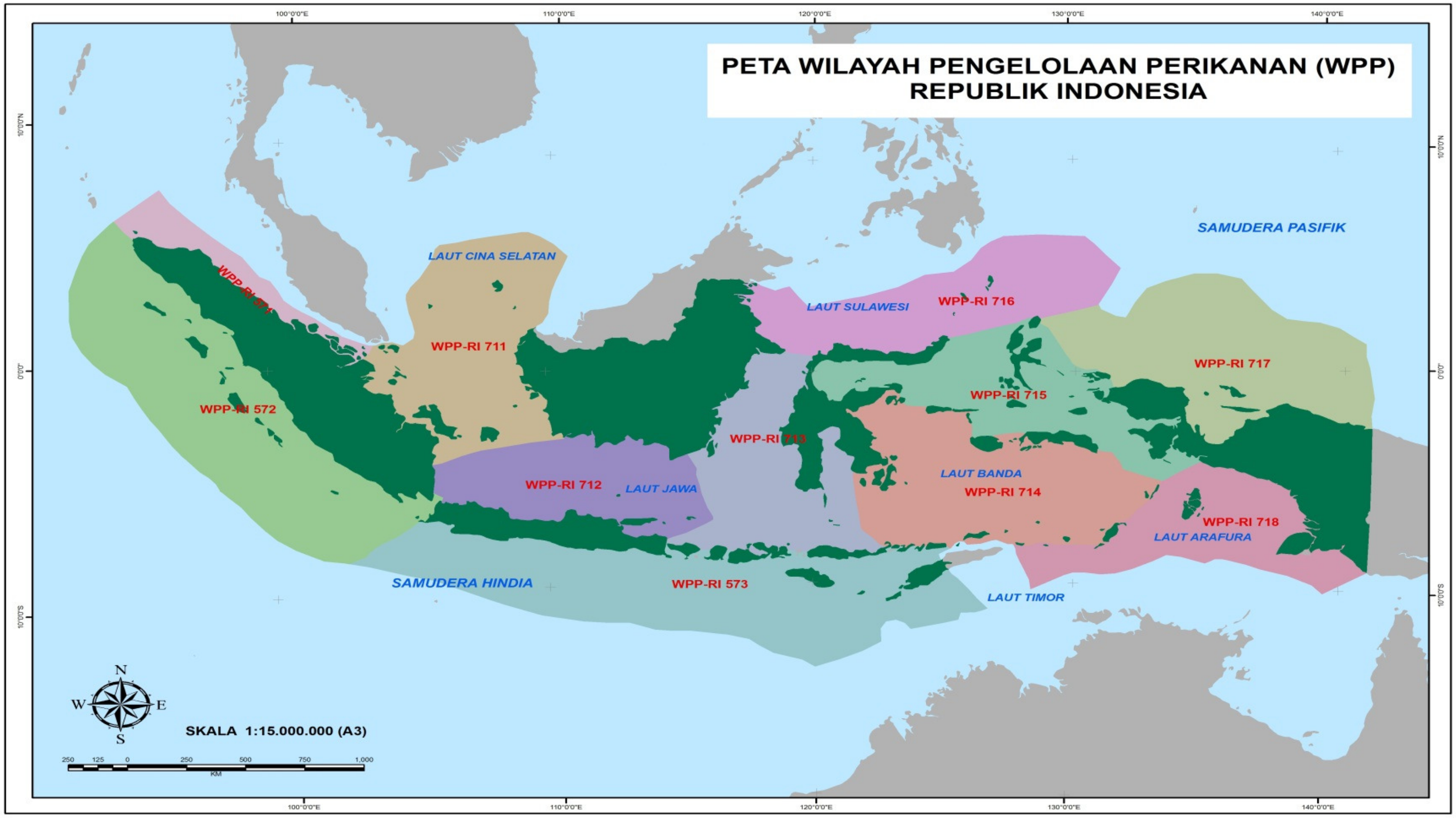
Designing Fish Logistics System for Indonesia based on Central Sulawesi Resources



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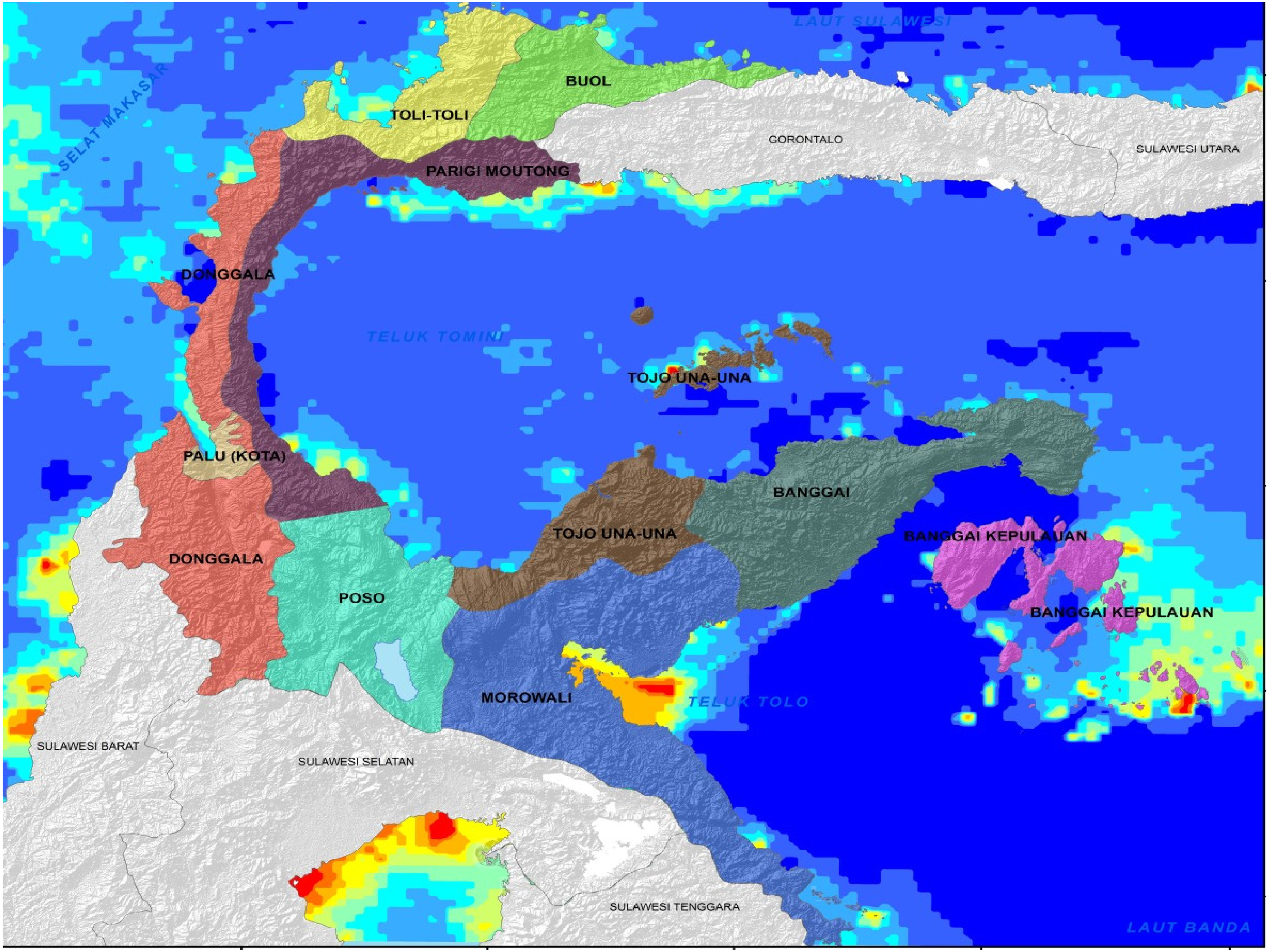


