Jumputan Wastewater Optimization Model Using Green Logistic Network Approach

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Abstract —*Jumputan* traditional textile industry produce extensive residual waste water beside their main products, traditional fabrics. Over the years, the local government and *jumputan* producers gave high attention in reducing the bad effect of these wastewater and to protect the environment at the same time. Various techniques appeared in literature to model the problem, one is green logistics network optimization model. This paper proposes the use of network optimization model in optimizing the wastewater treatment processing. The green logistics network approach is used in building the prototype application that used to optimize the waste bank processes. The sensitivity test was conducted on model parameters, i.e. buying price of wastewater, and selling price of clean water produced. The sensitivity analysis was done for Waste Bank parameters in the proposed prototype. From the result of sensitivity test, the optimal solution of Waste Bank operation was modeled. Several insights were observed from the problem, and the optimal production rate and schedule were achieved in the highest profit level. Besides that, the optimal combination of purchasing price of wastewater and selling of clean water at below local water company (PDAM) rate also determined, therefor craftsmen could buy cheaper water to get higher profits.

Keywords— Jumputan, Network Optimization, Green Logistics, Cost Optimization, Waste Water

I. INTRODUCTION

Logistics is widely used to describe the transport, storage and handling of products as they move from raw material source, through the production system to their final point of sale or consumption [1]. Later, green logistics was introduced when environmental factors and information technology (IT) were integrated with logistics. There are several functional areas, such as green supply-demand, reverse logistics as well as logistics IT. The development of IT has also increased business innovation which integrate IT in optimizing business processes [2] in order to meet customer demand.

The production of Palembang's traditional textile, called *jumputan*, produce extensive waste water that could harm the environment. Waste water produced increase as the *jumputan* craftsman rise their production. Green logistic approach could be applied to tackle waste that pollutes the environment. Green logistics is a concept that could be implemented on the reduction of bad impacts from industry to environment and also social life. Therefor this concept will make logistics as a sustainable system which balance social aspects, economic, as well as environmental [1].

In the production of *jumputan*, typically craftsmen throw away their wastewater directly to drainage around their home as production center. Based on our survey in *Tuan Kentang Seberang Ulu I Palembang area*, craftsmen use this strategy to reduce their cost. Wastewater were not reprocessed due to high cost in development of wastewater treatment. Although clean water is required as main component in production, craftsmen prefer to buy clean water from local water company (PDAM) compared to reprocessed it using wastewater treatment.

From the observations and interviews at the *jumputan* production center, generally the craftsmen want to develop their business, to increase the profit through efficient processes, and to comply with government regulation on clean environment. However, they often had difficulty in managing the environmental effect while enhancing process efficiently. They effort to process wastewater together or in public wastewater treatment facility, such as by developing wastewater bank. A waste bank typically is an organization or unit which manage waste to reduce environmental pollution. Waste bank is one of community-based waste management system that enables public to actively participate in managing their environment [3]. On the other hand, the application of network optimization modelling could improve craftsman's service quality and business profitability [4,5,6].

This paper discusses the concept of waste bank and model of *jumputan* wastewater network optimization using green logistics framework for minimizing the total cost of the network in the form of mixed integer linear programming models. The main contribution of this paper is to examine the application of the concept of integrated logistics network in optimizing and resolve the issue of green logistics problem on *jumputan* Palembang.

II. GREEN LOGISTIC MODELING

A. Green Logistic Network

The green logistics network problems naturally complex as there is a large number of factors and constraints to consider. It could be also part of reverse logistics concept [7]. To solve the problems, we could model the problem in form of green logistics network where the environmental factor included. There are two approaches in modelling network problems where the environmental aspects added in green logistic network. First, environmental aspects are considered as an obstacle or a goal in traditional network model. Second approach, environmental aspects are modeled in form of reverse logistics or closed-loop supply chain network with environmental objectives or constraints [1].

B. Green Logistic Modeling

Green logistics operation is modeled as an interconnected system. In industrial practices, it involves government, business, logistics operators as well as general public problem due to its complexity [10]. Green logistics problem could be modeled and solved in form of combinatorial optimization problem, multi-objective facility problem, or mixed integer linear programming model [6,7]

C. Network Optimization

One objective of network optimization is to find the optimal solution in production planning and integrated distribution, by investigating the integration effectiveness through computational studies of a mufti-producers, mufti-retailers, multi-users and multi-periods logistics problem. The objective typically is to maximize total profit [8].

In green logistics optimization problem, a Single Product Single Facility network problem for a proposed waste bank is observed. It is assumed that the waste bank processes a single product, the waste water, with a specific capacity for a specific period and produces final product, the clean water. The network cost consists of production cost and inventory cost. Waste water produced by craftsmen will be sent to waste bank, processed into clean water, and distributed back to the craftsmen. Clean water demand from craftsmen at waste bank are estimated and calculated for a specific period. The typical logistics network model for wastewater optimization problem could be seen in Fig 1.

