A design of optimization based logistic strategy for seaweed agroindustry: a case study in South Sulawesi Indonesia

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Abstract. This research designs an optimization-based logistic strategy for seaweed agroindustry with case study in South Sulawesi Indonesia. To achieve the objective, an optimization mathematical model was designed to represent the logistic system. A Genetic Algorithm (GA) was designed to find the optimization model solution used as decision making guidance for logistic strategy. A Case study in South Sulawesi Indonesia as the largest seaweed producer in Indonesia was used to test the model. The result indicated that the optimization model design can calculated long-term logistic aspect with which can be used for policy-making and decision making as strategy for seaweed-downstream logistic.

1. Introduction

Design of logistics strategy is a design of strategies that will be used to achieve logistic objectives. This design can be in the form of mathematical model, graphical model, conceptual model and representative computer simulations from conditions of real-world logistic systems that will apply the strategy. According to [1], decision making on logistics strategy is divided into three parts: logistic design or strategy (Long term), planning (long term) and operational (short term). Logistic strategy is a long-term decision for several years, including location and capacity of facilities, products produced or stored at different locations, types of transportation and information systems. This long-term strategy is a kind of efficiency-oriented strategy.

One type of logistics strategy model design is the design of optimization-based logistic strategy model. This type of logistic strategy design is most appropriate for long-term decision-making types, because optimization is used to find an optimum solution in the most efficiency-oriented strategy research. The optimization model is one type of mathematical model that represents a problem in the form of mathematical optimization [2]. Based on this understanding, it can be concluded that the design of logistics-based optimization strategy model is representative of the logistics strategy model design in the form of mathematical formulation with the aim to optimize logistics objectives with right time, place, quality, quantity and price with minimum cost.
This research is focused on the design of seaweed agroindustry logistics strategy with case study in South Sulawesi Indonesia. According to [3], Indonesia is the world's second largest producer of seaweed after China with South Sulawesi is the largest exporter and seaweed producer in Indonesia with 28 percent contribution to national production of 10.2 million tons. About 85% is exported in the form of dried seaweed and 15% is processed first into powder and chips. Thus, the added value of seaweed obtained by the importing country. The effort to get big added value from seaweed commodity can be done by developing seaweed agroindustry. Promoting seaweed agro-industry in the country, especially downstream industries to create and develop products of high-quality seaweed and competitive.

Support for the development of downstream seaweed agro-industry in Indonesia has been done by the government through the discourse of export ban of seaweed in the form of raw materials / commodities. This downstream process will certainly not work without a study on the design of appropriate seaweed agroindustry, one of which is the study and design of long-term seaweed agro-industry in Indonesia.

Although it is important to use as a basis for decision making and seaweed downstream policy, research on supply chain modelling and management, logistics and all that is involved is very little. Several studies on this field, especially in Indonesia have been conducted by [4] on model design on the development of a sustainable seaweed industry cluster, [5] on the business development strategy of seaweed, [6] proposes the cooperation and coordination of all parties involved in the strategy of developing a sustainable seaweed industry cluster. The strategy of handling the risks of seaweed supply shortage is done by the selection of suppliers [7]. According to [8] wastewater industry's waste management strategy through the efficiency of waste water handlers and added value enhancements, [9] on risk management in the seaweed supply chain in Indonesia. According to [10], designed a conceptual model of logistics system in seaweed agro industry in South Sulawesi. These studies are more directed to the planning and operation of seaweed agroindustry.

Based on the above statements and references, it can be concluded about the importance of design development of logistics model of seaweed agro industry. This study aims to design a mathematical model of optimization design logistics strategy seaweed agroindustry. The model constructed in this study considers the logistical issues of seaweed agro-industry such as high logistics costs, and consideration of timely logistical objectives, quantities, prices and places so it can be concluded that the problem is an optimization problem. The results of minimization cost is presented and solve using genetic algorithm to find an optimal points, so this study also calculates an optimum point for decision making of seaweed agroindustry logistics strategy. This research contributes to developing a model of logistics seaweed agroindustry design strategy with case study on South Sulawesi area as a seaweed producing area in South Sulawesi with consideration of several issues to achieve the objective of a logistic system.

The rest of this paper is constructed as follow, first we describe the problem in seaweed logistic system. In this section, we present the problem in detail and define variables, parameters and indexes for optimization mathematic modelling. Also, we explain the assumptions for the model. Next, we present genetic procedures [11] as model solution for optimization modelling. Then an example case in South Sulawesi Indonesia is used to test the model. The next section we discuss the model and the result from the model testing using the example case. Finally, we present conclusion and future research direction.

2. Material and methods

2.1. Problem description
Preliminary research is conducted to understand the description of the problem in the development of seaweed agroindustry. The seaweed agro-industry logistics system generally has 4 main sphere classifications ie raw material source, intermediary, producer and exporter. Sources of raw materials supply seaweed (usually in dried form) to intermediaries for further sale to producers who process
these commodities into semi-finished or finished products. Types of seaweed materials such as Eucheuma spinosum, Eucheuma cottonii, Gelidium sp. etc. Processed household ingredients such as Alkali Treatment Carragenan (ATC) chips, Alkali Treatment Spinosum (ATS) chips, Semi Refined Carrageenan (SRC), Refined Carragenan (RC), processed household. This semi-finished product can be processed into other high value-added products such as sweets, cakes, jams, sweets, candies, etc. or exported.

