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Reviving local economies through bamboo: A community-based socio-ecological approach

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Abstract

Bamboo is a strategic biological resource that plays a vital role in rural communities' social, cultural, and economic life. Amidst the global push for sustainable development and green economy initiatives, the economic potential of bamboo as a local commodity in West Papua remains vastly underutilized. This study aims to explore patterns of bamboo utilization among local communities, understand their perceptions of its economic value, analyze its contribution to household income, and examine community expectations for government support and sustainable bamboo conservation efforts. The research adopts a descriptive-quantitative approach complemented by qualitative techniques to enhance data depth. Data were collected through structured questionnaires and focus group discussions (FGDs) with local community members in the study area. Quantitative data were analyzed using descriptive statistics, while qualitative data were processed using thematic analysis. Findings reveal that bamboo use is still mainly limited to domestic needs such as construction materials, household tools, and customary purposes. Communities exhibit positive perceptions of bamboo's economic potential but face limited market access, inadequate training, and lack of financial support. Bamboo's contribution to household income remains supplementary and relatively low. Nevertheless, there is a strong expectation for active government involvement in training, market facilitation, strengthening local institutions, and promoting community-based bamboo conservation. This study highlights the significant potential of bamboo as a green economic commodity in West Papua, while emphasizing the need for cross-sectoral support and development strategies that are contextual and participatory. It also represents one of the initial studies to specifically map the socio-economic potential of bamboo in West Papua based on the lived experiences and perceptions of local communities.

Keywords: Bamboo; Economic Value; Community Empowerment; West Papua; Sustainable Development

1. Introduction

Bamboo is one of human society's most important natural resources, playing a vital role in economic, social, cultural, and ecological aspects of life. As a plant with a fast growth cycle, bamboo can be harvested relatively quickly compared to other types of wood, and it has high resilience to climate change and natural disasters (Lodovico et al., 2007). These characteristics make bamboo a highly potential renewable natural resource for developing various products and driving the green economy.

Amidst the growing global discourse on the green economy and sustainable development, the utilization of bamboo as a strategic commodity has not been maximized in many regions of Indonesia, including West Papua. However, bamboo is a fast-growing plant resilient to climate change and natural disasters. It is one of the most promising biological resources for development within sustainable economic frameworks (Lodovico et al., 2007).

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Several countries have successfully made bamboo a strategic commodity. In China, the bamboo industry employs more than 10 million workers and generates billions of dollars in economic value each year (INBAR, 2020). This success has been driven by research, the development of bamboo-based products, regulatory support, and sustainable training for communities. Despite its significant potential in Indonesia, bamboo development has not yet been systematically integrated into regional development policies.

In Indonesia, there are over 160 species of bamboo, widely distributed across nearly all regions, including West Papua. Its utilization has become integral to daily life, ranging from construction materials for houses, household tools, food (shoots), to artistic tools and traditional medicine (Widjaja and Kartika sari, 2001). However, the contribution of bamboo to increasing household income in rural areas is still not optimal. Most of its utilization is still consumptive for domestic needs, not as a high-value-added economic commodity.

Bamboo strategically supports the Sustainable Development Goals (SDGs), particularly in poverty alleviation, job creation, climate change mitigation, and natural resource conservation (FAO and INBAR, 2018). Its derivative products, such as woven goods, furniture, building materials, and handicrafts, have high market value if managed through a community-based creative industry approach. Therefore, bamboo-based economic development must begin with mapping bamboo utilization by communities, their perceptions of its economic value, and the opportunities and challenges they face at the local level.

Bamboo is an important part of the lives of the people of West Papua, especially in rural areas that still uphold traditional values and local wisdom. Specific research on bamboo utilization in this region is still limited, especially when compared to other regions in Indonesia. One study shows that bamboo utilization in Eastern Indonesia, including Papua, has great potential to support village self-reliance through a local resource-based approach. Traditionally, bamboo is used as a building material for houses, fences, agricultural tools, and various household items such as containers and cooking utensils (Abdullah et al., 2019). From a social and economic perspective, local communities consider bamboo a versatile and easily accessible resource. Its economic potential has not been fully optimized, especially in developing value-added products. Bamboo processing is still carried out simply and is not yet connected to industrial supply chains or modern markets.

Bamboo is important in maintaining ecological balance, especially in soil and water conservation in tropical regions such as West Papua. This plant has remarkable natural characteristics—an extensive and strong root system that can stabilize soil, reduce erosion risk, and maintain soil structure to remain fertile and productive (Zhang and Jiang, 2019). Not only that, bamboo is also known as a plant that can manage water naturally. Its stems can store water, while its roots help maintain groundwater flow. This ability is beneficial for reducing surface runoff and maintaining soil moisture, especially in areas with high rainfall such as West Papua. Furthermore, bamboo also has an important contribution to watershed management (DAS). It is a natural filter that captures sediment and pollutants, improving water quality. This function is highly relevant for West Papua, which is known for its extensive river networks and freshwater ecosystems, which are crucial for human livelihoods and biodiversity (Sharma and Bhatt, 2018).

However, the development of the bamboo sector in West Papua still faces several challenges. Bamboo possesses several ecological characteristics that make it highly effective in soil and water conservation, particularly in tropical regions like West Papua, which experiences high rainfall and varied topography. One of bamboo's key advantages lies in its extensive and deep root system, which can bind and stabilize soil. Bamboo roots form a dense network that effectively prevents erosion caused by rainwater or wind and strengthens soil structure on steep slopes (Widjaja and Kartika sari, 2020). Additionally, fallen bamboo leaves and stems that decompose enrich the soil with organic matter, enhancing fertility and supporting the natural growth of other vegetation. This role is vital in ecosystems with high biodiversity, such as West Papua (FAO a damp; INBAR, 2018).

From a hydrological perspective, bamboo can store water within its stems, helping maintain soil moisture and groundwater flow. This characteristic is highly beneficial for areas with unpredictable rainfall patterns, as it helps reduce surface runoff and prevent flooding and drought (Zhou et al., 2022). Additionally, bamboo plays a crucial role in watershed management. It acts as a natural filter, trapping sediments and pollutants, thereby improving water quality and supporting the overall ecological functions of watersheds (Mishra et al., 2017). These four functions demonstrate that bamboo is a versatile plant from an economic perspective and an essential component of sustainable nature-based environmental conservation strategies.

Bamboo is crucial in maintaining ecological balance, particularly regarding soil and water conservation in tropical regions like West Papua. Its unique characteristics, such as an extensive root system and water management capabilities, make it highly effective in stabilizing soil, reducing erosion risks, and enhancing soil fertility (Zhang and

Jiang, 2019). Additionally, bamboo plays a vital role in watershed management by regulating water flow and improving water quality, which is highly relevant for West Papua, which has numerous rivers and important freshwater ecosystems (Sharma and Bhatt, 2018).

This study aims to explore the patterns of bamboo utilization by local communities in West Papua, understand their perceptions of bamboo's economic value, analyze bamboo's contribution to household income, and explore their expectations regarding government support and conservation efforts.

By understanding the socio-economic dynamics of bamboo utilization locally, this study is expected to provide important input for formulating contextual, participatory, and sustainable bamboo-based economic development strategies. This research also fills a knowledge gap regarding the potential of bamboo in supporting the Sustainable Development Goals (SDGs) in remote and indigenous areas.

