Optimizing Rattan Waste Processing with Green Supply Chain Model Approach In Furniture Production For Exporting Via Ocean Freight

Gohan Lasuli Silvia[1], Sutanto[2], and Alexander Yonathan Christy[3]
[1,2,3] ***Department of Mathematics, Faculty of Mathematics and Natural Sciences, Sebelas Maret University***
Ir. Sutami Street No. 36, Surakarta, 57126, Indonesia
Corresponding author's email address: sutanto71@staff.uns.ac.id

ABSTRACT

This study examines the impact of waste utilization on cargo maximization and supply chain efficiency in the rattan industry by implementing the green supply chain concept. In this industry, waste is often viewed as a problem; however, with the right approach, it can be transformed into a valuable resource. Through the analysis of processing waste into new products, this research demonstrates that waste utilization not only enhances material usage efficiency but also reduces environmental impact. Cargo maximization is achieved by leveraging by-products generated from waste, thereby optimizing container space. The findings of this study aim to provide insights for industry stakeholders on the importance of integrating sustainability principles into the supply chain and how this can contribute to improved economic and environmental performance

Keywords: Green Supply Chain Model, Waste Processing, Rattan Furniture, Sea Freight, Container Volume.

1. INTRODUCTION

The rattan handicraft industry is one sector that has great potential for export, especially in countries rich in natural resources like Indonesia. Craft products made from rattan have high aesthetic value and increasing demand in the global market. However, this industry also faces several challenges, one of which is logistics efficiency and waste management. During the production process, rattan waste is often neglected or discarded, even though it has the potential to be processed into value-added products. Additionally, another common issue is the suboptimal utilization of space and weight in cargo, which leads to higher transportation costs and inefficiencies in product distribution. Efficiency in cargo utilization becomes crucial in the context of globalization and increasingly tight competition, where logistics costs can affect product competitiveness in the international market.

In this situation, the concept of cargo maximization through the utilization of rattan waste as additional products emerges as a potential solution. By implementing a green supply chain model, where waste is repurposed as raw materials for new products, the handicraft industry can not only improve resource usage efficiency but also optimize cargo capacity. This will reduce transportation costs per unit of product, enhance operational sustainability, and strengthen the competitive position of handicraft products in the global market.

Cargo maximization aims to utilize every inch of space and every gram of weight available in shipments. By producing additional crafts from rattan waste, the industry can fill empty spaces in cargo containers, which would typically be wasted. This not only reduces the cost per unit of shipment but also allows for more products to be shipped in a single shipment, thereby improving overall logistics efficiency. Reducing empty space and fully utilizing cargo capacity means fewer shipments are needed for the same volume of products. This directly lowers transportation costs, which is a key component in the selling price of products in the export market. With lower logistics costs, rattan handicraft products can be sold at more competitive prices, or companies can increase their profit margins.

Using waste as raw materials for additional products supports sustainable business practices and a green supply chain. This aligns with global trends increasingly prioritizing environmentally friendly products and socially responsible production processes. Industries that can demonstrate a commitment to sustainability are likely to be favored in international markets, especially in countries with strict environmental regulations. Products made from waste not only add variety to the product portfolio offered by companies but also provide added value. These products can be marketed as part of the company's sustainability initiatives, attracting environmentally conscious consumers. Furthermore, by maximizing cargo, companies can sell more products with relatively the same shipping costs, meaning total export value also increases.

In the context of supply and demand, utilizing waste for additional products allows the industry to be more flexible in adjusting to demand fluctuations. If there is higher demand for certain products, the waste generated from primary production can quickly be transformed into products that meet market demands, without needing to start from

scratch. Cargo maximization through the utilization of rattan waste is not just a technical solution for improving logistics efficiency but also a business strategy that can provide a competitive edge in the export industry. By integrating the green supply chain concept, the rattan handicraft industry can reduce costs, enhance sustainability, and add value to the products they offer to international markets. This makes the cargo maximization model relevant and important for adoption by companies that wish to remain competitive in the ever-evolving global market.

2. LITERATURE REVIEW

Supply Chain Management

Supply Chain Management is an approach that is applied to form suppliers, entrepreneurs, warehouses, and storage places in an efficient unit so as to produce products and distribution with the right quality, location, and time to get the minimum cost by satisfying consumer needs [1]. Supply Chain Management is management that is carried out continuously in order to obtain highly competitive business partners without ignoring consumer needs that focus on developing innovative solutions and synchronizing the flow of products, services and information to form unique consumer assessments [2].