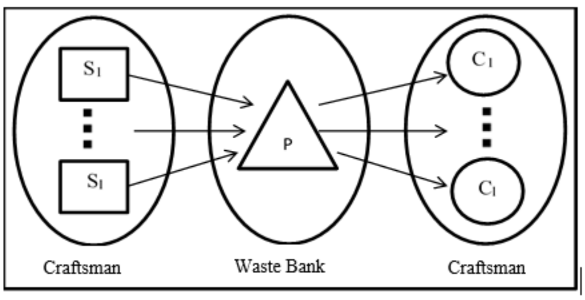

Fig. 1. Logistics Network Model for Wastewater Optimization Problem

Beside that, another model a Single Product Multi Facility network could also be observed to capture the real problem in jumputan industry. In this model, it is assumed each craftsman could produce various product and therefor will also produce various diferent type of wastewater content. In result create more complex problem in waste bank optimization modelling.

III. Research Methodology

In this paper, green logistic network optimization problem will be modelled and solved using mixed integer linear programming approach. Research was done in central production of *jumputan* craftsmen in area of *Tuan Kentang Palembang*. To solve the problem, a prototype application was developed using PHP and mySQL. Real data from craftsman production schedule was used to solve the analysis using prototype application developed.

Data was collected through interview craftsmen in *Tuan Kentang* area, and observation their business processes. Some critical data were collected, such as waste water produced every production schedule, cost associated with *jumputan* production, delivery and logistics costs, number of *jumputan* produced, and volume of clean water.

Finally, sensitivity analysis was conducted to reach the optimal selling price of clean water and buying price of wastewater from waste bank as well as to observe the highest profit possible achieved by optimization model.

IV. Research Analysis And Results

A. Analysis of Green Logistic Network Optimization Model

Green logistic network optimization model of *jumputan* craftsmen in *Tuan Kentang* could be used to model the main product resulted, which ready to be sold, as well as its waste water. One production period could be identified as long as seven day which will produce 200 pieces of fabric with a length of 3m each set. Every piece of *jumputan* produced will be sold at 100.000 rupiahs/piece. In this production rate, the final waste water resulted will be around 640 liters.

Once production cycle was finish*, jumputans* are ready to send to distributors or customers. On the other hand, the colored waste water will be treated and sent to waste bank. In waste bank, wastewater will be cleaned using filter technology, such as using local coconut based active carbon, manganese zeolite, or using membrane. After treatment processes, the clean water resulted then will be distributed back to craftsmen to be used in *jumputan* production (Fig. 2). In the long term, by optimizing the processes, all craftsmen will gain benefit from using this clean water compared buying from PDAM and reducing environmental pollution at the same time.

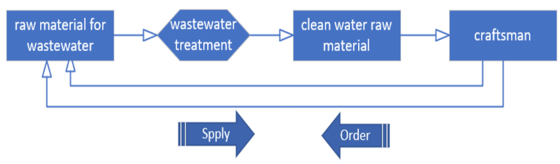

Fig. 2. Waste Bank Distribution Process

B. Wate Bank Optimization model

Previous study [11] provided the analysis of investment cost optimization of the waste bank for wastewater based on green supply chain framework. The study observed processing capacity, the optimal configuration, and optimal volume of clean water produced. From the example calculation, it was designed the capacity of waste water filter 500 liters/hour or about 5000 liters/day and 32m^2 reservoir capacity. Using this capacity, it was observed that waste bank could accommodate around 32,000 liters waste water. Finally, the optimal costing structure were also observed where for processing of 5000 liters/day it is required 18.000 rupiahs or 3,6 rupiahs/liter. Inventory handling cost for wastewater is 5000 rupiahs for 5000 liters as well as handling cost for 5000 liters clean water produced.

Those previous data are used as base data in this paper for calculating the objective function, buying price of craftsmen wastewater and selling price the clean water. Then from the calculation above, network optimization model will be developed as following.

First, the calculation of optimal clean water required by craftsmen to produce the *jumputan*. From survey, it was identified that craftsmen typically need 640 liters of clean water for each production period or 7 days. In the area of *Tuan Kentang* there are 25 craftsmen, so if calculated clean water needed by all craftsmen in one production period or 7 days are about 16,000 liters.

Secondly, the capacity of waste bank in producing waste water is calculated and validated. The filter capacity chosen should be able to work at 500 liters/hour capacity. This capacity is equal to the capacity of 5000 liters for one day and if multiplied by 6 working days the waste bank could produce 23,850 liters/week.

