Data Driven Optimization Approach to Fish Resources Supply Chain Planning in Aceh Province

Nurdin\textsuperscript{1,2}, M. Zarlis\textsuperscript{3}, Tulus\textsuperscript{3}, Syahril Efendi\textsuperscript{3}

\textsuperscript{1}Doctoral Student in Computer Science, Universitas Sumatera Utara, Medan, Indonesia
\textsuperscript{2}Department of Informatics, Universitas Malikussaleh, Lhokseumawe, Aceh, Indonesia
\textsuperscript{3}Department of Computer Science, Universitas Sumatera Utara, Medan, Indonesia

* nurdin@unimal.ac.id

Abstract. Aceh is one of the provinces in Indonesia that is rich in the potential of marine and fisheries resources. Many fish resources become superior commodities, therefore good planning and management needs to be done. Fish resource data that will be used in this research is large-scale data from the district and city in Aceh province, then a data driven optimization approach is needed. Optimization has become one of the high technology in planning and management in the supply chain. Supply chain networks as logistics and production process from network that is connected between organizational units that operate from suppliers to the community. The supply chain of fish resources is very complex because it is caused by number of factors, such as the diversity of products from fish resources and short expiration periods. In this paper proposes that the supply chain network built consists of suppliers, distribution centers and consumers. The location of suppliers, distribution centers and consumers comes from 10 regions in the province of Aceh, for fish resource suppliers taken from Coastal Fishing Ports (CFP) and Fish Landing Base (FLB).

1. Introducing

Smart decision making is very important for every individual, government, manager, organizational leader or anyone. Decisions can be important and many are mediocre. Decisions that need to be taken in relation to the management of marine and fisheries resources require the role of intelligent decision-making systems, let alone this decision-making process contains large amounts of data.

Given the global challenges, parties related to fisheries resource planning are organized in a network that is included in various processes and activities to produce the final product and distribute it to the community. The main objective is to improve the right product quality at the right place and the right time with minimum costs \cite{4,12,13,14}. This network is referred to as the supply chain. Supply chain management is complex and challenging because of a number of factors, such as diversity of products from fish resources, products with short expiry dates and utilization of suppliers from abroad \cite{7}.

Because of the complexity of the decision-making process in the supply chain, there is an increased need for modeling methodologies \cite{2,6}, which can support identification and implementation strategies for high-performance supply chain design. This complexity arises because of the large
number of variables and data, hierarchical decision structure, the uncertainty of various input and the dynamic nature of interactions between supply chain elements [2].

The production of fish sources is a type of product that expires quickly. This condition adds to the level of difficulty in supply chain management. This difficulty includes the period of storage of fish before and after processing. So, it is necessary to pay attention to the amount of raw material that will be stored and the products that will be sent to the distribution center, as well as the storage capacity.

Seyedhosseini and Ghoreshi [10] presented an integrated modeling of production-distribution planning for products expired short. The supply chain network that they pay attention to consists of production facilities and multiple distribution centers. The challenge for businesses that are involved in fishery supply chain management is that the value of the product decreases significantly with time at a rate that is highly dependent on the environment [3]. According to them temperature and humidity are key factors.

The proposed optimization model explicitly contains uncertain parameters, namely the parameters of fish availability and market demand. In the literature the problem of optimization with uncertainty appears on stochastic program topics [5,1,9,11]. In such a model, objective function is generally a minimization of expectation costs or maximizing profit expectations (linear or non-linear). With the calculation of this expectation value, the uncertain parameters that are often termed as random parameters need to have a probability distribution function. Such conditions are the main weakness of the stochastic program model. The optimization model that can also handle uncertain parameters is data driven optimization or also known as robust optimization [8].

2. Methodology

2.1. Problem description

Fish resources are fishery products that have a variety of types and have the characteristics of rotten or fast expiration, the process of distributing fish resources from suppliers to consumers requires a long time. So that a good distribution system, the right place and time is needed so that the quality of fish resources is maintained at a minimum cost, it is necessary to supply chain distribution planning. Supply chain management is the entire production process from processing, marketing distribution, to the desired product to the consumer by minimizing operational costs. To minimize total operational costs in the supply chain of fish resources, an optimization approach is needed by using a mathematical model.