Processing activities in the form of obtaining raw materials, transforming these raw materials into goods in process and finished goods, and delivering these goods to consumers through a distribution system with an integrative approach in managing the flow of products, information, and money by involving parties from upstream to downstream consisting of suppliers, factories, distribution networks and logistics services [3][4].

Supply Chain Management has the main components of upstream, internal and downstream. Upstream of the supply chain includes the activities of a manufacturing company with its suppliers (which can be manufacturers, assemblers, or both) and their connections to their suppliers (second-tier suppliers). Supplier relationships can extend to multiple strata, all the way from material origin. In the downstream part of the supply chain, the main activity is procurement. The internal part of the supply chain includes all the in-house processes used in transforming inputs from suppliers into the organization's outputs. It extends from the time inputs enter the organization. Within the internal supply chain, the main concerns are production management, manufacturing, and inventory control. The downstream part of the supply chain includes all activities that involve delivering products to end customers. In the downstream supply chain, more attention is directed to distribution, warehousing, transportation, and after-sales service [5].

Green Supply Chain Management

The implementation of GSCM in the company turns out to have great benefits, especially in improving the environmental and business performance of the company's GSCM aspects by building long- term buyer-supplier relationships. This is supported by collaborative relationships between customers and suppliers can lead to improved environmental performance and better product/service quality. One reason for this improvement is that consumers are now more knowledgeable about business environmental violations. Companies and all their partners in the supply chain will achieve sustainable business if products and services that have a negative impact on the environment are abandoned in favor of environmental principles [6][7][8]. There is a kind of symbiotic mutualism that exists between companies and suppliers if the supply chain also pays attention to environmental aspects.

On the other hand, according to Turnip (2009), the implementation of GSCM in the company will provide the following benefits:

1. GSCM encourages companies to mitigate risks and innovate.

2. The analytical process in GSCM will lead to continuous process innovation which in turn increases the adaptability of the company to changes in its environment.

3. Negotiations with customers and suppliers carried out in GSCM will improve the alignment of strategies and business processes between the company, customers and suppliers.

4. Potential for production cost savings through efficiency in the use of natural resources and energy.

5. The company's reputation as a company that cares about the environment will increase the attractiveness of the company in the eyes of customers.

6. More careful management of the natural resources used by the company will also provide assurance of supply for the company in the future.

Components of Green Supply Chain Management

Green Supply Chain Management (GSCM) is an approach that integrates the principles of environmental sustainability into the entire supply chain, from start to finish. The goal is to minimize environmental impacts at every stage of the supply chain process. GSCM not only focuses on production, but also includes waste management, recycling, and efficient use of resources. The following are the components of the methodology in Green Supply Chain:

1. Green Procurement

Companies should consider the environmental impact of the raw materials they purchase, including using materials that are recyclable, renewable or produced from environmentally friendly processes. This also includes selecting suppliers that implement environmentally friendly practices. This can be implemented by purchasing materials from suppliers that have environmental certifications such as ISO 14001.

2. Green Manufacturing

Reduce the negative impact of production processes on the environment by using clean technology, reducing energy use, minimizing waste, and improving process efficiency by using more energy- efficient production processes.

3. Green Distribution

Reduce the carbon footprint of the distribution process by optimizing delivery routes, arrangement of goods, and form of packaging.

4. Green Packaging

Design environmentally friendly packaging, such as using recyclable materials, reducing the size and weight of packaging, and ensuring that packaging can be recycled or reused.

5. Reverse Logistics

It involves managing products after consumer use for recycling, repair or safe disposal. Reverse logistics plays a role in reducing waste and increasing recycling, as well as maximizing the use rattan raw materials by creating by-products from leftover furniture materials.

6. Green Transportation

Optimizing energy use during delivery of goods through eco-friendly or fuel-efficient vehicles, and planning optimal delivery routes to reduce greenhouse gas emissions.

7. Waste Management

Involves reducing waste generated from production, distribution and post-consumption processes. The company strives to reduce hazardous waste and manage recycling.

8. Design for Environment (DfE)

Incorporate environmental considerations in the product design stage to minimize negative impacts on the environment. DfE aims to design products that are easier to recycle and have a longer life cycle.

9. Lifecycle Assessment (LCA)

Calculates the environmental impact of a product or process over its entire life cycle, from raw material procurement to final disposal. The goal of LCA is to understand where the greatest environmental impacts occur and take steps to reduce them [9].

