

# Fish Export Optimization On Cold Supply Chain

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**Abstract:** *The cold supply chain of fresh and perishable food is crucial to preserve and to extend and ensure the shelf life of products, such as fresh fish. This cold supply chain is commonly used and cost effective compared to continually increasing production to meet increasing demands for these foods. Fish and Fishery products are among the most traded food commodities worldwide and there is a growing number of exporting countries focus their export on these products. Planning an efficient cold supply chain to optimize fish export is starting by identifying factors that have a crucial impact on fish export activities as well as estimating costs to maximize these factors according to their priorities. This research aims to optimize fish export using Goal Programming method and Analytical Network Process (ANP) approach where the integration of these methods gives the estimated cost to be minimized as well as to maximize the factors that count as an important role in fish export. Based on the results obtained, the priority order that affects fish exports is equipment, policy, quality, quantity and price. Equipment becomes a crucial factor because to get the fish with the best quality required a complete tool with good condition. From the order of priority, goal programming is modeled. The result of goal programming gives estimation of cost to be spent by 3 actors. These are fisherman, port and company. Cost estimation for fisherman is IDR 1,060,120,000, for port is IDR 658.458.700 and for company is IDR 657.224.000. The cost will be allocated to maximize equipment, quality and quantity.*

**Keywords:** Cold supply chain, Goal Programming, ANP, Fish Export Optimization

## 1. Introduction

Organizations are facing great challenges to meet dynamic global demand, to remain competitive in the world market of supply chain, not only performance but also supply chain coordination needs to be improved (Cook & Heiser, 2010). Supply chain is a set of approaches applied to integrate suppliers, companies, warehouses and other storage areas efficiently so that products are produced and distributed with the exact quantity, exact location and time to reduce costs and satisfy customer needs (Simchi-levi., et all, 2004). Basically, supply chain management is very important in export distribution activities. Accommodated with this supply chain, distribution activities can be controlled thoroughly from initial suppliers to final customers (Kosasih, 2009). Export distribution needs to be managed well because exports become one source of income for both the State and the company. Good supply chain management can produce good quality products, reduce inventory, reduce costs and improve services (Indrajit & Djokopranoto, 2003; Anatan & Ellitan, 2008).

As the times progressed, lifestyles become more diverse. This has an impact on product demand where demand for products is increasingly diverse and plentiful. One of the commodities that attract the attention of consumers is the fishery sector. With diverse demand led to the development of the concept of supply chain where this development aims to maintain the standard of food quality and safety (Lailossa, 2015). Cold Supply Chain (cold chain) is basically a logistics system that helps in maintaining and providing a range of facilities to ensure ideal storage conditions for perishable goods from the point of origin to the point of sale (Sople, 2011). Cold supply chain is present due to perishable fish characteristics where fish temperature should be maintained from -18<sup>0</sup>C to -22<sup>0</sup>C for good quality. Any temperature changes that occur in fish can cause fish quality degradation

therefore it is important to keep fish temperature stable (Islam & Habib, 2013).

With the characteristics of fish, then cold supply chain performance is considered very crucial. If the product does not meet market requirements, standards or regulations, then the product may be refused (Nunes et al., 2003). For example, Indonesia is geographically 2/3 of Indonesia is an ocean (Rustam, 2016). Unfortunately its only able to meet the fish export of 82.46% and suffered a loss of 461.64 million US dollars (Directorate General of Capture Fisheries, 2014). This will certainly would inflict financial loss if we don't put this matter seriously. Therefore, effective and efficient cold supply chain planning is needed to increase export productivity by reducing expenditure and increasing revenues (Islam & Habib, 2013; Ferris et al., 2001). One way that can be used is by optimizing the factors that affect fish exports (Islam & Habib, 2013). To be able to optimize the factors, an approach that can give an estimate of how crucial these factors are is needed. Analytic Network Process (ANP) is a mathematical theory that allows a decision maker to deal with dependent factors as well as systematic feedback (Tanjung & Devi, 2013). ANP method is able to overcome the weakness of AHP in the ability to accommodate the interrelationship between criteria or alternatives (Saaty, 1999). With ANP method, we get priority from factors influencing fish export so that factor can followed up. To be able to maximize these factors then efficient cost planning is needed. Therefore, an approach is needed to be able to estimate the costs to be incurred. Goal programming is one of the mathematical models that can be used as a basis for making complex decisions to analyze and create problem solutions that involve multiple objectives, in order to obtain an optimal problem-solving solution (Hillier & Lieberman, 1990). The results of goal programming provide an estimate of the costs that must be incurred in order to maximize these factors.

This research differs from optimization research in general. This is because the scope of research is the supply chain of fishery commodities. In general, the optimization system applied to the scope of the object is narrower. For example, Britain (2011) conducted optimization research within the scope of purchasing raw materials in a company. So also with Marpaung (2009), on the research planning optimization of production in a company. Both studies have the same objective of optimizing productivity but the scope chosen is still relatively narrow (company). This study was adopted because most of the optimization was done for a small scope so the study illustrates that optimization can be done for a wider scope (fish exports). Basically, this research is very important in increasing the export of fish because this research aims to optimize the factors that affect fish exports by planning costs efficiently so that fish export activities can run more optimally.

