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Optimization and Computing Model of Fish Resource Supply Chain Distribution Network

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Abstract. Aceh is a province that is rich in fishery resource potential. Fish resources become one of the leading commodities, therefore we need a supply chain optimization model. Optimization is one of the technologies widely used in supply chain network management. Fish resource supply chain becomes very important because it is caused by several factors, including the diversity of types of products from fish resources and their short expiry. The steps used in this research is literature review, determine parameters and decision variables, formulate the objective function and constraint function, modeling and model implementation. The purpose of this research is to get an optimization model in planning and managing the fish resource supply chain by using mixed integer linear programming, so that the resulting model can solve problems in the limitations of fish resources in certain areas, can distribute all consumer demand quickly. This new model can minimize transportation costs to suppliers, minimize transportation costs from suppliers to distribution centers and minimize transportation costs from distribution centers to consumers, and minimize product inventory costs to suppliers and to distribution centers.

1. Introduction

Aceh is one of the provinces in Indonesia which is rich in marine and fisheries potential resources. The land area of Aceh Province is 57.365.67 km2, while the area of its waters reaches 295.370 km2 consisting of 56,563 km2 of territorial and archipelagic waters and 238,807 km2 of exclusive economic zone waters [1].

The most prominent commodities in Aceh waters are large and small pelagic fish species such as tuna, tuna, skipjack, mackerel, bloating, flying, siro and tembang namely demersal fish such as curses, white pomfret, gulamah, kuro and shrimp and coral fish such as grouper, yellow tail and snapper, lobster, crab, small crab and squid also decorate along the Aceh waters. In fact, the potential economic value of Aceh's capture fisheries waters is estimated at Rp. 6.34 trillion / year (assuming a fish price of US $ 2.24 / Kg). In addition to having a large potential of capture fisheries, Aceh also has potential for aquaculture, even reaching 55,896 ha (not including the potential for marine cultivation) consisting of brackish cultivation of 50,691.70 ha and freshwater aquaculture of 5,204.3 ha [1].

Based on this data, planning and management of potential fish resources is needed as one of the main factors in improving economic development, especially in Aceh Province and Indonesia in general. With the challenges of globalization, the parties related to the management of fisheries are organized in a distribution network in a variety of processes to get a final product and then distribute it to consumers, the aim is to improve the quality of good products and the right time with minimum logistics cost [2], [3], [4].

Besides that, the mathematical optimization model [5], [6] represents a solid conceptual paradigm for analyzing and solving problems that arise in the integrated planning of the fish resource supply chain and in the continued development of the necessary software. This model can produce a realistic mathematical representation of the production logistics system and can describe complex relationships between the components of an integrated system. Furthermore, the development of information technology and the development of optimization algorithms result in a decision support system based on the optimization model of fish resource management planning.

Because the structure of the planning and allocation of the fish resource supply chain model of Mixed Integer Linear Programming (MILP) is seen as providing a mathematical optimization framework to represent the characteristics of the problem [7], put forward the MILP model that integrates all components in the supply chain including factory location and sales. [8] formulate a two-stage model of the supply chain that can determine the optimal quantity to be produced in each factory and then send the production to the distribution center. [9] presents MILP models and computational strategies for solving two echelon supply chain problems, with uncertainty at the inventory level. [10], [11] completing a multi-period production system that integrates management planning. However, it should be noted that most of what appears in the literature discusses management planning in the supply chain in general, none of which specifically addresses fish resources.

The optimization model proposed explicitly contains uncertainty parameters, namely fish availability parameters and market demand parameters. Uncertainty (demand uncertainty) is one of the problems faced by companies or organizations that can have a negative impact on profits experienced by the company. In addition, companies are also required to shorten product lead time assembling, stabilize market uncertainty and be able to minimize inventory levels [12]. In dealing with the above conditions, we need an artificial intelligence based model for integrated supply chains to support the industrial revolution era 4.0 [13]. Meanwhile, to overcome and reduce the uncertainty problem in the supply chain, the optimization model using a data driven based MILP approach is used [14]. The results of this study can be continued and developed again using the ant colony algorithm to find the shortest route [15]. So we need a MILP model for integrated fish supply chain distribution network planning [16]