LAUT SULAWESI
SELAT MAKASAR
TOLI-TOLI
BUOL
GORONTALO
SULAWESI UTARA
PARIGI MOUTONG
DONGGALA
TELUK TOMINI
TOJO UNA-UNA
PALU (KOTA)
BANGGAI
TOJO UNA-UNA
BANGGAI KEPULAUAN
DONGGALA
POSO
BANGGAI KEPULAUAN
MOROWALI
TELUK TOLO
SULAWESI BARAT
SULAWESI SELATAN
SULAWESI TENGGARA
LAUT BANDA

Logistics

Bawersox (1978) :

logistics is a strategic management process in the form of goods delivery and storage, including spare parts and finished goods from suppliers, inter company's facilities and to their customers.

Ghiani et al (2004) :

logistics system related to distribution process, warehousing, transportation terminals, the process of those processing, and others.

Introduction

- Indonesia, from fishing business point of view is divided into two territories: **industrial areas** in Java and **production areas** outside Java.

- Raw materials flow from production areas to industrial ones.

- Inefficient logistics impede the flow of raw materials. Such a case, a lot of fish processing industries in Java are facing raw material deficits.

- Central Sulawesi has sea waters located in Makassar Strait, Tolo Gulf, Tomini Gulf and the Celebes Sea, with a large quantity of fish resources. Therefore, it has a promising chance to become a source of fish raw materials demanded by industries in Java. However, the opportunity has not been realized due to the lack of fish logistics network efficiency.

- In order to solve the problem, a proper logistic model is a must.

Research Objective

to design ***a specific logistic model*** for fish in Indonesia based on Central Sulawesi resources as a productive supplier for Jakarta and Surabaya (Java) as industrial areas.

Some Previous Studies – Critical Review

- Some researchers have been trying to develop logistic and transportation models, but it seems the findings have not fully suited to solve the logistical problems encountered in fish business.

- In ***p-Median Model*** introduced by Hakimi (1965), placing a hub close to the demand point can minimize the movement costs.

- O'Kelly (1986 and 1987) developed ***a quadratic models of hub-and-spoke*** with an interfacility linkage costs causes lower cost but at the same time hub facilities increase.

- Campbell (1994) formulated ***p-Hub Median*** (p-HM) and related it to ***p-Median*** (pM). It describes the problem of discrete hub location.

- Aykin (1995), about one and several hubs provide two solutions: fist is that the movement from the origin to the destination through a hub (single), and second to allow the flow from the origin to different hubs (multiple) determined by destination.

- Zapfel and Warner (2002) integrates operational decisions in a transport system of pure hub-and-spoke to obtain the lowest costs of transportation due to the depot-overlapping cooperation.

- The model implies efficient logistics as a function of distance, inter-hub interaction, and hub-spoke and logistics operations integration. In fact, the model is suitable for air passengers or cargo air transports with a large volume and relatively stable frequency. However, it is still difficult to be applied to solve fish logistic problems facing the supply inconsistency with a low quantity.

