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Market dynamics and structural challenges in competitiveness of bamboo in Malaysia's wood-based industry

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Tel./fax.: +60-3-9769-1883, ♥email: norfaryanti@upm.edu.my
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Abstract. *Kamaruddin N, Al-Edrus SSO, Haida Z. 2026. Market dynamics and structural challenges in competitiveness of bamboo in Malaysia's wood-based industry. Asian J For 10 (1): r100113. https://doi.org/10.13057/asianjfor/r100113.* This study examines the competitiveness of bamboo within Malaysia's wood-based industry, with particular attention to market dynamics and structural constraints influencing its industrial adoption. Using Porter's Five Forces as an analytical framework, the study draws on structured questionnaire and semi-structured interview data from nine industry stakeholders, including manufacturers and relevant government agencies. The findings indicate high awareness of alternative raw materials among respondents, alongside a more cautious level of readiness to adopt bamboo in production. While most stakeholders recognise bamboo's potential to complement conventional timber, fewer indicate readiness to invest in high-value engineered bamboo products. This pattern suggests that industry preparedness is shaped more by market uncertainty, investment risk, and supply-chain reliability than by technical feasibility. Analysis through Porter's Five Forces positions bamboo as a promising yet structurally constrained competitor within Malaysia's wood-based sector. Weak supplier power, strong buyer influence, persistent competition from established timber products, and high barriers to entry collectively limit bamboo's competitive position. Qualitative insights further highlight challenges related to fragmented supply chains, limited certification systems, and uneven access to financing, which reduce firms' willingness to commit to large-scale adoption. Although exploratory in nature and based on a limited sample, the study provides insight into the competitive conditions shaping bamboo's industrial uptake in Malaysia. The findings highlight the importance of addressing structural and institutional constraints, particularly certification development, financing mechanisms, and industry–research linkages, to strengthen bamboo's competitiveness. These insights are relevant to ongoing policy discussions under Malaysia's National Agrocommodity Policy (2021-2030) and Biomass Action Plan (2022-2030), especially in supporting diversification within the wood-based industry.

Keywords: Bamboo industry competitiveness, circular bioeconomy, forest policy, market dynamics, wood-based industry

INTRODUCTION

Malaysia's wood-based industry represents a cornerstone of the national forestry and rural development agenda, underpinning employment, export revenue, and stewardship of forest resources (Obidzinski et al. 2014; Ratnasingam et al. 2018). For decades, the sector's competitiveness has relied heavily on natural forest timber and plantation species. As the world demands more accountability for deforestation and climate change, traditional industries are being pushed to abandon old models for greener, more diversified alternatives. In parallel, the global shift toward low-carbon, circular, and bio-based economies has heightened expectations for the wood-based industry to reduce reliance on finite forest resources while maintaining industrial competitiveness (Scarlat et al. 2015; Griscom et al. 2017; FAO 2018; Miller et al. 2021).

Within this transition, bamboo has gained increasing attention as a renewable feedstock capable of complementing conventional timber. Bamboo's role in land rehabilitation and biomass productivity has also been demonstrated across degraded tropical landscapes (Chantarat et al. 2023). Its rapid growth and suitability for a range of industrial applications have positioned bamboo as a potential component of green industrial transformation in many countries. In Malaysia, bamboo development aligns closely with national priorities articulated in the National Agrocommodity Policy (2021-2030) and the Biomass Action Plan (2022-2030). Both frameworks emphasise feedstock diversification, biomass-based value creation, and low-carbon industrial ecosystems (Ministry of Plantation Industries and Commodities 2021; Kaushal et al. 2022; MTC 2022). These policy frameworks identify bamboo as a strategic commodity with potential to support downstream manufacturing and rural economic participation.

Despite this policy recognition and well-established ecological attributes, bamboo remains marginal within Malaysia's wood-based industry. Its industrial uptake has been constrained by persistent market and institutional barriers, including uncertain demand, weak standardisation and certification systems, fragmented supply chains, and the entrenched dominance of established timber products (Chin et al. 2017; Juliana et al. 2025). While prior studies have examined bamboo's technical performance and niche applications, particularly in furniture and bioenergy, there is limited empirical evidence on its market competitiveness

within Malaysia's existing industrial and policy environment. In particular, little is known about how competitive forces within the wood-based industry shape firms' willingness to adopt bamboo at scale.

At a broader level, integrating bamboo into Malaysia's forest economy represents more than a substitution strategy; it reflects a shift toward a bioresource-based industrial model emphasizing resource efficiency, circularity, and resilience. As a Non-Timber Forest Product (NTFP), bamboo can complement national reforestation, carbon market development, and rural livelihood agendas, aligning with Malaysia's commitments under the Sustainable Development Goals (SDGs) and the Paris Agreement (Wong 2020; Diansyah et al. 2022). However, bamboo's transition from a peripheral resource to a mainstream industrial input depends not only on ecological attributes but also on its ability to compete within existing market structures. Understanding competitive forces, including buyer power, supplier reliability, barriers to entry, substitute materials, and industry rivalry, is therefore essential for assessing bamboo's realistic role in Malaysia's wood-based sector.