2.2. Mathematical Model

The mathematical model built is based on a diagram model Supply chain distribution network for fish resources as shown in Figure 1. There are several types of fishery products which are potential commodities of fish resources in the province of Aceh, namely: types of fish Pelangis, types of fish Demersal and types of fish Karang. Each type of fish resource product is assumed to take on the supply chain diagram as shown in Figure 1. Mathematical models used in planning the distribution network of fish resource supply chains as follows:

2.3. Notations to be used

Parameter :

- $BT_{pd}^v$ Transportation cost (Rp.) by using the route $v \in V$ from Suppliers $p \in P$ to the Distribution Center $d \in D$
- $BT_{dk}^v$ Transportation cost (Rp.) by using the route $v \in V$ from the Distribution Center $d \in D$ to Consumers $k \in K$
- $BP_d$ Fixed costs for operational opening of Distribution Centers $d \in D$ (Rp.)
- $CP1_p$ Costs for operational storage of Products at Suppliers $p \in P$ (Rp.)
- $CP2_d$ Costs for operational storage of Products in the Distribution Center $d \in D$ (Rp.)
- $KP_p$ Supplier capacity $p \in P$ (Ton)
- $KD_d$ Distribution Center capacity $d \in D$ (Ton)
Total production of Products \( m \in M \) by Suppliers \( p \in P \) (Ton)

Product request \( m \in M \) by Consumers \( k \in K \) (Ton)

Initial Product inventory \( m \in M \) at the Supplier \( p \in P \) (Ton)

Initial Product inventory \( m \in M \) in the Distribution Center \( d \in D \) (Ton)

Amount of Products \( m \in M \) sent from Suppliers \( p \in P \) to Distribution Center \( d \in D \)

Amount of Products \( m \in M \) sent from the Distribution Center \( d \in D \) to Consumers \( k \in K \)

Set are defined as follows:

- \( P \) Set of Supplier, given the index \( p \)
- \( D \) Set of Distribution Center, given the index \( d \)
- \( K \) Set of Consumer, given the index \( k \)
- \( M \) Set of Products (fish resources), given the index \( m \)
- \( V \) Set of Vehicle Routes, diberi indeks \( v \)

The main objective of this model is to minimize the total operational costs in the distribution network the fish resource supply chain. Mathematically the objective function can be expressed as follows:

\[
\text{Minimize} = \sum_{p \in P} \sum_{d \in D} \sum_{m \in M} \sum_{v \in V} BT_{pd}^v R_{pd}^m + \sum_{d \in D} \sum_{k \in K} \sum_{m \in M} \sum_{v \in V} BT_{dk}^v S_{dk}^m + \sum_{d \in D} BP_d + \sum_{p \in P} \sum_{m \in M} CP1PA_p^m + \sum_{d \in D} \sum_{m \in M} CP2PA_d^m
\]

With the following constraint functions:

\[
\sum_{p \in P} \sum_{m \in M} R_{pd}^m \leq KP_p^m \quad \forall d \in D
\]

\[
\sum_{p \in P} \sum_{m \in M} R_{pd}^m = \sum_{d \in D} \sum_{m \in M} S_{dk}^m \quad \forall k \in K
\]

\[
\sum_{d \in D} \sum_{m \in M} S_{dk}^m \leq KD_d^m \quad \forall k \in K
\]

\[
\sum_{k \in K} \sum_{m \in M} S_{dk}^m = PP_k^m \quad \forall d \in D
\]

\[
PA_p^m = JP_p^m - \sum_{p \in P} \sum_{m \in M} R_{pd}^m \quad \forall d \in D
\]

\[
PA_d^m = \sum_{p \in P} \sum_{m \in M} R_{pd}^m - \sum_{d \in D} \sum_{m \in M} S_{dk}^m \quad \forall k \in K
\]

\[
R_{pd}^m, S_{dk}^m \geq 0, \quad \forall p \in P; \forall d \in D; \forall k \in K
\]

3. Results and Discussion

The fish resource planning supply chain network proposed in this paper includes three levels of distribution network, namely Suppliers, Distribution Centers and Consumers, can be seen in Figure 1:
Figure 1. Supply chain distribution network for fish resources

