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Comparation of P-Median, P-Center, and Maximal Coverage on Facility Location Problem of Bokabo Tobacco Supply Chain, Sumenep District

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***Abstract*— Madura Island is the largest tobacco producing area in Indonesia with an area of 30-33% of the total area of tobacco plantations in Indonesia. However, during the last 3 years the area of tobacco plantations on the island of Madura has decreased which affects the decline in tobacco productivity. This is caused by the volatility of prices that is played by the middlemen as a market monopoly to the company's warehouse. The design of new supply chain is assumed that supply chain flow to the company's warehouse is done without the middlemen. It has an aim that with this paper, it can recommend the farmers group to ship bokabo tobacco directly to company's warehouse. This assessment by comparing three location facility method that consists of p-median, p-center, and maximal coverage will determine the best facility location in several criteria so that the warehouse can be built according to the existing problem. The result of comparison of several methods with the object is bokabo tobacco supply chain of Sumenep District. It is showed that p-median is the best method in C1, C2, C4 and C8 which means that if there is a warehouse builder wanting the average distance of demand to main facility, average distance of demand for main facility and reserve, average distance of demand to reserve facility, and minimum cost for each distribution should use p-median problem. While for C3 it is filled by p-median for small r (boundary range) and for large r (boundary range) is filled by maximal coverage which means that maximal coverage and p-median is applicable for this problem. The next C5 is filled by maximal coverage which is a method that has superiority in filling the demand between primary and backup facilities. The last result, C6 and C7 are filled by p-center which means p-center will minimize the maximum distance to primary facilities, primary and backup facilities.**

Keywords; Madura Island, Bokabo Tobacco, P-Median, P-Center, Maximal Coverage, Facility Location.

I. INTRODUCTION

Madura Island is one of the largest tobacco producing sites in Indonesia with 30-33% of total tobacco plantation area in Indonesia. This is reinforced by the evidence that tobacco is an annual crop with the area of smallholder plantation crops according to the second largest crop species in Indonesia after corn plantation crops with 40% percentage of the plantation crops in indonesia. [1]

Indonesia is a country that has several provinces. One of them is East Java. According Badan Pusat Statistika Indonesian, East Java is the province that contributes the largest tobacco area with a percentage of 53% by 2016. East Java, although it has a large area of tobacco plants, but based on the data, it can be indicated that it has several problems on the growth of plantation area of tobacco in the last 3 years. The declining growth in the area of tobacco plantation crops for about 8.47%. It has given an impact to tobacco plantation production in Madura Island.

The fluidity of production is due to the unstable price of tobacco. Unstable prices are caused by the middlemen who plays prices and monopolizes the market. This led to several studies about eliminating the middlemen on the Supply Chain as in the "Manajamen Supply Chain Management of Tobacco Type Bokabo of Sumenep District" research [2] which is using the p-median method for minimizing cost of supply chain.

The supply chain of bokabo tobacco in Sumenep is a tobacco flow which is consisting of seed breeders to farmers, fertilizer to farmers, and farmers to company warehouses. Geographically, the Madurese environment is very suitable for tobacco growth because it is easily adapted to the local environment. [1]

Several other studies with different objects and different methods are able to minimize transportation costs on the supply chain flow. As in the study [3] on "An Efficient Modified Greedy Algorithm for p-median Problem" which uses p-median problems in the case, similar cases have also been studied by [4] on "A computational comparison of different algorithms for very large p-median problems" also used the p-median problems in the case [5] on "A Multi-Criteria Assessment Of The P-Median, Maximal coverage and P-Center Location Models "using p-median problem, Maximum coverage and P-Center Location in the case. So it can be concluded that there are some methods besides P-Median which is able to minimize the cost on supply chain problem, but also P-Center and Maximal coverage method are able to minimize the cost too.

Therefore, this research is positioned as a continuation of the thesis of "Bokabo Tobacco Supply Chain Management of Sumenep District" (Nabil, 2017) which is further added with the application and comparassion of P-Median, P-Center and

Maximal coverage method which are expected to be able to contribute as a model of the best solution in the existing problems.