This study investigates the market dynamics, competitive forces, and institutional conditions that shape bamboo's role within Malaysia's wood-based industry supply chain. Specifically, it aims to (i) assess bamboo's competitiveness relative to conventional wood-based materials, (ii) identify key supply-chain, market, and institutional constraints affecting adoption, and (iii) examine how existing policy and governance arrangements influence readiness for integration. Drawing on empirical data from industry stakeholders and applying Porter's Five Forces framework, the study evaluates bamboo's current competitiveness, adoption barriers, and institutional enablers required to strengthen its market viability. By linking empirical findings to competitive structure, the study contributes to forest policy and bioeconomy debates on resource diversification and NTFP mainstreaming. It argues that enhancing bamboo's competitiveness through certification parity, coordinated policy instruments, and targeted financial mechanismsis central to realising the objectives of the National Agrocommodity Policy (2021-2030) and the Biomass Action Plan (2022-2030), and to advancing a more resilient and diversified forest-based bioeconomy in Malaysia.

MATERIALS AND METHODS

Study area

This study did not focus on a single, geographically bounded site, but instead adopted a multi-location approach, reflecting the spatial distribution of key actors within Malaysia's wood-based and bamboo-related sectors. Respondents were drawn from several states representing different forestry, industrial, and institutional contexts across the country. Specifically, participating organizations were located in Sarawak (n=1), Wilayah Persekutuan Putrajaya (n=2), Wilayah Persekutuan Kuala Lumpur (n=1), Terengganu (n=1), Selangor (n=2), Johor (n=1), and Pahang (n=1). These locations encompass both Peninsular Malaysia and East Malaysia, capturing variation in resource availability, industrial maturity, and governance settings relevant to bamboo and wood-based value chains. Sarawak is characterised by extensive forest resources and large-scale timber operations, while Peninsular states such as Putrajaya, Selangor, Terengganu, and Pahang represent manufacturing hubs, policy institutions, and emerging bamboo-based enterprises. This geographically dispersed study area supports the exploratory objective of the research by providing a national perspective on market dynamics, competitiveness, and institutional readiness for bamboo adoption.

For analytical clarity, this study distinguishes between willingness, readiness, and adoption. Willingness captures expressed openness to bamboo use, readiness reflects firms' capacity to invest and operationalize bamboo processing, and adoption refers to actual implementation in production. This distinction helps explain why high awareness does not translate into widespread industrial uptake.

Research design

This study adopts a mixed-method design integrating quantitative and qualitative approaches to provide a comprehensive understanding of market dynamics and policy readiness for bamboo adoption within Malaysia's wood-based industry. A cross-sectional structured-questionnaire was used to capture data from industry actors at a single point in time, reflecting prevailing market perceptions and adoption trends (Dawadi et al. 2021). Complementing this, semi-structured interviews were conducted with policy actors, regulators, and key industry stakeholders to obtain in-depth qualitative insights into institutional barriers, investment attitudes, and policy alignment. This combination enhances both the breadth and depth of the findings, consistent with best practices for policy and market analysis in forestry research (Kallio et al. 2016). The structured-questionnaire and interview guide are provided as supplementary materials to enhance transparency and replicability.

Sampling strategy

A purposive sampling approach was employed to ensure the inclusion of participants with direct relevance to Malaysia's wood-based and bamboo-related sectors. The sample comprised nine organizations, including manufacturers, government agencies, and policy institutions. This approach prioritized respondents possessing industry-specific knowledge, regulatory involvement, or strategic decision-making roles, ensuring the validity and contextual depth of the responses (Palinkas et al. 2015). In total, nine organizations participated in the study. While this sample size is sufficient for exploratory analysis aimed at generating in-depth insights, it inherently limits the scope of inference and precludes statistical generalization across the broader wood-based industry. The findings should therefore be interpreted as indicative rather than representative, reflecting the perspectives of key industry actors rather than population-level trends. This

approach prioritizes analytical depth over breadth and enables a nuanced examination of competitive and institutional dynamics within an emerging green industry. Consistent with established qualitative research practice, the study relies on analytical generalization to inform theory and policy discussions, rather than to produce statistically generalizable conclusions (Yin 2014).