Third, the total quantity of clean water produced by water treatment is calculated around 80% of total wastewaters processed (1). It is estimated as efficiency value of filter processing due to the normal operation of filter absorption. Quantity capacity could be calculated using the following formula:

$$\sum Q_{AB} = 80\% \times Q_L \qquad (1)$$

where:

ΣQ_{AB} = Quantity of clean water

ΣQ_L = Quantity of waste water

Lastly, the inventory costs are costs which allocated for collecting wastewater and stocking clean water (2). In the paper, there are two category of inventory cost, i.e. inventory cost for saving clean water and cost for saving wastewater due to the different requirement of equipment used. To find the cost of inventory use the following formula:

$$\sum B_{inv} = \sum I_{nv} \, x \, C \qquad (2)$$

where:

ΣB_{inv} = Total inventory costs

ΣI_{nv} = Volume of inventory (waste water, clean water)

C = Inventory cost per-liter (waste water, clean water)

C. Formulation of the Linear Programming Model

The formulation of linear programming model in this study have several assumptions, i.e. wastewater production, clean water sales, profit optimization and costs minimization are assumed linear. The objective function of modelling is to maximize the profit from selling water and to determine the optimum price of buying waste water and selling clean water.

The decision variables used in modelling to obtain the maximum profit are consist of the calculation of the total sales of clean water, total cost of production and total cost of purchasing waste water from craftsmen. The following are decision variables used in modelling:

- The total sale of clean water (3) is calculated from total clean water bought by craftsmen from waste bank. From this, the total cost will be obtained from total clean water produced multiplied by the selling price of clean water sold to craftsmen. The following is the formula to calculate total clean water sales:

$$T = \lfloor Q_b \times C_j \rfloor \qquad (3)$$

where:

T = Total selling water

Q_b = Quantity of clean water

C_j = Cost of selling

- The total production cost (4) includes the cost of the wastewater production process and the total purchase of raw materials or wastewater from the craftsman. Total production costs is used as a component in determining the maximum profit could achieved by system. The following calculations are used to calculate total production costs:

$$P = \left[(X_{ij} \times C_{ij}) + (Q_l \times C_b) \right] \qquad (4)$$

where:

P = Total production costs

X_{ij} = Production process quantity

C_{ij} = Cost of the process

Q_l = Quantity of waste water

C_b = Cost of buying waste water

Later, the objective function to maximize total profit from network optimization modelling in waste bank operation is observed (5). The objectives function was derived from (3) and (4) to minimize total cost while at the same time is to maximize total clean water sales. The formulation of the model used to optimize the sales profit of clean water is as follows:

$$Z = \left[Q_b \times C_j \right] - \left[(X_{ij} \times C_{ij}) + (Q_l \times C_b) \right] \qquad (5)$$

The formulation to get the maximum profit is calculated from the total sales of clean water reduced by the total production costs and the total cost of purchasing raw materials or waste water (5). From this formulation, it would be achieved the maximum profit from each waste water production.

The other important components of modelling are constraints. From observation and literature review, it was observed two constraints that could be used to improve the quality op optimization processes. First, the amount of production should not exceed the maximum capacity of the water filter in processing waste water. Secondly, clean water produced are to satisfy demand. It assumes that waste bank will not produce exceed the demand at the certain time period. The following constraints were developed for the effectiveness of waste bank operations:

- The production capacity constraint. It is assumed that maximum level of clean water that could be produced are limited by the capacity of filters used (6). This production capacity constraint is defined to ensure the optimal solution will be achieved by the model, due to the technical ability of filter component. Following are the formulations used to limit waste production.

$$\sum X_{ij} \leq K \qquad (6)$$

where:

$\sum X_{ij}$ = Waste production process

K = Production capacity of wastewater

- Demand constraints. Waste bank is assumed would only produces clean water to satisfy demand (7). It will ensure that clean water production will not exceed the actual demand, or this constraint will ensure the craftsmen will get the clean water they need for production. Following is the formula used to limit the amount of clean water produced by Waste Bank.

$$\sum Q_b \leq D \qquad (7)$$

where:

$\sum Q_b$ = Total Quantity of clean water
D = Demand (Request for clean water)

D. Research Results

Data collected from the results of observations and interviews conducted directly at the *Jumputan* craft center located in the area of Tuan Kentang, Palembang, are presented in Table 1.

From the table presented, the production process is conducted four times in one month, starting from the purchase of waste materials, the production process to the sale of water starts from February 25, 2019 until March 4, 2019. The first production is conducted on February 27, 2019, the second production is 01 March 2019, third production March 03, 2019 and fourth production March 04, 2019 with a total waste of 15200 liters. The details in the table do not include the costs of waste and clean water inventory, clean water inventory costs and daily waste of IDR 5,000 for 5000 liters of waste water and clean water.

The first data obtained is using the purchase price of IDR 2 waste, the selling price of clean water IDR 12 and IDR 4 for the cost of one-liter membrane. Profit is obtained according to the model that has been made from the details of the above costs. The following is shown in Table 1.