In designing a logistic system of seaweed agroindustry to reach the right amount, timely, precise condition, right consumer, exact product, exact place, and proper cost / price then formulation must consider the number of logistics facilities built include raw material, industry, transportation, as well as warehousing. According to [1] and [12], strategic design on a logistics network is a long-term decision-making step consisting of building logistics facilities and capacity. Includes processing facilities, warehousing and distribution facilities. Based on that opinion, the optimization mathematical formulation model under this study should cover these aspects.

Based on the description of the problem then the assumptions used in the design of seaweed agroindustry system strategy in South Sulawesi are:
1. The speed of the fleet in transporting raw materials and products is considered constant.
2. No product return (compliment).
3. Use make-to-stock system
4. Transportation costs are considered constant as distribution costs for the distribution of raw materials and certain products (including the cost of product rejection, social costs, tolls, taxes etc.).
5. Development cost of the facility of a product is considered as total investment cost
6. The transported product in logistic system is considered as batch ordered product
7. Warehouse assumed can store all type of product

The notations used in this study are tabulated in Table 1.

2.2. Problem formulation
The goal formulation consists of a minimization of logistics facilities, costs and distances of seaweed processing distribution.

| Notation | Description |
|----------|-------------|
| \( X^{cp1}_{im} \) | The number of factory capacity of semi-finished product to be built in the \( i \)-th region (Integer) |
| \( X^{cp2}_{jn} \) | The total capacity of the finished product factory \( n \) to be built in the area \( j \) (Integer) |
| \( X^{cg}_{js} \) | The total capacity of the seaweed material warehouse to be built in the area \( s \) (Integer) |
| \( X^{g\flat}_{ip} \) | Factory warehouse capacity of semi-finished product \( m \) that must be built in region \( i \) (Integer) |
| \( X^{g\flat2}_{jn} \) | Factory warehouse capacity for finished product \( n \) that must be built in area \( j \) (Integer) |
| \( X^{g\flat1}_{jnk} \) | Transit storage capacity that must be built at the distribution port on area \( k \) (Integer) |
| \( X^{flow1}_{sim} \) | Decision variable for the flow of goods from the source of raw materials of seaweed in area \( s \) to the factory of semi-finished products \( m \) in region \( i \) (binary, 1 if selected, 0 if not selected) |
| \( X^{flow2}_{imjn} \) | The decision variable for the flow of factory goods of semi-finished products \( m \) in region \( i \) to product factory \( n \) in area \( j \) (binary) |
| \( X^{flow3}_{ink} \) | The decision variable for product flow of the finish good factory \( n \) in area \( j \) to distribution port \( k \) (binary) |
The capacity of semi-finished products factory with formulations $\sum_{i=1}^{M} X_{im}^{cp1} \geq B_{B}$.

The total intermediate product warehouse must exceed the capacity of the finished product factory by the integer variable formulation of the semi-finished product storage capacity multiplied by the binary logistic flow from the semi-finished product factory warehouse to the finished product factory which will be supplied with the formulation, $\sum_{i=1}^{l} \sum_{m=1}^{M} X_{im}^{cp2} X_{imj}^{low} \geq X_{jn}^{cp2}$.

The finished product warehouse and port distribution warehouse exceeds consumer demand derived from the outcome of the demand prediction model of the predicted neural network in the previous section. So the formulation is the capacity of the finished product warehouse and distribution times the cost, $\sum_{j=1}^{l} \sum_{n=1}^{N} C_{jn}^{gp2} X_{jn}^{gp2} \geq D$, and $\sum_{k=1}^{K} C_{jk}^{gp2} X_{jk}^{gp2} \geq D$.

The capacity of semi-finished plants is capable of processing all raw materials to ensure raw materials are not stored for too long and the number of processing plants capable of estimating seaweed yields from farmers. $\sum_{i=1}^{l} \sum_{m=1}^{M} X_{im}^{cp1} X_{sim}^{low1} \geq B_{B}$.
The capacity of the finished product factory cultivates beyond the demand that comes from the consumer.

2.3 Model solution with genetic algorithm

2.3.1 Chromosome design. The chromosome or genotype in the genetic algorithm is the number of parameters that define a proposed solution to a problem to be solved. Chromosomes are composed of genes that contain solution values (Alele) that are possible for solving the problem. In a single iteration the genetic algorithm consists of several chromosomes called the population. The chromosome for a number of solutions from the above plural purpose case is design in Figure 1.

![Figure 1. Binary chromosome](image)

The above chromosomes represent one example of binary variables of seaweed logistics flow from raw material source to semi-finished product plant $X_{sim}^{flow1}$. The value of Alele in the gene is binary for selection, which is 1 if the stream is selected and 0 if not selected. The chromosome design for two other binary variables is equal ($X_{imjn}^{low2}, X_{jnk}^{low3}$).