To address potential limitations arising from the small sample, triangulation was applied by integrating multiple data sources, structured-questionnaire responses, interview transcripts, and secondary policy documents, to ensure consistency and credibility of the interpretations. Organizations were selected to represent upstream, midstream, and downstream industry segments, as well as policy, research, certification, and investment functions that influence material adoption decisions. Specifically, manufacturers were chosen to reflect variation in product focus (e.g. panel boards, plywood, engineered wood, bamboo products), company scale (small, medium, and large enterprises), and geographical location across Peninsular Malaysia and East Malaysia. Inclusion of a bamboo-focused small enterprise enabled insight into niche and emerging production models, while large manufacturers and exporters provided perspectives from established timber markets. In addition, government agencies, a certification body, and a research institute were selected based on their direct roles in policy formulation, standards development, technological support, and investment facilitation. Collectively, these criteria ensured that the sample captured a broad range of decision-making perspectives relevant to competitiveness, supply chain structure, and institutional readiness, while remaining closely aligned with the study's analytical focus.

Data collection

Two primary instruments were employed: a structured questionnaire and semi-structured interviews. The questionnaire was designed to collect quantitative data on stakeholder awareness, willingness to adopt bamboo, investment readiness, and perceptions of market competition. Closed-ended items with Likert-type scales facilitated standardized responses, enabling subsequent statistical analysis.

The semi-structured interviews were conducted either face-to-face or virtually, depending on participant availability. Each session lasted approximately 30-45 minutes and followed an interview guide covering themes such as policy support, financing mechanisms, certification issues, and supply chain constraints. The semi-structured format provided flexibility for participants to elaborate on emerging topics while allowing comparability across interviews (Kallio et al. 2016). All interviews were recorded and transcribed verbatim for analysis, with participant confidentiality strictly maintained.

Although limited to nine organizations, the purposive design ensures analytical, not statistical, generalization (Palinkas et al. 2015). Each respondent represents a key institutional or manufacturing role, allowing in-depth exploration of strategic decision factors. The integration of quantitative survey data with qualitative interviews strengthens triangulation and enhances interpretive validity (Denzin 2012; Batra 2021). In qualitative inquiry, small samples are valid when participants possess deep expertise and relevance to the research problem, yielding rich, contextualized data (Mason 2010; Guest et al. 2020). The purposive inclusion of senior decision-makers and policy actors, therefore, ensures credible and meaningful insights into institutional readiness and market dynamics within Malaysia's wood-based sector.

Data analysis

Quantitative data from the questionnaire were analysed using descriptive statistics to summarize key indicators such as stakeholder awareness, willingness to adopt bamboo, and investment intentions. Frequency distributions, means, and percentages were computed using SPSS software to identify prevailing trends and highlight patterns within the dataset.

Qualitative interview data were analysed using thematic analysis following the six-step framework proposed by Braun and Clarke (2006). NVivo software was used to support systematic coding and categorisation of recurring themes, enabling identification of policy drivers, market challenges, and institutional gaps.

Methodological triangulation was employed by integrating quantitative and qualitative findings to enhance validity and credibility. Convergence between numerical indicators (e.g. adoption readiness) and thematic insights (e.g. policy alignment and investment barriers) provided mutual reinforcement of results and reduced the risk of method-specific bias (Denzin 2012; Bazeley and Jackson 2013). All data were cross-checked for consistency across sources prior to thematic synthesis.

Analytical framework

The interpretation of results was guided by Porter's Five Forces framework, which is particularly suited for analysing the entry of an emerging material into an established industrial system. The framework examines the competitive forces shaping bamboo's market position relative to conventional timber products, including (i) the bargaining power of suppliers, (ii) the bargaining power of buyers, (iii) the threat of substitutes, (iv) barriers to entry for new market participants, and (v) the intensity of industry rivalry. By focusing on structural market conditions rather than firm-specific performance, the framework allows systematic assessment of how existing value chains, incumbent industries, and institutional arrangements influence the adoption of alternative raw materials. This analytical lens enables a structured evaluation of the opportunities and constraints facing the bamboo sector, linking observed market behaviour with policy environments, supply-chain readiness, and investment conditions relevant to material transition processes.

RESULTS AND DISCUSSION

Profile of respondents

A total of nine organisations participated in the study, representing key segments of Malaysia's wood-based manufacturing and governance landscape. Respondents included manufacturers producing veneer, plywood, sawn timber, joinery components, decking, laminated boards, panel products, and blockboards, alongside representatives from government agencies, a research institute, and a certification body. These organisations occupy strategic positions across upstream and midstream segments of the wood-based supply chain, providing perspectives on material sourcing, processing, regulatory oversight, and market engagement. A summary of the respondent profiles, including organisation type, location, and company scale, is presented in Table 1.