II. LITERATURE REVIEW

A. *Supply Chain Management*

Supply chain management (SCM) includes the integration of vision, culture, process and strategy to organize an optimal flow of high-quality, value-for-money raw materials, or components from reliable and innovative suppliers and ultimately providing customers with high quality products they designed and manufactured at competitive prices [6].

SCM also encompasses all the activities involve to get the right product into the right consumers hands in the right quantity and at the right time" in the supply chain [7], [8]. SCM has gained increasing importance in the production processes and strategic planning of global manufacturing companies, and it is considered as a contemporary topic of competitiveness [9].

B. *Facility Location Problems*

According to [10] the issue of location aims to find the best suitable location for important facilities such as warehouses, ports, fire stations or military installations. In real life, the necessity to fulfill a demand with some facilities requires to create a backup supply system. This is very common on a large scale, demand may not be served directly if the supply of the nearest facility runs out to serve other demand. So in some cases a queuing system should be established to demand and serve them when their nearest facility is available.

C. *Madura Tobacco*

Tobacco planting area in Madura is mostly can be found in hill. These planting area are located in eastern part of Mount Tembuku (470 m high), Mount Merangan (398 m high), and Mount Gadu (341 m high). Southern planting area is dominated by lime mineralization and clay texture soil. Rainfall in this area is low with less than 200 mm of average water precipitation in wet season. [11].

III. PROBLEM STATEMENT

This section compares the application of supply chain method between p-median, p-center and Maximal coverage method on bokabo tobaco sumenep distric.

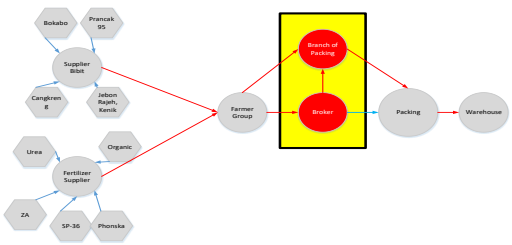

Figure 1. Bokabo Tobacco Supply Chain Sumenep District

A. *Assumptions, notations, and parameters*

- Capacity of plant yield according to normal condition.
- Transportation costs, planting, and selling prices are stable.
- The purchasing prices of bokabo tobacco seeds and fertilizer are stable.
- The middlemen are not included in this supply chain of bokabo tobacco in Sumenep District.

Considering the defined problem and its assumptions, a model is designed for the proposal SC. The notation, parameters, and decision variable are as follows:

Indices

i = Index to declare the breeder
j = Index to declare fertilizer shop
k = Index to declare Farmer Group
c = Index to declare Representation Warehouse
Parameter
hb_j = the price of fertilizer by fertilizer shop j
hp_c = bokabo tobacco price by company's warehouse c
btp_ik = fixed delivery costs from farmer group i to farmer group k
btp_jk = fixed delivery costs from fertilizer shop j to farmer group k
btp_kc = fixed shipping costs from farmer group k to company's warehouse c
bp_ik = shipping cost of bokabo tobacco seeds from breeder i to poktan k
bp_jk = shipping cost of fertilizer from fertilizer shop j to poktan k
bp_kc = delivery costs of fertilizer from farmer group k to company's warehouse c
dem_c = bokabo tobacco demand at company warehouse c
dem_ik = bokabo tobacco seeds demand in farmer groups k
dem_jk = bokabo tobacco fertilizer demand in farmer group k
TDS_ik = number of seeds shipped from seed breeder i to farmer group k
TDD_jk = number of fertilizer shipped from fertilizer shop j to farmer group k
TDP_kc = number of bokabo tobacco products shipped from farmer group k to company warehouse c
TS_i = number of seeds produced by the breeder i
TD_j = number of fertilizer available at fertilizer shop j
TP_k = number of bokabo tobacco produced by farmer groups k
d_ik = distance between breeder i to farmer group k
d_jk = distance between fertilizer shop j to farmer group k
d_kc = distance between farmer group k to company's warehouse c
Kap_i = Maximum vehicle capacity for shipping the seeds
Kap_j = Maximum vehicle capacity for shipping the fertilizer
Kap_k = Maximum vehicle capacity for shipping the tobacco

B. *Mathematical Model*

Mathematical model for grouping the farmer groups are done to simplify the existing problems. In this paper that

grouping of farmer is done by using facility location method. There are 3 method that are being used. Thus are, P-Median, P-Center, dan Maximal coverage. In this supply chain, there are 15 nodes (p) to be a center node of thus method.