Some Previous Studies

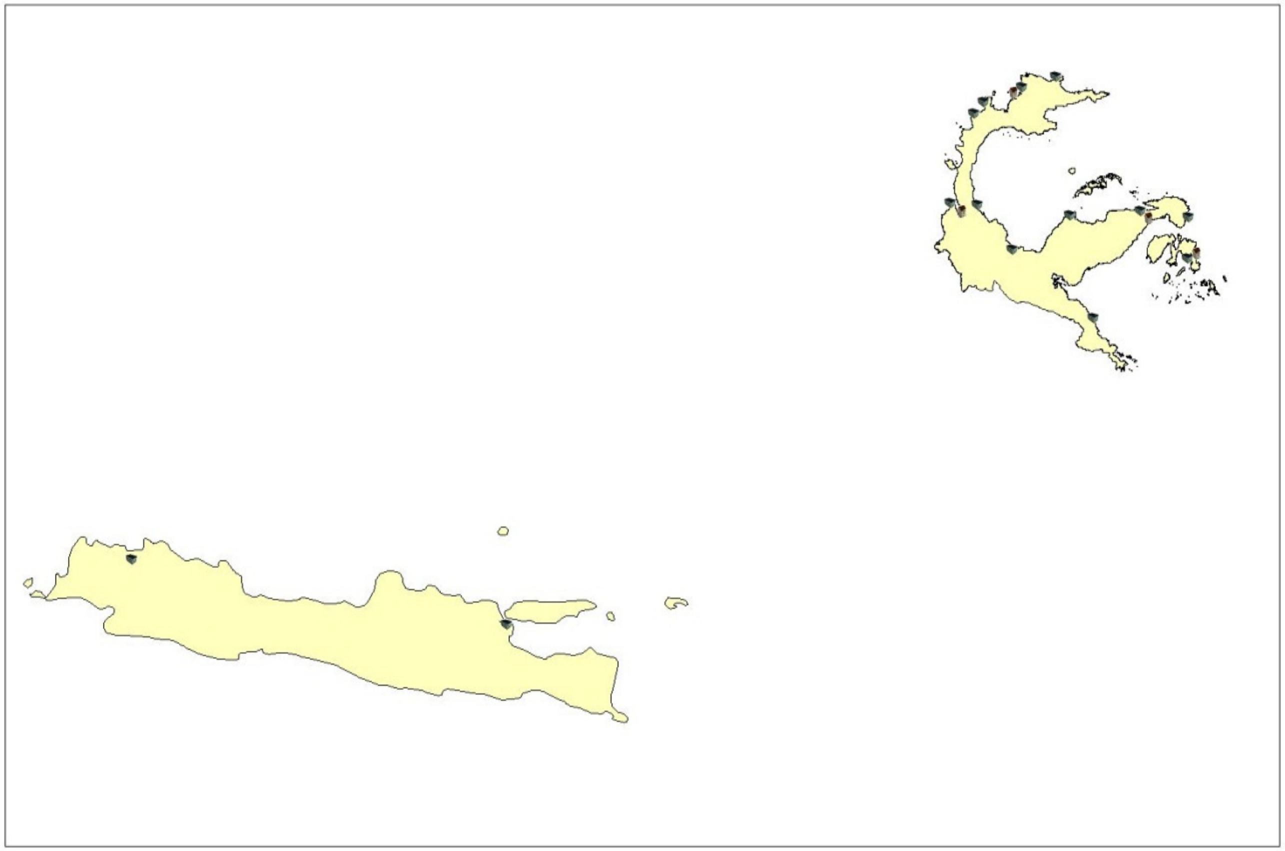
- **Kuby and Gray (1993)** integrates stop-overs and feeders in a mixed-integer program for a case where a facility location has been determined by analyzing the case of cargo package network managed by Federal Express. The model allows less flights but they cause higher loading factors and the total flow distance is reduced. Therefore, saving investment occurs for aircraft, labor and fuel. Stopover and feeder services seem to be close to the fish logistics characteristics. Neverthless, a shortage of fish quantity create extra costs for the waiting times, and the fish flow movement will always be violated.

- **Wu (2008)** examined a logistic relationship between two warehouses, Guangzhou in Southern China and in Hong Kong. A mixed integer model specified can indicate the number and the composition of vehicles for each route. Although the model can solve the scenario supply which is smaller than the demand, the transhipment presence for fish logistics may create a significant holding costs that mcauses inefficient logistics.

- **Agarwal and Johari (2013)** developed an integrated model that can simultaneously minimize distribution costs; optimizing plant location, determining the flow in a network, and determining the composition and the frequency of freights. This multi-echelon model is similar to three-entity logistics model (factories, wholesalers, retailers) analyzed by Ma and Suo (2006), that each echelon has logistics costs; from factories to wholesalers, inventory costs for wholesalers, and product delivery costs from wholesalers to retails. The costs at each echelon can be observed along fish logistics process. Unfortunately, such a model has not been applied for fish logistics. The model used for goods produced by manufactures in a larger volume continuosly without considering holdong costs needed to keep fish quality and to wait for fish sufficient quantity to be transported to the destination.

CENTRAL SULAWESI FISH LOGISTICS AT GLANCE

Figure 1
Fish Landing Locations Observed in Central Sulawesi



Fishing grounds of Central Sulawesi located in four fishery management areas and rich of fish resources that makes Central Sulawesi appears to be crucial for Indonesia logistics connectivity, especially as a supplier of fish raw materials.

In this study, fish landings are the locations where the fish are landed by a fishing boats.

Fish landings are found along the coastal areas of Central Sulawesi, but only a few of them or only those supported by large fishing boats can supply for cold storages continuously. Small boats with limited fishing gear makes them not capable to supply frozen fish industry continuously. Therefore, this study focused on 12 fish landings operating 46 large fishing boats .

Table 1
Maximum Capacity for Fish Landings and Per-Fishing Boat

No	Fish Landings	Production Capacity (Kg/month)	Fishing Boats (Unit)	Per-Boat (Kg/month)
1	Labuan Bajo	46,690	4	11,673
2	Ogoamas	43,760	3	14,587
3	Ogotua	84,750	4	21,188
4	Baolan	147,632	9	16,404
5	Buol	48,268	4	12,067
6	Tinakin	37,870	4	9,468
7	Balantak	47,910	3	15,970
8	Pagimana	40,200	3	13,400
9	Bente	74,438	4	18,610
10	Ampana	45,000	5	9,000
11	Poso	38,025	2	19,013
12	Toboli	10,000	1	10,000
	Total	664,543	46	14,447

Source: Logistics Survey, Avril-May 2015

Fishing boat caughts are landed at fish landing areas to be delivered to cold storages. Thus, fish landing capacity shows the total amount of fish available in fish landings during a certain period, for example, for one month. Mathematically, fish landing capacity is obtained by multiplying the number of trips and the catch volume per-trip for the entire fishing boats.

When the fish has been landed, logistics players who have fishing boats contact the cold storage businessmen. Logistics players make a decision whether to supply cold storages or not, it depends on fish price they offer. However, very often, fish landings posses plentiful volume of fish. In such circumtance, fishing boat owners are not interested in fish price, because the fish must be immediately transported to cold storages or the fish will no longer kept causing substantial losses for the fishing boat owners.

Table 2
Cold Storage Capacity and Fish Demand (kg/month)

No	Capacity	Toli-Toli	Palu	Luwuk	Tinakin	Total
1	Cold Storages	135,000	100,000	75,000	87,500	397,500
2	Demand :					
	Surabaya					159,000
	Jakarta					238,500

Source: Logistics Survey, Avril-May 2015

Logistics activities in Central Sulawesi operating four cold storages producing prozen fish to fullfil the order from Jakarta and Surabaya (Java), namely Tolitoli Cold Storage with a capacity of 270 tons, Palu (200 tons), Luwuk (150 tons), and Tinakin (175 tons).

A cold storage has a multiple function; as a fish freezing plant, and as a temporary storage to wait for definite volume to be transported to Java. In other words, cold storage owners must be able to send all the fish stocks or they must be able to create a zero inventory.

