

Modeling of an Industrial Ecosystem at Traditional Shipyards

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Modeling of an Industrial Ecosystem at Traditional Shipyards in Indonesia for the Sustainability of the Material Supply Chain

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Abstract - Traditional shipyard in East Java Indonesia has produced lot of wooden fishing boats. However, the sustainability of its production process has not yet been discussed. In this study, we aimed to investigate how the model of industrial ecosystem on wooden boat building. We surveyed to the traditional shipyards and interviewed the worker, the owner and the project leader. We also discussed about the activities of sustainable supply chain to support the industrial ecosystem. Finally, some recommendations are proposed to support the regulations on environment, social, and economics sectors to achieve the sustainability of the material supply chain.

Keywords - Industrial ecosystem, wooden fishing boat, sustainability, supply chain.

I. INTRODUCTION

East Java province has been appointed as a shipbuilding industrial cluster in Indonesia. There are four main cities in this cluster, namely Surabaya city, Gresik, Lamongan, and Tuban regencies. Lamongan is the central of traditional boat building for fishermen. Traditional shipyards build boats made from wooden. The main materials of traditional fishing boat are wood and driving machine. The owner bought wooden log from Perum Perhutani (state-owned enterprises forestry department) or they went to forest to bargain it with local farmer. Meanwhile, the driving machines come from the countries and cities nearby. The sustainability of wood and driving machine is important to boost the performance of traditional shipyard.

Sustainability of the material is necessary to achieve sustainable boat building industries. Sustainability supply chain means that key business processes with supply chain partners should be integrated to achieve the sustainability objectives. There are three dimensions of sustainability, namely economic, environment, and social. The social sector involves community, social, and employee development [1]. The economic sector enhances the financial profit; meanwhile the environment sector concentrates on green or environmental benefits relating buying products [2]. When the shipyards implement the green production process, the number of wooden material consumed will be less. Subsequently, the sales growth and reputation of shipyard increase [3].

The industrial ecosystem adopted circular economy involves efficient use of natural environment resource. Some activities such as reducing, reusing and recycling should be implemented in the process of production, circulation, and consumption [4]. The reasons for adopting operational environmental sustainability approaches in the developing country such as Thailand have been studied by [5]. The results showed that Thai manufacturing obtained the benefits such as environmental awareness and cost saving from conservation of energy. Sustainability performance assessed in terms of products, processes, and policies related to sustainability [6]. In this study, we aim to model the industrial ecosystem of wood, driving machine and iron plate used in the boat building process in Indonesia. This study is expected to extend the adoption of environmental sustainability approaches in Asia. Furthermore, we propose some recommendations for the materials sustainability in economic, and environment sectors.

The remaining of the paper is organized as follows. Section 2 discusses the research methodology. Section 3 and 4 describe the results and discussions of the modeling industrial ecosystem in traditional fishing boats building, respectively. Finally, conclusions and future research are presented in Section 5.

II. METHODOLOGY

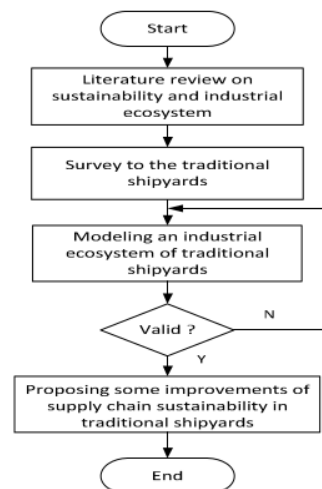


Fig. 1. Research Methodology

Fig 1 shows the research methodology of modeling an industrial ecosystem at the traditional shipyard. Firstly, we reviewed several literatures about sustainability theory and industrial ecosystem. Secondly, we did survey to the traditional shipyards in Lamongan regency, East Java, Indonesia. We visited the five largest traditional shipyards. We interviewed the workers, the owner, and the project manager of these shipyards related to materials for building wooden boats and its residue. In total, there are 20 respondents. The interview questions are semi-structured. Subsequently, we made a model of boat building industrial ecosystem at traditional shipyards as can be seen in Figure 2. We did the model validity test by five experts' judgment at those five traditional shipyards. If the experts disagree with the model, we modify it according to their suggestions. Finally, some improvements were proposed to the boat building industrial ecosystem in order to achieve the sustainability of materials supply chain and boost the shipyard's performance.