To achieve these objectives, a quantitative-descriptive approach with qualitative data reinforcement is used to obtain a comprehensive and in-depth understanding of the reality of bamboo utilization by the community.

2. Literature review

2.1. Economic Value of Bamboo

Bamboo has high economic potential, primarily through cultivation and sustainable forest management. This plant grows quickly, can be harvested relatively quickly, and has various benefits and added value from all parts of the plant. In Indonesia, financial analysis indicates that bamboo cultivation is more profitable than teak in the long term, with advantages in operational cost efficiency, resilience to market price fluctuations, and the potential for utilization of harvests for various industries such as construction, handicrafts, and alternative energy (Presto et al., 2021).

According to Abadia and Abawi (2020), land restoration using bamboo in Ethiopia improves environmental conditions and significantly enhances community well-being. The program increased farmers' income by selling bamboo stems and their derivatives while creating new job opportunities in processing, distribution, and bamboo supply chain management. These findings are reinforced by a systematic review conducted by Alameri et al. (2024), highlighting that bamboo is a strategic commodity in supporting improved livelihoods for rural communities, particularly through its contributions to the forestry, energy, and construction sectors.

Zhong et al. (2012a, 2012b) note that globally, the development of the bamboo industry has demonstrated significant economic contributions, as seen in China. In that country, government policies actively support community-based bamboo production systems and strengthen local economic structures through industrializing bamboo products. This economic potential makes bamboo a reliable commodity for supporting sustainable development, especially in developing countries.

Furthermore, bamboo-based products offer extensive opportunities for business diversification and high added value in various industrial sectors, such as textiles, construction, handicrafts, and food. Innovations in bamboo raw material processing open up opportunities for the creation of environmentally friendly and high economic value products. For example, bamboo fibers can be combined with textile waste such as cotton and polyester to produce high-quality fabrics in the textile industry. These fabrics have high market value, support circular economy principles, and reduce industrial waste (El-Morsy et al., 2023). Bamboo-based textile products are known for their antibacterial properties, high absorbency, and natural softness, making them competitive in the global market.

According to Cadena-Iñiguez (2018), besides the textile industry, the food industry also shows great potential through the utilization of edible bamboo. In Mexico, several bamboo species that produce shoots (young bamboo shoots) have been identified as a nutritious alternative food source with promising market prospects. The development of bamboo as a food crop in the region enriches the diversity of food sources and has the potential to increase farmers' income and strengthen local food security.

Bamboo has also been widely utilized as a structural and decorative material in the construction and design sectors due to its high mechanical strength, flexibility, and pressure resistance. Bamboo is commonly used in constructing eco-friendly houses, producing household furniture, and community-based creative design products. One example is the use of bamboo in urban farming racks in tourist villages, which combine aesthetic and educational elements (Titi et al., 2023). The added value of these products lies not only in their economic aspects but also in their contribution to promoting tourism and preserving local culture.

Rathor et al. (2022) emphasize that utilizing bamboo in various industrial sectors opens up significant opportunities for local economic development, innovative products, and strengthening bamboo's position as a sustainable and multifunctional global commodity.

Despite facing challenges such as limited capital, low managerial capacity, and suboptimal market access, bamboo-based microenterprises still show promising economic prospects. Pieter and Utomo (2023) revealed that bamboo microenterprise operators in the Gonangium region of Indonesia face obstacles in business management, raw material supply continuity, and connectivity to broader markets. However, interventions through technical training, entrepreneurship mentoring, and product promotion facilitation have proven effective in improving the performance and sustainability of these businesses.

Soliven et al. (2024) also found similar results in the Philippines, where strengthening the bamboo supply chain from production to distribution successfully improved logistics efficiency and increased profit margins for farmers and local bamboo businesses. Better logistics systems and partnerships between farmers, industry players, and the government are key factors in creating a productive and inclusive bamboo ecosystem.

Meanwhile, a study in Ethiopia by Dessie et al. (2023) highlights that the level of bamboo utilization by local processors is highly dependent on the availability of technology, policy support, and access to raw materials and markets. The active involvement of local governments and training institutions is considered important for enhancing production capacity and expanding the reach of small- and medium-sized bamboo-based businesses. With a strong ecosystem—including access to financing, technical training, and integration into national and global supply chains—micro bamboo businesses have the potential to become resilient and sustainable drivers of the local economy.

Economic valuation of bamboo resources indicates that this plant has a high total economic value (TEV). This value includes direct benefits such as construction materials, food, and energy, as well as indirect benefits such as its role in maintaining ecosystem functions, providing environmental services, and supporting biodiversity conservation. A study conducted in Lebak District, Banten, revealed that the direct economic value of bamboo comes from harvests for construction materials and handicrafts. In contrast, its indirect value includes contributions to soil and water conservation and the preservation of local culture tied to its use (Iqbal et al., 2014).

From a technical perspective, the feasibility of bamboo cultivation further strengthens the prospects for developing this commodity. Puspita et al. (2024) indicate that in NADA District, East Nusa Tenggara, agroclimatic conditions and community social factors support commercial bamboo cultivation. Factors such as land availability, basic community skills, and increasing market demand for bamboo products make bamboo a viable commodity for development within rural development based on local resources.

Furthermore, the economic potential of bamboo lies not only in the utilization of its raw materials but also in its regenerative characteristics, making it an efficient renewable resource. With a harvesting system that does not damage the parent plant and a fast growth cycle, bamboo offers ecological advantages that strengthen its position as a sustainable economic commodity (Alameri et al., 2024).

3. Social Value of Bamboo

Bamboo plays an important role in community empowerment, particularly in rural and urban fringe areas, by providing business opportunities based on local potential and traditional skills. Bamboo weaving training conducted in Kesari Village, Central Java, is a concrete example of how enhancing human resource capacity can stimulate community creativity in producing high-value craft products. These activities not only strengthen local skills but also build the confidence and independence of rural communities in managing businesses based on the natural resources around them (Anggika and Ilyas, 2024).

In addition to training, mentoring in developing bamboo-based microenterprises is crucial in creating an inclusive local economy. An empowerment program in East Java, which combines agricultural product processing and bamboo, has successfully opened new small-scale business opportunities, increased family income, and built networks among micro-business actors. This approach encourages the formation of resilient and adaptive independent business units that can adapt to market changes (Abdillah et al., 2023).

Furthermore, strengthening community capacity in managing bamboo as an economic resource also reduces social inequality and enhances regional competitiveness. In their systematic study, Alameri et al. (2024) show that bamboo development can promote livelihood diversification, particularly for communities living near forest areas and marginal

lands. This underscores that bamboo is valuable from an economic perspective and strategic as a tool for sustainable social empowerment.

Bamboo also holds significant cultural value and is deeply rooted in various communities' social and spiritual lives worldwide. In many Asian cultures, bamboo is not only utilized as an economic resource but also as a symbol of resilience, simplicity, and harmony with nature. Ethnobotanical studies conducted among the Dulong community in Yunnan, China, reveal that bamboo is an integral part of their traditional ecological knowledge system. The Dulong people utilize various bamboo species for household needs and traditional ceremonies and to support their agricultural and conservation systems. Their relationship with bamboo is multifunctional and non-exploitative, based on the principles of sustainability and local wisdom in maintaining the balance of the forest ecosystem (Cheng et al., 2023).