Supply chain structure of fish resources in the province of Aceh, starting from Fishermen as suppliers, then brought to the distribution center warehouse to be distributed to consumers. In this supply chain research uses scenarios by changing the distribution center capacity to determine the sensitivity in the selection of distribution centers based on capacity and fixed costs of different distribution centers. This supply chain network adds inventory problems to anticipate uncertainty in the supply of fish resources. Fish resource suppliers consist of Coastal Fishing Port (CFP) and Fish Landing Base (FLB) locations in Aceh Province, as follows: CFP Lampulo, FLB Kuala Peukan Baro, FLB Meureudu, FLB Peudada, FLB Pusong, CFP Idi Rayeuk, FLB Kuala Langsa, FLB Calang, FLB Padang Seurahet dan FLB Kuala Tuha. Map of the location of fish resource suppliers in Aceh Province in Figure 2:

Figure 2. Map of the location of fish resource suppliers in Aceh Province

For distribution centers and consumers come from 10 districts and cities in the province of Aceh, as follows: Banda Aceh City, Pidie District, Pidie Jaya District, Bireuen District, Lhokseumawe City, East Aceh District, Langsa City, Aceh Jaya District, West Aceh District, Nagan Raya District. The data used in this paper is the data of fish resource production in Aceh Province. The following is a graph of the production of fish resources according to the quarter in districts and cities in the province of Aceh, in figure 3.
While the graph of the value of fish resource production according to the quarter in the districts and cities in the province of Aceh, in Figure 4.

4. Conclusion
Production of fish resources is a type of product that is fast expired, so we propose a supply chain network of fish resource planning into three levels of distribution networks, namely suppliers, distribution centers and consumers. To anticipate uncertainty in the supply of fish resources, it is necessary to add inventory problems. The purpose of this study is to produce a model of supply chain distribution network design for fish resources in the province of Aceh, determine the number of suppliers and distribution centers of fish resources needed to minimize logistic costs.

References
[1] Birge JR, Louveaux., FV., Introduction to stochastic programming., New York: Springer., 1997
[2] Biswas, S., Narahari, Y., Object Oriented Modeling and Decision Support for Supply Chains., *European Journal of Operational Research*, 153 (4), 2004: 704–726.

[3] Blackburn, J., Scudder, G., Supply Chain Strategies for Perishable Products: The Case of Fresh Produce. *Production and Operations Management* 18(2) 2009: 129–137.

[4] Ferguson, B.R., Implementing supply chain management. *Production and Inventory Management Journal*. (3) 2000: 64-7.

[5] Kall P., Wallace S., Stochastic programming. Chichester: Wiley., 1994

[6] Lau, J.S.K, G. Q. Huang, K. L. Mak, L. Liang., Agent-Based Modeling of Supply Chains for Distributed Scheduling. *IEEE Transactions on Systems, Man, and Cybernetics – TSMC*, 36 (5) 2006: 847–861.

[7] Lee, H. L., Aligning supply chain strategies with product uncertainties. *California Management Review* 44 (3) 2002: 104-119.

[8] Mulvey, J. M., Vanderbei, R. J., and Zenios, S.A., Robust Optimization of large-scale system. *Operations Research*, 43 (2) 1995: 264-281.

[9] Ruszczynski A, Shapiro A, Stochastic programming. Handbooks in operations research and management science, vol. 10. New York; North-Holland.

[10] Seyedhosseini, S. M and Ghoreyshi, S. M., “An integrated model for production and distribution planning of perishable products with inventory and routing considerations”. *Mathematical Problems in Engineering*, Vol. 2014, Article ID 475606.

[11] Sen., S, Higle JI, Introductory tutorial on stochastic linear programming models. Interfaces; 29 (2)1999: 33-61.

[12] Shepherd, C., Gunter, H., Measuring supply chain performance: current research and future directions. *International Journal of Productivity and Performance Management* 55 (3/4) 2005: 242-258.

[13] Xu, J. Y. He and M. Gen., “A class of random fuzzy programming and its application to supply chain design”. *Computers and Industrial Engineering*, vol. 56, no. 3, 2009: 937-950.

[14] Yu., V. F N., Normasari., M. E. and Luong., H. T., “Integrated location-production-distribution planning in a multiproducts supply chain network design model,” *Mathematical Problems in Engineering*, vo. 2015, Article ID 473172, pp. 1-13.