TABLE I. TYPICAL WASTE BANK PRODUCTION COST

	Waste Vol	Waste Price / liter IDR 2	Membrane Cost / Liter IDR 4	Production Cost	Waste Percentage	Selling Price IDR 14
		Waste Cost	**Membrane Cost**		**Production 80%**	**Selling Cost**
P1	3370	IDR 6,740	IDR 13,480	IDR 20,220	2696	IDR 37,744
P2	4290	IDR 8,580	IDR 17,160	IDR 25,740	3432	IDR 48,048
P3	3840	IDR 7,680	IDR 15,360	IDR 23,040	3072	IDR 43,008
P4	3700	IDR 7,700	IDR 14,800	IDR 22,200	2960	IDR 41,440
Total Production	15200	Total Production Cost		IDR 91,200		
Total Cost of Waste Purchases				IDR 30,400		
Total Cost of Water Sales						IDR 170,240
Profits						IDR **48,640**

(Source: Survey of *jumputan* craftsmen's location, 2019)

To find out the price of waste purchase and sale of clean water that can optimize the profit of the Waste Bank and save on the purchase of clean water for craftsmen from the PDAM, it can be seen from the results of a sensitivity analysis using a prototype that has been made.

E. Sensitivity Trial Results Using Prototype

The test results in Table 1 with a price limit of IDR 14 for clean water, clean water prices are limited to IDR 14 because the PDAM sells clean water at a price of IDR 14.73 per liter. The Waste Bank is trying to sell water at a price below the price sold by the PDAM. The purchase price of waste is tested in the range of IDR 1 to IDR 3 and the selling price of water is tested from IDR 12 to IDR 14. From the data that has been tested with this price range, it is obtained the maximum profit at the waste purchase price of IDR1 and sale of IDR14 with a profit of IDR 79,040. From the data in the table above Waste Bank gets a profit of IDR 48,640, the results of the trial can be seen in the following graph.

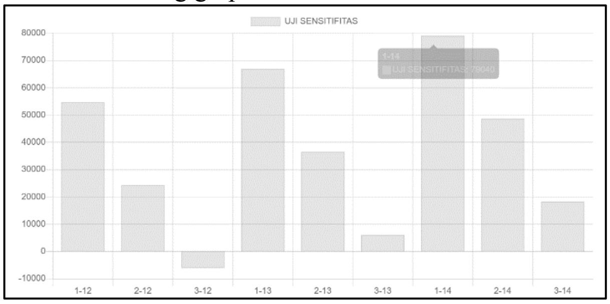

Fig. 3. Load Sensitivity Test of 15,200 Without Inventor Costs

To observe the sensitivity of price and profit, it is tested again by increasing the burden or increasing the amount of waste from the data samples that have been used. The initial data used uses a load or volume of waste of 15,200 liters that will then be compared with the total waste volume of 20,000 liters, 25,000 liters and 30,000 liters. Of the several volumes of waste tested plus the cost of an inventory of waste and clean water at a cost of IDR 1 per liter, the following graph shows some samples mentioned above:

- The results of the trial volume of 15,200 liters of waste load using the cost of waste and clean water inventory by getting the highest profit at the purchase price of waste IDR1 and sales of IDR14 with a profit of IDR51,680

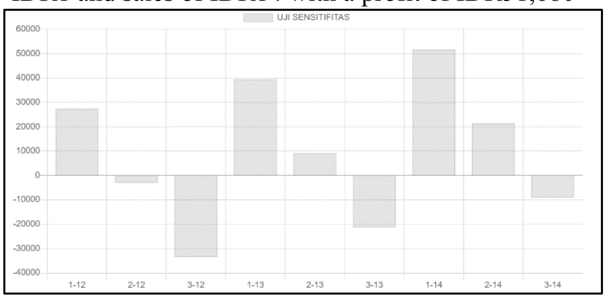

Fig. 4. Costs Load Sensitivity Test of 15,200 with Inventory Costs

- The results of a 20,000 liter waste volume load test using the cost of waste and clean water inventory by earning the highest profit at the waste purchase price of IDR 1 and selling of IDR 14 with a profit of IDR 68,000.

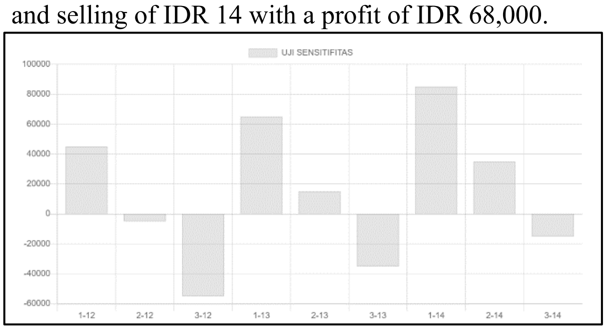

Fig. 5. Load Sensitivity Test of 20,000 with Inventory Costs

- The results of a trial load of 25,000 liters of waste volume using the cost of waste and clean water inventory by earning the highest profit at the purchase price of waste IDR 1 and sales of IDR 14 with a profit of IDR 85,000.