The cultural value of bamboo is also reflected in intangible cultural heritage, such as weaving arts, traditional music (e.g., bamboo musical instruments), and bamboo architecture found across various regions of Indonesia and Southeast Asian countries. In this context, bamboo preserves ancestral traditions and serves as a means of economic empowerment and strengthening the collective community identity. Therefore, preserving bamboo as part of cultural elements plays a strategic role in village revitalization and strengthening the character of local communities (Soetjipto et al., 2019). Thus, bamboo is a valuable natural resource and a symbol and medium for transmitting cultural values that support sustainable development based on local wisdom.

Bamboo has been strategically utilized as a means of revitalizing tourist villages, particularly in the context of environmental conservation and community-based economic development. In various regions, bamboo is used not only as a building material or raw material for handicrafts, but also as a key element in planning tourist areas that promote environmentally friendly and sustainable principles. In Indonesia, various initiatives to revitalize villages through bamboo-based land conservation demonstrate that this plant can restore local ecosystems while creating a distinctive visual identity and aesthetic value for tourist destinations. Activities such as large-scale bamboo planting ( ), the construction of bamboo-based tourism infrastructure, and craftsmanship skill training have encouraged active community involvement and increased local participation in sustainable tourism management (Soetjipto et al., 2019).

Bamboo is not limited to rural areas, but has also expanded to urban areas and become part of the branding strategy for urban farming-based tourism communities. Titi et al. (2023) show that using bamboo-based products, such as display racks for plants and urban agricultural products, not only enhances the aesthetics of the environment but also strengthens the identity of adaptive tourist villages in response to sustainability issues. In this context, bamboo also strengthens residents' social interactions, creates educational spaces, and bridges the gap between urban communities and the potential of rural tourist villages.

Combining ecological, economic, and social functions makes bamboo a leading commodity in tourism destination development. Bamboo offers visual appeal and reflects deep participatory and local sustainability values.

Socio-economic policies in China play a central role in shaping a resilient and sustainable bamboo industry through a community-based production approach. The Chinese government actively promotes the development of the bamboo sector through regulations, economic incentives, and technical and institutional support, enabling local communities to participate directly in the bamboo value chain, from cultivation to industrial processing. Studies conducted by Zhong et al. (2012a, 2012b) show that this system not only increases the productivity and efficiency of the bamboo industry but also strengthens the rural socio-economic structure by creating jobs, increasing income, and improving the quality of life for communities.

This structured management system integrates economic, environmental, and social dimensions into a comprehensive development policy framework. Bamboo is a strategic commodity in rural spatial planning and poverty alleviation efforts. The model implemented in China has become an important reference for developing countries in Asia and Africa in designing renewable natural resource-based development strategies. This aligns with the global need to create a green economy model based on participatory, inclusive, and sustainable principles. China's success proves that bamboo is not just an economic commodity, but can also be an effective and contextually replicable rural development policy instrument in various regions.

Globally, interest in bamboo research continues to grow rapidly, in line with increasing awareness of the importance of sustainable natural resource utilization in addressing environmental and socio-economic challenges. A systematic review by Alameri et al. (2024) confirms that bamboo significantly improves rural livelihoods, particularly through job creation, strengthening local economies, and providing access to affordable building materials. Additionally, bamboo's strong root system supports land conservation and the natural rehabilitation of degraded land.

Furthermore, bamboo is crucial in strengthening community economic resilience through livelihood diversification, including bamboo cultivation, household industries, crafts, and bamboo-based tourism. Its fast-growing nature, abundance, and flexibility in processing into various products make bamboo a strategic resource in the green economy and modern bioeconomy. Bamboo has been adopted as part of sustainable development strategies that integrate ecological, social, and economic aspects in various countries such as China, India, Ethiopia, and Indonesia.

As research advances and global attention toward bamboo grows, this commodity is increasingly recognized as a multifunctional solution to global challenges such as climate change, rural poverty, and environmental degradation. Bamboo is a focus of technical and agronomic research and a key subject in public policy studies, community empowerment, and resource-based economic transformation.

Bamboo has high economic value as a strategic commodity through various utilization pathways, ranging from cultivation, industrial product processing, to micro-enterprise development. In the context of cultivation, bamboo offers advantages in terms of cost efficiency, short harvest cycles, and stable market value (Presto et al., 2021). Bamboo-based industrial products span the textile, construction, food, and handicraft sectors—each with significant market potential and competitiveness at both local and global levels (El-Morsy et al., 2023; Cadena-Iñiguez, 2018). Meanwhile, bamboo-based microenterprises drive local economies, mainly when supported by skills training and adequate market access (Pieter and Utomo, 2023).

Beyond its economic value, bamboo also holds significant social value. Various community empowerment programs utilize bamboo as a medium to enhance skills, create employment opportunities, and strengthen family economies (Anggika and Ilyas, 2024; Abdillah et al., 2023). The cultural value of bamboo is reflected in traditional practices, architecture, weaving arts, and local ecological knowledge, as found in the Dulong community in China (Cheng et al., 2023).

Additionally, bamboo development contributes to environmental conservation and community strengthening through village tourism revitalization programs and community-based development (Sestito et al., 2019; Titi et al., 2023). An integrated and sustainable approach to bamboo development promotes economic well-being and reinforces social, cultural, and ecological values within an inclusive and resilient long-term development framework (Alameri et al., 2024).

4. Research methodology

4.1. Research Approach

This study employs a descriptive quantitative approach with qualitative analysis reinforcement, aiming to comprehensively understand perceptions, utilization patterns, and the economic potential of bamboo in local communities. This approach was chosen because it allows researchers to describe general trends within the population while exploring the accompanying social and cultural dynamics.

4.2. Research Location and Time

The research was conducted in areas with indigenous or local communities known for their bamboo utilization traditions, such as Miyah District, Tambra Regency (or other relevant locations). The study was carried out over one month, including data collection and validation.

4.3. Population and Sample

The population in this study consists of all households that utilize bamboo for daily needs, whether for personal consumption or economic activities. Purposive sampling was used to select respondents with experience or involvement in bamboo utilization, with a sample size of 27 respondents as reflected in previous analyses.

4.4. Data Collection Techniques

Data was collected using a combination of the following techniques

- Closed and open questionnaires to explore quantitative data (harvest quantity, frequency, price, perceptions, etc.) and qualitative data (community expectations).
- Semi-structured interviews to deepen understanding of local narratives regarding the value of bamboo.
- Direct observation of bamboo utilization and management activities.

- Documentation to record bamboo species in the local language and the forms of their derivative products.

4.5. Research Instruments

The instruments used include

- Structured questionnaire (for quantitative variables: age, gender, occupation, number of harvests, selling price, economic contribution, etc.).
- Interview guides (for qualitative questions about expectations, challenges, and perceptions of bamboo's value).
- Field observation forms.
- Visual aids (maps, photo documentation, bar and circle diagrams).

4.6. Data Analysis Techniques

- Quantitative data is analyzed using descriptive statistics (percentages, frequencies) and visualized as pie charts and bar charts to illustrate respondent characteristics, perceptions, and the economic contribution of bamboo.
- Qualitative data is analyzed using a thematic analysis approach, which involves grouping open-ended narratives into broad themes: economic value, training, conservation, government role, and local utilization.
- Integrative analysis links quantitative and qualitative data results to develop contextual and applicable conclusions and recommendations.