2. Description of Problem Formulation

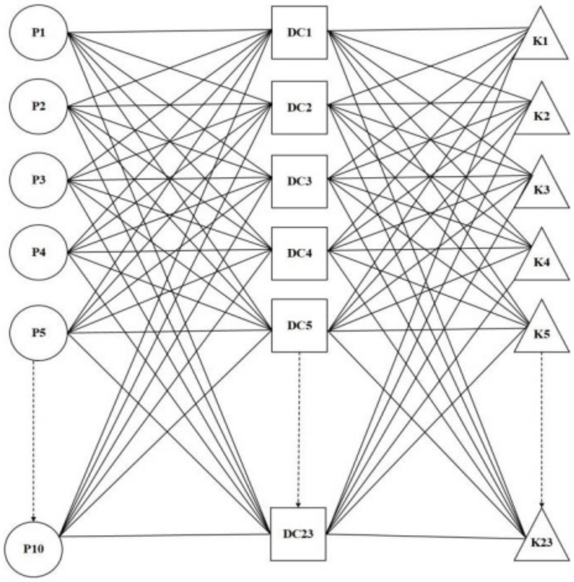
Fisheries resources have many types and are easy to rot or expire quickly, so we need a model for the distribution of fish resources. Types of fisheries that are commodities in Aceh are: pelangis fish species, demersal fish species and reef fish species [17].

Distribution of fish from suppliers to the community requires a long time, it requires a good distribution model, with the right time so that the quality of fish remains good with minimal cost. Therefore an integrated supply chain planning model is needed, with the aim of minimizing supply chain operating cost. To minimize the total operational costs in the supply chain using a data driven optimization approach, due to the uncertainty parameter, namely the availability of fish resources parameters at suppliers and market demand by consumers.

Fish resource suppliers come from 10 Fish Landing Places (FLP) in Aceh province. For distribution centers and consumers consisting of 23 districts and cities in the province of Aceh. Establish an optimization model for planning and managing fish resource potential by using a supply chain distribution network [17]. To produce an optimal solution in minimizing the cost of the distribution network of fish resource supply chains using the method MILP [16].

3. Model Formulation

The formulated model is based on the supply chain distribution network model as shown in Figure 1.



P1..P10 :Supplier
DC1..DC23: Distribution center
K1..K23: Consumer

Figure 1. Supply chain network for fish resource distribution

1) Set

P	Supplier, index *p*
D	Distribution centers, index *d*
K	Consumer, index *k*
M	Product, index *m*
V	Vehicle Routes, index *v*

2) Parameter

BT_{pd}^{vm}	Cost of transporting the product using the route v∈V from the supplier p∈P to the distribution center d∈D (Rp)
BT_{vm}^{dk}	Cost of transportation The product uses the route v∈V from the distribution center d∈D to consumers k∈K (Rp)
C_{pm}	Operating costs for product storage at suppliers $p \in P$ (Rp)
C_{md}	Costs for operational storage of products at Distribution Centers $d \in D$ (Rp)
BT_{p}	Costs associated with supplier selection $p \in P$
BT_{pv}	Transportation costs associated with suppliers $p \in P$ through the route $v \in V$
KP_{p}	Supplier capacity $p \in P$ (Ton)
KD_{d}	Distribution center capacity $d \in D$ (Ton)
JP_{p}^{m}	Product production amount $m \in M$ by the supplier$p \in P$
PP_{k}^{m}	Product request $m \in M$ by consumers $k \in K$

3) Decision variable

R_{pd}^{vm}	Product Amount $m \in M$ will be sent from the supplier $p \in P$ to the distribution center $d \in D$ through the route $v \in V$
S_{vm}^{dk}	Product Amount $m \in M$ will be sent from the distribution center $d \in D$ to consumers $k \in K$ through the route $v \in V$
PA_{pm}	Initial product inventory $m \in M$ at the supplier $p \in P$
PA_{md}	Initial product inventory $m \in M$ at the distribution center $d \in D$

4) Binary variable

a_{kpv}	Binary variable worth 1, if consumers $k \in K$ visited from suppliers $p \in P$ use the route $v \in$ V, is worth 0 if not.
X_p	Binary variable worth 1, if a supplier $p \in P$ selected, is worth 0 if not.
Y_{pv}	Binary variable worth 1, if route $v \in V$ used to visit suppliers $p \in P$, is worth 0 if not.

