Potential and opportunities for the development of the coconut palm industry as an alternative wood substitution material

ABSTRACT

The economic condition of coconut farming today seems increasingly worrying because its flagship product is still dominated by copra and oil. Various efforts are being made to increase the added value of products and revenues, ranging from downstream utilization of coconut products to the follow-up results. Coconut Development Program through rejuvenation activities, prioritized replacing old coconut plants or unproductive plants. In the central areas of coconut, coconut stalks are generally used as fuel, simple bridges, pillars of the house, so that its role in improving the economy of farmers has not been reliable. Interest towards coconut wood processing is still low because various related factors have not been simultaneously in an integrated system. This paper aims to present the utilization of coconut palm as an alternative source of wood that needs to be developed because it has multiple impacts, including (1) substitution of conventional wood from natural forests, (2) additional sources of income for farmers and state foreign exchange and (3) encouraging and supporting the coconut rejuvenation program. Systematic approach to writing in the form of a review based on literacy as a secondary data source. Based on its physical and mechanical characteristics, coconut stems have the potential to be used as raw materials for buildings and furniture. Market opportunities for building materials, home building and furniture from coconut wood both domestically and ~~abroad~~ internationallyare still quite large. The strategic step in growing the coconut wood processing industry is to create an industry in stages so that farmers/producers and other actors obtain added value.

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Keywords: coconut trunk, processing technology, wood characteristics, wood substitution, building materials, furniture, added value.

1. INTRODUCTION

In Indonesia, especially the central area of coconut, shell, coir, and coconut stem is the result of follow-up that has not been optimally utilized. Coir and shells are used as fuel, craft materials, and a small part is processed into charcoal and activated charcoal. While coconut rods are generally used as fuel, bridges are simple, and only a small part is processed into building materials and household crafts as well as alternative sources of wood for various purposes considering their potential and characteristics [1]. The area of deep coconut species in 2023 is estimated to be 2,501,630 ha, [2],which means that there are approximately 250 million coconuts. If each coconut tree has an average w~~W~~ood yield of 0.8 m^3, then the potential coconut wood produced as much as 200 million m^3.

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Coconut Development Program through rejuvenation activities, prioritized replacing old coconut plants or unproductive plants. To improve the rejuvenation program, it is very important to revitalize coconut farming through the establishment of economic institutions [3,4,5]. Overall, the area of unproductive coconut plants is approximately 240,000 ha [2]with a population level of 100 trees/ha, approximately 24,00 000 coconut trees will be obtained. Of these, it is worth making effective logs of about 19,200,000 m^3, and the remaining 4,800. 000 m^3 softwood the amount is very meaningful in substituting the needs of wood for the purposes of building materials, home furnishings, fuel, and others. The rejuvenation Program has not worked as expected because it is constrained by the reluctance of farmers to cut down coconut trees.

Logging of coconuts in the rejuvenation process using either clearcutting or gradual cutting methods will cut or reduce the income of farmers in a minimum period of 5 years. In addition, rejuvenation costs a lot, especially in the first year. On the other hand, felled coconut stalks have not been used optimally or have not been given a decent price so that they do not provide added value for farmers that they can use for rejuvenation. The development of the coconut wood processing industry is expected to provide added value to coconut trunks so that farmers are encouraged to rejuvenate. Coconut wood industrialization in the Philippines, India, and Sri Lanka has long been developed, while in Indonesia it has not been seriously worked on. Efforts to develop the coconut wood industry was initiated in 1989, in cooperation with the German government to study the possibility of exporting coconut sticks to Western Europe. But these efforts have not been followed up. With this cooperation, it will provide a great opportunity to create a sustainable coconut wood processing industry. The main problems in raising the economic value of coconut, among others: lack of information and not widespread processing technology among farmers, limited skilled workers, lack of investor interest, and weak institutional systems. This paper would like to present the extent to which the potential and opportunities for product development, the availability of processing technology in increasing the economic value of products, problems and strategies for the development of coconut palm products as raw materials for the wood industry.

2. METHOD

To perform descriptive exploration and data analysis using a scientific review process taken from several references to research findings. Various data are collected and discussed in a descriptive manner.

3. RESULTS AND DISCUSSION

3.1. Potential and Opportunities for Coconut Wood Development

3.1.1. Physical Structure of Coconut Wood

Coconut is classified as a monocot plant that has a different wood structure than other types of wood and has advantages and disadvantages. The characteristics of coconut stems and structural composition contribute to the condition to maintain the integrity of size and shape during the drying process, making them suitable for a wide range of structural applications [6]. The condition of the coconut stem after reaching a certain size does not increase in size or shrink so that its dimensions do not change and do not warp during the drying process [7,8,9].