4.7. Validity and Reliability

To ensure data validity

- Triangulation of sources was conducted by cross-checking questionnaire data, interviews, and observations.
- Results are validated through small focus group discussions (FGDs) to confirm initial findings.
- Readability and comprehension tests of the instruments are conducted on a limited number of test respondents prior to the primary survey.

5. Results and discussion

5.1. Respondent Characteristics

The respondents in this study were primarily male, accounting for 70.4%, while female respondents accounted for 29.6%. When categorized by age group, most respondents were over 50 (54.2%), followed by the 41–50 age group at 29.2%, and the 31–40 age group at 16.7%. Based on primary occupation, most respondents work as farmers, accounting for 60.7%, followed by civil servants at 25.0%, and traders at 3.6%. Meanwhile, 10.7% of respondents had jobs outside the categories mentioned. Regarding family size, nearly half of the respondents (48.1%) had more than five family members, while 40.7% had between three and four family members. 7.4% of respondents had one to two family members, and only 3.7% had fewer than one family member. Overall, these characteristics indicate that most respondents are male heads of households of mature age, working in the agricultural sector, and have a relatively large number of dependents.

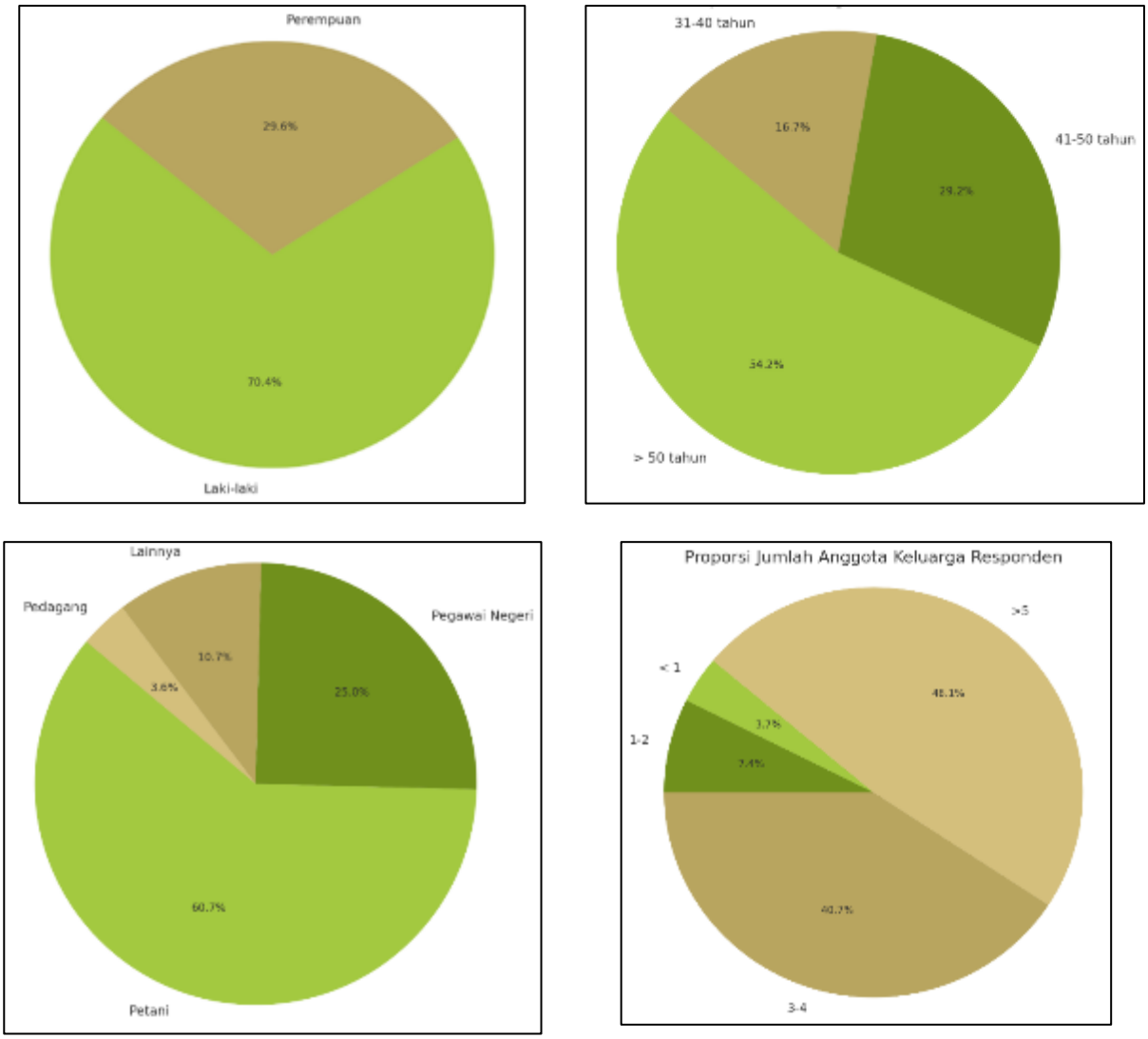

Figure 1 Respondent Characteristics Table

5.2. Bamboo Use by the Community

Most respondents (85.2%) stated that they use bamboo in their daily activities, while the remaining 14.8% stated that they do not use bamboo. Bamboo is widely used by the community in various activities, particularly for building construction (32.7%), food such as bamboo shoots (30.6%), and household tools (18.4%). In addition, bamboo is also used as a material for artistic tools, such as musical instruments (8.2%), and traditional medicine (2.0%). Other activities that use bamboo account for 8.2%. Thus, the use of bamboo in the community's daily life is widespread and diverse, reflecting the importance of bamboo in supporting the local community's life and economic and cultural activities.

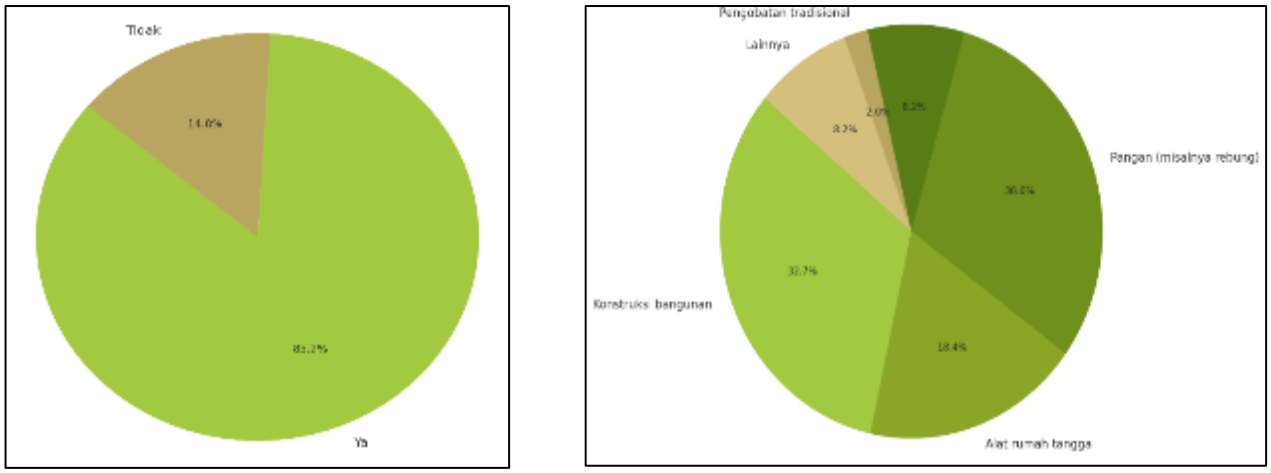

Figure 2 Percentage of Bamboo Users and Types of Use

In the local language, the community recognizes various types of bamboo. The most commonly mentioned types are Bajorek, Keb/Kena/Keb war, Nan, Wau, and IWar, the most popular and widely known types of bamboo in the community. Additionally, there are other types of bamboo such as Namwamba/Narwampubwat, Manger, Iri/Irori, Siow, Biko/Biwott/Biko, as well as less commonly mentioned types like Wowed, Narau/Nawa/Nurani, Ikaw, Bayar/Binya, and Pron.