III. RESULTS

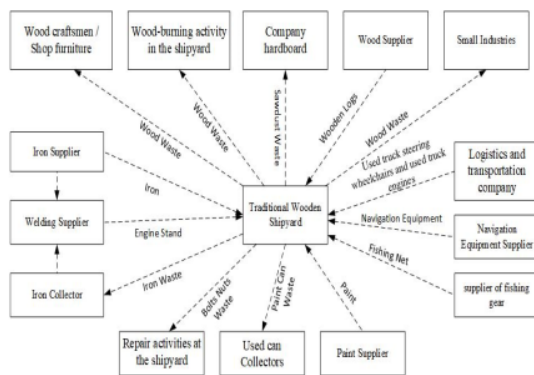


Fig. 2. Industrial Ecosystem in Traditional Shipyard

Fig 2 illustrates how the traditional wooden shipyard set up a network with local businesses. Waste from the shipyard converted into a valuable input to other businesses by re processing, repair, upgrade and other engineering processes. Here the explanations the input and output of the shipyard and other local businesses.

Traditional wooden shipyards are using wood as the main material. They get the logs from the wood suppliers and then use it as basic material for building wooden ships. Residue from woodcutting and sawdust sometimes cannot be used again in wood processing. Waste can produce goods worth more by selling the waste to local businesses such as 1) Shipyard sell wood waste to craftsmen to serve as new products such as household furniture. 2) Shipyard sell wood waste to small industries for firewood for the combustion process in the food industry. 3) Wood waste to be used by the shipyard back for bending wood combustion.

The traditional wooden shipyard also get iron material supply to produce ships in the form of a long metal, bolt

and nut. In the process of producing the ships is not all iron can be used, because of some process there will be a part that did not use by the shipyard, the left part can be waste. Shipyard can sell the Iron waste to collector's iron that can be value-added and bring financial benefits to the shipyard.

When producing a new ship, the shipyard still have bolt nut left. When the materials stored too long, the condition will decrease and the bolt nut rusty so it is not well used to build new ships. To avoid the loss of a waste of the bolt nut, the residue of bolt nut shipyard can be used to another process like repairing the ship.

Welding suppliers get iron from the residue that is not used at the shipyard. Besides that, they also get a supply from iron suppliers and iron residue that still has good quality from iron collectors. After the iron processed, welding supplier supplies the engines stand to supply to the shipyard.

Moreover, in the process of ship construction paint is an important material for the finishing process of the ship. In building a ship with a size about 30 GT the shipyard needs more than 24 cans of paint. For increasing the value, waste paint cans sold by the shipyard to the collectors of cans. The cans collectors also get revenue from waste cans of paint.

However, not all materials can be resold in order to get revenue, there is some equipment that cannot be recycled again by shipyard including the navigation equipment, nets and fishing line and fishing gear. The driver's seat is obtained from the company's logistics and transport in the form of waste can be reused with coupled sponge and foam.

While the ship's engines obtained from a supplier of Singapore in the form of used machinery from trucks that have been used for 5 years, since the regulations in Singapore that the maximum use of the vehicle is 5 years, then the machine will be fixed so it can be used by the shipyard again.

TABLE 1
TYPES OF MATERIAL REUSE

Companies and materials used	Structural Change	Recycle Process Description	Recycle Type
Wood craftsmen / Shop furniture (wood waste)	Subtractive	Wood waste are made into new product by change the shape and cutting of wood (wood craft)	Non-destructive recycling
Wood-burning activity in the shipyard (Wood waste)	No change	Reuse the residue / wood waste for incineration in shipyard	Direct use
company hardboard (Sawdust waste)	subtractive	Waste sawdust are made into new product by change the shape of sawdust	Non-destructive recycling
Small industries (wood waste)	subtractive	Reuse the residue/ wood waste for incineration in the food industry	Non-destructive recycling

Companies and materials used	Structural Change	Recycle Process Description	Recycle Type
Logistics and transportation company (Used truck steering chairs and used truck engines)	additive	Cleaning, Adding oil, and changing the broken engine part	Non destructive recycling
Used can Collectors (paint cans waste)	No change	Reuse the residue / waste paint cans obtained from shipyards	Direct use
Repair activities at the shipyard (bolts nuts waste)	No Change	No changes to the bolt nut. The waste directly used for ship repair activities	Direct Use
Iron collectors (iron waste)	No change	Residue / iron waste of the shipyard sold back to the supplier of welding	Direct use
Welding supplier (The engine stand)	additive	Welding or casting of the iron from wholesalers and suppliers	Non destructive recycling