4. Results and discussion

4.1. Optimization Model

The following are objective model functions and model constraint functions for the fish resource supply chain distribution network

$$\begin{aligned} Minimum \sum_{p \in P} BT_p X_p + \sum_{p \in P} \sum_{v \in V} BT_{pv} Y_{pv} + \sum_{p \in P} \sum_{d \in D} \sum_{m \in M} \sum_{v \in V} BT_{pd}^{vm} R_{pd}^{vm} + \\ \sum_{d \in D} \sum_{k \in K} \sum_{m \in M} \sum_{v \in V} BT_{vm}^{dk} S_{vm}^{dk} + \sum_{p \in P} \sum_{m \in M} C_{pm} PA_{pm} + \sum_{m \in M} \sum_{d \in D} C_{md} PA_{md} \end{aligned} \quad (1)$$

Equation (1) objective function to minimize fish resource supply chain costs.

$$\sum_{p \in P} \sum_{v \in V} a_{kpv} Y_{kpv} = 1 \;\; \forall k \in K \quad (2)$$

Equation (2) constraint function, stating that each supplier visits the customer only once.

$$X_p - Y_{pv} \geq 0 \quad \forall p \in P, v \in V \quad (3)$$

Equation (3) constraint function, stating that each supplier to visit the facility must be greater than zero.

$$\sum_{p \in P} \sum_{m \in M} R_{pd}^{m} \leq \sum_{p \in P} \sum_{m \in M} KP_{pd}^{m} \qquad \forall d \in D \quad (4)$$

Equation (4) constraint function, stating that the number of fish resource products sent to the distribution center must be smaller than the supplier capacity.

$$\sum_{p \in P} \sum_{m \in M} R_{pd}^{m} \;\geq\; \sum_{d \in D} \sum_{m \in M} S_{dk}^{m} \qquad \forall_k \in K \quad (5)$$

Equation (5) constraint function, stating that the number of fish resource products sent from suppliers must be greater than the number of products to consumers.

$$\sum_{d \in D} \sum_{m \in M} S_{m}^{dk} \leq \sum_{d \in D} \sum_{m \in M} KD_{m}^{d} \qquad \forall k \in K \quad (6)$$

Equation (6) constraint function, stating that fish resource products sent from the distribution center to consumers do not exceed the distribution center capacity.

$$\sum_{k \in K} \sum_{m \in M} S_{m}^{dk} = \sum_{k \in K} \sum_{m \in M} PP_{m}^{k} \qquad \forall d \in D \quad (7)$$

Equation (7) constraint function, stating that fish resource products sent from the distribution center to consumers must meet consumer demand.

$$\sum_{p\in P}\sum_{m\in M} PA_p^m = \sum_{d\in D}\sum_{m\in M} PA_d^m + \sum_{p\in P}\sum_{m\in M} JP_p^m - \sum_{p\in P}\sum_{m\in M} R_{pd}^m \quad \forall_d \in D \tag{8}$$

Equation (8) constraint function, stating that the total supply of fish resource products at the supplier consists of the supply of fish resource products at the distribution center plus the number of fish resource products at the supplier minus the fish resource products at the distribution center.

$$\sum_{d\in D}\sum_{m\in M} PA_d^m = \sum_{d\in D}\sum_{m\in M} PA_d^m + \sum_{p\in P}\sum_{m\in M} R_{pd}^m - \sum_{d\in D}\sum_{m\in M} S_m^{dk} \quad \forall_k \in K \tag{9}$$

Equation (9) constraint function, stating the total inventory of fish resource products at the distribution center consisting of inventory at the distribution center added by fish resource products from suppliers minus the number of fish resource products sent to consumers.

$$R_{pd}^{vm}, S_{\le dk}^{vm}, PA_{pm}, PA_{pd} \ge 0 \qquad \forall p\in P, d\in D, m\in M, v\in V \tag{10}$$

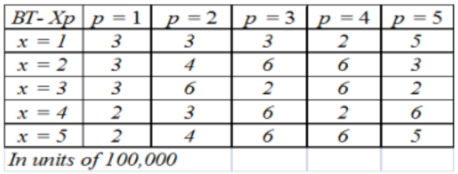
Equation (10) constraint function, stating that each variable is an integer

Equation (1) through equation (10) is an optimization model for the fish resource supply chain distribution network.