P-Median

The grouping of P-Median is as follows:

Indices:

i = farmer group
j = Group of center node

Parameter
n = total farmer group node
dij = distance between nodes i and j
p = number of clusters wanted
Decision Variables

xij = 1 if node i becomes a member at the cluster node at node j; 0 if otherwise
yj = 1 if the cluster node lies on j; 0 if otherwise
Having known the node of each cluster and cluster member,
Objective Function:

$$\min \sum_{i=1}^{n} \sum_{j=1}^{n} d_{ij} x_{ij} \quad (1)$$

Subject to:

$$\sum_{j=1}^{n} x_{ij} = 1 \quad \forall i \quad (2)$$

$$x_{ij} \leq y_j \quad \forall i, j \quad (3)$$

$$\sum_{j=1}^{n} y_j = p \quad (4)$$

$$x_{ij} = \{0, 1\} \quad \forall i, j \quad (5)$$

$$y_j = \{0, 1\} \quad \forall j \quad (6)$$

Equation (1) means that it have to minimize the total distance between farmer group i with center group node j. Equation (2) means that each farmer group i has only 1 center node j. Equation (3) means that the number of nodes that are being centered should be smaller than the many of center nodes. Equation (4) means that the number of center nodes must be equal to a predetermined p value, in this case is 15. Equation (5) means that the value of x from i to j has the possibility of values 0 and 1 (biner number). Equation (6) means that the value of y or cluster node which is used consists of a binary number. Thus are having the possibility of values 0 and 1.

P-Center

The criteria for grouping p-center are as follows:

Index

i = farmer group
j = Group center node
Parameter
n = total farmer group node
dij = distance between nodes i and j
p = number of clusters wanted

Decision Variables

xij = 1 if node i becomes a member at the cluster node at node j; 0 if otherwise

yj = 1 if the cluster node lies on j; 0 if otherwise

Objective function

$$\min(\max(d_{ij} x_{ij})) \quad (7)$$

Subject to:

$$\sum_{j=1}^{n} x_{ij} = 1 \quad \forall i \quad (8)$$

$$x_{ij} \leq y_j \quad \forall i, j \quad (9)$$

$$\sum_{j=1}^{n} y_j = p \quad (10)$$

$$x_{ij} = \{0, 1\} \quad \forall i, j \quad (11)$$

$$y_j = \{0, 1\} \quad \forall j \quad (12)$$

Equation (7) means that the objective goal is to minimize the farthest distance from nodes i and j. Equation (8) means that each farmer group i has only 1 center node of group j. Equation (9) means that the number of nodes used as the center should be smaller than the many of center nodes. Equation (10) means that the number of center nodes must be equal to a predetermined p value. Equation (11) means that the value of x from i to j and has the possibility of values 0 and 1. Equation (12) means that the value of y or cluster node used consists of a binary set which is having the possibility of values 0 and 1.

Maximal coverage

The criteria for classifying maximal coverage are as follows:

Index

i = farmer group
j = Group center node
Parameter
n = total farmer group node
demij = demand between nodes i and j
p = number of clusters wanted
Decision Variables
xij = 1 if node i becomes a member at the cluster node at node j; 0 if otherwise
yj = 1 if the cluster node lies on j; 0 if otherwise
Having known the node of each cluster and cluster member,

Objective function

$$\max(\sum_{i \in I} \sum_{j \in J} dem_{ij} \; x_{ij}) \quad (13)$$

Subject to

$$\sum_{j=1}^{n} x_{ij} = 1 \quad \forall i \quad (14)$$

$$x_{ij} \leq y_j \quad \forall i, j \quad (15)$$

$$\sum_{j=1}^{n} y_j = p \quad (16)$$

$$x_{ij} = \{0, 1\} \quad \forall i, j \quad (17)$$

$$y_j = \{0, 1\} \quad \forall j \tag{18}$$

Equation (13) means that the objective goal is to maximize the demand between nodes i and j. Equation (14) means that each farmer group i has only 1 group center node j. Equation (15) means that the number of nodes to be centered should be smaller than the many of center nodes. Equation (16) means that the number of center nodes must be equal to a predetermined p value. Equation (17) means that the value of x from i to j has the possibility of values 0 and 1 (biner number). Equation (18) means that the value of y or cluster node used consists of a binary set which is having the possibility of values 0 and 1.

