The communal salt farmer ventures grouping strategy in Sumenep District using the P-Median method to minimize transport distance in food supply chain network.

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Abstract. Advance research has successfully shown that the farmers grouping in the supply chain network can reduce the total distance of commodity transport. The purpose of this study is to group the communal salt farmer ventures (KUGAR) in Sumenep District to minimize the total transport distance of salt commodities in the food supply chain network. Location coordinates and salt production capacity of each communal salt ventures are required to be able to calculate the total transport distance. Site survey was conducted for each communal salt ventures to mark locations on the Google map and record production capacity. Using the Google map API the distance data between communal salt ventures is collected and built distance matrix from one origin venture to another destination venture. The communal salt ventures grouping is done by the P-Median method. The experiment was conducted with an alternative of 2 groups, 3 groups, 4 groups. Total minimum transport distances as low as 127.82 km are achieved with 4 groupings. The first group was centered at Asapok Angin venture in the village of Pragaan Laok, the sub-district of Pragaan with 13 ventures member. The second group was centered at Mekar Jaya venture in Karanganyar village, Kalianget sub-district with 41 ventures member. The third group was centered at Usaha Bersama VII venture in the village of Gersik Putih, Gapura sub-district with 16 ventures member. The fourth group was centered at Persada Indah VII venture in the village of Kertasada, the Kalianget sub-district with 20 ventures member.

1. Introduction

The national salt demand in Indonesia was 3.61 million tons in 2014, consisting of industrial salt and consumption salt 2.13 million tons and 1.48 million tons respectively. In the same year, national salt production in Indonesia yield 2.19 million tons. This production is not sufficient for national demand. Salt production of Communal Salt Ventures (KUGAR) contributed up to 1.88 million tons while the state-owned company PT. Garam accounts for 315 thousand tons[1]. The Communal Salt Ventures, as known as Kelompok Usaha Garam Rakyat (KUGAR) is a community of salt farmers who produce salt independently. Indonesia does not hold a lot of salt deposits on the Indonesian mainland. However, the salinity of seawater in several Indonesian seas has very high salinity levels, especially along the Madura-Bali strait[2]. Therefore, salt production in Indonesia is carried out by evaporation of seawater on the southern coast of Sampang District[3], Pamekasan District[4], Sumenep District[4] of Madura Island, the north coastal of Jawa island[5], the nort coast of Bali island[6] the east coast of Aceh

Province[7] dan north coast of Lombok island[7]. As is generally the case for farmer that face economic, welfare, legal, health and occupational risks, in many Asian countries[8], African countries[9], European countries[9][10], Australians[11], dan Americans[10], as well as Indonesian farmer[12][13], including Indonesian salt farmer[14][15].

2. Related work

The condition of farmers including salt farmers in Indonesia, India, China also experienced health problems[16], work safety[17], economic welfare[18][19], social problem and legal conflicts[20]. There have been many efforts from researchers to solve farmers' problems with various approaches. Kurniawan[20] and Nuswardani[21] successfully revealed the potential of social and legal conflicts faced by salt farmers in Madura and provided policy recommendations for the local government to protect and empower the salt farmers in Madura. Bagiyo et.al.,[22] has provided strategic planning to build the production capacity of salt farmers in the northern coastal region of East Java. Nurdin et.al,[23] designed crop technology in an effort to reduce the risk of farmer injury in harvesting activities. Arendra et.al.,[24][25] also developed an energy saving dryer to assist farmers in processing post-harvest commodities. Badruzzaman and Sifa[15] have developed sea water pump turbine technology to increase the productivity of salt farmers.

The supply chain management approach was carried out by several researchers to reduce the distribution costs of agricultural commodities. Akhmad et.al.,[14] developed a new method using the interval model for the food supply chain network of salt commodity. Winarso[4][26] conducted a comparative study of three methods of grouping the location of tobacco farming facilities in Madura to reduce the cost of tobacco distribution.Similar conclusion was reached by research studies on grouping of farmers in a supply chain network framework, with the right grouping, it can reduce the transport costs of agricultural commodities. Finally, the farmers grouping can increase farmers' income[12][13], increase farm production and increase national food security[27].