Zero Waste

The concept of zero waste comes from a philosophy that seeks to redesign the life cycle of resources, so that all products are reused, recycled, or processed into new materials without anything ending up as waste. Zero waste is an attempt to change the way waste is viewed, not just as something to be disposed of, but as a valuable resource. Zero waste focuses on preventing the creation of waste upstream, different from conventional waste management methods that focus more on downstream management. Zero waste is part of a broader strategy to create a sustainable society that balances environmental and economic needs. There are several key principles in the concept of zero waste including reducing the amount of waste generated in the first place, maximizing the reuse of existing materials and products, as well as facilitating material recycling, designing products and production processes in such a way that they produce the minimum amount of waste possible, and using materials that can be recycled or biodegraded, the application of zero waste also emphasizes the importance of community participation in promoting sustainability practices at the local level [10].

Many sectors have started to implement the zero-waste approach, especially in the manufacturing, construction, and food industries. Many manufacturing companies, especially in the furniture sector, have started to adopt zero waste practices by redesigning products to make them more recyclable and reusing production waste.
Zero waste can reduce a company's operational costs through reduced waste management costs and the purchase of new raw materials. By recycling and reusing materials, companies can reduce dependence on limited resources, which ultimately results in cost efficiency [11].

3. METHOD

List of Notations

K : Profit

M : Manufacturer

R : Retailer

X : Quantity of products from manufacturer

Z : Quantity purchased by retailer

D : Market demand

d : Market basic demand

v : Product volume

w : Product weight

V : Container volume limit

W : Container mass limit

P : Manufacturer selling price

C : Production cost

P_M : Selling price of the product from the manufacturer

P_R : Selling price of the product from the retailer

C_M : Production cost of the product from the manufacturer

T_M : Tax per item shipped

F_C : Fixed shipping cost

C_W : Waste processing cost per kilogram

α : Price elasticity

β : Coefficient of waste product (kilogram/product), $0 < \beta < 1$

γ : Persentage of waste that can be processed

y : Recycled waste product purchased by the retailer

C_D : Production cost of recycled products

P_D : Selling price of recycled product by manufacturer

D_S : Secondary demand for recycled product

P_S : Secondary price of recycled product

d_S : Basic secondary demand

Supply Chain Model Without Waste Processing

Supply chain modeling involves the use of mathematical models and algorithms to analyze and design supply chain systems. These models can be used to optimize various aspects of the supply chain, such as costs, time, and efficiency. The following are some steps and components in supply chain modeling:

$$K_M = ZP_M - XC_M - \beta X C_W$$
$$K_R = DP_R - ZP_M - ZT_M - F_C$$
$$D = d - \alpha P_R$$

Constraints

1. $X \geq Z \geq D$
2. $Z.v \leq V$
3. $Z.w \leq W$
4. $Z.P_M > XC_M + \beta XC_W$
5. $\left(d - \alpha P_R\right).P_R > ZP_M + ZT_M + F_C$
6. $0 < \beta < 1$
7. $0 < \alpha < \frac{d}{P_R}$

Modified Supply Chain Model

$$K_M = ZP_M + y.P_D - XC_M - \gamma\beta XC_D - (1 - \gamma)\beta C_W$$
$$K_R = DP_R + D_S P_S - ZP_M - yP_D - (Z + y)T_M - F_C$$

Constraints

1. $X \geq Z \geq D$
2. $Z.v + yV_S \leq V$
3. $Z.w + yw_S \leq W$
4. $Z.P_M > XC_M + \beta XC_W$
5. $\left(d - \alpha P_R\right).P_R > ZP_M + ZT_M + F_C$
6. $0 < \beta < 1$
7. $0 < \alpha < \frac{d}{P_R}$
8. $\gamma\beta X \geq y \geq D_S$
9. $0 < \gamma < 1$
10. $0 < \alpha_S < \frac{d_s}{P_s}$
11. $P_D > \frac{\gamma\beta X}{y}(C_D - C_W)$
12. $D_S P_S > yT_M$

4. RESULTS AND DISCUSSION

The integration of supply chain models and cargo optimization offers an innovative approach to enhance operational efficiency and sustainability in the rattan craft industry. Traditional supply chains, which focus on the flow of goods from raw material sources to end consumers, often face challenges such as high operational costs, suboptimal container capacity, and inefficient waste management. By integrating the principles of green supply chain management, companies can reduce their environmental impact through the utilization of production waste and optimization of shipping capacity.