IV. MEASUREMENT CRITERIA

Comparison between methods definitely requires reference criteria. The criteria considered in this study aims to measure and test the efficiency of the solution basically in terms of the average distance between the demand and facility location, the number of demands covered and the maximum distance between the demand and facility location. The comparative criteria used based on [5] and will be added Supply Chain Cost Criteria (C8). The detail of the criterria will be used in this study are as follows:

A. *C1 (Average distance of demand to main facility)*

This criteria evaluates the average distance between each location of the demand and its nearby facilities. This criteria is a common criteria for facility location analysis. The average effectiveness can be measured using this parameter.

B. *C2 (Average distance of main facility demand and reserve facility)*

This criteria evaluates the average distance between each demand and all designated facilities. In other words, these criteria measure the performance of the solution by looking at the distance to the main location and the distance to the backup location. Backups have a meaning if the demand could not be met in the main location.

C. *C3 (Average distance of demand to reserve facility)*

This criteria evaluates the average distance between each demand and reserve facility. The main purpose of this criteria is to measure the effectiveness of the reserve stock when its parent runs out to serve other needs. Spacing close to the backup facility plays an important role to improve the performance of the allocation plan especially in cases where the number of demands is high.

D. *C4 (Ratio of demand with primary needs and reserves in available capacity)*

This criteria measures the ratio of demand locations covered by at least n facilities. To make a fair comparison, when measuring the performance of the p-MP and p-CP models, we calculated this value by applying coverage r to each facility as used in the MCLP model. This ratio shows the ratio of demands that can receive primary and backup services within a certain time.

E. *C5 (Ratio of demand with at least key coverage within reach threshold)*

This criteria quantifies the ratio of demand locations covered by at least one facility. Again we use the parameter r to measure the performance of the model p-MP and p-CP. By calculating this ratio, we strive to determine the ratio of demands that receive at least one service within the time limit or distance.

F. *C6 (Maximum distance to primary facility)*

In this criteria, we aim to determine the worst case performance of the location model by calculating the maximum distance between the demand and the main facility.

G. *C7 (Maximum distance to backup facility)*

Similar to C6, this criteria determines the maximum distance between demand and backup facilities.

H. *C8 (Supply Chain Management Cost Required)*

This criteria is a necessary criteria if you want to find the minimum cost overall. The required equations are as follows:

Objective Function:

Objective Function 1 (Farmer and farmer group)

$$\sum_{\forall i}\sum_{\forall k}\left(\left(\frac{TDS_{ik}.bp_{ik}.d_{ik}}{Kap_i}\right) + btp_{ik}\right) \tag{19}$$

Objective Function 2 (fertilizer shop and farmer group)

$$\sum_{\forall j}\sum_{\forall k}\left(\left(\frac{TDD_{jk}.bp_{jk}.d_{jk}}{Kap_j}\right) + btp_{jk}\right) + \sum_{\forall j}\sum_{\forall k}(TDS_{jk}.hb_{jk}) \tag{20}$$

Objective Function 3 (Group of farmers and tobacco shrimp)

$$\sum_{\forall k}\sum_{\forall c}\left(\left(\frac{TDP_{kc}.bp_{kc}.d_{kc}}{Kap_c}\right) + btp_{kc}\right) + \sum_{\forall k}\sum_{\forall c}(TDS_{kc}.hb_{kc}) \tag{21}$$

Subject to

Seeds sent to farmer groups should not be more than a lot of breeders produced by breeders.

