same stick. Rather, they seem to assess the beneficial features and challenges that bamboo-based materials may pose as separate ones.

Table 3: Correlation Matrix for Awareness Measures

	General Familiarity	Specific Awareness	Benefits Awareness	Challenges Awareness
General Familiarity	1.00	**0.59**	0.18	0.35
Specific Awareness	0.59	1.00	0.21	0.20

Benefits Awareness	0.18	0.21	1.00	0.06
Challenges Awareness	0.35	0.20	0.06	1.00

Summary of Key Findings

The Awareness Index, in general, describes a cautiously optimistic industry. Manufacturers are highly aware of the reasons why bamboo must be looked into especially regarding sustainability and environmental performance - but they do not fully comprehend how to use bamboo in a practical manufacturing process. Although the idea of bamboo is well established, more technical acquaintance and application specific information are still in progress. Such a discrepancy between theoretical awareness and practical knowledge could be one of the reasons behind the slowness of industrial adoption despite the positive policy environment and increasing market interest.

Discussion

This research gives empirical evidence on the character of industry education about bamboo-based composites in Malaysian industry of manufacturing particleboard, chip board and furniture. The results all point to the fact that, although bamboo is well known as an environmentally friendly material, there is still imbalanced awareness, which is more of a concept and less about technical and application specific knowledge. This trend can be used to understand why there has always been a difference between policy zeal, technical viability, and real-world industrial adoption.

Inequality in General Awareness in the Industry

The general familiarity level among the manufacturers as demonstrated by the moderate mean of 3.03 and the near balance of low, moderate, and high levels highlights an unequal level of exposure of manufacturers to bamboo materials in the industry. This heterogeneity implies that awareness is not spreading in a homogenous way but rather influenced by firm-related factors including market orientation, technological sophistication and previous participation in sustainability-related programmes.

This conclusion aligns with the research results that have recorded disjointed knowledge of bamboo uses by manufacturers. Haron et al. (2014) discovered that the knowledge of bamboo veneer differed widely among companies and mainly depended on the production orientation and willingness to use other materials. In the same manner, Morales et al. (2017) noted that organisational strategies and sustainability investments have a strong effect on the level of manufacturers using bamboo-based materials. Nurazizah (2025) also stressed the fact that the previous experience of working with sustainability projects is a determinant in forming the baseline awareness in resource-intensive industries.

Combined with these results, these findings indicate that general awareness of bamboo cannot be simply regarded as a factor of industry-wide awareness, but a variable directly related to the organisational situation. Consequently, extensive awareness campaigns could not be very effective without targeted interventions taking into consideration the heterogeneity of firms.

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Intense Internalisation of the Bamboo Advantages

Unlike general familiarity, the level of awareness of benefits of bamboo is significantly elevated and uniform among the respondents with a mean score of 3.60 and none of the firms reporting low awareness. This implies that bamboo sustainability discourses have been effectively internalised in the industry. Environmental characteristics like renewability, environmental friendliness, and conformity to the global sustainability objectives seem to be an established concept and are accepted by many.

This trend corresponds to the available literature pointing to the increasing significance of the sustainability-based material consciousness. According to Ameh and Shittu (2021), with the growing environmental pressure, bamboo is becoming progressively popular as a sustainable choice in construction and production. Likewise, Zhang et al. (2022) proved that sustainability-related stories have risen the level of awareness and perceived credibility of bamboo composites dramatically.

The great internalisation of benefits, however, does not necessarily imply any realistic involvement. The results indicate that the knowledge of the benefits of bamboo is mostly abstract and not practical through real-life experience in the industrial field. That is why the material substitution is not yet extensive in the mainstream manufacturing in the context of high benefit awareness.

Triumph of trials in Bamboo Utilisation

The level of awareness regarding the issues related to the adoption of bamboo is moderate with high uniformity since the mean score is 3.24 with low standard deviation and 96.1 per cent of the respondents lie in the moderate category. Such consistency shows that there is an industry understanding in terms of the constraint like stability in supply, complexity in processing, and cost factors. This process of normalisation of challenge is justified by previous studies. According to Grunewald et al. (2013), the manufacturers tend to see issues related to alternative materials as a natural state of operations instead of uncommon obstacles. Deng et al. (2016) also did not find the processing and supply issues as a significantly known problem in the manufacturing of bamboo, but they are hardly perceived as an insurmountable challenge. The point is that the difficulties do not prevent the manufacturers to consider bamboo. Rather, they seem to be the common and accepted risks. This implies that low rate of adoption is less to do with fear of issues, but lack of clear and proven avenues of dealing with them on large scale.

The Disjunction between Conceptual Awareness and Technical Knowledge

One of the important contributions of this work is the determination of the difference between the general knowledge and the particular technical awareness. Though the respondents indicate that they are quite familiar with bamboo, their level of knowledge about bamboo use and product line is quite low with an average of 0.66 out of 2. This is a gap that demonstrates a lack of in-depth knowledge about the concept of bamboo as a material because manufacturers understand the concept of bamboo but know nothing about its industrial uses. This effect has been well covered by the literature on sustainable material transition. As it was observed by Gayda (2025), manufacturers have been enthusiastic about recognizing the potential of bamboo without having comprehensive knowledge of its processing and performance properties. The same researchers (Tahir et al., 2015) established that the lack of technical knowledge is a barrier

to effective implementation, even in cases when the general awareness is high. This knowledge gap shows that the current promotion of events in awareness building has focused more on promotion rather than building capacity. Unless the manufacturers have more technical knowledge, they are unlikely to shift the awareness to informed consideration or testing, which further supports the stagnation in adoption.