First, the research focused on a specific subset of stakeholders, manufacturers directly engaged in raw material procurement and processing rather than the broader forestry or consumer goods markets. Second, the wood-based manufacturing industry in Malaysia consists of a relatively small number of active players compared to mass consumer sectors; hence, a limited but targeted sample can adequately capture prevailing industry perceptions. Third, the respondents were senior decision-makers or technical managers, whose strategic oversight provides high-value insights into firm-level readiness and policy alignment. Finally, as an exploratory investigation into market and competition aspects of bamboo, the study prioritised the depth and strategic relevance of information over statistical generalisation.

Overall, the composition of respondents reflects the diversity and structure of Malaysia's wood-based industry while ensuring the credibility of insights drawn regarding market awareness, adoption potential, and competitive positioning of bamboo as an alternative raw material.

Willingness to adopt alternative raw materials

The structured questionnaire results indicate high awareness but moderate commitment among respondents toward the use of alternative raw materials within the wood-based manufacturing sector (Table 1). Across the nine participating organizations, awareness of bamboo as a potential industrial raw material was consistently high (88.9%), 6 out of 9 respondents (66.7%) reported that their companies had actively considered adoption (Figure 1). Similarly, 66.7% expressed willingness to transition towards alternative materials, suggesting a general openness to diversification, albeit tempered by practical or economic constraints. Respondents noted that while bamboo aligns with sustainability narratives, uncertainty regarding market acceptance and profitability limits large-scale adoption. Several participants emphasised that incentives, technical support, and market demand assurances are prerequisites for transition.

Readiness to commit resources declined further when respondents were asked about investment in higher-value or technologically intensive applications. Only four respondents (44.4%) reported willingness to invest in advanced engineered bamboo products such as composites or laminated structural panels. This pattern highlights a clear gap between conceptual acceptance and readiness for capital-intensive adoption.

A similar pattern was observed in relation to production modernization. Six respondents (66.7%) indicated readiness to pursue Industry 4.0, related upgrades, suggesting that interest in digitalization and process improvement exists alongside, but does not necessarily translate into, investment in new material systems. Open-ended responses frequently referred to uncertainty surrounding market demand, return on investment, and technical feasibility as factors shaping adoption decisions.

Market dynamics

When describing market conditions, respondents identified both opportunities and constraints associated with bamboo adoption. Reported opportunities included reduced reliance on natural forest resources, potential for product diversification, and alignment with national sustainability initiatives such as the National Agrocommodity Policy (2021-2030) and the Biomass Action Plan (2022-2030). Representatives from government agencies emphasised bamboo's relevance within existing policy frameworks as a renewable and fast-growing material.

Table 1. Profile of study respondents in Malaysia's wood-based industry

Respondent ID	Organisation type	Location	Company scale	Primary product / Function
R1	Furniture manufacturer	Johor	Medium enterprise	Panel boards and joinery
R2	Veneer and plywood producer	Selangor	Large enterprise	Plywood and laminated boards
R3	Blockboard & decking manufacturer	Sarawak	Medium enterprise	Engineered wood
R4	Government agency (policy unit)	Putrajaya	-	Forestry and commodity policy
R5	Research institute	Selangor	-	Wood composites R&D
R6	Private manufacturer	Terengganu	Small enterprise	Bamboo furniture and craft
R7	Timber exporter	Pahang	Large enterprise	Sawn timber and components
R8	Certification body	Kuala Lumpur	-	Product standards and compliance
R9	Government investment agency	Putrajaya	-	Industrial development support

Note: Although the sample size may appear limited, the response rate was consistent with exploratory studies targeting specialized industrial sectors. Several factors justify this scope. -: Absent

At the same time, manufacturers consistently raised concerns regarding consumer demand and market acceptance of bamboo-based products. Respondents noted that end markets remain dominated by established timber species, particularly in applications where certification, performance consistency, and brand familiarity are critical. Additional concerns related to production costs, variability in material quality, and uncertainty over the scalability of bamboo processing technologies. These responses reflect a market environment in which perceived opportunities are tempered by demand-side and cost-related considerations.

Competitive landscape

Respondents described a competitive landscape in which bamboo competes with well-established materials and production systems. Manufacturers reported continued reliance on conventional timber and engineered wood products, citing existing certification systems, stable supply networks, and established customer relationships as key factors influencing material choice. Several respondents indicated that bamboo was considered cautiously, with limited large-scale substitution implemented within current production lines.

Supply-side constraints were also highlighted. Respondents referred to limited availability of consistent bamboo feedstock and insufficient processing capacity suitable for industrial-scale production. Small and medium enterprises, in particular, identified capital requirements associated with processing equipment, certification, and production upgrades as barriers. Competitive pressure from incumbent timber producers with economies of scale and established market access was frequently mentioned. Together, these responses describe competitive conditions that influence firms' material decisions within the wood-based industry.

