Implementation supply chain management concept in the industrial symbiosis of the fragrant lemongrass distillation

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Abstract. The citronella oil refining industry contributes greatly to improving the community's economy. In the supply chain of citronella oil, the community usually acts as a supplier (fragrant lemongrass farmers), manufacturers (distillers of citronella oil), and distributors (collectors of citronella oil). The main problem in the citronella oil refining industry is the uncertainty of the supply chain. Fragrant lemongrass supply chain mapping is done to determine the capacity and needs of all actors involved from raw material sources to retail consumers. Thus, the continuity of fragrant lemongrass supplies increased production capacity in refineries, and market potential can be estimated more precisely. On the other hand, integration between industries is needed to prevent the impact of environmental damage while increasing profits. The symbiosis model of the citronella refining industry is expected to optimize the potential and existing resources through an industrial system that is efficient, integrated, easy to implement, and environmentally sound. This paper will discuss how the application of supply chain management concepts in the symbiosis of the citronella refining industry so that the objectives of cooperation in the environmentally sound supply chain can be realized.

1. Introduction

Indonesia has great potential for the essential oil industry. Indonesia is also one of the main producers of essential oils in the world with the ability to supply around 85% of the world's essential oil needs. Citronella oil is one type of essential oil that has a good market and is very competitive in foreign markets. Fragrant lemongrass is a source of important essential oils that has several benefits. It had activity as antibacterial [1,2], as antidiabetic [3], and anticancer agents [4]. It's leaves also widely used as tea herbal [5]. Fragrant lemongrass essential oil is used traditionally as medicines and food seasoning and it also used as raw materials for the chemical industry.

Fragrant lemongrass plants and citronella oil refining have a positive impact not only on the agricultural sector but also on the economy of the community, especially rural communities. Some things that can be done to develop the citronella oil refining industry are improving the quality of fragrant lemongrass plants, empowering fragrant lemongrass farmers, and improving the technology of citronella oil refining. However, the most important thing to do is to improve the competitiveness of lemongrass oil through quality improvement, competitive prices, continuity of supply, integrated guidance, utilization of appropriate technology, and encouraging the development of small and medium scale derivative products. In addition, it must also be considered how the citronella refining industry interacts and cooperates with other industries in the use of materials, heat, energy, water, by-products, and waste management. This interaction is known as industrial symbiosis. The main purpose of industrial
symbiosis is to build industrial systems that are environmentally friendly. To maintain the continuity of products and the competitive price of produced citronella oil, the supply chain of citronella oil from upstream to downstream must be clearly and precisely mapped.

Research on industrial symbiosis has been widely carried out from various perspectives. One of them is a study of two types of industries in an eco-industrial park [6]. The study discusses the symbiosis between the sugar industry and the fertilizer industry in an environmentally friendly industrial park by describing it in a simulation model. Research conducted by Yazan et al. studies of industrial symbiosis based on material and energy flows and the suitability of supply and demand for waste as the main input [7]. This analysis is used to formulate corporate strategies and local government policies on how to achieve perfect symbiotic conditions in the industrial world. Meanwhile, research conducted by Zhang et al. discusses combining a cleaner production approach with industrial symbiosis in a mutually beneficial way [8]. Other studies discuss industrial symbiosis for small and medium-sized companies [9, 10]. Reference Puente describes the grouping of small and medium-sized companies in an industrial area by taking into account the possibility of replacing resources with waste products and opportunities to share waste management services and infrastructure [9]. While Patricio et al. illustrates the motivations and obstacles faced to build partnerships and symbiosis in small and medium-sized companies [10].

In addition to interactions with other industries in a symbiotic relationship, the citronella oil refining industry also has links with all actors in the supply chain. Therefore, supply chain mapping needs to be done to identify the problems that occur in the lemongrass oil industry. Supply chain management is the integration of business resources both inside and outside the company to get a competitive supply system and focus on synchronizing the flow of products and information to create high customer value [11]. This research will formulate a symbiosis between the citronella oil refining industry and other industries and how the interaction works from the supply chain concept. This research will also formulate several industrial symbiosis alternatives that occur between several supply chain actors in the small and medium scale citronella oil refining industry. The aim is not only to increase the production capacity and quality of the citronella oil produced but also to ensure that the existence of the citronella oil refining does not have a negative impact on the environment.