## 2. Literature Survey

In order to optimize the export of fish, it is necessary to know what factors influence the fish exports. Therefore, factor identification is needed. One technique that can be done is to map the cold supply chain. Cold Supply Chain (cold chain) is basically a logistics system that helps in maintaining and providing a range of facilities to ensure ideal storage conditions for perishable goods from the point of origin to the point of sale. A well-organized and efficient cool chain is organized to reduce waste, decay and help keep intact fragile items thereby helping to maintain the quality of harvested food products thereby ultimately making cost-effective systems effective for farmers and ensuring the best quality to end users (Sople, 2011). Based on the concept of cold supply chain, there are several studies that have been done as done by Kitinoja (2013). In the study, it is explained that perishable objects (fish, milk, potatoes and green vegetables) should be at cold or frozen temperatures to keep the quality maintained. Therefore, cold supply chain is used to maintain the quality of these perishable objects. In this journal, cold supply chain planning is emphasized on cold storage work system. During the process of distribution (from upstream to downstream) underway cold storage must be able to keep temperature optimal point. In addition to the journal of Rahayu & Adhi (2016), it is explained that seafood products have perishable characteristics so that proper and controlled handling is required. In this journal, it is emphasized that the handling can be done for perishable objects with good logistic practice supported by good practices (GMP), standard sanitation operation procedure (SSOP) and good hazard analysis critical control point (HACCP).

By doing supply chain mapping, it will provide illustration of activities / factors of any kind that can affect fish exports. These factors necessarily need to be maximized so that fish export activities can be more optimal. But priority is needed to be more focused. One of the techniques that can solve the problem is with ANP method. Analytic Network Process (ANP) is a mathematical theory that allows a decision maker to face dependent factors as well as systematic feedback (Tanjung & Devi, 2013). From the concept of ANP, there are several studies that have been done such as Kurniawati et al

(2013), in his journal explained the selection of suppliers should be done well because it can improve the products produced by a company. The output of this journal is the selection of the best suppliers based on predetermined criteria where the criteria are obtained based on the results of interviews with the company. In addition, Balaji (2012), in his journal explained that ANP method can be integrated with other methods to be able to optimize the performance of the object detection system. The weight of the ANP is used as input for the next method.

Knowing the priority of factors affecting fish exports is not enough to optimize the export of fish. This is because these factors need to be maximized. To be able to maximize these factors, cost efficient planning is required. One approach that can be done is by goal programming method. Goal programming is one of the mathematical models that can be used as a basis for making complex decisions to analyze and create problem solutions that involve multiple objectives, to obtain an optimal problem-solving solution (Hillier & Lieberman, 1990). The concept of goal programming has been widely applied in several studies for optimization purposes. As research conducted by Marpaung (2009), In his research explained that goal programming can be applied to optimize the production of a company. This study emphasizes that optimal production planning can increase profits, reduce costs, reduce production shortages and buildup of finished goods. In addition, Harjianto (2014) also apply the concept of goal programming to optimize production. In this study, the concept of goal programming applied for the optimization of production with different types of products and has a priority. The essence of his research explains that prioritizing production planning is important because it can affect costs and revenues.

Based on the concept of ANP and GP, if both methods are integrated, it will certainly produce more optimal results in the scope of cold supply chain. Integration of these two methods is done by Britain (2011). It is explained that in determining the purchase decision of raw materials required integration ANP and GP to get more optimal decision. This research emphasizes that for raw materials purchased can be more optimal then if the supplier is planned but the selection of raw materials to be purchased also needs to be done. The output of this research is the selection of the best suppliers based on the weight of the results of ANP and the selection of raw materials of what must be purchased with goal programming method so that the cost incurred will be more efficient and the benefit will gain. In addition, Puspaningtyas et al (2013) also conducted research related to the integration of ANP and GP. In this journal it was emphasized that the ANP and GP integration was done to select vendors for road construction projects. Broadly speaking the core of this study is not too different from previous studies but the emphasis in this study is the scope of the research is broader than previous research. Therefore, in this research emphasize that to optimize fish export can be done with integration of ANP and GP with wider scope (fish export).

### 3. Methodology

This study was conducted in one of the ocean fishing ports which has the largest production volume in Indonesia. The stages of this research consist of 7 sections: (1) data collection, (2) mapping the cold supply chain of fish exports, (3) determining factors affecting fish exports, (4) forming ANP model, (5) forming questionnaires and Processing with ANP, (6) forming GP model, (7) processing data with GP.

#### 3.1 Data Collection

The first step is to collect data. The data collected will be the basis for data processing. Data collected are factors affecting fish export along with quantitative data, cold supply chain condition and questionnaire. Quantitative data (quality and quantity of fish) and cold supply chain conditions were obtained from interviews while factors affecting fish exports, reference programming goals and cost of equipment were obtained from literature studies.

#### 3.2 Mapping Cold Supply Chain Fish Export

Cold supply chain data is used as the basis for determining factors affecting fish exports and where mapping techniques with cold supply chain can provide illustration of field conditions during fish export activities to identify any factors that may affect fish export activities. To be able to map the cold supply chain of fish exports, interviews are conducted to port parties. Cold supply chain mapping produces factors that can affect fish exports.

#### 3.3 Determining Factors That Affect Fish Exports

After mapping the cold supply chain, the factors affecting fish export is then known. Factors determined not only based on cold supply chain mapping but also supported by literature review. The factors then validated through a validation process. It aims to determine the factors in accordance with the conditions that occur in the field. The validation stage is done by interviewing port parties.

#### 3.4 Formulation of ANP Model

If the validation phase has been completed then proceed to the formulation of ANP model. This process is carried out with the aim of illustrating the relationship of influencing factors in fish export activities. Basically, ANP is flexible by allowing feedback relationship without need of hierarchy (Saaty, 1996). The meaning of feedback is between factors affecting each other. For example, the quantity factor can influence the factor of the actor because the more the quantity obtained then the profit earned is increased. Likewise, the factor of the actor affects the quantity because if the actor is not careful in catching fish then the quantity obtained will be less.