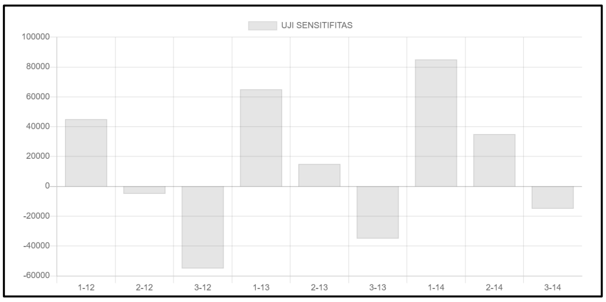

Fig. 6. Load Sensitivity Test 25,000 with Inventory Costs

- Fourth the results of the trial load volume of 30,000 liters of waste by using the cost of waste and clean water inventory by getting the highest profit in the purchase price of waste IDR1 and sales of IDR14 with a profit of IDR 102,000.

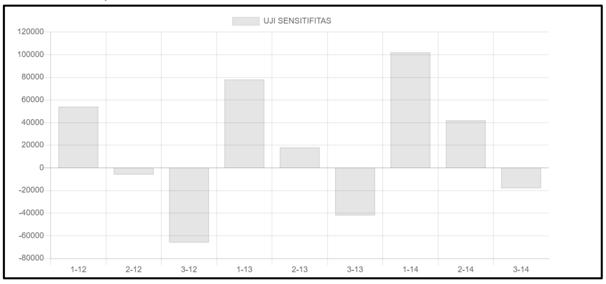

Fig. 7. Load Sensitivity Test of 30,000 with Inventory Costs

From the various experiments conducted, it could be observed that by increasing or adding more the wastewater amount produced, the profits obtained tend to increase. On the other hand, as the amount of waste water processed getting lower, it coub be observed that the profits gained will also reduced. The bigger volume of waste water produced, the higher profits will be achieved linearly.

V. Conclusions

In this paper, green logistics optimization network problems are discussed. Single product single facility network as well as multi facility network are observed. Mixed integer linear programming models were developed for these problems. The models that was studied provide useful tools for addressing questions that arise in managing green logistics networks of *jumputan* production, especially when wastewater treatment is operated. In order to study the problems, small data from research object was used and analyzed in several scenarios. The sensitivity analysis was done by varying wastewater volume and selling price.

From the experiments we yield managerial insights. It is observed that higher volume of waste water handling will expect the increase of total profit.

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Paper 1

by Muhammad Herdiansyah

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C. *Network Optimization*

One objective of network optimization is to find the optimal solution in production planning and integrated distribution, by investigating the integration effectiveness through computational studies of a mufti-producers, mufti-retailers, multi-users and multi-periods logistics problem. The objective typically is to maximize total profit [8].

In green logistics optimization problem, a Single Product Single Facility network problem for a proposed waste bank is observed. It is assumed that the waste bank processes a single product, the waste water, with a specific capacity for a specific period and produces final product, the clean water. The network cost consists of production cost and inventory cost. Waste water produced by craftsmen will be sent to waste bank, processed into clean water, and distributed back to the craftsmen. Clean water demand from craftsmen at waste bank are estimated and calculated for a specific period. The typical logistics network model for wastewater optimization problem could be seen in Fig 1.

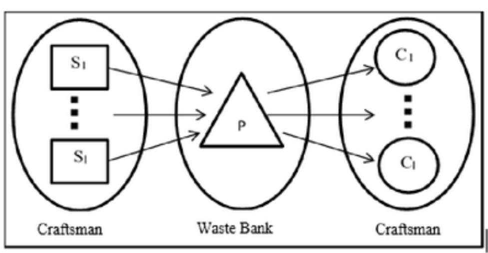

Fig. 1. Logistics Network Model for Wastewater Optimization Problem

Beside that, another model a Single Product Multi Facility network could also be observed to capture the real problem in jumputan industry. In this model, it is assumed each craftsman could produce various product and therefor will also produce various diferent type of wastewater content. In result create more complex problem in waste bank optimization modelling.

III. Research Methodology

In this paper, green logistic network optimization problem will be modelled and solved using mixed integer linear programming approach. Research was done in central production of *jumputan* craftsmen in area of *Tuan Kentang Palembang*. To solve the problem, a prototype application was developed using PHP and mySQL. Real data from craftsman production schedule was used to solve the analysis using prototype application developed.

Data was collected through interview craftsmen in *Tuan Kentang* area, and observation their business processes. Some critical data were collected, such as waste water produced every production schedule, cost associated with *jumputan* production, delivery and logistics costs, number of *jumputan* produced, and volume of clean water.

Finally, sensitivity analysis was conducted to reach the optimal selling price of clean water and buying price of wastewater from waste bank as well as to observe the highest profit possible achieved by optimization model.