$$\sum_{\forall k} TDS_{ik} \leq TS_i \quad \forall i \tag{22}$$

The fertilizer sent to the farmer group should not be more than the fertilizer available at the fertilizer shop

$$\sum_{\forall k} TDD_{jk} \leq TD_j \quad \forall j \tag{23}$$

Tobacco shipped by farmer groups should not be more than representative warehouse demand.

$$\sum_{\forall k} TDP_{kc} \leq TD_c \quad \forall c \tag{24}$$

Seeds and fertilizers are accepted for each farmer group according to the needs of farmer groups. And the tobacco shipped by the farmer meets the demand

$$TDS_{ik} = dem_{ik} \quad \forall k \tag{25}$$

$$TDD_{jk} = dem_{jk} \quad \forall k \tag{26}$$

$$TDP_{kc} \leq dem_c \quad \forall c \tag{27}$$

The amount of tobacco shipped must be the same as the tobacco produced by the farmer group.

$$TDP_{kc} = TP_k \tag{28}$$

The definition of each decision variable

$$TP_k, TS_i, TD_j, TDS_{ik}, TDD_{jk}, TDP_{kc} \geq 0 \tag{27}$$

V. COMPARING RESULT

The result criteria from each method with the help of MATLAB software. Here is the result between the criteria of the comparison method between p-median, maximal coverage, and maximal covering. Comparing result is run by 30 replication, 8 criteria and 3 method (*P-Median, P-Center, and Maximal Coverage*). For making fair comparing, we decide to assume r (maximum radius of distance for reaching facilities). Thus radius are 5 km, 7 km, 9 km, 10 km, 12 km, and 14 km.

Table 1. Comparing Result

	r	Method				r	Method		
		P-Median	P-Center	Maximal Coverage			P-Median	P-Center	Maximal Coverage
C1	5	3.29	3.94	3.72	C3	5	20.73	20.67	21.09
	7	3.20	3.84	3.65		7	19.67	21.05	19.87
	9	3.31	3.83	3.75		9	20.67	20.90	20.30
	10	3.26	4.03	3.83		10	19.79	21.76	19.39
	12	3.30	4.01	4.92		12	21.07	22.32	19.20
	14	3.20	4.01	4.25		14	20.19	21.77	19.27
C2	5	19.56	19.55	21.09	C4	5	2.07	2.81	4.15
	7	18.57	19.90	19.87		7	0.70	1.03	1.08
	9	19.51	19.76	20.30		9	0.52	0.62	0.76
	10	18.69	20.57	19.39		10	0.33	0.45	0.33
	12	19.88	21.10	19.20		12	0.27	0.35	0.28
	14	19.06	20.59	19.27		14	0.22	0.25	0.22

Table 1. Comparing Result (Continued)

	r	Method				r	Method		
		P-Median	P-Center	Maximal Coverage			P-Median	P-Center	Maximal Coverage
C5	5	0.80	0.68	0.83	C7	5	11.80	9.30	13.00
	7	0.91	0.87	0.97		7	11.80	9.40	11.70
	9	0.97	1.00	1.00		9	11.10	9.10	8.80
	10	0.99	1.00	1.00		10	11.10	8.90	10.90
	12	1.00	1.00	1.00		12	11.10	8.60	12.40
	14	1.00	1.00	1.00		14	10.92	9.80	12.80
C6	5	11.80	9.30	13.00	C8	5	7,978,155,593.30	7,984,372,816.42	7,983,846,151.64
	7	11.80	9.40	11.70		7	7,972,163,192.26	7,972,639,589.78	7,984,402,083.60
	9	11.10	9.10	8.80		9	7,977,065,767.18	7,990,577,235.06	7,989,731,364.90
	10	11.10	8.90	10.90		10	7,970,752,243.09	7,980,637,018.46	7,982,276,594.37
	12	11.10	8.60	12.40		12	7,969,437,263.97	7,981,877,461.90	7,975,824,102.87
	14	10.92	9.80	12.80		14	7,982,468,930.87	7,976,912,781.41	7,972,436,760.30