Challenges in supply chain transformation

Open-ended structured questionnaire responses were coded into seven thematic categories representing perceived challenges in transforming the wood-based supply chain (Figure 2). The most frequently cited themes related to market and demand uncertainty, as well as investment or capital constraints. These issues were mentioned by a majority of respondents.

Technological and process-related challenges were identified with moderate frequency. Respondents referred to limitations in processing equipment, technical capability, and workforce skills relevant to bamboo processing. Concerns related to supply and raw material consistency were also reported, particularly with respect to the availability of bamboo feedstock and the lack of structured sourcing arrangements. Themes associated with sustainability and ESG commitments, policy and regulatory frameworks, and promotion or market awareness were mentioned less frequently. These topics appeared less prominent in respondents' descriptions of immediate challenges affecting supply chain transformation. Overall, the coded responses summarise a range of market, financial, technological, and supply-related challenges identified by respondents in relation to bamboo adoption within the wood-based industry.

Linking findings to Porter's Fiver Forces

Responses from structured questionnaires and interviews highlighted several conditions relevant to competitive forces within the sector. On the supply side, respondents described bamboo sourcing as fragmented, characterized by small-scale growers, informal harvesting, and a limited number of commercial plantations. Manufacturers identified supply reliability and material quality consistency as constraints affecting procurement decisions.

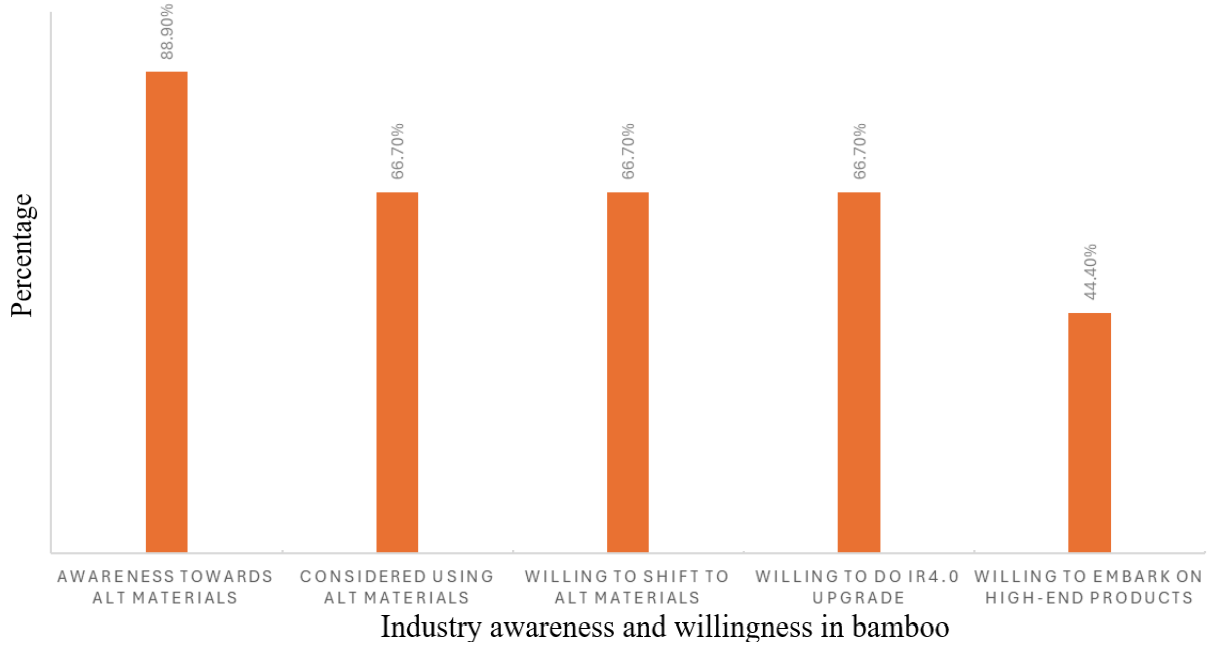

Figure 1. Industry awareness and willingness to adopt alternative raw materials in Malaysia's wood-based sector