IV. Research Analysis And Results

A. *Analysis of Green Logistic Network Optimization Model*

Green logistic network optimization model of *jumputan* craftsmen in *Tuan Kentang* could be used to model the main product resulted, which ready to be sold, as well as its waste water. One production period could be identified as long as seven day which will produce 200 pieces of fabric with a length of 3m each set. Every piece of *jumputan* produced will be sold at 100.000 rupiahs/piece. In this production rate, the final waste water resulted will be around 640 liters.

Once production cycle was finish, *jumputans* are ready to send to distributors or customers. On the other hand, the colored waste water will be treated and sent to waste bank. In waste bank, wastewater will be cleaned using filter technology, such as using local coconut based active carbon, manganese zeolite, or using membrane. After treatment processes, the clean water resulted then will be distributed back to craftsmen to be used in *jumputan* production (Fig. 2). In the long term, by optimizing the processes, all craftsmen will gain benefit from using this clean water compared buying from PDAM and reducing environmental pollution at the same time.

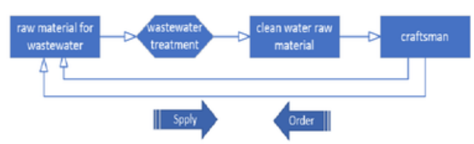

Fig. 2. Waste Bank Distribution Process

B. *Wate Bank Optimization model*

Previous study [11] provided the analysis of investment cost optimization of the waste bank for wastewater based on green supply chain framework. The study observed processing capacity, the optimal configuration, and optimal volume of clean water produced. From the example calculation, it was designed the capacity of waste water filter 500 liters/hour or about 5000 liters/day and 32m^2 reservoir capacity. Using this capacity, it was observed that waste bank could accommodate around 32,000 liters waste water. Finally, the optimal costing structure were also observed where for processing of 5000 liters/day it is required 18.000 rupiahs or 3,6 rupiahs/liter. Inventory handling cost for wastewater is 5000 rupiahs for 5000 liters as well as handling cost for 5000 liters clean water produced.

Those previous data are used as base data in this paper for calculating the objective function, buying price of craftsmen wastewater and selling price the clean water. Then from the calculation above, network optimization model will be developed as following.

First, the calculation of optimal clean water required by craftsmen to produce the *jumputan*. From survey, it was identified that craftsmen typically need 640 liters of clean water for each production period or 7 days. In the area of *Tuan Kentang* there are 25 craftsmen, so if calculated clean water needed by all craftsmen in one production period or 7 days are about 16,000 liters.

Secondly, the capacity of waste bank in producing waste water is calculated and validated. The filter capacity chosen should be able to work at 500 liters/hour capacity. This capacity is equal to the capacity of 5000 liters for one day and if multiplied by 6 working days the waste bank could produce 23,850 liters/week.

Third, the total quantity of clean water produced by water treatment is calculated around 80% of total wastewaters processed (1). It is estimated as efficiency value of filter processing due to the normal operation of filter absorption. Quantity capacity could be calculated using the following formula:

$$\sum Q_{AB} = 80\% \times Q_L \quad (1)$$

where:

ΣQ_{AB} = Quantity of clean water
ΣQ_L = Quantity of waste water

Lastly, the inventory costs are costs which allocated for collecting wastewater and stocking clean water (2). In the paper, there are two category of inventory cost, i.e. inventory cost for saving clean water and cost for saving wastewater due to the different requirement of equipment used. To find the cost of inventory use the following formula:

$$\sum B_{inv} = \sum I_{nv}\, x\, C \quad (2)$$

where:

ΣB_{inv} = Total inventory costs
ΣI_{nv} = Volume of inventory (waste water, clean water)
C = Inventory cost per-liter (waste water, clean water)

C. Formulation of the Linear Programming Model

The formulation of linear programming model in this study have several assumptions, i.e. wastewater production, clean water sales, profit optimization and costs minimization are assumed linear. The objective function of modelling is to maximize the profit from selling water and to determine the optimum price of buying waste water and selling clean water.

The decision variables used in modelling to obtain the maximum profit are consist of the calculation of the total sales of clean water, total cost of production and total cost of purchasing waste water from craftsmen. The following are decision variables used in modelling:

- The total sale of clean water (3) is calculated from total clean water bought by craftsmen from waste bank. From this, the total cost will be obtained from total clean water produced multiplied by the selling price of clean water sold to craftsmen. The following is the formula to calculate total clean water sales:

$$T = \left[Q_b \times C_j\right] \quad (3)$$

where:

T = Total selling water
Q_b = Quantity of clean water
C_j = Cost of selling

- The total production cost (4) includes the cost of the wastewater production process and the total purchase of raw materials or wastewater from the craftsman. Total production costs is used as a component in determining the maximum profit could achieved by system. The following calculations are used to calculate total production costs:

$$P = \left[(X_{ij} \times C_{ij}) + (Q_l \times C_b)\right] \quad (4)$$

where:

P = Total production costs
X_{ij} = Production process quantity
C_{ij} = Cost of the process
Q_l = Quantity of waste water
C_b = Cost of buying waste water

Later, the objective function to maximize total profit from network optimization modelling in waste bank operation is observed (5). The objectives function was derived from (3) and (4) to minimize total cost while at the same time is to maximize total clean water sales. The formulation of the model used to optimize the sales profit of clean water is as follows:

$$Z = \left[Q_b \times C_j\right] - \left[(X_{ij} \times C_{ij}) + (Q_l \times C_b)\right] \quad (5)$$

The formulation to get the maximum profit is calculated from the total sales of clean water reduced by the total production costs and the total cost of purchasing raw materials or waste water (5). From this formulation, it would be achieved the maximum profit from each waste water production.

The other important components of modelling are constraints. From observation and literature review, it was observed two constraints that could be used to improve the quality op optimization processes. First, the amount of production should not exceed the maximum capacity of the water filter in processing waste water. Secondly, clean water produced are to satisfy demand. It assumes that waste bank will not produce exceed the demand at the certain time period. The following constraints were developed for the effectiveness of waste bank operations:

- The production capacity constraint. It is assumed that maximum level of clean water that could be produced are limited by the capacity of filters used (6). This production capacity constraint is defined to ensure the optimal solution will be achieved by the model, due to the technical ability of filter component. Following are the formulations used to limit waste production.

$$\sum X_{ij} \le K \quad (6)$$

where:

$\sum X_{ij}$ = Waste production process
K = Production capacity of wastewater

- Demand constraints. Waste bank is assumed would only produces clean water to satisfy demand (7). It will ensure that clean water production will not exceed the actual demand, or this constraint will ensure the craftsmen will get the clean water they need for production. Following is the formula used to limit the amount of clean water produced by Waste Bank.

$$\sum Q_b \leq D \tag{7}$$

where:

$\sum Q_b$ = Total Quantity of clean water
D = Demand (Request for clean water)

D. Research Results

Data collected from the results of observations and interviews conducted directly at the *Jumputan* craft center located in the area of Tuan Kentang, Palembang, are presented in Table 1.

From the table presented, the production process is conducted four times in one month, starting from the purchase of waste materials, the production process to the sale of water starts from February 25, 2019 until March 4, 2019. The first production is conducted on February 27, 2019, the second production is 01 March 2019, third production March 03, 2019 and fourth production March 04, 2019 with a total waste of 15200 liters. The details in the table do not include the costs of waste and clean water inventory, clean water inventory costs and daily waste of IDR 5,000 for 5000 liters of waste water and clean water.

The first data obtained is using the purchase price of IDR 2 waste, the selling price of clean water IDR 12 and IDR 4 for the cost of one-liter membrane. Profit is obtained according to the model that has been made from the details of the above costs. The following is shown in Table 1.

TABLE I. TYPICAL WASTE BANK PRODUCTION COST

	Waste Vol	Waste Price / liter IDR 2	Membrane Cost / Liter IDR 4	Production Cost	Waste Percentage	Selling Price IDR 14
		Waste Cost	Membrane Cost		Production 80%	Selling Cost
P1	3370	IDR 6,740	IDR 13,480	IDR 20,220	2696	IDR 37,744
P2	4290	IDR 8,580	IDR 17,160	IDR 25,740	3432	IDR 48,048
P3	3840	IDR 7,680	IDR 15,360	IDR 23,040	3072	IDR 43,008
P4	3700	IDR 7,700	IDR 14,800	IDR 22,200	2960	IDR 41,440
Total Production	15200	Total Production Cost		IDR 91,200		
Total Cost of Waste Purchases				IDR 30,400		
Total Cost of Water Sales						IDR 170,240
Profits						IDR **48,640**

(Source: Survey of *jumputan* craftsmen's location, 2019)

To find out the price of waste purchase and sale of clean water that can optimize the profit of the Waste Bank and save on the purchase of clean water for craftsmen from the PDAM, it can be seen from the results of a sensitivity analysis using a prototype that has been made.

E. Sensitivity Trial Results Using Prototype

The test results in Table 1 with a price limit of IDR 14 for clean water, clean water prices are limited to IDR 14 because the PDAM sells clean water at a price of IDR 14.73 per liter. The Waste Bank is trying to sell water at a price below the price sold by the PDAM. The purchase price of waste is tested in the range of IDR 1 to IDR 3 and the selling price of water is tested from IDR 12 to IDR 14. From the data that has been tested with this price range, it is obtained the maximum profit at the waste purchase price of IDR1 and sale of IDR14 with a profit of IDR 79,040. From the data in the table above Waste Bank gets a profit of IDR 48,640, the results of the trial can be seen in the following graph.