3. Problem statement, objective and research method

How is the communal salt ventures grouping in the salt supply chain network in Sumenep district with the shortest transport distance? To uncover this problem, the communal salt ventures data needs to be known. This data consists of the number of the communal salt ventures, the location coordinates of each communal salt ventures, the transport distance between communal salt ventures, the land area of salt evaporation ponds and the production capacity of each communal salt ventures.

This study visited every communal salt ventures site in Sumenep District, East Java Province Indonesia, to complete the research data. The land area of salt evaporation ponds and the communal salt ventures production capacity is surveyed directly at each communal salt ventures site. The latitude and longitude coordinates location of each communal salt ventures site were tagged on the Google Map during the site visit. The facilities location map and the transport distance matrix between the facilities were made, based on recapitulation data. The transport distances between communal salt ventures (KUGAR) are found with the Google Map API. The next step, grouping the communal salt ventures using P-Median method with the objective function, the shortest transport distance.

4. Assumptions, parameters, notations and mathematical model

This research assumes that each of the communal salt ventures has one location, as a reference coordinates point for P-Median grouping. The accuracy of location coordinates measurements are assumed to be the same, with a level accuracy of 100 meters.

4.1. Parameters used:

n = number of communal salt ventures (KUGAR)
d_{ij} = distance from communal salt ventures *(i)* site coordinates to group center *(j)* coordinates
p = number of group

4.2. index used:

i = communal salt ventures (KUGAR)
j = group center

4.3. decision variable:

x_{ij} = 1, if point i becomes a member at group j; 0, for the others

y_j = 1, if the group center point is at point j; 0, for the others

4.4. mathematical model of transportation distance:

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

4.5. objective function:

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

4.6. constraint functions:

$$\sum_{j=1}^{n} x_{ij} = 1 \ \forall i \quad x_{ij} \leq y_j \ \forall i,j \quad (3)$$

$$\sum_{j=1}^{n} y_j = p \quad x_{ij} = \{0,1\} \forall i,j \quad y_j = \{0,1\} \forall j \quad (4)$$

5. Result and discussion

The site survey for each communal salt ventures obtained a total of 90 ventures, some of the data partialy displayed in table 1. The salt evaporation ponds area and salt production capacity in Sumenep District is 1018.04 hectare and 178,345.15 Tons/year respectively. The latitude and longitude location coordinates of each communal salt ventures site recorded in table 1. The total of 90 ventures distributed on the south coast and east coast in 4 out of 27 sub-districts in Sumenep district, namely sub-district of Pragaan, Saronggi, Gapura and Kalianget.

Table 1. Communal Salt Venture (KUGAR) properties in Sumenep District.

No	Communal Salt Venture	Land Area (Hectare)	Production Capacity (Ton/Year)	Location Coordinate	
				Latitude	Longitude
1	Asapok Angin	11.42	1769.1	-7.112136	113.65729
2	Usaha Mulya	11.49	1780	-7.112138	113.65731
.	…	.	.	.	.
90	Persada Indah VIII	11.40	2086.2	-7.041011	113.90514
	TOTAL	1018.04	178345.15		

Records of the latitude and longitude coordinates tagging of each salt ventures site are used to find the transport distance between ventures locations using Google Map API. Data transport distances between 90 ventures is formed into a transport distance matrix with a size of 90×90. The transport distance matrix data shown in Table 2 partially. This transport distance matrix is used to calculate the total transportation distance according to the mathematical model of equation 1. Iteratively, the P-median method determines the communal salt ventures membership of each group, determines the center point of each group and calculates the total transportation distance with the objective function minimizing the transportation distance according to the objective function of equation 2 with the limiting function of equation 3 and equation 4. The P-median grouping is done with an alternative of 2 group center points, 3 group center points, and 4 group center points.