This chromosome design is done for integer values in the determination of the capacity of the finished product factory, the semi-finished product factory, the raw material warehouse capacity and the capacity of the finished product warehouse. Figure 2 is an example of chromosome design for factory capacity of semi-finished products $X_{im}^{cp1}$. Applies equally to other integer variables.

![Figure 2. Integer chromosome](image)

2.3.2 Fitness function, mutation, crossover. Fitness function is to map the chromosome representation into the objective function to evaluate the optimal value of the result of chromosome representation. The weight of each of the above objectives is assumed to be equally important (ignored) so that the fitness function at the calculation stage with the genetic algorithm here is the purpose function itself. The mutations used in this study were Polynomial Mutation (PM) and crossover using Simulated Binary Crossover (SBX) [11]. Then when the combinatorial genetic algorithm process reaches maximum generation and steady state condition, the termination process is implemented.

2.4 Implementation of optimization model of logistics strategy on seaweed agroindustry in South Sulawesi

The data used in this study were taken from South Sulawesi Indonesia. The trial did not use all of the districts in South Sulawesi, but the best 4 were taken using the RELIEFF attribute reduction technique. The reduction of the number of pilot districts is based on the long-term decision-making efficiency of both the calculation results and the performance of the genetic algorithm approach used to address the NP-Hard complex problem case. The idea of RELIEFF is to rank the attributes of those who have the highest importance / contribution based on the data to the lowest. Based on the result of the previous formulation on the mathematical model the attributes are the main consideration is the location of the built facility which also affects the logistic variable. The results of the RELIEFF calculations are
selected from 4 areas that will be piloted, namely Takalar (900 thousand tons / year), Wajo (250 thousand tons / year), Luwu (230 tons /year) and bulukumba (160 tons / year). Selayar, Makassar and Barru are used, the dried seaweed, ATC and SRC with seaweed products are food, industry and pharmacy Matrix distance test for Z3 formulation is taken with the help of google map. While logistic costs and logistic facility investment per km and per ton were obtained from distribution cost assessment (Supply Chain Indonesia 2016) and investment cost assessment from the trade ministry (2015).

The factory of semi-finished and finished products for the trial of this case is assumed to be built on the area. The cost of raw materials, construction of facilities, transportation using the standard range of South Sulawesi region. This trial case is used for the case of export logistics outside the province so it requires the location of the port point for sea transportation. The port location used is Selayar, Makassar and Barru. Semi-finished products used are dried seaweed, ATC and SRC with finished seaweed products are food, industrial and pharmaceutical.

3. Result and discussion
The combinatorial algorithm of Genetic Algorithm calculation based on the probability of PM 0.2 and SBX 0.5 is based on the Evolutionary Algorithm. This framework is a framework containing all the evolutionary algorithm-type calculation algorithms that allow users to modify algorithms according to design and written in java programming language.

Based on the case study, this study simulated 176 variables of the combination of indexes on the variables. After calculation using genetic algorithm with simulation on java programming obtained optimization point with minimization condition. The minimization objective consisted of cost and distance on the decision of the facility construction location, the cost of building an industrial facility and cost of transportation mode.

The cost of goods distribution from transport to port is IDR 606,157,937,523 (about 606 billion per year) with logistic facility investment cost of IDR 11,517,000,812,939 (about 11 trillion). The total capacity of semi-finished products to be built is 1,757,974 (1.76 million tons), finished products 289,927 (290 thousand tons) with total raw material warehouse capacity 1,529,941 (1.5 million tons).

With the development of this logistics facility, the uptake of domestic seaweed will be maximal so that the problem of farmers who always sell raw seaweed commodities (not processed first) becomes insurmountable. So that this downstream logistics strategy can run optimally because seaweed is usually sold at a price of about 10,000 thousand per kilogram whereas if processed, for example, pure carrageenan can produce 180,000 per kilogram of seaweed (value added 1,700%). The design of this logistics strategy also helps the government to reduce unemployment through employment and the availability of markets for the sale of seaweed commodities produced by farmers.

4. Conclusion
This research aimed to develop a mathematical model of logistics agroindustry design seaweed. The model constructed in this study considers the logistical issues of seaweed agro-industry such as the amount of domestic seaweed, demand, high logistics costs, and timely logistical objectives, quality, quantity, price and place. This research contributes to developing a model of logistics seaweed agroindustry design strategy with a case study on South Sulawesi area as a seaweed producing area in South Sulawesi with consideration of several issues to achieve the objective of a logistic system. The results showed that the model designed to determine logistic aspects of long-term seaweed agroindustry with a case study in South Sulawesi. These aspects are important for use in decision making and long-term strategy policies. Extending research model of decision-making strategy is a model that was built able to determine aspects of long-term strategy with minimization logistics costs on logistics agroindustry seaweed with case studies in South Sulawesi. The weakness of the strategy model built is that it has not considered medium-term planning as a bridge to the implementation of the model at the operational level. Based on these weaknesses, this research proposes further research on planning strategy logistics agroindustry seaweed.
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