2. Literature review

2.1. Supply chain management

According to Lambert, Supply Chain Management (SCM) is the integration of business processes from end-users through initial suppliers who provide products, services, and information that provide added value to customers [12]. Supply Chain Management is the design and management of value-added processes that cross organizational boundaries to meet the real needs of end customers [13]. Supply Chain Management is often discussed as managing the flow of information and materials from "suppliers to customers". From a practical point of view, SCM is associated with the exchange of information, shared resources, and better relations between supply chain actors. The key factor for optimizing the supply chain is to create an easy and accurate flow of information between networks or chains, and the movement of goods effectively and efficiently so as to produce the maximum satisfaction of the end-user.

The SCM strategy is a series of strategic activities on the flow of goods that create a reconciliation between what is needed by the end customer and the capability of the resources available in the supply chain network. The SCM strategy can be achieved if the company has the ability to operate efficiently and of high quality, fast, flexible, and innovative. To make the right strategy, the supply chain must understand the characteristics of products and markets [11]. In addition, it is important to determine how the manufacturing process or service process is evaluated, including the procurement process, new product development, raw material transformation, shipping, and customer service [13]. According to Lambert, supply chain maps can be complex in line with the number of companies that exist at each level [12]. Therefore, determining the company's position on the supply chain map is an important thing.
that must be defined. Basically, the Company can consider the following reasons in the supply chain mapping, namely 1) the volume of sales or purchases; 2) the criticality of purchased components; 3) the ability to innovate, and 4) access to markets. The core process in integrating and managing the supply chain is to coordinate all processes at each stage carried out. The final step is to determine the level of integration and management that must be applied to each relationship.

2.2. Symbiosis industry

Industrial symbiosis is used to describe the physical exchange and joint management of material inputs and outputs determined by the company's geography [14]. Companies involved in industrial symbiosis are included in the industrial ecosystem. Symbiosis occurs due to economic considerations (such as reducing costs for waste disposal) and the environment (such as access to limited water supplies). An industrial symbiosis is a form of cooperation between various industries. This form of cooperation can increase the profits of each industry and ultimately have a positive impact on the environment. In this symbiotic process, industrial waste is processed into raw materials by other industries. This symbiotic process will be very effective if the industrial components are arranged in an integrated industrial park (eco-industrial park).

The country that first applied the principles of industrial ecosystems in industrial estates was Denmark. The exchange of 'waste' between independent industries in a sector has been going on for centuries for a simple reason, namely for better business purposes. However, the formation of 'industrial ecosystems' is still a relatively new phenomenon. Industrial ecology is divided into 3 (three) levels, which are focused on the facility level, inter-company level and the level on a regional or global scale [15].

3. Research method

This research was conducted in several areas that have fragrant lemongrass fields and citronella oil refining in West Java, Indonesia. Based on the survey results, mapping of the supply of citronella oil supply chains was carried out, starting from sources of lemongrass seedlings, lemongrass farmers to companies that bought citronella oil. The next downstream industry was not observed in this study. The focus of this research is to identify the supply chain of citronella oil and formulate efforts that must be made to increase the production capacity of refined citronella oil so that it can maintain the continuity of production and supply of citronella oil to the buying company. Refined citronella oil is dominated by small and medium scale refiners and still uses simple technology.

Supply chain mapping is a simultaneous depiction of the physical and information flow that occurs to all actors involved in the supply chain. Physical or material flow is to ensure the right type, quantity, and quality of materials that meet the buyer's requirements. Activities in this flow are buying fragrant lemongrass, conducting distillation (production process) and transferring materials to customers. The flow of information is to ascertain the type of goods needed, how much, when, and where the goods are needed. This mapping requires supplier data, customer needs, and the time required. The steps to create a supply chain map are to determine who the supply chain actors are and map the supply chain flow. Citronella supply chain actors consist of suppliers (upstream supply chains), producers/refiners (internal supply chains), and customers (downstream supply chains). The last stage of this study was to analyze alternative industrial symbiosis that occurred in the citronella oil refining industry. This alternative was formulated based on the results of a survey to regions in West Java by looking at the area of land planted with citronella and the number of citronella oil refiners.

4. Result and discussion

Citronella oil has a high market price after nutmeg and pepper oil. Lemongrass can live in critical or marginal soils. Recent studies have shown that citronella plants can grow in former mining areas, such as coal mines and others [16]. Potential areas in Indonesia that have been cultivating lemongrass are special areas in Aceh, West Java and Central Java. In the West Java region, some regions that
specifically develop citronella plants are BB (994 Ha), C (25 Ha), G (104 Ha), Sb (30 Ha), and Sm (10 Ha).