Table 1 Comparison of Supply Chain Models Before and After Modification for Manufacturers

	Before Waste Processed	**After Waste Processed**
Product	X	$X\gamma\beta X$
Production Cost	$X.C_M$	$X.C_M + \gamma\beta XC_D$
Waste	βX	$(1-\gamma)\beta X$
Waste Processing Cost	βXC_W	$(1-\gamma)\beta XC_W$
Sales	Z	Zy
Income	ZP_M	$ZP_M + yP_D$

Table 2 Comparison of Supply Chain Models Before and After Modification for Distributors

	Before Waste Processed	**After Waste Processed**
Purchase	Z	Zy
Shipping Cost	$Z.T_M + F_C$	$Z.T_M + yT_M + F_C$
Sales	D	DD_S
Income	DP_R	$DP_R + D_SP_S$

Cargo optimization is a crucial component of the green supply chain, with its primary goal being to reduce the number of inefficient shipments by maximizing container capacity usage. This not only lowers transportation costs but also reduces carbon emissions, which is one of the main objectives of the green supply chain. Rattan waste, which typically pose a challenge in traditional supply chains, can be transformed into by-products such as accessories or decorative items, helping to fill empty space in containers and decreasing the need for new raw materials.

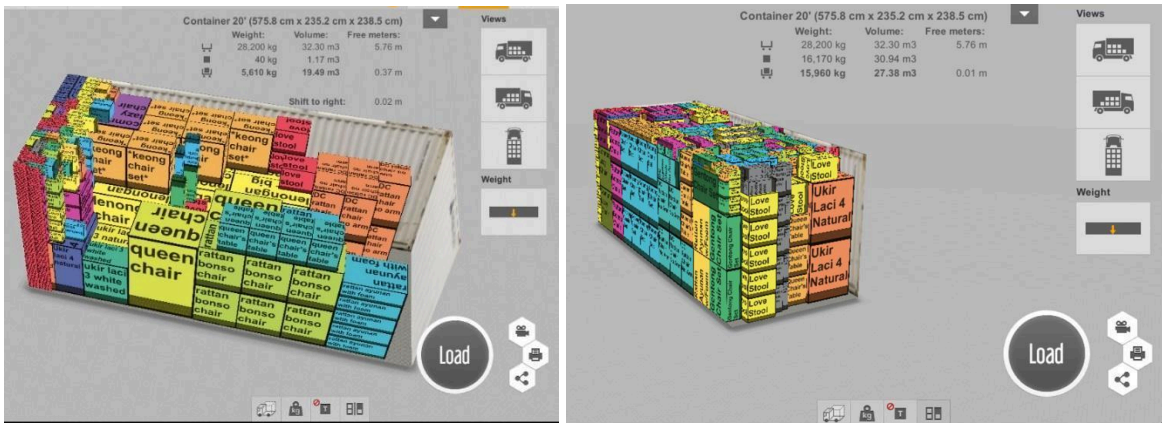

Figure 1 Before and After Cargo Optimization

With this strategy, container usage can be optimized to achieve maximum efficiency in cargo shipping. The mathematical model used to integrate cargo optimization with the green supply chain aims to maximize container utilization while minimizing costs and emissions. In this model, products generated from waste are prioritized to fill empty spaces, allowing companies to reduce waste and enhance shipping efficiency. The impact of this integration is evident not only in terms of reduced operational costs and increased profitability but also in the reduction of the company's carbon footprint, which is becoming increasingly important for meeting global environmental regulations. Furthermore, the adoption of a green supply chain provides a competitive advantage for companies in a global market that increasingly prioritizes sustainability.

Although challenges in implementation, such as operational complexity and the need for eco-friendly raw materials, still exist, the benefits gained from this integration are far more significant. By combining cargo optimization and the green supply chain, companies can not only achieve higher operational efficiency but also play a crucial role in maintaining environmental sustainability, ultimately enhancing their reputation and competitiveness in the international market.

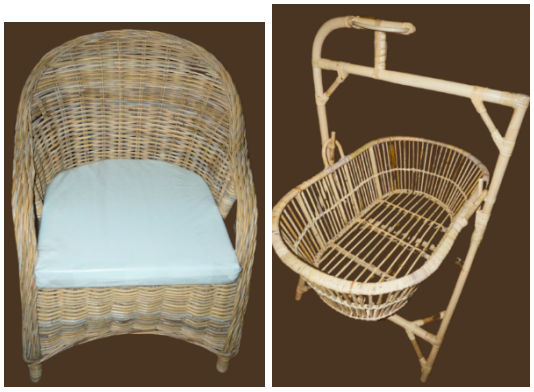

Figure 2 Export Product of Rattan Craft

Figure 1 Export Product from Rattan Waste

5. CONCLUSION

By adding high-density items and reorganizing the arrangement of goods, cargo dimensions can be maximized by reducing empty space and approaching the allowable weight limits of the container. This strategy not only enhances shipping efficiency but also contributes to reducing logistics costs and environmental impact. Thus, a systematic approach to utilizing space and weight will bring significant benefits to the success of the logistics process, maximizing profits for both producers and distributors.

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