Formulation of this model is done by conducting interviews with the port and literature review. Once the model is established, next step is to proceed to the validation process. Validation in the process of forming this model aims to

model ANP that is made in accordance with actual conditions. This validation stage is done by interviewing with the port.

#### 3.5 Establishment of ANP Questionnaire and Processing

If this stage has been completed then proceed with the formulation of the questionnaire. The basis of this questionnaire formulation is an ANP model in which a verifiable ANP model is transformed into a questionnaire. The questionnaire was assessed by the interviewee where the interviewee is based on the type of non-probability sampling with the sampling purposive sampling technique. This is based on the method used where the ANP emphasizes that the interviewee must be an expert in their field or understand in thoroughly detail related issues raised. The interviewees are determined by 3 people where each interviewee represents the actor / actor in the activities of the fish export. This is done so that the results of the questionnaire are universal (not biased) and can describe the actual conditions that occur in the field. The results of this questionnaire will serve as the basis for data processing ANP where the data processing is done with the help of super decision software. The output of this ANP is a priority sequence of factors affecting fish exports. The goal is that these factors can be maximized so that the productivity of fish export can increase.

#### 3.6 Goal Programming Model Formulation

After the ANP output is obtained then proceed to GP model formulation. GP model formulation process is based on ANP weight where ANP output will be used as input to form GP model. When forming the model also conducted literature review with the aim of finding a formula related to goal programming model for optimization. The purpose of the formulation of this model is to illustrate the ideal conditions that should occur in the field. In the process of formulation of this model there is a validation process where the process is done by interviewing the port party.

#### 3.7 Goal Programming Processing

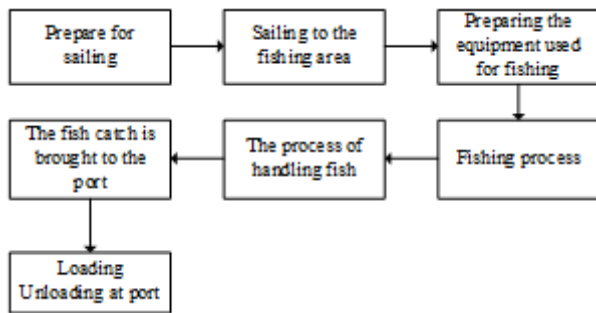
Verified GP model is processed with LINGO software. The output obtained from GP is the estimated cost to maximize the factors affecting fish exports along with the tolerance of value change (sensitivity analysis). The output of this research is to propose to the parties - actors in the export of fish (port, fisherman and company) related to the estimated cost to maximize the factors affecting fish export. So, the cost incurred can be more efficient.

### 4. Model Formulation

The process of formulation an ANP model begins with mapping the cold supply chain of fish exports. Flow of cold supply chain fish export consist of three tiers: tier I (fisherman), tier II (fisherman - port) and tier III (fisherman-port-company).

**Tier I (Fishermen)**

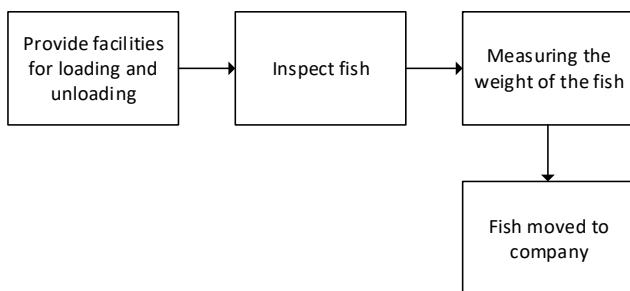
The flow of fish export activities begins by preparing the need for sailing which needs to be prepared such as checking the condition of the ship, preparing ice and hold and providing sufficient fuel. After that the fisherman sailed to the fishing area where the targeted fishing area has set by the port. Fishermen who have arrived then prepare equipment for catching fish such as set up fishing gear etc. If the equipment is set up then continue to the process of fishing where fish caught should be directly handled as directly placed on the insulated hold, cleaned etc. Once completed, the fish is taken to the port for loading and unloading process (see Figure 1).



**Figure 1:** Cold Supply Chain Fish Export (Tier I – Fishermen)

**Tier II (Fishermen - Port)**

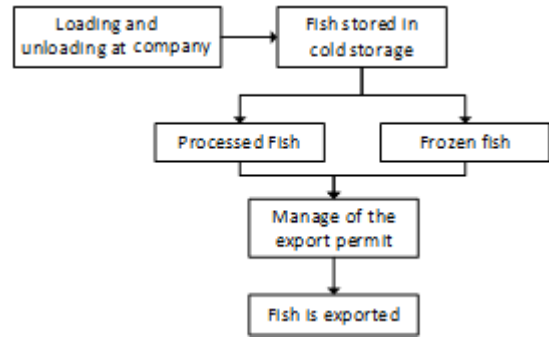
Loading and unloading process carried out in the eastern and western ports. For the process of loading and unloading can run smoothly then loading and unloading facilities must be complete such as sufficient clean water, mooring area etc. If the fish has gone through the loading and unloading process, then the fish will be inspected so that the quality of the fish exported has the best quality. After the inspection process is complete then the fish will be transferred to the company for export (see Figure 2).