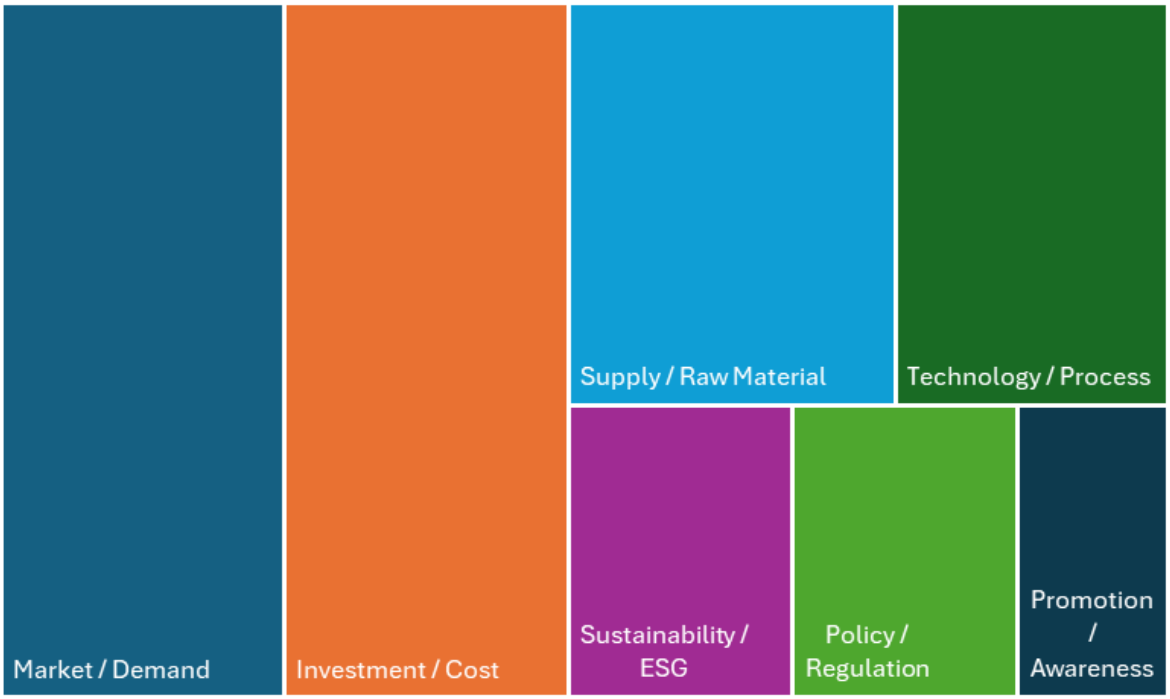

Figure 2. Key challenges affecting bamboo adoption in Malaysia's wood-based industry

On the demand side, respondents reported that buyers continue to prioritize certified timber and engineered wood products. Requirements for certification, proven performance, and competitive pricing were frequently mentioned. Several firms expressed caution toward introducing bamboo-based products due to uncertainty over customer acceptance and demand stability.

Competition from substitute materials was also noted. Respondents referred to conventional timber, engineered panels, plastic composites, and imported materials as well-established alternatives within existing value chains. Adjustments required to modify production lines for bamboo processing were described as costly and technically demanding. Barriers related to market entry, including investment in processing equipment and regulatory complexity, were reported alongside uncertainty over commercial returns. Respondents further described the wood-based sector as highly competitive, with established firms benefiting from existing infrastructure, customer relationships, and export networks.

Discussion

This study examined the competitiveness of bamboo within Malaysia's wood-based industry by integrating empirical findings with Porter's Five Forces framework. Global bamboo markets have expanded rapidly in response to sustainability-driven demand, with significant growth projected over the next decade (Alamerew et al. 2024). High awareness of bamboo's sustainability potential coexists with limited readiness for investment and adoption, reflecting structural rather than attitudinal barriers. The findings reaffirm bamboo's potential to support diversification, reduce pressure on natural forests, and contribute to sustainable forest management (Garcia et al. 2024; Le et al. 2025). However, despite alignment with national strategies such as the National Agrocommodity Policy (2021-2030) and the Biomass Action Plan (2022-2030), bamboo remains marginal within Malaysia's industrial landscape. This gap reflects challenges in policy implementation and market readiness rather than limitations inherent to the resource itself (Alves et al. 2025). To explain this persistent gap between potential and uptake, the findings are interpreted through Porter's Five Forces framework.

Competitiveness analysis using Porter's Five Forces

From a competitiveness perspective, the Five Forces analysis highlights several structural conditions constraining bamboo's industrial uptake. Buyer power remains strong due to entrenched preferences for certified timber products that offer established performance assurance, predictable pricing, and stable demand. In contrast, upplier power is weak, reflecting fragmented bamboo cultivation, limited processing capacity, and the absence of standardized grading and certification systems. The threat of substitutes remains high, as conventional timber and engineered wood products dominate existing value chains. Barriers to entry particularly capital-intensive processing requirements and technological readiness, further limit new investment, while intense rivalry among incumbent timber producers reinforces bamboo's vulnerable competitive position. These findings are consistent with observations that sustainability-oriented materials often face an "awareness–action gap" in resource-intensive industries (Garcia et al. 2024; Le et al. 2025).

To enhance analytical clarity, Table 2 explicitly maps the study's key empirical findings to each of Porter's Five Forces. This structured summary synthesizes quantitative indicators and qualitative insights, illustrating how specific market and institutional conditions shape bamboo's competitive position within Malaysia's wood-based industry.