Table 2 shows the fish logistics activity in Central Sulawesi, where at maximum fish landing capacity (monthly), cold storages can only accommodate half of them.

Because of zero inventory, all frozen fish are transported to meet the demand for Jakarta (60%) and Surabaya (40%).

Table 3
Logistics Costs from Fish Landings to Cold Storages (Rp/kg fish)

No	Fish Landings	Toli-Toli	Palu	Luwuk	Tinakin
1	Labuan Bajo	2,935	1,235	4,735	5,935
2	Ogoamas	1,795	1,868	5,368	6,568
3	Ogotua	1,480	1,730	5,230	6,430
4	Baolan	959	2,504	6,004	7,204
5	Buol	1,718	3,418	6,918	8,118
6	Tinakin	7,004	5,304	1,804	759
7	Balantak	6,764	5,064	1,564	2,764
8	Pagimana	3,939	2,239	1,325	2,525
9	Bente	5,008	3,308	3,308	4,508
10	Ampana	4,262	2,562	1,908	3,108
11	Poso	3,964	2,264	2,464	3,664
12	Toboli	3,464	1,764	2,664	3,864

Source: Logistics Survey, Avril-May 2015

Three groups of logistics costs as a consequence of fish logistics activity in Central Sulawesi: costs incurred by fishing boat owners to reach cold storage (C1), holding costs (C2), and shipping costs from cold storages to destinations (C3). Logistic costs C1 including the costs of loading-unloading fish, boxes, icebergs, communications, vehicle maintenance, and transportations. Each item of costs is weighted by fish volume to obtain fish logistics cost per-kg, and summed it to obtain the logistics costs from fish landing areas to cold storages. All of the costs under the fishing boat owners' expenditures.

As shown in Table 3, most of the fish logistics costs are increasing as a function of distance. This indicates a significance of transportation costs in the total costs. Logistics costs to reach Palu cold storage from Ogotua fish landing should be more expensive than that from Ogoamas fish landing to Palu cold storage. Although Ogoamas is closer to Palu, but the logistics costs other than transportation is much higher. The reason is that Ogotua don't pay for the loading or unloading fish from the fishing boats to the fish landings and to the pick-ups.

Table 4
Holding Costs at Cold Storages

No	Item	Toli-Toli	Palu	Luwuk	Tinakin
1	Volume (kg)	135,000	100,000	75,000	87,500
2	Holding Costs :				
	Total	54,000,000	54,000,000	46,275,000	63,000,000
	Per-kg	400	540	617	720

Source: Logistics Survey, Avril-May 2015

- During the interval time to fullfil the volume freight, holding costs must be covered under cold storage owners, including electricity, laborers, water, depreciation, and packing.

- The proportion of electricity cost is particularly significant for holding costs or about 70% due to freezing and storages activities. Table 4 shows that holding costs per-unit with largely fixed costs, tends to decrease as the impact of the increase of fish volume storaged.

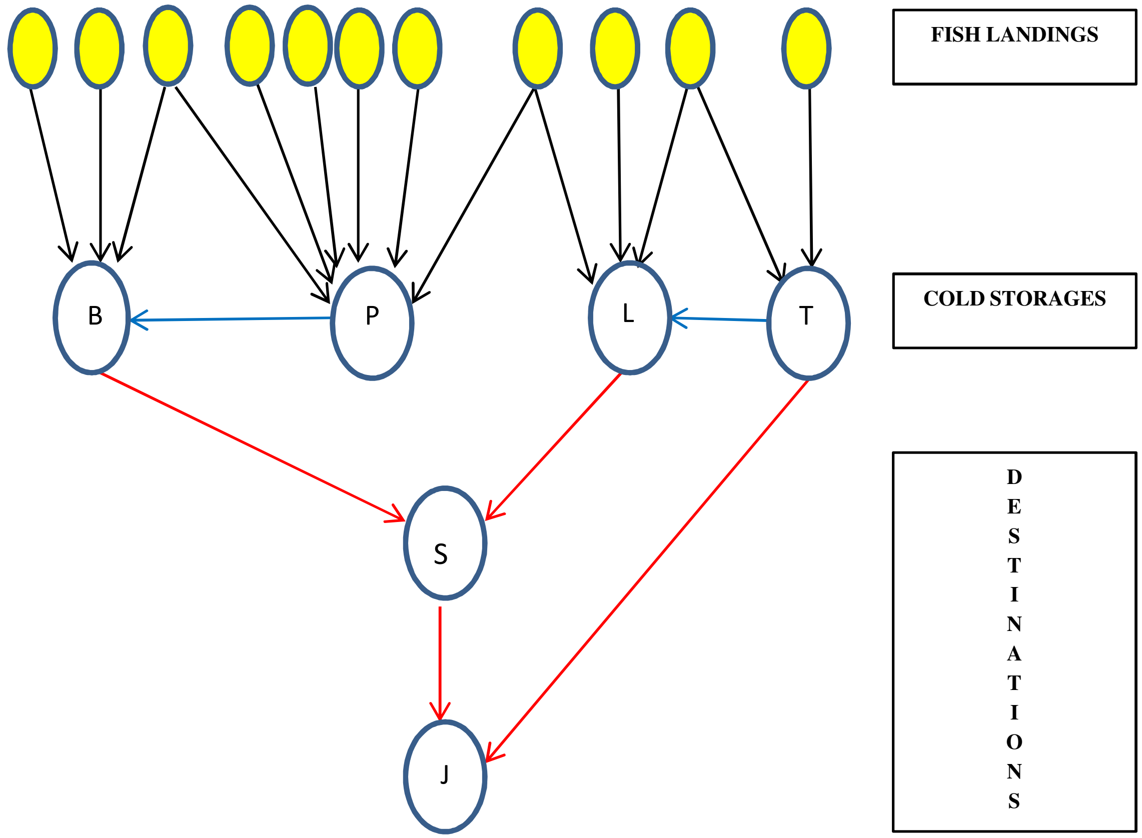
Table 5
Shipping Costs from Cold Storages to Destinations (Rp/kg)

No	Cold Storages/Hub	Surabaya	Jakarta
1	Baolan	2,098	2,879
2	Palu	1,550	2,283
3	Luwuk	2,200	2,956
4	Tinakin	2,100	2,700

Source: Logistics Survey, Avril-May 2015

PROBLEM DESCRIPTION

Figure 2
Fish Logistics Network of Central Sulawesi to Jakarta and Surabaya



- Fishing boat owners may sell the fish to any cold storages. This occurs as the absence of a competitive logistics network that lead fishing boat owners to deliver their freights to the particular cold storages. Consequently, logistics become ineficient and the fishing boat owners suffer from unprofitable operation.