**Figure 2:** Cold Supply Chain Fish Export (Tier II - Fishermen – Port)

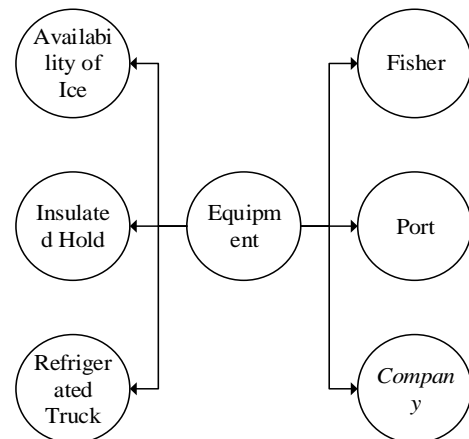
**Tier III (Fishermen - Ports - Company)**

Fish that have arrived at the company are directly stored in cold storage. After that the fish is separated into 2 types of processed fish and frozen fish where the frozen fish will be directly exported while the processed fish will go through the processing before it is exported. After the fish is separated then the port must take care of the export license. If the fish has obtained an export license then the fish is ready to be shipped to the consumer (see figure 3). Cold supply chain mapping results supported by literature review related to the cold supply chain of fish exports will produce factors affecting fish exports (see table 1).



**Figure 3:** Cold Supply Chain Fish Export (Tier III – Fishermen – Port – Company)

There are 4 factors that do not pass validation (see table 1) this is because these factors do not occur when the fish export activities take place so that factors must be eliminated. The validation process is done by interviewing the port. The purpose of this validation is to confirm that the factors defined describe the conditions that occur in the field. Before these factors are transformed into an ANP model form, it is necessary to determine feedback between factors. In total, there are 8 relationships between factors that will be transformed into the ANP model. Here is an example of determining relationships between factors that is shown in Figure 4.



**Figure 4:** Feedback Equipment Factor to Sub-Factor Equipment and Actor

From Figure 4 there is a feedback relationship between the equipment factor with the actor (fisherman, port and company). Basically, the equipment affects the performance of fishermen, ports and company because to maintain the quality of the fish require adequate equipment but there are differences from the tools used for each actor.

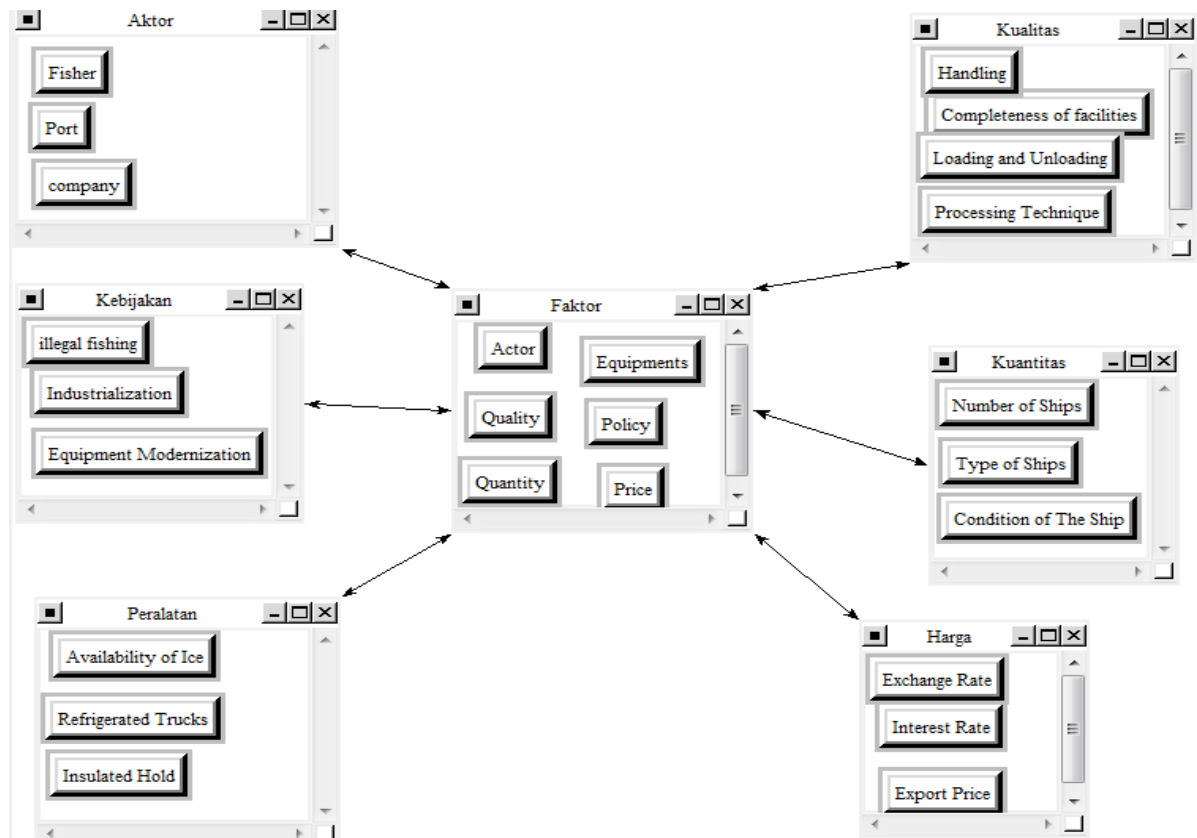
As a fisherman, to maintain the quality of fish, insulated holds required so that fish temperature remains in frozen conditions when taken to the port for loading and unloading process.

Similarly, ports and companies where adequate equipment when loading and unloading must be provided by the company (clean water and mooring area) to maintain the quality of the fish. For the company, in maintaining the quality of fish equipment can affect in terms of fish processing and fish storage where the equipment used to process and storage of fish (cold storage) should be sterile.

For the relationship of the equipment and sub factor factors, the availability of ice may affect the equipment because ice can be a temporary storage alternative if there is a problem in the insulated hold. Refrigerated trucks may affect the equipment because during the fishing process from the loading and unloading areas to the company, refrigerated trucks should be used because fish should not be exposed to direct sunlight and fish temperature should remain optimal (-18<sup>0</sup>Cto -22<sup>0</sup>C) to prevent decay. Insulated hold may affect the equipment because of the perishable characteristic of the fish

that the captured fish must be kept at a temperature of -18<sup>0</sup>C to -22<sup>0</sup>C to maintain its quality.