In terms of everyday use, the Bajorek type of bamboo is the most widely used by the community, followed by Keb/Kena/Keb war, IWar, Namwamba, and Wau/Wau. In addition, the Kep and Ibura types of bamboo are also quite frequently used by the community. Other types used with lower frequency include Wow/Wow, Irori, Bik, Pron, Upah, and Fani.

Thus, it can be concluded that Bajorek and the Keb group are the main types of bamboo in terms of local language recognition and daily use by the community. This indicates that these two types of bamboo play an important role in meeting the daily needs of the local community.

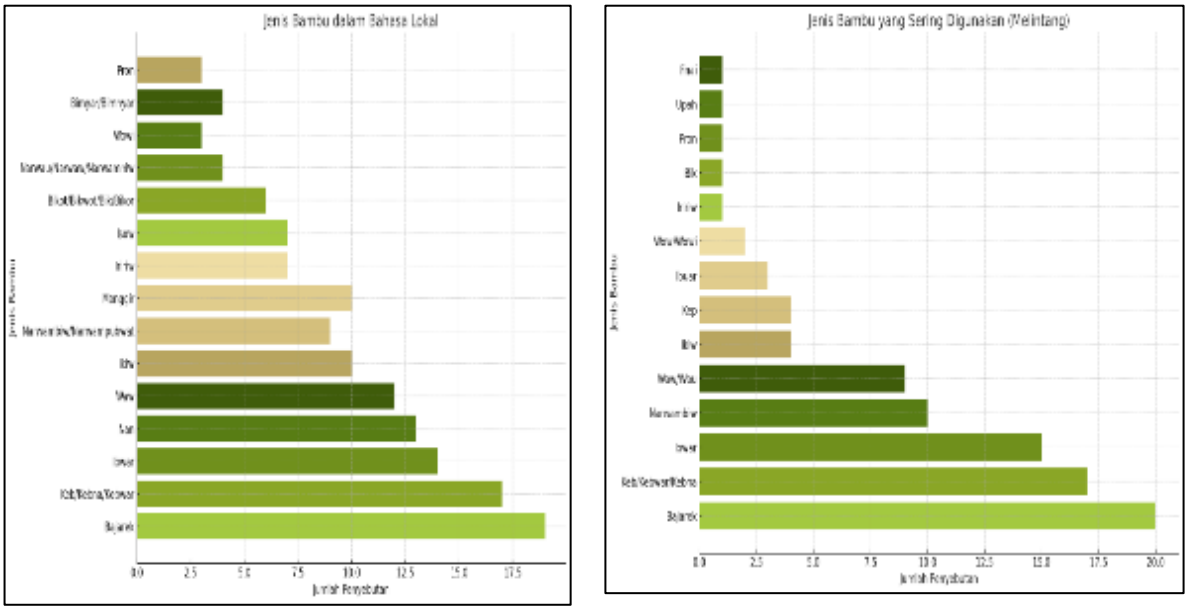

Figure 3 Names of Bamboo Types in Local Languages and the Most Commonly Used Types

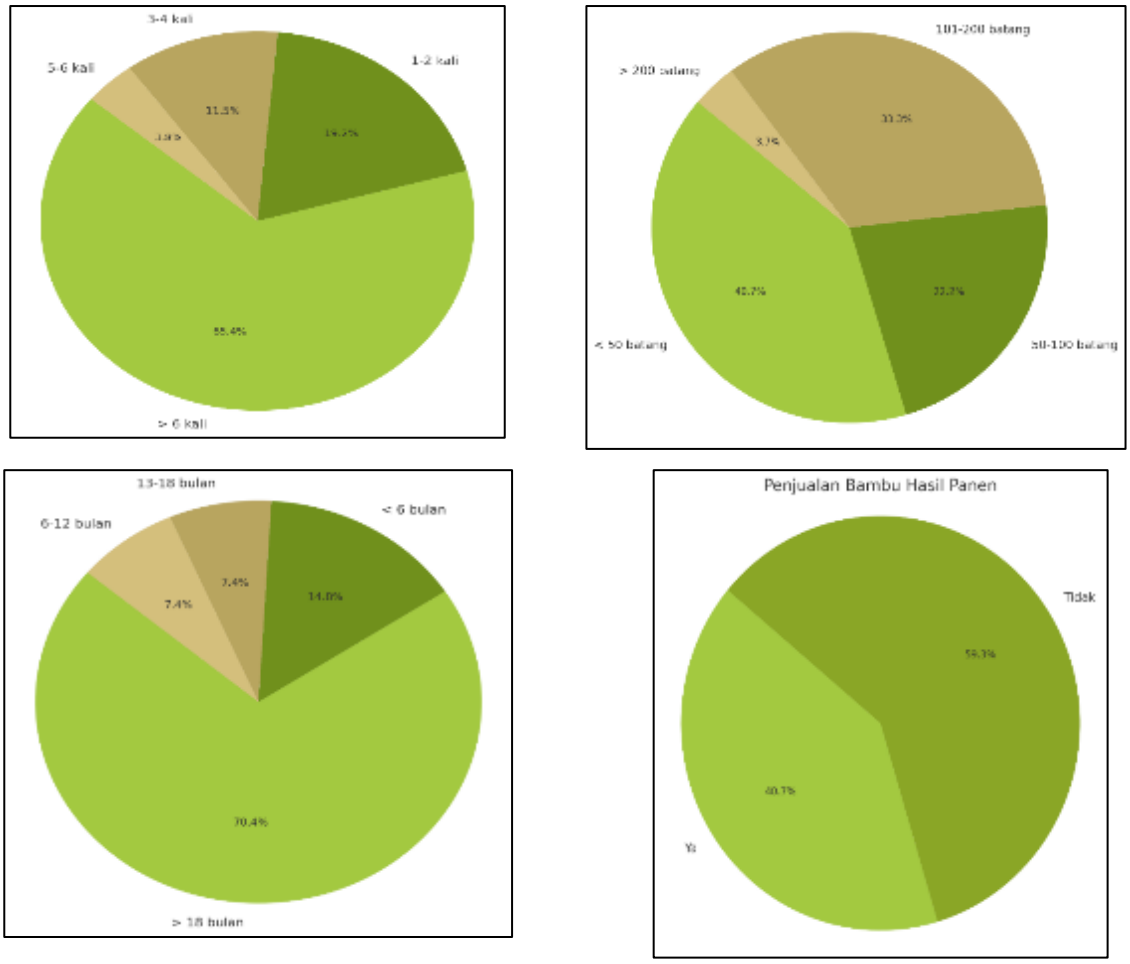

Figure 4 Percentage of bamboo cut and sales of bamboo harvest

Respondents' frequency of bamboo harvesting in a year was more than six times, accounting for 65.4%. Furthermore, 19.2% of respondents harvested 1–2 times, 11.5% harvested 3–4 times, and only 3.8% harvested 5–6 times a year.