- The ineficient logistics network limits the fish quantity that should be supplied to the cold storages in spite of the large volume of fish available on fish landings. The lower the quantity of fish in cold storages the higher the cost-per-unit to freez the fish.

- The costs also increase as the longer waiting time to make the volume needed sufficient to be transported to Jakarta and Surabaya.

MODEL DEVELOPMENT

The logistics model we developed answers the total amount of fish supplied for cold storages and where those fish volume derived so that the logistics costs can be minimized.

Some facts require us to make rational assumptions for the model, as follows:

- Fish landings as places where fishing boats unload the fish have been figured out.
- Cold storage locations have been known as the initial places to deliver fish to Jakarta or Surabaya (Java).
- Frozen fish demand in Jakarta and Surabaya has been known.
- The fish must go through cold storages in Central Sulawesi before transported to Jakarta or to Surabaya, so that a mixed integer programming (MIP) is suitable to solve the fish logistics problems.

Let us suppose ***l***, ***s***, and ***d*** respectively are the index of fish landings, cold storages, and destinations.

Below are some parameters in the model :

I	: the total volume of fish
L	: the number of fish landings
S	: the number of cold storages
D	: the number of destinations
Q_l	: fish capacity on fish landing l
W_s	: storage capacity of fish in cold storage s
R_d	: demand for fish in the destination d
LC_{ls}	: logistics cost-per-kilogram of fish transported from fish landing ***l*** to cold storage ***s***
F_s	: freezing cost-per-kilogram of fish in cold storage ***s***
LC_{sd}	: shipping costs-per-kilogram of fish transported from cold storage ***s*** to destination ***d***

The following are three decision variables :

x_{ls}	: the volume of fish transported from fish landing ***l*** to cold storage ***s***
x_{sd}	: the volume of fish transported from cold storage ***s*** to destination ***d***
y_s	: is binary, valued 1, if the fish is flowed through the cold storage ***s*** and 0 otherwise

Mixed integer programming is specified to minimize the total logistics costs :

$$Min \quad \sum_{s=1}^{S}\sum_{l=1}^{L} LC_{ls}x_{ls} + \sum_{s=1}^{S} y_s F_s I_s + \sum_{d=1}^{D}\sum_{s=1}^{S} LC_{sd}\, x_{sd}$$

subject to :

1) The fish volume transported from fish landings to cold storages does not exceed the fish capacity on the fish landings :

$$Q_l \geq \sum_{s=1}^{S} x_{ls} \qquad \forall\, l, s$$

2) Cold storage capacity does not exceed the fish volume transported to cold storages :

$$W_s \leq \sum_{l=1}^{L} x_{ls} \qquad \forall\, l, s$$

3) The fish volume transported to the destinations from cold storages does not exceed the cold storage capacity :

$$W_s \geq \sum_{d=1}^{D} x_{sd} \qquad \forall\, s, d$$

4) The fish volume transported from cold storage to destination does not exceed the fish volume transported to the cold storages :

$$\sum_{l=1}^{L} x_{ls} = \sum_{d=1}^{D} x_{sd} \qquad \forall\, l, s, d$$

5) All customer demands at the destinations can be satisfied :

$$R_d = \sum_{s=1}^{S} x_{sd} \qquad \forall\, d$$

6) All continuous variables x_{ls} and x_{sd} are positive :

$$x_{sd} \geq 0 \qquad \forall\, s, d$$
$$x_{ls} \geq 0 \qquad \forall\, l, s$$

7) Decision variable y_s is binary :

$$y_s \in \{0,1\} \quad \forall\, s$$

COMPUTATION AND ANALYSIS

- Computation datas are based on 12 fish landings, 46 fishing boat owners and 4 cold storages routinely carry out the logistics activities in Central Sulawesi.
- The data was derived from a field survey.
- The survey was also conducted for logistics providers in Jakarta and Surabaya.
- The researches studied the one-month logistics data chosen in 2014.
- The Solver software 2015 allows us to applied the model.

The current case

The term current case in the study is the ongoing logistics activities whose costs must be minimized.