The level of wood density varies according to the cross-section and along the trunk. High-density wood (> 600 kg m^3) is found on the outside up to 10 cm thick, medium-density wood (400-600 kg m^3) is under high-density wood approximately 10 cm thick, while low-density wood is found in the middle with a radius of 5 cm. The wood at the end of the stem is approximately 1/4 of the stem part dominated by low density [10,11,12,13]. In microstructures, soft tissue (parenchyma) is interspersed by very hard tissue (vascular tissue). The variability of coconut wood characteristics allows obtaining a variety of products from a single coconut stem. The variability of basic timber density among tree species in different forest types has revealed changes in timber density associated with climate variables, especially in areas with lower rainfall and higher temperatures [14]. However, the processing process will be more complex, especially in its classification, drying and preservation.

The outer and middle coconut wood density structures (> 440 kg m^3) are in the range of other tropical wood densities such as Mahogany 490 kg m^3, Ramin 550 kg m^3, Teak 640 kg m^3, and Meranti Merah Tua 560-865 kg m^3 [15].Coconut wood exhibits strength comparable to traditional forest wood, making it a viable alternative for a wide range of construction applications. The physical and mechanical properties of coconut wood, including compressive strength and

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Coconut wood has properties that are not inferior to other woods that have been commonly used. However, the existence of large variability in one stem requires different utilization of each part. The properties of coconut wood, especially density and strength, depend on the age of the plant. Studies that quantitatively reveal the relationship between tree age and physical characteristics have never been conducted. This research is useful for determining the age of trees that are suitable for felling for the purposes of the wood processing industry.

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3.2. Utilization and Availability of Coconut Wood Technology

The physical structure of the wood according to the cross-section and elongation of the trunk determines the form of use of coconut wood. Broadly speaking, the form of use of coconut wood is based on its physical properties.

3.2.1. Building Materials

Generally, coconut wood is suitable for building houses with various qualifications (very simple houses to luxury houses), office and industrial buildings, recreational buildings and houses of worship in the Philippines [19,18]. In North Sulawesi, some coconut wood is used to build houses, especially middle-class houses to luxury houses. ~~Generally,the~~ The countries of Indonesia and the Philippines, offer sustainable and economically viable alternatives to construction materials. The durability and strength of coconut wood are comparable to traditional forest wood, making it suitable for a wide range of construction applications, from simple homes to luxury residences, office buildings, industrial structures, recreational facilities, and houses of worship [20,21,22].

3.2.2. Furniture and Other Craft Materials

Coconut wood is ideal for furniture at a density level of 500 - 700 kg/m³. At this rate, coconut wood is resistant to bending and loads. Coconut wood, especially those that have 900 kg/m³, is ideal for furniture. The furniture produced is relatively heavier compared to furniture from several other types of wood (Peter, et al~~.~~, 2021). Furniture made from coconut wood is relatively heavier due to its density level, has unique aesthetic value and strength comparable to traditional forest wood, making it a sustainable and durable choice for furniture construction [23,24,18].

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An important requirement of coconut wood for furniture is seen in terms of appearance. Important appearance characteristics are the color, texture and decorative shape of the surface. The surface of coconut wood has a beautiful decorative shape, namely a light brown color interspersed with dark brown due to the presence of parenchyma tissue and vascular tissue. This form of appearance distinguishes coconut wood from other types of wood.

Coconut wood is classified as resistant to pests and fungal attacks because it is affected by density and moisture content. In general, coconut wood is not resistant to the attack of white rot fungus (Coriolusversicolor). The wood part with medium and high density is somewhat resistant to another white rot fungus, namely Stereumhirsutum. The central part of the stem with a low wood density (<400 kg m^3) is sensitive to insect and fungal attacks. Therefore, coconut wood that will be used as a raw material for furniture should be preserved before use.

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The degree of ease of mechanical work. which is directly related to the technical phases of sawing, leveling, blanking, forming, bending and smoothing. Coconut wood has good to excellent mechanical processing quality. Good surface quality can be achieved with the right combination of machine speed, feeding rate and knife type. To get good surface quality in the machining process is affected by factors such as cutting speed, feed rate, and tool type.[24,18]. The optimal combination of cutting parameters such as cutting speed and feed rate will reduce the wear rate of the tool and improve the surface performance, which ultimately improves the overall quality of the machine parts [25,26].