Looking at the number of bamboo stems harvested per harvest, 40.7% of respondents harvested fewer than 50. 22.2% harvested between 50–100 stems, 33.3% harvested between 101–200 stems, and only 3.7% of respondents harvested more than 200 stems per harvest.

Regarding the time required until bamboo is ready for harvest, most respondents (70.4%) stated it takes more than 18 months. Meanwhile, 14.8% stated that it had been less than 6 months, and 7.4% of respondents each reported harvest times between 6–12 months and 13–18 months.

Regarding selling the harvested bamboo, 59.3% of respondents stated that they do not sell their harvested bamboo, while 40.7% of respondents stated that they sell their harvested bamboo.

Based on this data, it can be concluded that respondents generally harvest bamboo intensively (more than six times a year), with varying harvest quantities—though the majority are under 50 stems. The growth process until harvest typically takes more than 18 months. However, most respondents do not sell their harvest, indicating that bamboo is primarily used for personal or household needs rather than commercial ones.

5.3. Market Prices and Economic Contribution

Regarding bamboo selling prices in the local market, most respondents (20 people) stated that they did not sell their harvested bamboo. Among those who sold bamboo, three people sold it for less than Rp5,000 per stalk, while two others sold it in the price range of Rp5,000 to Rp10,000 per stalk.

Regarding average income from bamboo sales, most respondents (20 people) did not earn any income from this activity. Only six respondents reported less than Rp500,000, and one reported between Rp500,000 and Rp1,000,000.

When considering its contribution to household income, 20 respondents stated that bamboo sales did not contribute. Meanwhile, six respondents reported that bamboo contributed less than 25% to household income, and only one respondent mentioned a contribution between 26–50%.

Regarding bamboo utilization for derivative products, most respondents (14 people) did not produce any derivative products. However, some respondents utilized bamboo to make furniture (7 respondents), building materials (5 respondents), woven products (4 respondents), and handicrafts (1 respondent).

Regarding the average selling price of bamboo-based products, most respondents (20 people) did not have products to sell. Among those who sell products, three sell at prices below Rp50,000, 2 in the range of Rp50,000–Rp100,000, and only one respondent sells at prices between Rp100,001–Rp200,000.

Overall, this data indicates that although bamboo plays an important role in the daily lives of the community, its function as a direct source of income remains limited. Most respondents do not sell bamboo or its derivatives, indicating that bamboo utilization is more dominant for personal consumption or household needs rather than as a primary economic commodity.

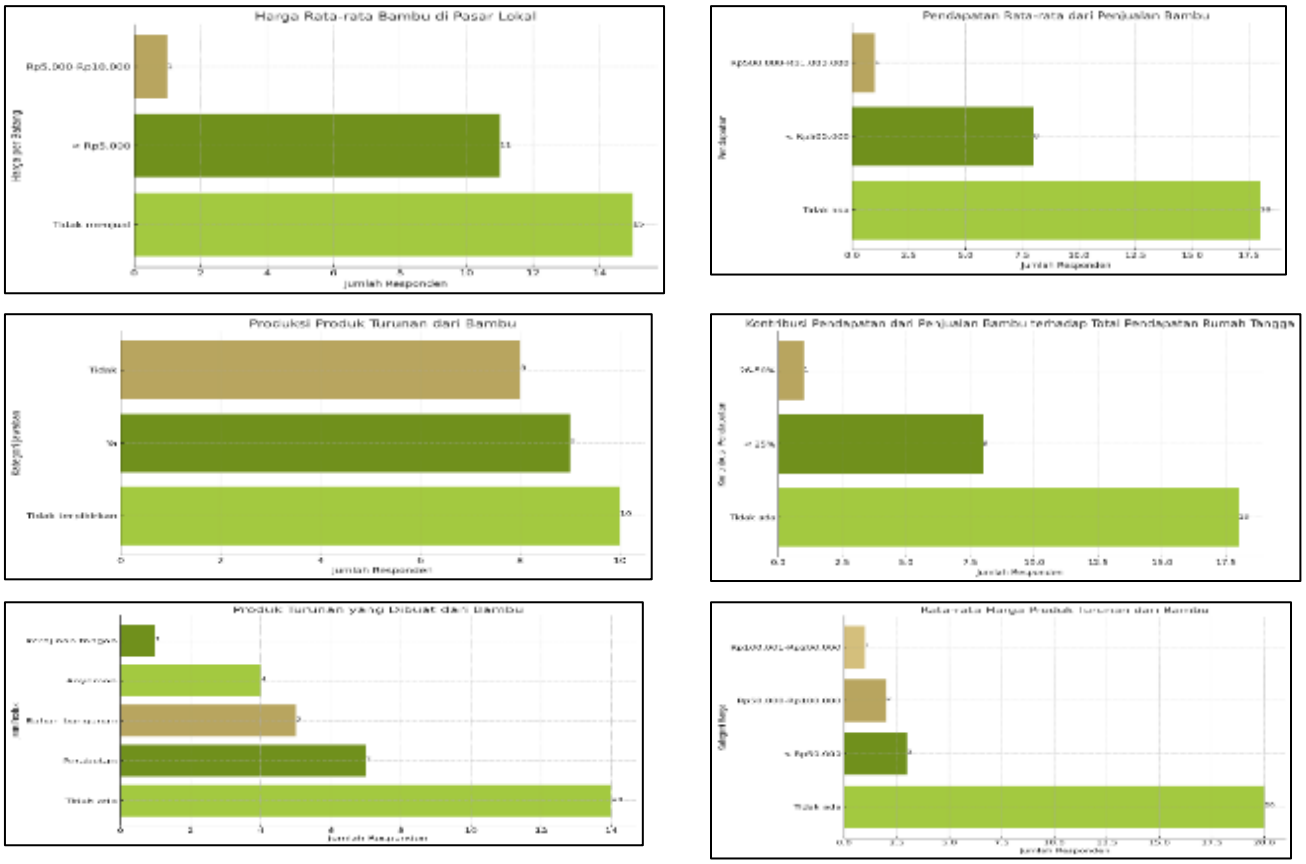

Figure 5 Average price of bamboo in the local market, price of bamboo derivative products, average income frombamboo products, contribution of income from bamboo sales to total household income

5.4. Perceptions of the Conservation Value and Management of Bamboo

Most respondents (74.1%) consider bamboo to be very important as a source of household income. Meanwhile, 25.9% of other respondents consider bamboo important, although not as a primary source of income. These findings indicate that, in general, the community recognizes the economic value of bamboo in their lives.

Regarding sustainable bamboo management, most respondents (63.0%) strongly agree that this approach can improve economic welfare. The rest (37.0%) agree. No respondents disagree or do not know, reflecting the community's positive perception of the importance of sustainable bamboo management.

Regarding the role of local government, 96.3% of respondents stated that the government needs to be actively involved in bamboo management. Only 3.7% considered government involvement unnecessary. This indicates high expectations from the community for policy support, programs, and assistance from the local government.