4.2. Data Collection

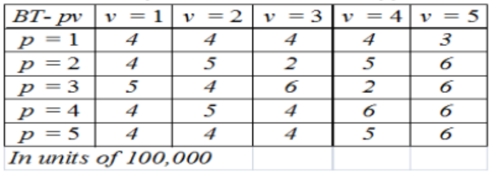
The data used in this paper is numerical data in the form of a matrix to support the calculation process using the Lindo program, as follows

Table 1. Supplier determination cost data



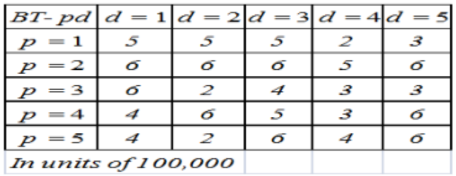
BT- Xp	$p = 1$	$p = 2$	$p = 3$	$p = 4$	$p = 5$
$x = 1$	3	3	3	2	5
$x = 2$	3	4	6	6	3
$x = 3$	3	6	2	6	2
$x = 4$	2	3	6	2	6
$x = 5$	2	4	6	6	5
In units of 100,000					

Table 2. Transportation cost data to suppliers



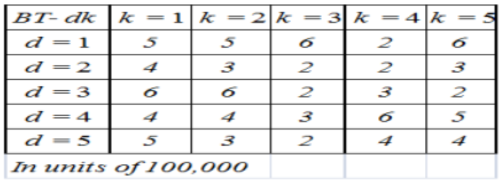
BT- pv	$v = 1$	$v = 2$	$v = 3$	$v = 4$	$v = 5$
$p = 1$	4	4	4	4	3
$p = 2$	4	5	2	5	6
$p = 3$	5	4	6	2	6
$p = 4$	4	5	4	6	6
$p = 5$	4	4	4	5	6
In units of 100,000					

Table 3. Transportation cost data from suppliers to distribution centers



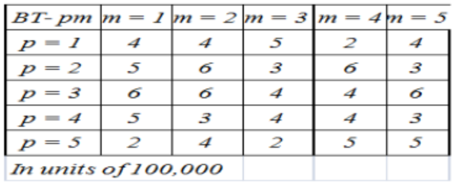
BT- pd	$d = 1$	$d = 2$	$d = 3$	$d = 4$	$d = 5$
$p = 1$	5	5	5	2	3
$p = 2$	6	6	6	5	6
$p = 3$	6	2	4	3	3
$p = 4$	4	6	5	3	6
$p = 5$	4	2	6	4	6
In units of 100,000					

Table 4.Transportation cost data from distribution centers to consumers



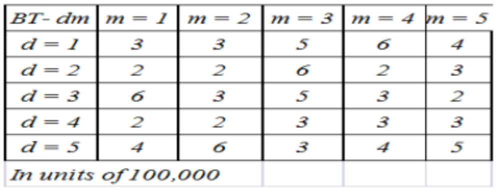
BT- dk	$k = 1$	$k = 2$	$k = 3$	$k = 4$	$k = 5$
$d = 1$	5	5	6	2	6
$d = 2$	4	3	2	2	3
$d = 3$	6	6	2	3	2
$d = 4$	4	4	3	6	5
$d = 5$	5	3	2	4	4
In units of 100,000					

Table 5.Product inventory cost data at suppliers



BT- pm	$m = 1$	$m = 2$	$m = 3$	$m = 4$	$m = 5$
$p = 1$	4	4	5	2	4
$p = 2$	5	6	3	6	3
$p = 3$	6	6	4	4	6
$p = 4$	5	3	4	4	3
$p = 5$	2	4	2	5	5
In units of 100,000					

Table 6. Product inventory cost data at the distribution center



BT- dm	$m = 1$	$m = 2$	$m = 3$	$m = 4$	$m = 5$
$d = 1$	3	3	5	6	4
$d = 2$	2	2	6	2	3
$d = 3$	6	3	5	3	2
$d = 4$	2	2	3	3	3
$d = 5$	4	6	3	4	5
In units of 100,000					

4.3. Mathematical Computation Model

To perform mathematical modeling calculations in this study using the Linear Interactive and Discrete Optimizer (LINDO) modeling application. The following is attached a mathematical calculation model to minimize the cost of selecting supplier locations from several existing suppliers, minimizing transportation costs to the supplier's place by using the chosen route, minimizing transportation costs from the chosen supplier's place to the distribution center by using the route, minimizing transportation costs from distribution center to consumers by using the route, minimizing product inventory costs at selected supplier locations, minimizing product inventory costs at selected distribution center locations.