After determining the relationship between factors is done then proceeded to form the ANP Model. The ANP model is then transformed into a questionnaire where the results of this questionnaire are used as inputs in ANP data processing (see Figure 5).



**Figure 5: ANP Model**

**Table 1: Factors Affecting Fish Exports**

Factor	Sub Factor	Reference	Validation
Actor	Fisher	Retnowati., et all, 2014	v
	Port		v
	Company		v
	Other Port		x
Quality	Loading Unloading	Pratama, et all, 2016	v
	Handling	Felix, 2012	v
	Processing Technique	Irianto&Soesiolo, 2007	v
	Completeness of Facilities	Islam &Habi, 2013	v
Price	Exchange Rate	Pranoto, 2009	v
	Export Price	Manik, 2006	v
	Price of Fish	Yudiarosa (2009)	x
	Interest Rate	Hidayat, 2006	v
Equipment	Insulated Hold	Islam & Habib, 2013	v
		Kitinoja, 2013	
	Refrigerated Truck	Lailossa, 2015	v
	Availability of Ice	Irianto&Soesiolo, 2007	v
Quantity	Number of Ship	Pratama, et all, 2016	v
	Type of Ship		v
	Fish Supplies	Yudiarosa, 2009	x
	Condition of the Ship	Irianto&Soesiolo, 2007	v
Policy	Illegal Fishing	Irianto&Soesiolo, 2007	v

	Industrialization	Center of Fisheries Research and Development (P4b. litbang.kkp.go.id)	v
	Equipment Modernization	Lailossa, 2015	v
Marketing	Offering Fish	Yudiarosa, 2009	x

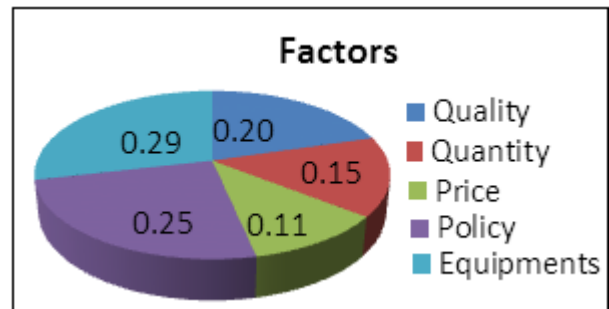
company	0.20601	0.051503
Fisher	0.50880	0.127201
Port	0.28519	0.071297
Actor	0.00000	0.000000
Equipments	0.30305	0.151525
Policy	0.05158	0.025792
Price	0.18895	0.094475
Quality	0.39738	0.198690
Quantity	0.05904	0.029518
Exchange Rate	0.09262	0.004375
Export Price	0.68040	0.032140
Interest Rate	0.22698	0.010722
Equipment Modernization	0.22905	0.002954
illegal fishing	0.69551	0.008970
Industrialization	0.07544	0.000973
Completeness of facilities	0.54705	0.054347
Handling	0.28482	0.028295
Loading and Unloading	0.11041	0.010969
Processing Technique	0.05772	0.005734
Condition of The Ship	0.26838	0.003961
Number of Ships	0.11722	0.001730
Type of Ships	0.61440	0.009068
Availability of Ice	0.54002	0.040913
Insulated Hold	0.35821	0.027139
Refrigerated Trucks	0.10177	0.007710

**Figure 6:** Output of ANP

## 5. Result and Discussion

The results of data collection with a comparison scale questionnaire will be the basis of ANP processing. The ANP output can be seen in figure 6. Because the respondents are set to fill out the questionnaire as many as 3 people then the following is the recapitulation of weights for all respondents (see table 2). Based on ANP result (see table 2), average weight for quality factor, quantity and equipment serve as input in goal programming. This ANP output will provide an overview of what factors have a significant impact on fish exports so that these factors can be handled first. The ANP results show that from the level of urgency that need to be addressed first is the equipment, policies, quality, quantity and price respectively. The weight of this ANP will give priority order so that recommendation from GP will also follow priority pre-existing.

### 1) Factor



**Figure 7:** Weight of Factors

**Table 2.** Recapitulation of ANP Weight

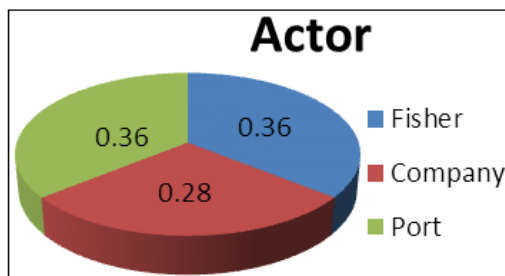
Factor	Weight				
	Fisher	Port	Company	Mean	
<b>Actor</b>					
1	Fisher	0.48	0.08	0.51	0.36
2	Company	0.39	0.25	0.21	0.28
3	Port	0.12	0.67	0.29	0.36
<b>Quality</b>					
1	Loading and Unloading	0.08	0.10	0.11	0.10
2	Handling	0.24	0.56	0.28	0.36
3	Completeness of Facilities	0.57	0.28	0.55	0.46
4	Processing Technique	0.11	0.06	0.06	0.07
<b>Quantity</b>					
1	Type of Ships	0.13	0.76	0.61	0.50
2	Number of Ships	0.21	0.14	0.12	0.16
3	Condition of the Ship	0.66	0.10	0.27	0.34
<b>Price</b>					
1	Export Price	0.68	0.73	0.68	0.70
2	Exchange Rate	0.09	0.19	0.09	0.12
3	Interest Rate	0.23	0.08	0.23	0.18
<b>Policy</b>					
1	Illegal Fishing	0.23	0.73	0.70	0.55
2	Industrialization	0.67	0.19	0.08	0.31
3	Equipment Modernization	0.10	0.08	0.23	0.14
<b>Equipments</b>					
1	Availability of Ice	0.12	0.19	0.54	0.28
2	Insulated Hold	0.61	0.73	0.36	0.57
3	Refrigerated Truck	0.27	0.08	0.10	0.15