Regional experiences provide useful analytical contrasts, but their relevance to Malaysia lies in selective transferability rather than direct replication. China's bamboo competitiveness is underpinned by vertically integrated supply chains, mandatory national standards, and sustained state investment in R&D and innovation clusters (INBAR 2018). While Malaysia lacks comparable industrial scale, the transferable element lies in certification parity and coordinated governance rather than plantation expansion alone. India's National Bamboo Mission demonstrates how public–private partnerships and concessional financing can link smallholders to processing hubs (Rathour et al. 2022); however, Malaysia's more capital-intensive wood-based sector suggests that financing mechanisms and technology transfer are more immediately relevant than smallholder-led expansion. Indonesia's experience highlights the value of integrating bamboo into green export strategies through eco-labelling and policy incentives (Ekawati et al. 2022; Gunawan et al. 2022), a model that aligns closely with Malaysia's export-oriented timber industry. Across these cases, competitiveness is not driven by ecological endowment alone but by institutional coherence, certification systems, and market assurance areas where Malaysia continues to face structural fragmentation (Wahab et al. 2023).

Empirical evidence from bamboo value-chain studies

Beyond the present case, empirical value-chain studies from other regions provide external validation for these patterns and reinforce the structural challenges identified in this study. Value-chain analyses from Indonesia and Ethiopia show that bamboo adoption is frequently constrained by fragmented upstream supply, weak coordination between growers and processors, and limited access to finance and technology, even where resource availability is high (Ekawati et al. 2022; Gelaw et al. 2025). These findings align closely with the present study, where respondents highlighted supply inconsistency, investment risk, and technological readiness as key barriers to industrial uptake. Evidence from Malaysia's engineered wood processing sector further suggests that sustainability-oriented material transitions are often hindered by capital intensity, skills gaps, and uncertainty over market returns, particularly among small and medium enterprises (Mustaffa et al. 2025). At the same time, empirical work from China demonstrates that bamboo competitiveness improves significantly when supply-chain organization, certification systems, and market incentives, such as carbon pricing and green financing are integrated into national industrial strategies (Pan et al. 2025). Collectively, these studies indicate that bamboo's market performance is shaped less by material properties than by institutional maturity, value-chain coordination, and demand-side assurance. For Malaysia, this comparative empirical evidence underscores that advancing bamboo beyond niche applications will require addressing structural supply-chain weaknesses and market confidence in parallel, rather than relying solely on ecological justification or resource potential.

Based on the empirical evidence, the study indicate that improving bamboo's competitiveness requires resolving structural constraints within the wood-based industry rather than relying solely on bamboo's ecological credentials. The analysis points to several policy-relevant considerations, including the need to strengthen certification parity, improving access to green financing, and reinforcing industry–research linkages to support technological upgrading and supply chain integration. These considerations are presented as interpretive insights derived from the study's evidence and are discussed as potential pathways for sectoral development, rather than as prescriptive solutions (Xue et al. 2024; Gairola et al. 2025).

Table 2. Mapping empirical findings to Porter's Five Forces

Porter's Force	Empirical evidence from this study	Competitive implication for bamboo
Supplier Power	Fragmented bamboo cultivation; limited commercial plantations; inconsistent feedstock quality; absence of standardized grading and certification	Weak supplier power constrains scalability, cost stability, and industrial confidence
Buyer Power	Strong preference for certified timber; demand for proven performance and price predictability; cautious buyer attitudes toward bamboo	High buyer power limits market pull and slows adoption
Threat of Substitutes	Dominance of conventional timber, engineered wood panels, and imported materials with established supply chains	High substitution pressure reduces incentives to switch to bamboo
Threat of New Entrants	Capital-intensive processing technologies; certification costs; technological readiness barriers, especially for SMEs	Moderate-to-high entry barriers deter new investment
Industry Rivalry	Intense competition among incumbent timber producers with economies of scale and established export networks	Strong rivalry positions bamboo as a vulnerable entrant

Source: Questionnaire responses and interview findings

Limitations

This study is exploratory and subject to several limitations. The small sample size restricts statistical generalization and reflects the perspectives of selected industry and institutional actors rather than the full diversity of the wood-based sector. Although respondents were purposively selected to represent key segments of the value chain, the findings may underrepresent views from informal producers, downstream retailers, or end consumers. In addition, the cross-sectional design captures perceptions at a single point in time and does not account for dynamic market or policy changes. These limitations suggest that future research should incorporate larger samples, longitudinal analysis, and consumer-side data to deepen understanding of bamboo's evolving competitiveness.