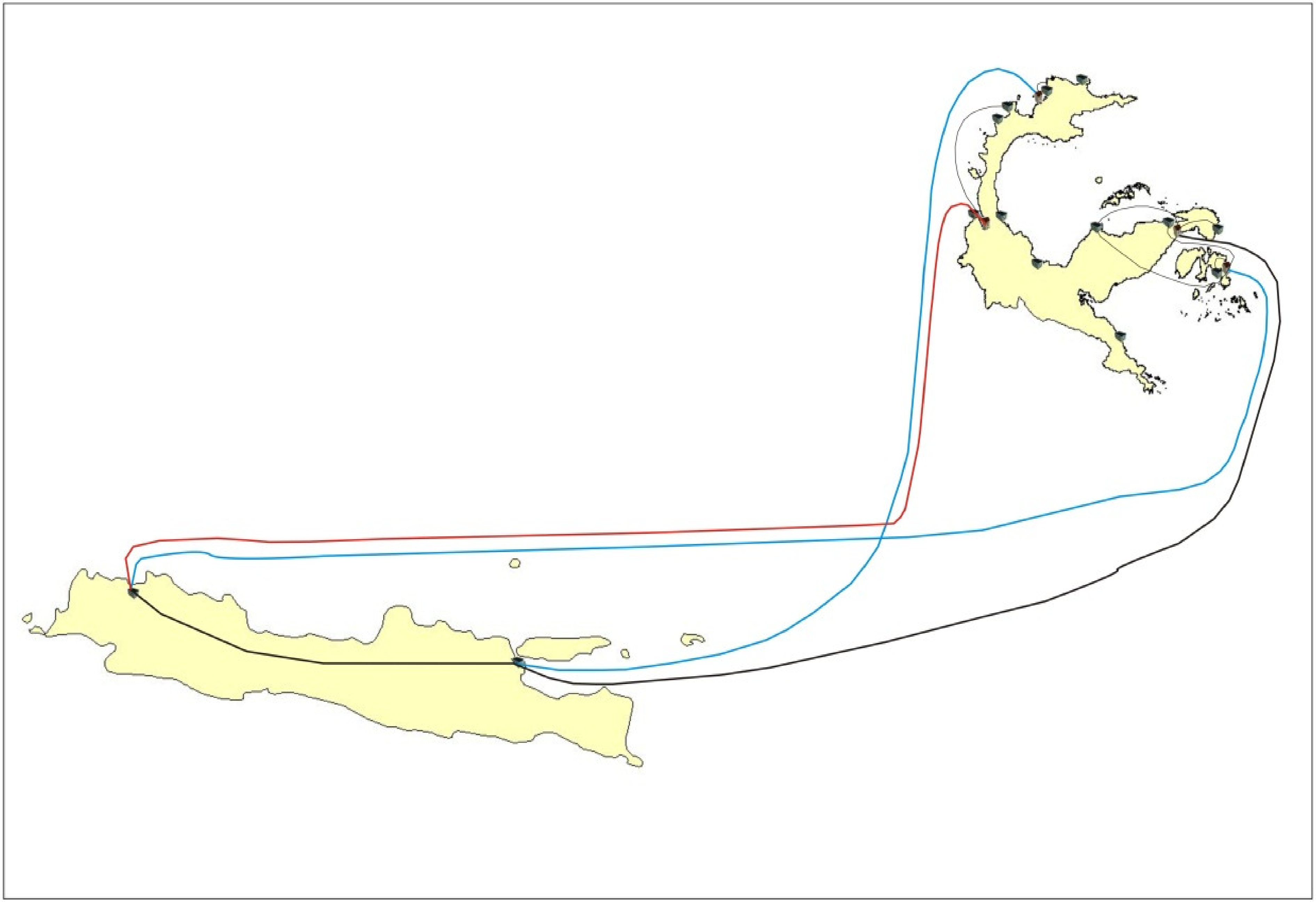
Table 6

Computational Result Summary of a Current Case for 397,500 kg of Fish Demands

Fish Landings	Cold Storages					Capacity	Not Used
	Tolitoli	Palu	Luwuk	Tinakin	Total		
Labuan Bajo	-	46,690	-	-	46,690	46,690	-
Ogoamas	-	-	-	-	-	43,760	43,760
Ogotua	-	53,310	-	-	53,310	84,750	31,440
Baolan	135,000	-	-	-	135,000	147,632	12,632
Buol	-	-	-	-	-	48,268	48,268
Tinakin	-	-	-	37,870	37,870	37,870	-
Balantak	-	-	47,910	-	47,910	47,910	-
Pagimana	-	-	-	40,200	40,200	40,200	-
Bente	-	-	-	-	-	74,438	74,438
Ampana	-	-	27,090	9,430	36,520	45,000	8,480
Poso	-	-	-	-	-	38,025	38,025
Toboli	-	-	-	-	-	10,000	10,000
Total	135,000	100,000	75,000	87,500	397,500	664,543	267,043
Destination					Total		
Jakarta		100,000	51,000	87,500	238,500		
Surabaya	135,000		24,000		159,000		
Total	135,000	100,000	75,000	87,500	397,500		
LOGISTIC COSTS (MIP)					1,734,140,180		

- In the existing logistics, the cold storages can fullfil the fish demands in Java, or only 60% of fish landing capacity. In other words, 267,043 kg of fish were not transported to cold storages. The total 238,500 kg of fish demands in Jakarta fullfiled by three cold storages : Palu, Luwuk, and Tinakin. While the 159,000 kg of fish demands in Surabaya fullfiled by two cold storages : Tolitoli and Luwuk. The total logistics costs resulted through optimation for this configuration is 1,734,140,180 rupiahs
- The logistics costs have a correlation with the distance (of fish landings to cold storages), but not always consistent, so that the allocation of fish landings directed by logistics costs to a nearby cold storage.

Figure 3
Logistics Network of Current Case Configuration



Scenario 1 : Fish Landing Capacity

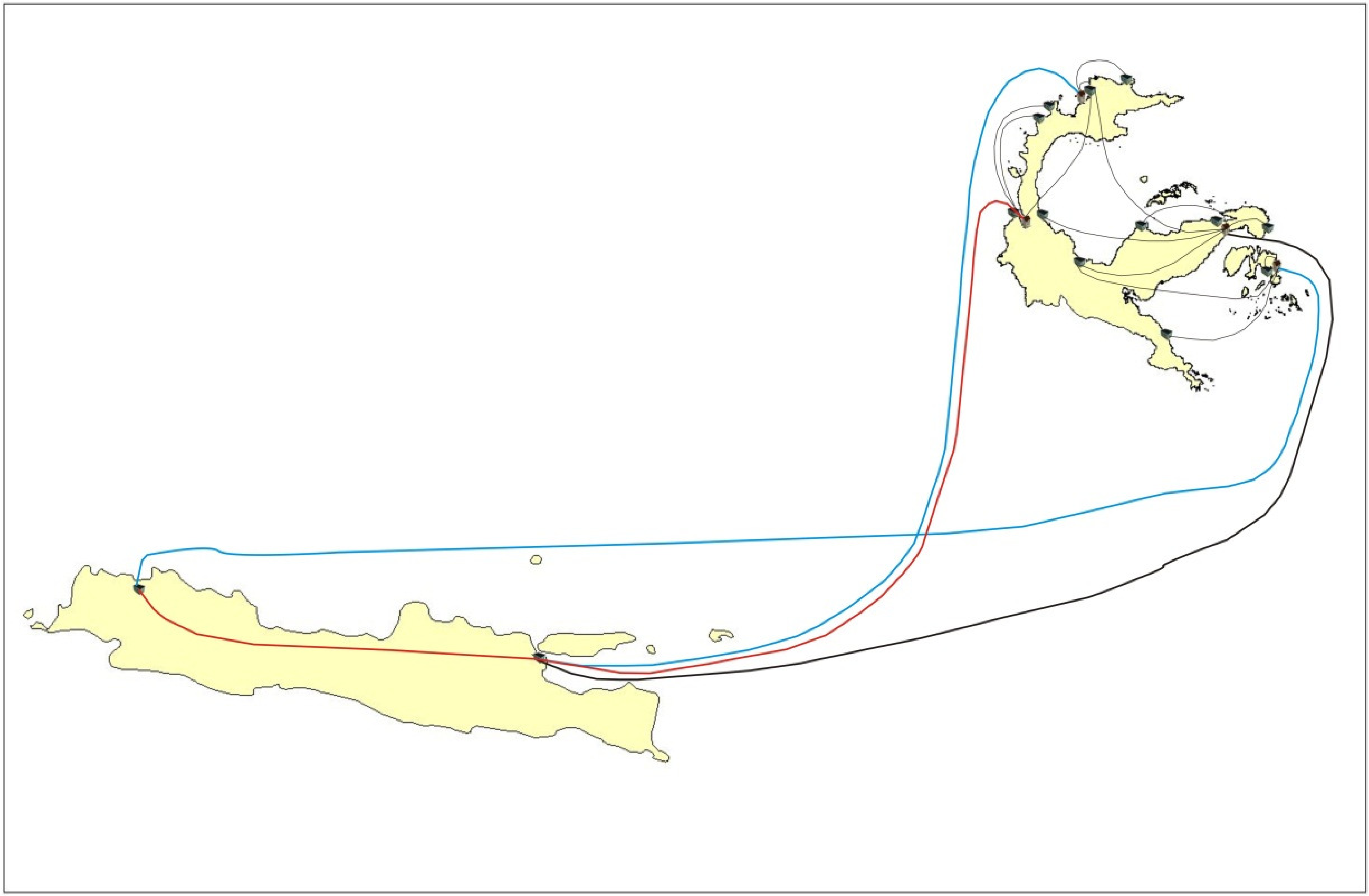
- In this scenario, the total fish volume on the fish landings will be transported to cold storages to fullfil Java demands.
- Instead of providing new cold storages, the existing cold storages should be operated fully. Therefore, the fish volume transported to Tolitoli cold storage is 164,543 kg/month, Palu 200,000 kg/month, Luwuk 150,000 kg/month, and Tinakin 150,000 kg/month. The entire fish volume is 664,543 kg/month or equal to fish landing capacity.
- Logistics costs, except for freezing fish is stated in kilogram, then the costs needed to allocate the supply is equal to the costs in the previous current case.
- Similar to the previous calculation that the unit cost of freezing fish was calculated based on cold storage capacity.