The last job, which is often called finishing, is the process of smoothing the surface, filling the pores of the wood and coating the surface which functions as a buffer for moisture from the air and prevents the original color of the wood from changing. The rapid development of wood processing technology has made the final work for coconut wood not a problem.

In processing coconut wood into furniture there are several technical problems that need to be considered, including:

a. The condition of coconut wood is difficult to nail because it has a high level of density which will cause the wood to split easily at the ends. Therefore, before nailing, nail holes should be made using a drill.
b. Coconut wood used as furniture is relatively heavy, which has an impact on transportation and transportation costs. It is recommended for furniture materials to use wood with medium and low-density levels as secondary components.
c. Coconut stems have a limited diameter for the size of wood (boards) so that furniture with a large surface requires careful and accurate connection of several pieces of wood.

3.2.3. Support Pole

The coconut stem has a unique structure, namely wood vein fibers that are unidirectional, relatively large and clearly visible on the surface and the hard part is found in the outer layer while the soft part in the middle of the stem causes coconut wood to be very efficiently used as a pole. Coconut wood poles are suitable for supporting electrical wires and telephones, as well as other vertical supports such as houses and bridges [27,28,17].

Drying treatment efforts are an important factor if coconut wood will be used as an electric pole or telephone pole. Drying sawn wood by wind drying took 2-2.5 months to reduce the initial moisture content by 38% in the natural part and 16.3% in the outer part to an average of 7.8% and 3.6%. Peelless round stems take 5 months to lower the moisture content to 12% and 3.5% with dry winds [29,30].

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The process of drying wood in the form of a round bar is to reduce moisture content and prevent problems such as cracking and rotting. Understanding the drying process and its impact on wood structure, mechanical properties, and dimensional stability is essential to ensure the long-term durability and performance of wood products [31,32].

The processing of coconut stems into charcoal is used as fuel and raw materials for the pharmaceutical and sanitation industries. The calorific value of coconut stem charcoal is 6,422 Kcal/kg, higher than coconut coir charcoal (5,926 Kcal/Kg) but lower than shell charcoal (7,394 Kcal/kg) and liquefied gas (10,817 Kcal/kg) [33,34,35,36].Traditionally, coconut trunks in Indonesia are mostly used as firewood for cooking and firewood in the brick and tile manufacturing industry.

3.3.3. Marketing

The market opportunities for traded coconut wood are wood for building materials, coconut wood houses, furniture and household accessories. The central areas of the coconut wood processing industry include Aceh (building materials and furniture), Central Java (building materials), West Nusa Tenggara (residential materials and furniture), East Nusa Tenggara (building materials and furniture) and North Sulawesi (building materials, houses, furniture and household accessories).

The opportunity for the development of coconut wood products in the future is very bright from the following factors:

a. The price of coconut wood is much lower than other natural wood in the same quality class or even a lower quality class. The price of class III meranti wood in North Sulawesi is IDR 2,000,000 -2,500,000/m³, while coconut wood is classified as class IV for IDR 1,500,000 -2,000,000/m³.
b. The demand for domestic and foreign coconut wood furniture is very high ~~so~~ that the domestic industry has not been able to meet all the demand. For example, in the early 2000 the furniture industry in East

Nusa Tenggara was reported to have not been able to meet the demand for coconut wood furniture ordered from Australia. In North Sulawesi, BLPT KaatenTomohon, North Sulawesi, which produces furniture and coconut wood house buildings, does not experience problems in terms of marketing products. With the number of processed coconut stems as many as 6000 per year, this industry has not been able to meet demand, especially from abroad. In West Nusa Tenggara, the high demand for coconut wood causes farmers to cut down coconut trees that are not yet eligible to be cut down as a source of timber. As a result, there are concerns that coconut felling that is not followed by rejuvenation causes the death of the fruit processing industry due to the lack of supply of coconut fruit. The lack of rejuvenation efforts after coconut felling is indeed a significant threat to the fruit processing industry due to the shortage of coconut fruit supply [37,38,39].

c. The development of coconut wood is ~~sluggish~~ slowand has decreased, but it is still in demand, especially for the manufacture of furniture, handicraft materials and accessories because it has a fiber line that provides its own aesthetic value compared to other types of wood.

d. Rural electricity development, especially on remote islands, faces obstacles in the provision of electricity poles due to the lack of smooth or unavailable means of transportation to these remote islands. State Electricity Center Limited Liability Company has explored the possibility of using coconut trunks available on the islands as a replacement for iron power poles.