Based on figure 7, the priority order is the factor of equipment, policy, quality, quantity and price respectively. Equipment is very crucial because without adequate equipment then fish export activities will be hampered. For example, if there is no insulated hold then the caught fish will quickly be damaged and the fish cannot be exported. Likewise, with the policy where all that is done refers to the rules / policies that have been determined but the difference is without any fishing action, policy can still be done but if without equipment then the fish cannot be caught. Quality is ranked 3<sup>rd</sup> because to get a good quality would require good equipment and policies / regulations are clear. Examples of good fishing conditions and policies related to how to handle fish can produce good quality fish. So also with the quantity where the most important thing in the export activity is the quality of the fish. The quantity of fish will certainly have hindered the export of fish if it is not supported by the quality of fish. The last factor is the price at which prices are adjusted so that the high price is determined by other factors (quality and quantity).

### 2) Actor

In terms of actors, the most crucial actors are fishermen and ports (see figure 8) because the port serves as a container in the export of fish such as issuing export permits to the destination country, providing facilities for the vessel to be

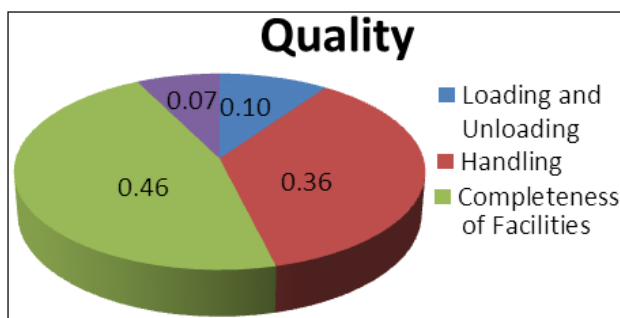
have a comfortable mooring, loading and unloading and so on. Likewise, with fishermen where the actor is an actor who has direct contact with the fish means that without the intervention of the fisherman then the company will not get the fish and fishermen also determine the quality of fish to be exported. Although the company has the lowest weight compared to other actors but the role of the company is also important in the absence of the company then the State revenue will be reduced because the company is the main actor directly related to the consumer.



**Figure 8:** Weight of Actor

### 3) Quality

In terms of quality, completeness of facilities and ways of handling plays an important role in determining the quality of fish (see figure 9), this is because a complete facility will determine the smoothness in the export of fish such as refrigerated trucks needed so that transporting fish from the loading and unloading area to the company fish is not exposed to direct sunlight and the temperature would still be consistent, cold storage is needed to keep the fish temperature consistent because before the fish is exported it needs to take care of the permission, quality sorting and so that there is "space" in the fish. The way the handler looks crucial because the fish could be damaged easily. Extra handlers are required when new fish are caught during the journey.



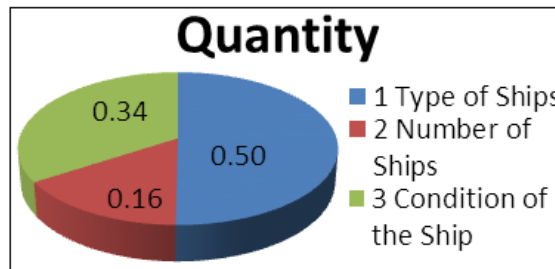
**Figure 9:** Weight of Quality

This way of handling will determine the quality of the fish and the number of fish that can be exported. For processing techniques and loading and unloading methods, these two activities are not very crucial because both activities only require patience from the workforce where this activity if done carefully, the quality of fish will be maintained.

### 4) Quantity

In terms of quantity, the thing to note is the type of ship and ship conditions (see figure 10) where these two aspects have the highest weight compared to the number of ships. This type of ship can be very crucial because basically the ship is

divided into several types with different specifications and purposes. For example, longline type vessels have the specification for catching tuna-type fish because they have fishing gear which suits the surface of tuna fish or *bouke ami* ships which are more suitable for catching squid because the fishing gear is designed based on the surface of the squid. The selection of this type of vessel must be adjusted to the focus of the company where if the focus of the captured fish is not in accordance with the type of ship used then the results will not be maximized.

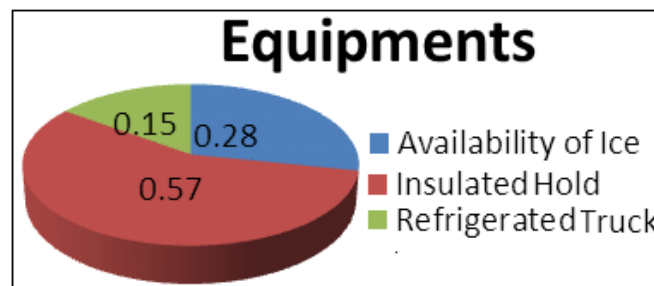


**Figure 10:** Weight of Quantity

If viewed in terms of ship condition, this is crucial because the condition of the vessel will affect the smooth fishing where the condition of a good ship would not only speed up fishing, but also improve the safety of fishermen. It is also due to uncertain sea conditions and the easily damaged condition of the fish, then the condition of the ship needs to be considered more serious so that the safety of the fishermen is maintained and the quality of the fish obtained would be well.