Table 1. Comparing Result. It shows to compare each criteria based on radius and method. In the first criteria (C1) which should be minimized so that it can be seen the best value is 3.20 km when radius equal to 7 and the method is P-Median. In the other side, (C2) is preferably minimized so it can be seen the best value is 18.69 km when radius equal to 10 and the method is P-Median. While the (C3) objective function criteria is to be minimized so it can be seen the best value is 19.20 km when radius equal to 12 and the method is using maximal coverage. On the fourth criteria (C4) the objective function to be maximized so that the best value is 4.15 when radius is equal to 5 and the method is maximal coverage. The next criteria (C5), objective function is maximize so that the best value obtained is a 1 ratio when radius is 9 and the methods are p-center and maximal coverage. In the 6th criteria (C6), the goal function is to be minimized so that the best value is 8.60 km when radius 12 and the method is maximal p-center. Seventh criteria (C7) has an objective function. The objective function is to be minimized so that the best value is 57.50 km when radius 10 km and the method is p-median and the last criteria is (C8), the objective function is to be minimized so that the best value is Rp 7,970,752,243,09. The detailed explanation about each criteria and each methods with the radius parameter is showed bellows, thus are:

A. C1 (Average distance of demand to primer facility)

The Result of C1 is as follows:

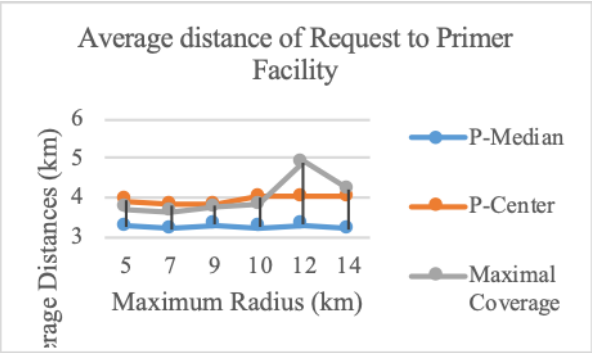

Figure 2. Average distance of demand to primer facility

Fig. 2. Average distance of demand to primer facility can be seen that P-Median is the most superior method compared to other methods for the average distance between the demands to the main facility. Then followed by Maximal coverage and P-Center.

B. C2 (Average distance of demand to primer facility and backup facility)

The Result of C2 is as follows:

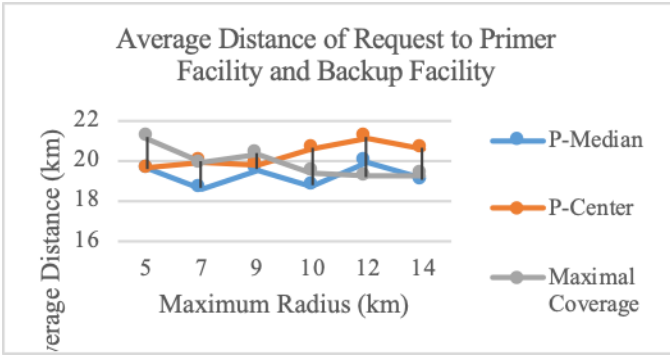

Figure 3. Average distance of demand to primer facility and backup facility

Fig. 3. Average distance of demand to primer facility and backup facility can be seen that P-Median is the most superior method compared to other methods for the average distance between demand to main facility and reserve. Then followed by Maximal coverage and P-Center. For the maximal coverage the greater the range of the range the smaller the average distance. This is in contrast to the P-Center that the greater the distance radius even greater the average distance.

C. C3 (Average distance of demand to backup facility)

The Result of C3 is as follows:

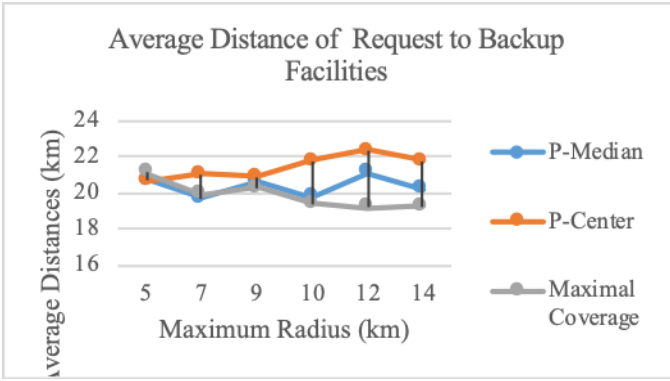

Figure 4. Average distance of demand to backup facility

Fig. 4. Average distance of demand to backup facility can be seen that the maximal coverage is superior in solving the problem if the main facility that became the primary goal is exhausted so that force to the backup facility. Then followed by p-median and p-center.