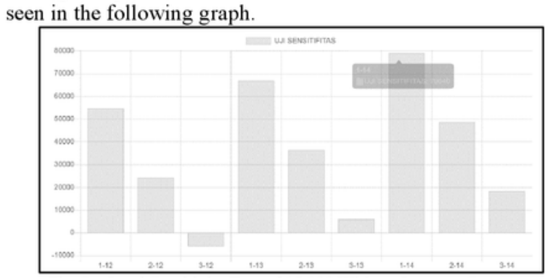

Fig. 3. Load Sensitivity Test of 15,200 Without Inventor Costs

To observe the sensitivity of price and profit, it is tested again by increasing the burden or increasing the amount of waste from the data samples that have been used. The initial data used uses a load or volume of waste of 15,200 liters that will then be compared with the total waste volume of 20,000 liters, 25,000 liters and 30,000 liters. Of the several volumes of waste tested plus the cost of an inventory of waste and clean water at a cost of IDR 1 per liter, the following graph shows some samples mentioned above:

- The results of the trial volume of 15,200 liters of waste load using the cost of waste and clean water inventory by getting the highest profit at the purchase price of waste IDR1 and sales of IDR14 with a profit of IDR51,680

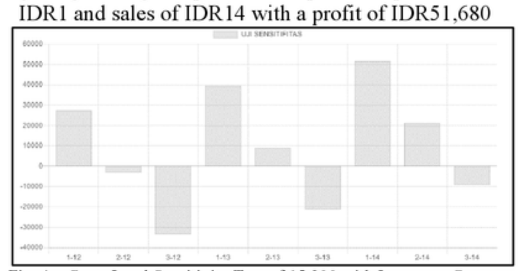

Fig. 4. Costs Load Sensitivity Test of 15,200 with Inventory Costs

- The results of a 20,000 liter waste volume load test using the cost of waste and clean water inventory by earning the highest profit at the waste purchase price of IDR 1 and selling of IDR 14 with a profit of IDR 68,000.

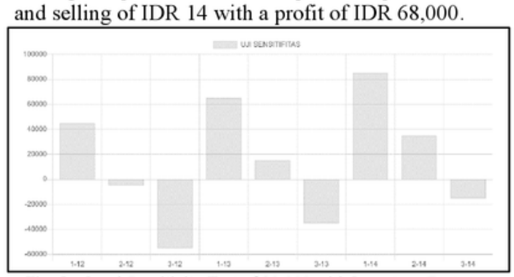

Fig. 5. Load Sensitivity Test of 20,000 with Inventory Costs

- The results of a trial load of 25,000 liters of waste volume using the cost of waste and clean water inventory by earning the highest profit at the purchase price of waste IDR 1 and sales of IDR 14 with a profit of IDR 85,000.

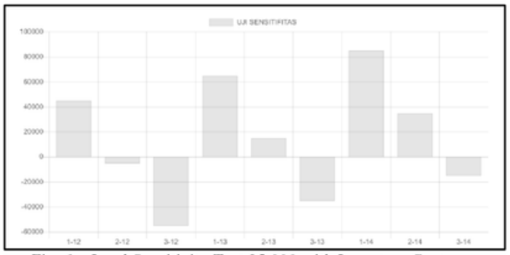

Fig. 6. Load Sensitivity Test 25,000 with Inventory Costs

- Fourth the results of the trial load volume of 30,000 liters of waste by using the cost of waste and clean water inventory by getting the highest profit in the purchase price of waste IDR1 and sales of IDR14 with a profit of IDR 102,000.

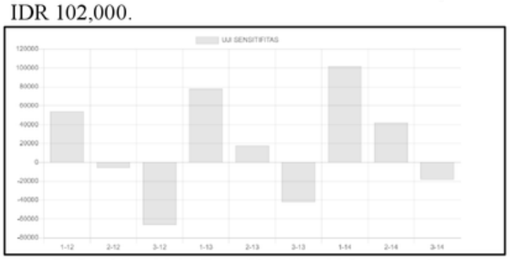

Fig. 7. Load Sensitivity Test of 30,000 with Inventory Costs

From the various experiments conducted, it could be observed that by increasing or adding more the wastewater amount produced, the profits obtained tend to increase. On the other hand, as the amount of waste water processed getting lower, it coub be observed that the profits gained will also reduced. The bigger volume of waste water produced, the higher profits will be achieved linearly.

V. Conclusions

In this paper, green logistics optimization network problems are discussed. Single product single facility network as well as multi facility network are observed. Mixed integer linear programming models were developed for these problems. The models that was studied provide useful tools for addressing questions that arise in managing green logistics networks of *jumputan* production, especially when wastewater treatment is operated. In order to study the problems, small data from research object was used and analyzed in several scenarios. The sensitivity analysis was done by varying wastewater volume and selling price.

From the experiments we yield managerial insights. It is observed that higher volume of waste water handling will expect the increase of total profit.

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