Table 7
Computational Results Summary for Scenario 1 – Fish Landing Capacity

Fish Landings	Cold Storages					Capacity
	Toli-Toli	Palu	Luwuk	Tinakin	Total	
Labuan Bajo	0	46,690	0	0	46,690	46,690
Ogoamas	0	43,760	0	0	43,760	43,760
Ogotua	0	84,750	0	0	84,750	84,750
Baolan	116,275	24,800	6,557	0	147,632	147,632
Buol	48,268	0	0	0	48,268	48,268
Tinakin	0	0	0	37,870	37,870	37,870
Balantak	0	0	47,910	0	47,910	47,910
Pagimana	0	0	40,200	0	40,200	40,200
Bente	0	0	0	74,438	74,438	74,438
Ampana	0	0	45,000	0	45,000	45,000
Poso	0	0	333	37,692	38,025	38,025
Toboli	0	0	10,000	0	10,000	10,000
Total	164,543	200,000	150,000	150,000	664,543	664,543
Destination	Toli-Toli	Palu	Luwuk	Tinakin	Total	
Jakarta		115,817		150,000	265,817	
Surabaya	164,543	84,183	150,000		398,726	
Total	164,543	200,000	150,000	150,000	664,543	
LOGISTIC COSTS (MIP)					3,040,193,683	

- The scenario changed the configuration of fish allocation from the fish landings to the cold storages, either the origins or the volumes. In the case where a fish landing has less stock, other fish landings can supply.
- Cold storages in Tolitoli, Palu, and Luwuk can fullfil Surabaya demands. Cold storages in Palu and Tinakin provide for Jakarta demands.
- This configuration changes the results where the total logistics costs appears to be 3,040,193,683 rupiahs or 4,575 rupiahs per kilogram of fish. It means that flogistics cost per-kilogram is higher (212 rupiahs) than it was met in current case.
- Although holding costs are significantly reduced as the increasing of fish volume stored in cold storages, the cost reduction can not compensate the cost increase occurs during the activities of fish logistics both from fish landings to cold storages and from cold storages to destinations.