In addition, all respondents (100%) supported bamboo forest conservation efforts in their areas. This overwhelming support reflects the community's collective awareness of the importance of preserving bamboo resources as part of their natural heritage and as a long-term economic resource.

Overall, the data indicates that the community has a strong understanding and high commitment to the importance of bamboo management and conservation. Additionally, there is a strong push for the government to actively develop bamboo's potential as a sustainable and competitive commodity.

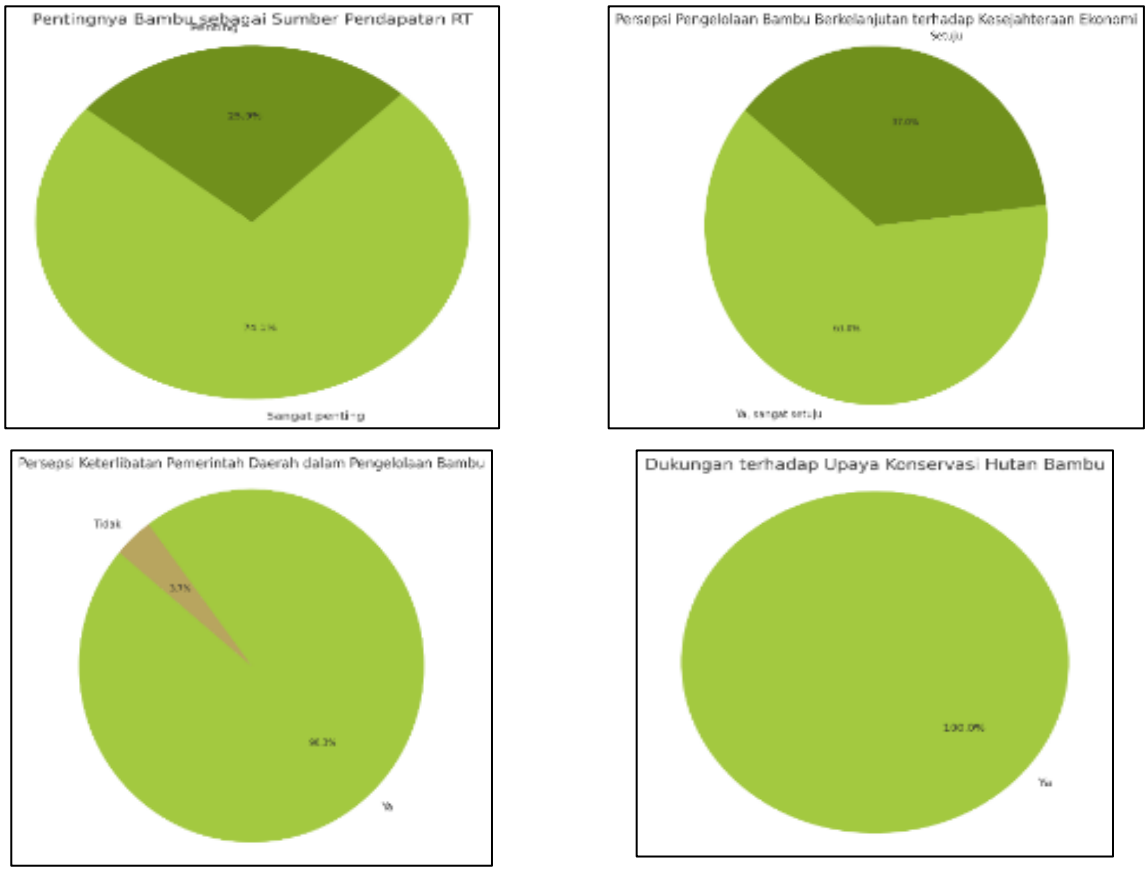

Figure 6 Public perception of bamboo for economic improvement, perception of government involvement, perception of sustainable bamboo management and support for bamboo forest conservation efforts

The study results indicate that bamboo plays an important role in local communities' social, economic, and ecological life, particularly in West Papua. More than 85% of respondents stated that they use bamboo in their daily activities, which include various needs such as building construction, household tools, food ingredients, and even artistic tools. These findings align with the FAO report (2018), which emphasizes that bamboo is a multifunctional resource capable of supporting rural communities.

From a social perspective, bamboo plays an important role in preserving local wisdom, culture, and the identity of indigenous communities. Most people in the study area are familiar with and utilize local bamboo species such as Bajorek, Keb war, iWar, and Namwamba. Knowledge about the types and uses of bamboo is passed down from generation to generation and is an integral part of the community's cultural practices. In addition, bamboo is also a

means of collective work in mutual assistance activities, such as house construction and traditional ceremonies. Furthermore, bamboo has potential for social empowerment, primarily through skills training for indigenous communities and women's groups (Sasaki et al., 2021).

However, despite its high utilization rate, the economic value of bamboo remains underutilized. As much as 59.3% of respondents do not sell the bamboo they harvest, and 74% do not receive direct income from bamboo sales. This indicates that bamboo is primarily used for personal needs rather than as an economic commodity. Nevertheless, some respondents have begun to develop derivative products such as furniture, woven goods, and handicrafts, which have the potential to generate economic value if developed through community-based small business approaches. As explained by INBAR (2022), bamboo can be a significant source of income if managed with support for training, product innovation, and supportive policies.

Income from the sale of bamboo-based products remains relatively low, with most respondents earning less than Rp500,000 monthly. This indicates that the bamboo economic value chain is still at an early stage and requires support in terms of market access, capital, and production technology (Widjaja and Kartika sari, 2020).

From an ecological perspective, bamboo is considered an environmentally friendly plant. 100% of respondents supported bamboo forest conservation, and 96.3% believe local governments must be more active in bamboo management. Bamboo is known for absorbing carbon, improving soil fertility, and playing a role in climate change mitigation (Zhou et al., 2022). Therefore, sustainable bamboo conservation is crucial to ensure the sustainability of biological resources and reduce pressure on natural forests.

The high level of interest in training is also noteworthy. 100% of respondents expressed interest in participating in training on bamboo management and processing of its derivative products. This indicates the presence of substantial social capital for community capacity building. Community expectations include providing training, production tools, and support from the local government through regulations and market facilitation.

Thus, bamboo-based economic development contributes to improving household welfare and strengthens communities' social and ecological resilience. Bamboo management must be carried out in a holistic, sustainable, and inclusively to optimize bamboo's potential as a strategic commodity.

5.5. Bamboo-Based Economic Development

The community knows bamboo has enormous potential to improve economic welfare, especially in their area. In general, there is hope that bamboo can become a leading commodity that has a positive economic, social, and environmental impact. This hope is in line with sustainable development, which emphasizes the integration of economic, social, and ecological dimensions in natural resource management (FAO and INBAR, 2018).

One of the main hopes of the community is the availability of training that can encourage the optimal use of bamboo. The government and related institutions are expected to provide special training on bamboo cultivation and management, including cultivation techniques, sustainable harvesting, and processing value-added products such as handicrafts, household furniture, and building materials. This training is expected to reach all community groups, including indigenous and vulnerable groups. The findings of Sasaki et al. (2021) reinforce that community-based training can increase production capacity and expand local economic opportunities. However, several studies warn that training without market access and financing support will only result in skills that are not optimally absorbed (Arnold et al., 2014).