TABLE 2
PROPOSED IMPROVEMENT OF SUPPLY CHAIN SUSTAINABILITY IN TRADITIONAL SHIPYARD

Environment	Economy	Social
Shipyards provide a special place for the disposal of residual waste / garbage so that the environment around the shipyard is not dirty / seedy and more comfortable.	Using paint cans into new products such as flower vases or bins which may have a resale value.	- Provide socialization to the community about the importance of waste treatment towards shipbuilding production waste - Provide socialization to the community about the laws that regulate the business development
Shipyards should use environmentally friendly materials	The government provides assistance to communities for the realization of cooperative development to accommodate the products produced by the surrounding community.	Providing training to workers (labor) regarding the specialization of work.
Shipyards should begin to expand its business by using the more sophisticated tools so as to reduce the risk of failure product and achieve the production process more environmentally friendly.	The government provides socialization and training on the benefits of technological developments in the trade.	Provide training to the women / local residents regarding the utilization of waste to be processed into handicraft products such as cage birds, caged chickens, desks, toys, and so forth.

Environment	Economy	Social
Government implement and tighten the regulations and on the use of materials that are not environmentally friendly. So that the shipyard can consider it again if the material used, the results of waste materials must be processed as possible.	Changing the combustion tools using coconut shells. So that the wood waste can be utilized into a product that has a resale value.	Sharing knowledge along with supply chain partners to be able to achieve the production process more environmentally friendly.
	Government give assistance to the shipbuilding workers in the forms of tool such as a drill, grinder, etc.	Forming shipyard workers' associations to make it easier for the government to provide regulations, assistance, and experience sharing.

Table 2 shows for ideas for the sustainability of the supply chain in a traditional shipyard in terms of 3 aspects: environmental, economic, and social. There are several proposals that have an impact significant on the sustainability of the supply chain shipyards, which are 1) Shipyard must use the tools more sophisticated working so as to reduce the risk of product failure and can achieve the production process more environmentally friendly. Reduced product failure could reduce waste production ships, so the impact both on the environment. 2) Provide training to women / local residents regarding the utilization of waste to be processed into handicraft products such as birdcages, chicken cages, desks, toys, and so forth. 3) Make use of tins of paint into new products such as flower vases or bins, which may have a resale value. By making paint cans into a product that is worth selling can increase the income of local people, but the problem is that people do not know how to promote the product to the consumer. Therefore, we propose that the government should assist communities to realize the construction of a cooperative that can accommodate products produced by the surrounding community. So that people's income increases.

IV. DISCUSSION

The proposed improvement from the expert judgment by using the more sophisticated tools in the production process at the traditional shipyard are in line with the article of Xie et. al. [7]. They studied on h4 to improve sustainability in the shipyard industry which includes selling and installation of main engines. The result showed that technological innovations and supply chain strategies for environment, economy, society 4 could be addressed to reduce the fixed cost for effective improvement and the industry of the energy efficiency of the main engine. The proposed technology developments at the traditional shipyard are also confirmed with the research of Ramirez-Pena et. al. [8]. They studied sustainable shipbuilding supply chain under industry 4.0 perspective which

contemplates economic, energy, environmental, functional and social aspects. The results showed that the technologies such as additive manufacturing and autonomous robots can improve economic, energy and environmental aspects of sustainable shipbuilding supply chain. Meanwhile, the implementation of horizontal and vertical integration and artificial intelligence can improve the functional and social aspects.

On the other hand, this study exhibits high levels of sustainability because the process is essentially based on wood. This research contradicts to Jaeger and Upadhyay [9] who studied about the major barrier for implementation of circular economy in ten companies including marine manufacturers. They found that several issues such as: recycled materials, design and production of the product, and disassembly of products were the barriers. Therefore, the sustainability of material supply chain at the traditional shipyard can be extended to develop a circular economy.

V. CONCLUSION

We have described the model of industrial ecosystem at traditional shipyard. There are several industries involved in the sustainability of materials supply chain, such as small industries on food and beverages, company hardboard, shop furniture, iron collector, welding supplier, used can collectors, shipyard for repairing service, and logistics and transportation company. The types of material reuse can be differentiated into three structural changes, namely subtractive, no change, and additive. Subtractive and additive are categorized into non-destructive recycling; meanwhile no change is direct use. Several improvements are proposed for supply chain sustainability in traditional shipyard. In environment sector, shipyard should use the sophisticated tools to reduce the risk of product failure and achieve production process efficiency. In economic sector, the shipbuilding workers ask the assistance of government not only in providing the perishable tools such as drill, grinder, and etc., but also in training and socialization on the benefits of technological development in the trade. Finally, in social sector, there should be an association of shipyard workers so that the government could convey the regulations, experience sharing, and provide assistance.

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