D. C4 (Ratio of demand with primary facility and backup facility within a range threshold)

The Result of C4 is as follows:

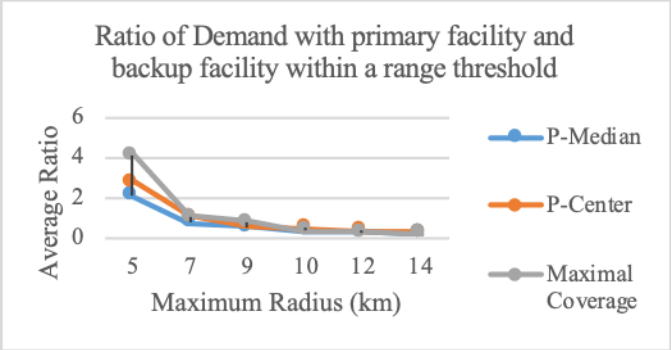

Figure 5. Ratio of demand with primary facility and backup facility within a range threshold

Fig. 5. Ratio of demand with primary facility and backup facility within a range threshold can be seen that P-median has always been the pre-eminent to determine the ratio of demand at the main facility with the reserve facility. The greater the ratio means that the main facility is much larger in the fulfillment of demand than the reserves. Then followed by P-Center and maximal coverage

E. C5 (Ratio of demand with at least primary coverage within a range threshold)

The Result of C5 is as follows:

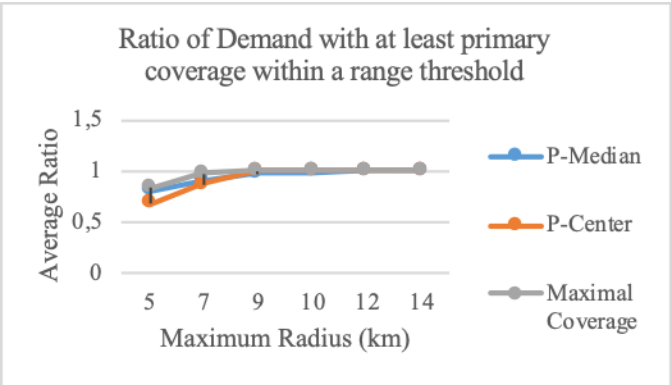

Figure 6. Ratio of demand with at least primary coverage within a range threshold

Fig. 6. Ratio of demand with at least primary coverage within a range threshold can be seen that the maximal coverage to be superior when determining the ratio of demand at the reach threshold. It is important to see the demand can be met at least in 1 facility. This means that the true demand is already covered by the main facility. Then followed by p-median and p-center.

F. C6 (Maximum distance to primary facility)

The Result of C6 is as follows:

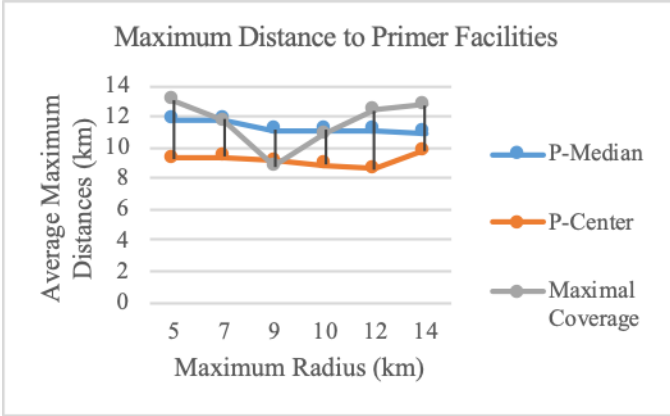

Figure 7. Maximum distance to primer facilities

Fig. 7. Maximum distance to primer facilities can be seen that P-Center is a superior method to minimize the maximum distance to the primary facility. Then followed by p-median and maximal coverage.