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3.3. Development Problems and Strategies

The processing of coconut wood products is currently not related to an agribusiness system, so it still faces problems, especially in the supply of raw materials. In operation, the industry buys coconut stems directly from farmers by searching all planting center areas with a "cash and carry" system. Farmers rarely sell the cut coconut stems directly to the processing industry. Farmers are even reluctant to cut down coconut trees even though they are already less productive because they are the only source of income. This situation causes the supply of coconut stem raw materials to be non-continuous, which will be detrimental to the industry.

Coconut trees that are 50-60 years old can still produce an average of 50 grains per year for 10 years. If the average price of coconut fruit is IDR 1000/piece, then the value of coconut trees for 10 years is calculated from the number of fruits produced at IDR 500,000 (500 grains x IDR 1000). By selling coconut sticks of IDR 500,000, if processed into coconut wood, the profit is 3 times. With this high profit rate, coconut farmers tend to sell all their coconut trees without rejuvenation. This situation is expected to have a negative impact on the availability of raw materials and fruit production in the long term.

The main problem in the development of the coconut wood processing industry is the availability of raw materials for coconut stems on a sustainable basis. If the price of coconut trunks offered is low, then farmers are not willing to sell it, while at a high price level, the felling of coconut trees is not controlled and is not followed by rejuvenation. This in the long term will reduce the supply of coconut raw materials for the coconut fruit processing industry and the coconut wood processing industry. Therefore, in developing the coconut wood processing industry, it is necessary to create a system that can ensure the availability of raw materials for the industry and on the other hand farmers get a decent income. Some thoughts on the development of a sustainable coconut wood processing industry.

a. At the level of economies of scale that are considered feasible for the coconut wood processing industry ranging from 2,000 - 20,000 m^3 per year. With an average wood yield of 0.8 m^3 per trunk (trees > 50 years old) and the number of plants 100 trees per ha, the planting area to supply wood for the industry is estimated to be 2,500 - 25,000 ha. The plant area that is the source of coconut wood is inevitably the area of people's plantations because the desired plant life is > 50 years. The processing industry is required to process coconut resources in a sustainable and sustainable manner through partnerships with farmers so that the supply of raw materials is guaranteed continuously for the long term. In other words, optimizing the entire supply chain to unlock the full potential of this sector and improve socio-economic conditions for producers [40,41,42].
b. Coconut stems are given a reasonable price of at least IDR 500,000/stem (according to the economic value of 10 years) for stems > 50 years old or > 15 m long. With this price, farmers are motivated to sell their coconuts. However, on the other hand, it is necessary for government intervention through the Provincial and Regency/City Plantation Offices to continue the allocation of free coconut seeds, so that farmers are still conditioned to carry out replanting, including provisions regarding the number of trees that can be cut down in an area (1/5 x the area of productive plants) and tree age limits and other implementation provisions. This regulation aims to secure the supply of coconut raw materials for the coconut fruit processing industry in the area concerned.
c. Felling coconut trees using the method of cutting down or gradually cutting down will decide or reduce farmers' income in a certain period of at least 5 years. Thus, while waiting for substitutes for coconut plants to produce, income can still be obtained and increased by introducing food and livestock crops or diversifying products on other coconuts.

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4. CONCLUSION

The development of the coconut stem industry as an alternative wood substitution material in an integrated manner as a building material, furniture and other handicrafts is expected to increase the economic value of coconuts and farmers' income.

The limited and unsustainable supply of raw materials has an impact on the slow development of the coconut wood processing industry. Thus, if the price of coconut stems is considered low and unfeasible, farmers are reluctant to sell them, on the contrary, farmers will be excited if the price of coconut stems is relatively high. To ensure that raw materials are available continuously, the wood processing industry is expected not only to exploit existing coconut stems but also to actively participate in preserving coconuts for the rejuvenation process. The source of financing for replanting can come from funds taken from part of the proceeds from the sale of coconut stalks, or the provision of free seeds allocated by the government through farmer groups.

The development of the coconut wood processing industry nationally is expected to provide opportunities for efforts to expand employment, improve the welfare of farming communities, increase regional revenues and foreign exchange receipts Therefore, it is necessary to immediately socialize all available technologies through job training centers, print/electronic media, social media, demonstrations, and other activities.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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