The community also believes that bamboo must be preserved as an important resource that supports long-term economic life. This plant can grow quickly, improve soil conditions, and provide environmentally friendly raw materials. Therefore, they hope there will be serious conservation efforts, including responsible harvesting and monitoring excessive exploitation practices. Research by Zhou et al. (2022) shows that bamboo has great potential as a nature-based solution for climate change mitigation and soil conservation. However, Mishra et al. (2017) caution that intensification without proper management can lead to land degradation and loss of biodiversity.

The community also hopes that local governments will play an active role in developing the bamboo sector through supportive policies, technical assistance, and support for production tools. Currently, many communities do not have access to simple processing tools or technology that can improve the quality of bamboo products. INBAR (2022) emphasizes the importance of government involvement in building a bamboo ecosystem through regulation, training,

financing, and market facilitation. However, FAO (2019) notes that common challenges in developing countries include weak inter-institutional coordination and the lack of sustainability of assistance programs.

Some communities also hope that bamboo can become a direct source of income for households through the development of handicrafts, furniture, and building materials that can be marketed locally and regionally. Currently, low selling prices and limited market access are the main obstacles. A study by Andini an damp; Sudibyo (2021) shows that innovatively managed bamboo products can significantly contribute to household income. However, without product diversification and appropriate marketing strategies, bamboo products lose out to mass-produced industrial products (Yuliana et al., 2020).

Looking ahead, the community hopes that bamboo will be utilized for current needs and managed sustainably as an economic investment for future generations. This perspective reflects the community's commitment to sustainable resource management. Widjaja and Kartika sari (2020) emphasize that bamboo is a long-term ecological and economic investment. However, a significant challenge lies in the low interest of the younger generation in engaging in the bamboo sector, primarily if not supported by incentives and innovations that align with contemporary developments (Siregar et al., 2021).

Additionally, the community stresses the importance of developing a fair and equitable bamboo economy that prioritizes indigenous communities and customary landowners. Therefore, these groups have strong historical and cultural ties to bamboo forest areas and are entitled to the economic benefits of managing these resources. The internationally recognized principle of Free, Prior, and Informed Consent (FPIC) emphasizes the importance of active participation of indigenous peoples in managing natural resources (UNDRIP, 2007). Therefore, the development of the bamboo economy must be inclusive and sensitive to indigenous rights to be socially acceptable and successful.

With these expectations, the community is optimistic that bamboo-based economic development can positively impact household welfare, preserve the environment, and strengthen local cultural identity. To achieve this, synergy between the community, government, and other stakeholders is needed in designing holistic, sustainable, and locally-based policies and programs.

Despite its great potential, the development of the bamboo sector in West Papua still faces significant challenges. Limited training is a major obstacle to developing the skills and knowledge needed to effectively manage and develop the bamboo industry (International Bamboo and Rattan Organization, 2020). In addition, weak local institutions and the absence of policies specifically supporting the development of the bamboo industry in West Papua are serious obstacles to the development of this sector. Fragmentation of research and development is also a challenge, with literature on bamboo research and development in Indonesia, including West Papua, described as minimal and fragmented (Zhang and Jiang, 2019).

However, despite these challenges, the West Papua bamboo sector has excellent development potential. West Papua can learn from successful bamboo development programs in other regions, such as the Bamboo land Social Enterprise initiative in Central Java, which focuses on training communities in high-quality bamboo processing (Sharma and Bhatt, 2018). Implementing community-based training programs can empower local communities by providing the skills and knowledge needed to participate in the bamboo industry (International Bamboo and Rattan Organization, 2020). Institutional strengthening and policy development specifically supporting the bamboo industry in West Papua are also necessary to drive the growth of this sector.

Integrating local traditional knowledge in developing the bamboo sector in West Papua is also an important aspect that needs to be considered. Traditional land and natural resource management practices, including bamboo, can serve as a strong foundation for sustainable development appropriate to the local context (Zhang and Jiang, 2019). By addressing existing challenges and leveraging available potential, West Papua can develop a bamboo sector that contributes to soil and water conservation and supports sustainable economic development and environmental preservation (Sharma and Bhatt, 2018).

To realize the full potential of the bamboo sector in West Papua, an integrated approach involving various stakeholders, including the government, local communities, the private sector, and research institutions, is needed. With close collaboration and the right strategies, the development of the West Papua bamboo sector can become a successful model of combining environmental conservation with sustainable economic development (International Bamboo and Rattan Organization, 2020).

6. Conclusion

This study discusses important issues regarding the low utilization of bamboo as an economic commodity in West Papua, despite the region's abundant bamboo resources. The main objectives of this study are to understand how local communities utilize bamboo, assess their perceptions of its economic value, analyze its contribution to household income, and explore their expectations regarding the role of the government and conservation efforts.

The main findings indicate that bamboo utilization in the study area is still traditional and limited to domestic needs such as building materials, household tools, and traditional customs. Although the community is aware of the economic potential of bamboo, they do not yet see real opportunities to develop value-added products. Bamboo currently contributes little to household income and is not yet a significant source of income. In addition, the community has strong hope that the government will be actively involved through training, market access, institutional strengthening, and community-based bamboo conservation.

The implications of these findings emphasize the importance of policy interventions and community empowerment programs to change perceptions and practices in bamboo utilization from consumptive to productive. Improving processing capacity, innovating bamboo products, and developing local and regional markets will be crucial to making bamboo a strategic commodity in the region. This study also enriches the literature on local resource-based development and provides an empirical foundation for formulating sustainable economic policies in indigenous territories.

However, this study has limitations, particularly in the limited scope of the study area and the quantitative methods that have not explored sociocultural aspects in depth. The model of bamboo's economic contribution to household income is still descriptive and has not measured long-term impacts.

Further research is recommended to expand the geographical scope, adopt a more participatory approach, and integrate comparative economic analysis with other regions that have successfully developed the bamboo industry. Studies on market ecosystems, supply chains, and technology-based innovations are also important to support the transformation of bamboo as a driver of the local economy.

In conclusion, bamboo in West Papua holds significant untapped potential. Transforming bamboo from a domestic commodity into a pillar of the local economy requires synergy between communities, the government, and the private sector. With an inclusive and locally-based approach, bamboo can become a relevant sustainable development solution for the future of West Papua’s communities.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there are no conflicts of interest in this study. The funders had no role in the design of the study; collection, analysis, or interpretation of data; writing of the manuscript; or decision to publish the study's results.

Statement of ethical approval

Ethical review and approval were not required for this study due to its non-interventional and community-based nature, where all participation was voluntary through informed consent and did not involve medical, clinical, or sensitive personal data.

Statement of informed consent

Informed consent was obtained from all participants involved in this study. Participation was voluntary after receiving an explanation of the study's purpose, benefits, and procedures.

Author Contributions

Conceptualization, M.A. and R.W.; Methodology, M.A. and R.M.; Software, R.M.; Validation, M.A., R.W., and D.D.; Formal Analysis, R.W.; Investigation, R.M.; Resources, D.D.; Data Curation, B.B.; Writing – Original Draft Preparation, M.A.; Writing – Review & Editing, R.W. and D.D.; Visualization, D.D.; Supervision, R.W.; Project Administration, M.A.; and Funding Acquisition, M.A.

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Data Availability Statement

Data supporting the findings in this study are available upon request from the corresponding author and cannot be published openly due to participant privacy and ethical considerations.

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