### 5) Equipment

Equipment factors have a great impact in fish export activities (see table 2). The magnitude of the effect of equipment factors on fish export activities is influenced by 3 sub factors are the availability of ice, insulated holds and refrigerated trucks.



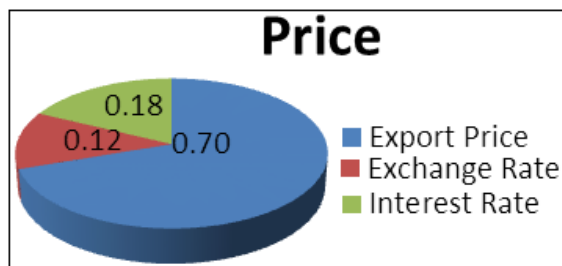
**Figure 11:** Weight of Equipment

Insulated hatch greatly affects the equipment (see figure 11) because it is useful for keeping the fish temperature optimally. This may be due to the perishable characteristics of the fish so that the insulated hold will play a crucial role in maintaining the quality of the fish. Basically, the fish cannot survive long on normal temperature and will trigger the occurrence of decayed fish. If viewed in terms of ice availability, this sub-factor also has an important role because this sub factor will be as a backup if there are things beyond the prediction of fishermen such as problems in hatch or excessive fish obtained. Refrigerated trucks can also play an important role during the transportation process from the

loading and unloading area to the company. Where these trucks need to be used because of the perishable nature of the fish so that the temperature of the fish should always optimal (-18°C & -22°C) to the hands of consumers.

**6) Price**

In terms of price that most affect the price is the export price (see figure 12). This is due to the current condition of export prices to united Europe that defined by Indonesia is defined as high as 22% - 24% when compared to another country (Thailand and Papua New Guinea). This condition must necessarily be accompanied by an increase in fish selling price to cover the high export prices of fish. This will have an impact on the profits obtained because if the selling price of fish is high then the consumer will change hands while if the selling price of the fish is too low will certainly reduce the company revenue.

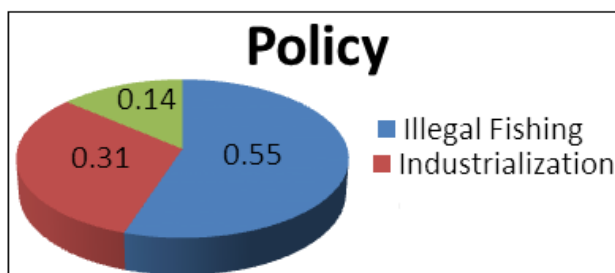


**Figure 12: Weight of Price**

For the sub factor of exchange rate and interest rate is not too significant because during these two sub factors are constant development will not affect the price of fish.

**7) Policy**

If viewed in terms of policy, the thing that affects the largest policy is illegal fishing (see figure 13). This is because these measures can reduce the number of fisherman caught fish. Basically, every ship has its own fishing area where the determination of fishing area is determined by the port to avoid conflicts in the field. However, due to the large / small income of fishermen is measured from the number of fish obtained, then the possibility of fishermen to conduct illegal fishing is high (fishermen catch fish not in the region).



**Figure 13: Weight of Policy**

In terms of industrialization, this policy is very profitable for company because with this policy, the company will get more profit by way of exporting processed fish. But not all companies can do it because of consumer demand. The sub-factor of equipment modernization does not have a big impact, this is because most actors have been comfortable with the tools used and the cost is expensive so it is less likely to modernize the equipment. However, modernization

of this equipment has a major impact in the smoothness of fish export activities because with more modern equipment, it will be faster to process fish, perform loading and unloading and even catch fish.

**Goal Programming Model**

Weights from ANP (see table 2) used as input in GP data processing. Before processing the data with the GP method required the formulation of the model. The formulation of GP models is based on field conditions. This GP model represents the current system condition. The purpose of forming this model is to illustrate the ideal conditions of the field conditions so that the deficiencies that occur in the current system can be optimized. The goal programming model uses the priority principle where priority setting is based on the ANP results. In forming the model, there are 3 objective factors that must be achieved. This is because these factors have a major impact so that the main objectives can be achieved by minimizing the overall variable deviation factors that affect fish exports. The factors chosen to serve as a function of constraints are quantity, quality and equipment this is because these three factors have a direct impact on the smoothness of fish export activities in contrast to the policy and price factors where these factors have a secondary impact on the smooth operation of fish exports (e.g prices will increase If the quality and quantity provided is good so to be able to increase the price then things that need to be emphasized is the quality and quantity).

**1. Quantity :  $aX_1 + bX_2 + cX_3 \geq A_1$**

On quantity constraint, the emphasis is on the income in which the decision variable is cost. Basically, the main objective of fish exporting is to increase revenues at a minimal cost, which means that on the constraint of this quantity the cost should be low and income should be as high as possible.

**2. Quality :  $dX_1 + eX_2 + fX_3 \geq A_1$**

On the constraint of quality, the emphasis is on improving the quality as high as possible to gain the maximum possible. For this constraint is generally the same as the quantity constraint this is because the exported quality must be in accordance with the quantity when loading and unloading means that if the quantity of quality exported in accordance with the quantity when loading and unloading will reduce the occurrence of waste.

**3. Equipment :  $gX_1 + hX_3 \leq A_2$**

Constraint of equipment focused on reducing equipment costs means that the cost of equipment used during fish export activities should be as small as possible so that the profit gained increasing

Note:

- a,b,c,d,e,f,g,h = Variable Decision Constant
- $X_i$  = Variable Decision
- $A_1$  = Income
- $A_2$  = Cost of Equipment

a, b, c, d, e, f, g, h are defined as constants of variable X. This constant value is derived from pairwise comparisons



matrix of each factor. The  $X_i$  variable is defined as the decision variable in which this decision variable represents the investment value that an actor must incur to optimize the fish export. The  $X_1$  variable represents the investment value that must be issued by the port,  $X_2$  represents the value of the investment that must be spent by the fisherman and  $X_3$  represents the value of the investment that must be issued by the company.  $A_1$  is defined as the value to be achieved so that fish exports can be optimized where  $A_1$  represents the export income of tuna and  $A_2$  represents the cost of equipment.