Familiarity Heightens Awareness of Challenges Rather Than Benefits

The correlation analysis shows that the familiarity with bamboo is more closely connected with the awareness of challenges ($r = 0.35$) rather than the awareness of benefits ($r = 0.18$). This implies that the more manufacturers are exposed to bamboo, the more aware they are of the limitations of operations and implementations related to it and not necessarily the benefits. The result is aligned with research by Xing et al. (2018), which revealed that exposure to the industry would bring out the challenges in processing and integration. Demir et al. (2022) also noted that familiarity does not necessarily lead to better perception of environmental benefits, which are usually already formed during initial stages of awareness. This trend is indicative of a learning curve where people start with high expectations only to be checked by reality. In that regard, increased awareness does not necessarily mean more positive attitudes, which is why it is essential to offer technical solutions, as well as awareness programs.

Independent Evaluation of Benefits and Challenges

The fact that there is no significant relationship between benefits awareness and challenges awareness ($r = 0.06$) shows that manufacturers do not evaluate the positive qualities of bamboo and its negative qualities as trade-offs. This compartmentalised appraisal indicates that there are rational and systematic decision making in the industry. Grunewald et al. (2013) registered the same tendencies in the process of material selection, benefits, and constraints are denoted independently. Gurgen et al. (2019) also showed that the recognition of material challenges has no negative effect on the recognition of benefits, which supports the autonomy of the evaluative dimensions. This observation means that raising awareness of the merits of bamboo on its own will unlikely decrease the alarming level regarding the challenges. Rather, the two dimensions need to be met in a complementary approach.

Policy and Industry Practice Implications

The results of this paper show that awareness of bamboo materials in the industry is quite developed at the conceptual level but was not developed properly at the operational one. Manufacturers know why bamboo should be adopted but they do not have the detailed details to incorporate it into the current production systems. This policy school of thought implies that the existing programs have been effective in disseminating sustainability narratives but not practical capability. According to Hartono et al. (2024), the manufacturers need to be better guided, have technical assistance, and case studies to transform awareness into informed decisions. Policies designed simply to promote but not to develop system to realize the implementation are thus unlikely to have an effect of fastening the adoption. To the industry stakeholders, the findings demonstrate the role of systematic transfer of knowledge such as technical training, pilot projects and collaboration between industry and research. The gap between the conceptual awareness and operational confidence would be facilitated through the provision of manufacturers with the access to the application-oriented information and real-life demonstrations. In general, the development of the usage of bamboo in particleboard and

furniture production will involve the transition between the awareness-building and the capability-building. Incidentally, it is crucial to increase the level of awareness and depth of the industry to support bamboo to cease being a symbol of sustainability and to become an element of significant application in the current manufacturing process.

Conclusion

This paper aimed to evaluate industry knowledge about bamboo-based products among industry participants in the production of particleboard, chipboard, and furniture, and this gap between policy aspirations and technical enthusiasm and factual industrial adoption is critical. The results indicate that, although bamboo is a known concept in the industry, knowledge has been very scattered and shallow. One of the positive indications of the effective diffusion of sustainability narratives is the high and stable awareness of the manufacturers about the superiority of bamboo, especially in terms of sustainability and environmental benefits. Nevertheless, there is no commensurability of this conceptual awareness with regards to equal amounts of particular technical expertise or application-related insight.

The findings also indicate that the awareness of the issues related to the use of bamboo is average and extremely consistent among the respondents and suggests that the issues are well-informed and perceived as manageable as opposed to being prohibitive. Notably, familiarity with bamboo is linked to heightened awareness of operational issues, less to heightened appreciation of benefits, thus indicating that as people get to know more about it, they encounter complexities of implementation, rather than continued belief. Furthermore, there is no correlation between the benefits awareness and the challenges awareness, which means that manufacturers consider these aspects separately, taking a rational and compartmentalised method to assessing the materials.

The research provides empirical data that differentiates between conceptual sustainability awareness and material operations knowledge since the lack of technical and application-specific awareness is a major bottleneck to the introduction of bamboo in the wood-based manufacturing sector of Malaysia. Bamboo is perceived as a concept of sustainability, though it is not clear how it can be incorporated into current manufacturing systems. This discrepancy between the intellectual acknowledgement and the functional comprehension is a decisive bottleneck in the process of material transition.

The results also indicate that policy interventions must evolve past emphasizing the need to raise awareness to emphasizing the need to build capabilities, such as technical training, pilot demonstrations, and collaboration of industry-research to facilitate effective transition to sustainability in the using of materials. Through the qualitative aspects of awareness, the stakeholders will be able to make the informed decision-making and enable the shift towards more sustainable material utilization of the wood-based manufacturing industry.

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