G. C7 (Maximum distance to backup facility)

The Result of C7 is as follows:

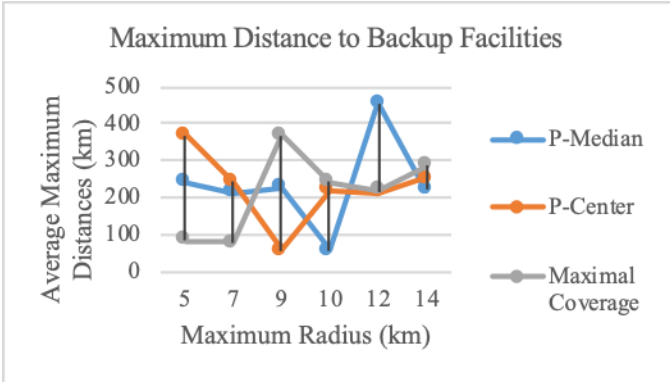

Figure 8. Maximum Distance to Backup Facilities

Fig. 8. Maximum Distance to Backup Facilities can be seen for r (range limit) small then the maximum distance to the smallest reserve facility is maximal coverage. As for the bigger r (range limit) then the maximum distance to the smallest reserve facility is p-center and p-median.

H. C8 (Supply Chain Management Cost Required)

The Result of C8 is as follows:

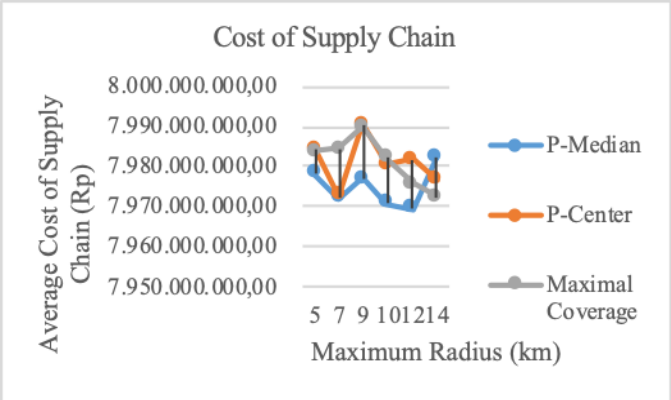

Figure 9. Cost of Supply Chain

Fig. 9. Cost of Supply Chain can be seen that p-median is the best method to determine the overall distribution cost that is between farmer to fertilizer shop, farmer to seed breeder, and farmer to warehouse with value from 7.970.000.000 up to 7.980.000.000. Then just followed by maximal coverage and p-center.

VI. CONCLUSION

From the results of analysis and discussion that has been done known that several methods give different effects for each criteria. This concludes that no one method is optimal for each type of problem. So in the case of bokabo tobacco supply chain in Sumenep District needs to match the method with the existing problem. Problems that always move dynamically causes the readiness of decision makers change in determining the warehouse that will be built or the decision of the farmers to choose which fertilizer or seed shop to be purchased and which warehouse will be the destination of delivery.

Table 2. Conclusion Result

	Small r	**Large r**
C1	P-MP	P-MP
C2	P-MP	P-MP
C3	P-MP	MCLP
C4	P-MP	P-MP
C5	MCLP	MCLP
C6	P-CP	P-CP
C7	MCLP	P-CP
C8	P-MP	P-MP

Table 2. Conclusion Result can be seen and concluded that p-median is the best method on criteria 1, criteria 2, criteria 4, and criteria 8. This means that if there is a warehouse planner wanting the average distance of demand to the main facility, the distance average demand for primary and reserve facilities, average distance of demand to reserve facility, and minimum cost for each distribution should use p-median problem. While for criteria 3 it is filled by p-median for small r (small range) and for big r (big range) are filled by maximal coverage. Which means that maximal coverage or p-median is suitable to be applied to this problem.

Criteria 5 is filled by maximal coverage which is a method that has superiority in demand between primary and reserve requirement. While for criteria 6 and 7 filled by p-center which means p-center will minimize the maximum distance to primary facility and reserve.

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