Based on the ANP result, the form of goal programming model used to optimize the fish export activities are as follows

• Objective Function:

$$Z_{\text{MIN}} = 0.28640 DA_3 + 0.20323 DB_1 + 0.15253 DB_2$$

• Constraint :

1) Quantity

$$0.03232 X_1 + 0.36623 X_2 + 0.05904 X_3 - DA_1 + DB_1 = 448331476$$

2) Quality

$$0.09441 X_1 + 0.11791 X_2 + 0.39738 X_3 - DA_2 + DB_2 = 448331476$$

3) Equipment

$$0.19474 X_1 + 0.39738 X_3 - DA_3 + DB_3 = 327400000$$

Note :

Z = Objective Function

$DA_i$  = Upper Variable Deviation

$DB_i$  = Lower Variable Deviation

From the results of the formulation of the model goal programming, the results are as follows

Variable	Value	Reduced Cost
DB1	0.000000	0.2032300
DB2	0.000000	0.1525300
DA3	0.000000	0.2864000
PORT	0.6584587E+09	0.000000
FISHER	0.1060120E+10	0.000000
COMPANY	0.6572240E+09	0.000000
DA1	0.000000	0.000000
DA2	0.000000	0.000000
DB3	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.6584587E+09	0.000000
6	0.1060120E+10	0.000000
7	0.6572240E+09	0.000000
8	0.000000	0.000000
9	0.000000	0.000000
10	0.000000	0.000000
11	0.000000	0.000000
12	0.000000	0.000000
13	0.000000	0.000000

**Figure 14: Goal Programming Results**

The results of GP (see figure 14) will illustrate the estimation of the costs to be incurred by the actor to be able to optimize fish exports. The estimated cost that must be spent by the port, the fishermen and company is IDR 658,458,700; IDR

1,060,120,000 and IDR 657,224,000 respectively. The estimated value will be allocated for equipment, quality and quantity (as per ANP results). For ports, the estimated cost can be used for RFID (Radio Frequency Identification) implementation to control overall fish export activities. Organize seminars aimed to fishermen and company in order to maintain and improve the quality of fish to be exported and provide umbrella tent when Loading and unloading takes place to avoid fish from direct sunlight contact. For fishermen, cost estimation can be allocated to buy longline / pursein boat because fisherman role only has an effect on quantity and quality hence good ship selection will increase quality and quantity of fish obtained. The company's estimated value can be allocated to the maintenance / purchase of tools such as insulated holds. Insulated hold is very important because as a place to store fish during sailing, its condition must always be optimal. Then the cost can also be allocated to buy refrigerated trucks because the current conditions of transportation used mostly still use open trucks and are susceptible to direct contact with sunlight. If refrigerated trucks have been used then the costs can be allocated for truck maintenance or modernize equipment to process fish to minimize the error of fish processing. The remainder can be allocated to provide training to its employees for skill in processing fish so that fish quality is maintained. To support the above GP results required sensitivity analysis which aims to provide an overview of the lowest and highest estimate values.

Objective Coefficient Ranges:			
Variable	Current Coefficient	Allowable Increase	Allowable Decrease
DB1	0.2032300	INFINITY	0.2032300
DB2	0.1525300	INFINITY	0.1525300
DA3	0.2864000	INFINITY	0.2864000
PORT	0.000000	0.000000	0.000000
FISHER	0.000000	0.000000	0.000000
COMPANY	0.000000	0.000000	0.000000
DA1	0.000000	INFINITY	0.000000
DA2	0.000000	INFINITY	0.000000
DB3	0.000000	INFINITY	0.000000

Righthand Side Ranges:			
Row	Current RHS	Allowable Increase	Allowable Decrease
2	0.4483315E+09	0.1047854E+09	0.1627589E+09
3	0.4483315E+09	0.5055313E+09	0.3254648E+09
4	0.3274000E+09	0.3773097E+09	0.8392597E+08
5	0.000000	0.6584587E+09	INFINITY
6	0.000000	0.1060120E+10	INFINITY
7	0.000000	0.6572240E+09	INFINITY
8	0.000000	0.000000	INFINITY
9	0.000000	0.000000	INFINITY
10	0.000000	0.000000	INFINITY
11	0.000000	0.000000	INFINITY
12	0.000000	0.000000	INFINITY
13	0.000000	0.000000	INFINITY

**Figure 15: Sensitivity Analysis**

From the sensitivity analysis results (see figure 15) it is known that for the port, the fishermen and the company tolerance of the permissible value changes to optimal value of the decision variable remains optimal is 0. It is interpreted that if slight change occurs, then the optimal value of the decision variable will change.

## 6. Conclusion

Based on the result of the research, it is known that to optimize the export activity of fish factor which has big impact in the fish export activity and need to be handled first is ordered as equipments, policy, quality, quantity and price.

From the priority sequence, the estimated cost that need to be issued by the actors to be able to optimize these factors are the port of IDR 658.458.700, the fisherman of IDR 1.060.120.000 and the company of IDR 657.224.000. For ports, these costs will be allocated to implement RFID, counseling / seminars and tent provision. For fishermen the cost is allocated to purchase a longline / pursein vessel and for the company the cost is allocated to equipment maintenance / purchasing, employee training and purchasing refrigerated trucks.

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