Figure 4
Logistics Network of Scenario 1 – Fish Landing Capacity



Scenario 2 : Standardized Results for Fishing Boat

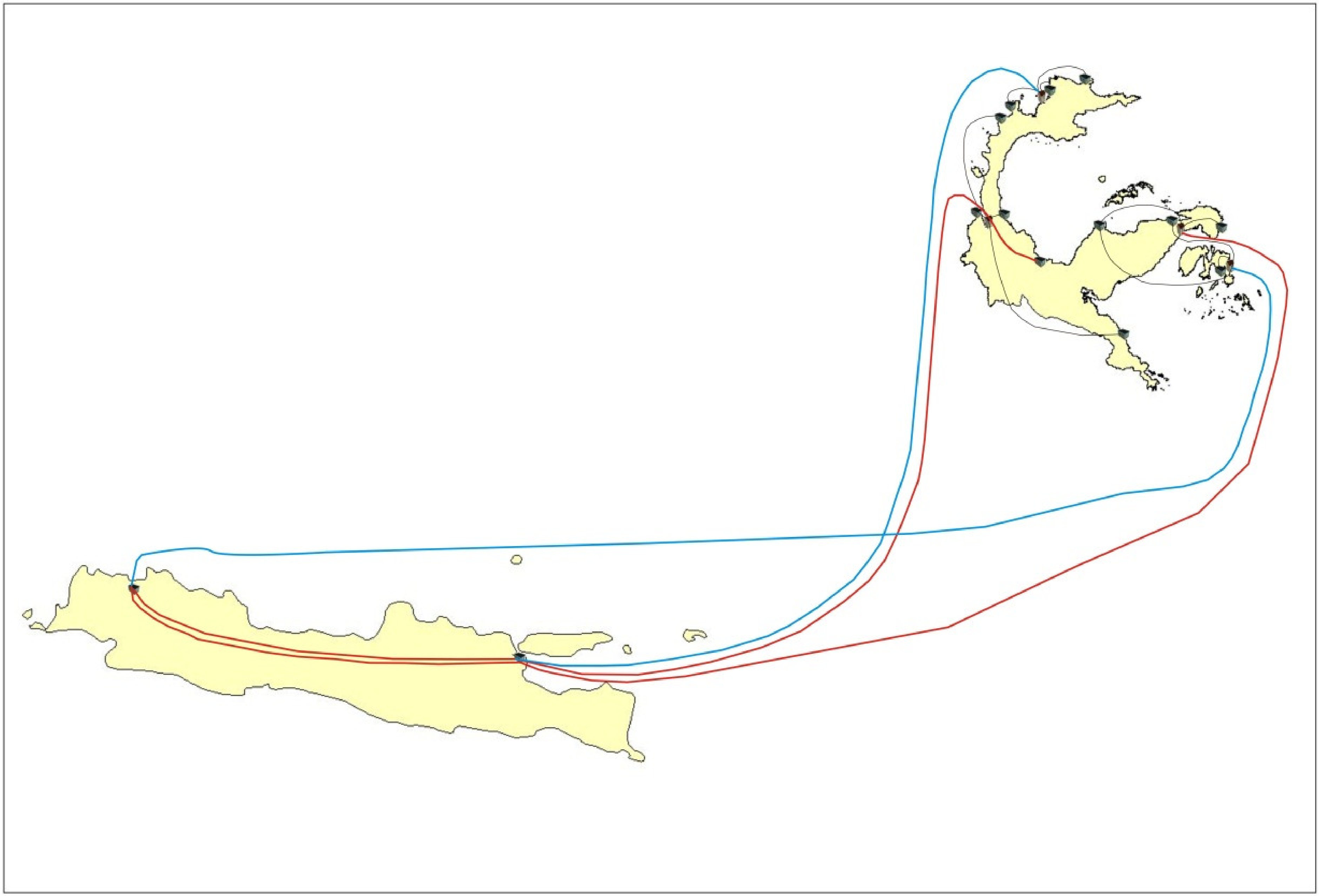
Each fishing boat must catch 20,000 kg per month.

Tabel 8
Computational Result Summary for Scenario 2 – 20,000 kg/boat/month

Fish Landings	Cold Storages					Capacity
	Toli-Toli	Palu	Luwuk	Tinakin	Total	
Labuan Bajo	0	80,000	0	0	80,000	80,000
Ogoamas	0	60,000	0	0	60,000	60,000
Ogotua	80,000	0	0	0	80,000	80,000
Baolan	180,000	0	0	0	180,000	180,000
Buol	80,000	0	0	0	80,000	80,000
Tinakin	0	0	0	80,000	80,000	80,000
Balantak	0	0	60,000	0	60,000	60,000
Pagimana	0	0	0	60,000	60,000	60,000
Bente	0	80,000	0	0	80,000	80,000
Ampana	0	0	90,000	10,000	100,000	100,000
Poso	0	40,000	0	0	40,000	40,000
Toboli	0	20,000	0	0	20,000	20,000
Total	340,000	280,000	150,000	150,000	920,000	920,000
Destination	Toli-Toli	Palu	Luwuk	Tinakin	Total	
Jakarta		218,000		150,000	368,000	
Surabaya	340,000	62,000	150,000		552,000	
Total	340,000	280,000	150,000	150,000	920,000	
LOGISTIC COSTS (MIP)					4,135,194,000	

- The fish landing capacity will increase from 664.543 kg to 920,000 kg. Logistics costs resulted from optimization is 4,135,194.000 rupiahs or 4,495 rupiahs per kilogram of fish. or more efficient (80 rupiahs per kilogram) compared to the costs of the first scenario. This indicates that there are synergies in line with the increase in the fish volume along the logistics system. Consequently, the supply chains structure to be more efficient to fullfil the fish demands.
- However, in this scenario, cold storage capacity should be increased : 40 tonnes in Tolitoli, and 80 tonnes in Palu. Cold storages in Luwuk and Tinakin remain the same capacity.
- These results indicate an improvement in the efficiency of the logistics system by the increase of fish volume. This condition allows the decrease in holding cost per-unit and the transportation costs per-unit is lower than before.

Figure 4
Logistics Network of Scenario 2 - 20.000 kg/boat/month



CONTRIBUTION TO INVESTMENT ANALYSIS

- The results of this research are valuable in order to fulfill the fishing industrial needs for raw materials to be more efficient. it can also be used as the basis in conducting the investment analysis needed by the investors in the field of logistics. Up to now, the fish logistics business in Central Sulawesi has not been improved as it is expected.
- Initial investment is calculated based on fish volume for the current case, scenario 1 and scenario 2. The net cash flows are found by taking into account the costs of fish logistics. Table 9 shows Net Present Value (NPV) with a discount factor (15%) for the three categories : current case, scenario 1, and scenario 2. If initial investment and fish volume increase then the NPV and IRR tend to be higher.

Table 9
Investment analysis for fish logistic business in Central Sulawesi

No	Current Case and Scenarios	I0 IDR (Rp)	Fish Volume (kg)	NPV (Rp)* (df = 15%)	IRR*
1	Current Case	40,000,000,000	397,500	26,140,902,334	40.20 %
2	Skenario 1	55,000,000,000	664,543	59,480,058,241	55.20 %
3	Skenario 2	65,000,000,000	920,000	95,721,958,424	68.30 %

CONCLUSION

- The research is to develop an efficient logistics design that can solve a fish distribution network from Central Sulawesi as local producers to Jakarta and Surabaya (Java) as industrial areas in Indonesia. A specific mixed integer programming for fish logistics has been developed in three operations : 1) from fish landings to cold storages, 2) in cold storagesf, and 3) from cold storages to Surabaya and Jakarta (Java). Each activity needs fish logistics costs.

- Optimation on the model helps us to determine a more efficient network and supply volume. In fact, the model was able to allocate certain fish landings supply for certain cold storages, and to allocate which cold storages supply for certain fish destinations. If the process runs well, a configuration of fish logistics system will be efficient.

- The model also allows us to make scenarios increase fish production. By assuming that the fish demands is equal to cold storage capacity, the increase of fish volume changes supply chain configuration. The condition can reduce logistics unit costs. Logistics design found can also be associated with investment analysis needed by investors to invest in fish logistics business in Central Sulawesi, Indonesia.

- For the global economic contex, it is interesting to integrate international fish network in the model.

Thank you