Actors in the supply chain of citronella oil in West Java are farmers as suppliers of lemongrass, lemongrass collector, citronella oil refiner, citronella oil collector, exporter, and consumer company of citronella oil. In the downstream (consumers) there is a large company that usually acts as an intermediary. Lemongrass is planted by farmers with seeds obtained from suppliers of lemongrass seeds. The harvest of fragrant lemongrass leaves is then purchased by fragrant lemongrass collectors and then sent to the citronella oil refiners. Some farmers also play a role as a small-scale citronella oil refiner. Distillers usually sell citronella oil they produce to fragrant lemongrass oil collectors.

Exporters or manufacturing industries as the last actors in the domestic citronella oil supply chain obtain citronella oil through intermediary traders. The flow of fragrant lemongrass then continues to the processing industry companies which produce soap, aromatherapy, candles, medicines, and other products. Intermediary traders buy fragrant lemongrass oil from collectors. Intermediary traders usually send to exporters who will then be exported outside of Indonesia. Material flow in the supply chain of lemongrass oil from upstream to downstream in West Java is illustrated in figure 1.

![Figure 1. The supply chain of citronella oil in West Java.](image)

Based on observations on refined lemongrass oil in several places, three symbiotic models were identified. The implementation of supply chain management concepts in the three symbioses of the fragrant lemongrass oil refining industry is explained in figures 2, 3 and 4.

- **Alternative 1**: Industrial symbiosis that occurs between lemongrass farmers, lemongrass oil refiners, and breeders (Figure 2). Lemongrass is brought to the refining location. The distillation process is carried out using water refining technology. Fragrant lemongrass waste generated from the distillation process is used as animal feed, and livestock manure is used to produce fuel. Figure 2 shows the concept of implementing supply chain management in symbiosis model 1 as follows: lemongrass farmers as suppliers, citronella oil refiners and breeders as manufacturers, and consumers.

![Figure 2. Implementation supply chain management concept in the industrial symbiosis models 1.](image)
• **Alternative 2**: Industrial symbiosis between fragrant lemongrass farmers and citronella oil refiners. Lemongrass is brought to the refining location. The fuel used for the process of refining citronella oil at that location is lemongrass waste that has been dried. This causes the refining industry without waste. Figure 3 shows the concept of supply chain management in the symbiosis 2 model as follows: lemongrass farmers as suppliers, citronella oil refining as manufactures, and finally, citronella oil is distributed to consumers.

![Image of Figure 3](image)

Figure 3. Implementation supply chain management concept in the Industrial symbiosis models 2.

• **Alternative 3**: Model 3 illustrates the symbiosis between lemongrass farmers and citronella oil refiners. Figure 4 shows the concept of supply chain management implementation in the symbiotic model 3 as follows: lemongrass farmers as suppliers; refining citronella oil as a manufacturer; citronella oil collectors, citronella oil processing companies, and citronella oil exporters as consumers. The symbiosis difference between models 2 and 3 is the citronella refining waste in model 2 as fuel while in model 3 it becomes fertilizer for citronella plants.

![Image of Figure 4](image)

Figure 4. Implementation supply chain management concept in the industrial symbiosis models 3.

5. **Conclusion**

The development of the citronella oil refining industry, especially for small scale, is highly dependent on the continuity of supply of lemongrass leaves as raw material. Therefore, planning the amount of lemongrass production by farmers becomes very important. Carefully calculates how much land should be planted with fragrant lemongrass and when lemongrass plants should be harvested. In the sales process, refiners cannot currently predict the price of fragrant lemongrass oil because the price of oil is determined entirely by fragrant lemongrass oil collectors or by buyers.

The analysis of the supply chain shows that actors in the fragrant lemongrass supply chain consist of lemongrass farmers, lemongrass collectors, citronella oil refiners, citronella oil collectors, and citronella oil consumers consisting of exporters, citronella oil processing companies and retail consumers. When combined on the three industrial symbiosis models identified in the citronella oil refining industry, it
will be seen at what level of improvement should be made (upstream to downstream of the supply chain). These three alternatives can be developed in accordance with the characteristics of the citronella refining industry which is currently being implemented.

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