Supplier (p) selection costs
+3xp10 + 3xp11 + 3xp12 + 2xp13 + 5xp14
+ 3xp20 + 4xp21 + 6xp22 + 6xp23 + 3xp24
+ 3xp30 + 6xp31 + 2xp32 + 6xp33 + 2xp34
+ 2xp40 + 3xp41 + 6xp42 + 2xp43 + 6xp44
+ 2xp50 + 4xp51 + 6xp52 + 6xp53 + 5xp54

Transportation costs to suppliers (p) by route (v)
+ 4pv10 + 4pv11 + 4pv12 + 4pv13 + 3pv14
+ 4pv20 + 5pv21 + 2pv22 + 5pv23 + 6pv24
+ 5pv30 + 4pv31 + 6pv32 + 2pv33 + 6pv34
+ 4pv40 + 5pv41 + 4pv42 + 6pv43 + 6pv44
+ 4pv50 + 4pv51 + 4pv52 + 5pv53 + 6pv54

Transportation costs from suppliers (p) to distribution center (d)
+ 5pd10 + 5pd11 + 5pd12 + 2pd13 + 3pd14
+ 6pd20 + 6pd21 + 6pd22 + 5pd23 + 6pd24
+ 6pd30 + 2pd31 + 4pd32 + 3pd33 + 3pd34
+ 4pd40 + 6pd41 + 5pd42 + 3pd43 + 6pd44
+ 4pd50 + 2pd51 + 6pd52 + 4pd53 + 6pd54

Transportation costs from distribution center (d) to consumer (k)
+ 5pk10 + 5pk11 + 6pk12 + 2pk13 + 6pk14
+ 6pk20 + 3pk21 + 2pk22 + 2pk23 + 3pk24
+ 6pk30 + 6pk31 + 2pk32 + 3pk33 + 2pk34
+ 4pk40 + 4pk41 + 3pk42 + 6pk43 + 5pk44
+ 4pk50 + 3pk51 + 2pk52 + 5pk53 + 4pk54

Product inventory operating costs (m) to suppliers (p)
+ 4pm10 + 4pm11 + 5pm12 + 2pm13 + 4pm14
+ 5pm20 + 6pm21 + 3pm22 + 6pm23 + 3pm24
+ 6pm30 + 6pm31 + 4pm32 + 4pm33 + 6pm34
+ 5pm40 + 3pm41 + 4pm42 + 4pm43 + 3pm44
+ 2pm50 + 4pm51 + 2pm52 + 5pm53 + 5pm54

Product inventory operating costs (m) at the distribution center (d)
+ 3dm10 + 3dm11 + 5dm12 + 6dm13 + 4dm14
+ 2dm20 + 2dm21 + 6dm22 + 2dm23 + 3dm24
+ 6dm30 + 3dm31 + 5dm32 + 3dm33 + 2dm34
+ 2dm40 + 2dm41 + 3dm42 + 3dm43 + 3dm44
+ 4dm50 + 6dm51 + 3dm52 + 4dm53 + 5dm54

5. Conclusion

This research creates a new model for optimizing the supply chain distribution network for planning and managing the potential of fish resources by considering uncertainty in supply, so there is a need for inventory at suppliers and distribution centers to meet consumer needs. This model is a model for minimizing transportation costs to suppliers, minimizing transportation costs from suppliers to distribution centers and minimizing transportation costs from distribution centers to consumers, and minimizing product inventory costs to suppliers and to distribution centers. The resulting model is part of the Mixed Integer Linear Programming form. The form of this number is found in the selection of suppliers and the selection of routes using binary variables (0,1).

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