Despite these limitations, the study provides grounded insights into the competitive conditions shaping bamboo adoption in Malaysia. It highlights that bamboo's future role within the forest-based bioeconomy depends less on ecological justification and more on resolving institutional, market, and supply chain barriers.

Policy and institutional implications

Taken together, the Five Forces analysis indicates that bamboo's limited competitiveness in Malaysia is driven primarily by institutional and market structures rather than material performance. Policy and institutional implications are therefore discussed in relation to the specific competitive constraints identified, namely weak supplier organization, strong buyer power, high substitution pressure, and elevated entry barriers, rather than as broad sustainability interventions. Empirical evidence consistently highlights gaps in institutional coordination, certification systems, investment readiness, and market confidence, suggesting that policy interventions should focus on these areas rather than broad, multi-level reforms.

First, institutional alignment emerges as a foundational requirement. Stronger coordination among key agencies, particularly the Ministry of Plantation and Commodities (MPIC), the Malaysian Timber Council (MTC), and the Ministry of Science, Technology, and Innovation (MOSTI)would help reduce fragmentation across policy, R&D, and market development functions. A unified framework under the Biomass Action Plan could streamline licensing, research support, and industry engagement, directly addressing constraints reported by respondents. Second, the absence of certification and eco-labelling systems for bamboo represents a critical barrier to market acceptance. Establishing national bamboo standards aligned with existing timber certification schemes would enhance buyer confidence and facilitate integration into domestic and export markets. This recommendation is strongly supported by respondents' emphasis on certification parity and performance assurance. Third, targeted investment incentives for engineered bamboo processing warrant prioritization. Questionnaire and interview data indicate that capital intensity and uncertain returns discourage private investment, particularly among small and medium enterprises. Fiscal incentives and green financing mechanisms could lower entry barriers and support technology adoption where market readiness remains limited.

More broadly, the findings suggest that Malaysia's bamboo sector reflects a familiar pattern in sustainability-driven transitions, where conceptual support outpaces commercial commitment (Baruch and Holtom 2008). Comparative experiences from countries such as China and Indonesia illustrate that competitiveness depends less on ecological potential than on coordinated institutional support, standardization, and market integration. For Malaysia, addressing these priority constraints is essential to move bamboo beyond niche applications and toward a more competitive role within the forest-based bioeconomy.

In conclusion, this study assessed the competitiveness and policy preparedness of bamboo within Malaysia's wood-based industry using empirical evidence from industry and institutional stakeholders and an analytical framework based on Porter's Five Forces. Based on the findings, although bamboo is widely recognised for its ecological and economic potential, its industrial uptake remains constrained by limited structural preparedness across institutional, financial, and technological domains. High investment costs, uncertain market demand, and fragmented support mechanisms contribute to stakeholder caution, resulting in limited barrier to commit to large-scale adoption. The analysis yields three interrelated conclusions that reflect foundational, enabling, and coordinating conditions shaping competitiveness. Although market potential for bamboo is evident, its competitiveness within Malaysia's wood-based industry is constrained by weaknesses at the most fundamental level of industrial readiness. Gaps in supply networks, limited processing capacity, and the absence of standardised certification systems undermine bamboo's position relative to established timber products. Without consistent quality assurance and certification parity, buyer confidence remains low, access to higher-value markets is restricted, and export readiness is constrained. These conditions indicate that bamboo's marginal industrial role is rooted in foundational institutional and market limitations rather than shortcomings inherent to the material. Beyond foundational constraints, the analysis shows that financial and technological conditions play a critical enabling role in shaping investment readiness. High capital requirements, uncertain returns, and limited access to tailored financing mechanisms discourage firms, particularly small and medium enterprises, from investing in bamboo processing technologies. These challenges are compounded by weak supplier organisation and fragmented upstream supply, which heighten perceived commercial risk. Improving investment readiness therefore depends on targeted financial instruments, technology support, and stronger industry–research linkages that reduce entry barriers without presuming immediate market transformation. Integrating bamboo into existing policy instruments (2021–2030) will streamline supply development and align it with national certification and financing systems. Such policy coordination can support competitiveness by reducing fragmentation and improving institutional coherence.

However, the evidence indicates that policy alignment functions as a facilitating condition rather than a standalone driver of industrial transformation. Porter's Five Forces analysis further suggests that bamboo's current competitiveness is shaped primarily by buyer caution, weak supplier organization, high entry barriers, and strong incumbent rivalry. Addressing these conditions requires targeted, evidence-informed interventions rather than broad policy ambition. This study is exploratory in nature, and its conclusions should be interpreted accordingly. Future research should focus on quantifying economic and environmental trade-offs, including cost–benefit assessments of bamboo processing, carbon mitigation potential, and consumer acceptance dynamics. Such work would complement the present findings and support more robust evaluation of bamboo's role within Malaysia's evolving forest-based bioeconomy.

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