The P-median grouping with 2 center points groups divides the membership of each of the 90 communal salt ventures into two groups. The P-median two grouping iteration found the lowest transportation distance of 534.86 km. The salt ventures selected as the center of the two group are Asapok Angin ventures at latitude -7.112136 longitude 113.65729 and Pasir Bumi ventures at latitude -7.058069 longitude 113.877224. The communal salt ventures membership in the Asapok Angin ventures group is 13 communal salt ventures, all of which are from 5 villages in the Pragaan sub-district. While the membership of the Pasir Bumi ventures group consists of 77 communal salt ventures distributed in 5 villages in Saronggi sub-district, 5 villages in Gapura sub-district, and 4 villages in Kalianget sub-district. Grouping with two center points resulting two venture groups that are not balanced. The first venture group consisted of 13 communal salt ventures in one sub-district with a land area of 203.01 hectare and production capacity of 31,449.4 tons/year, while the second venture group consisted of 77 communal salt ventures in three sub-districts with an area of 815.03 hectare and production capacity of 146,895.75 tons/year.

Table 2. Distance matrix (90×90) between Communal Salt Venture (KUGAR) location.

From \ To	Asapok Angin	Usaha Mulya	Nusantara	…	Persada Indah VIII
Asapok Angin	0.0	0.2	0.1	.	36.0
Usaha Mulya	0.2	0.0	0.1	.	36.0
Nusantara	0.1	0.1	0.0	.	36.0
…	.	.	.	0.0	.
Persada Indah VIII	36.0	36.0	36.0	.	0.0

Table 3. P-median grouping of Communal Salt Venture (KUGAR) with two centered (f), three centered (g), and four centered (h)

sub-District (a)	Village (b)	Identity number (c)	Number of Communal Salt Venture (d)	P-Median Grouping Center (e)		
				two centered (f)	three centered (g)	four centered (h)
1. Pragaan	1. Pragaan Laok	1-5	5	Asapok Angin	Asapok Angin	Asapok Angin
	2. Jaddung	6-7	2	Asapok Angin	Asapok Angin	Asapok Angin
	3. Pakamba Laok	8-9	2	Asapok Angin	Asapok Angin	Asapok Angin
	4. Sentol Daya	10-11	2	Asapok Angin	Asapok Angin	Asapok Angin
	5. Sendang	12-13	2	Asapok Angin	Asapok Angin	Asapok Angin
2. Saronggi	6. Nambakor	14-19	6	Pasir Bumi	Mekar Jaya	Mekar Jaya
	7. Kebundadap Barat	20-28	9	Pasir Bumi	Mekar Jaya	Mekar Jaya
	8. Saroka	29-30	2	Pasir Bumi	Mekar Jaya	Mekar Jaya
	9. Tanjung	31	1	Pasir Bumi	Mekar Jaya	Mekar Jaya
	10. Kebundadap Timur	32-35	4	Pasir Bumi	Mekar Jaya	Mekar Jaya
3. Gapura	11. Gersik Putih	36-48	13	Pasir Bumi	Usaha Bersama VII	Usaha Bersama VII
	12. Andulang	49	1	Pasir Bumi	Usaha Bersama VII	Usaha Bersama VII
	13. Gapura Tengah	50	1	Pasir Bumi	Usaha Bersama VII	Usaha Bersama VII
	14. Banjar Timur	51	1	Pasir Bumi	Usaha Bersama VII	Usaha Bersama VII
	15. Karangbudi	52-60	9	Pasir Bumi	Mekar Jaya	Persada Indah VII
4. Kalianget	16. Karanganyar	61-75	15	Pasir Bumi	Mekar Jaya	Mekar Jaya
	17. Marengan Laok	76-78	3	Pasir Bumi	Mekar Jaya	Persada Indah VII
	18. Pinggirpapas	79-82	4	Pasir Bumi	Mekar Jaya	Mekar Jaya
	19. Kertasada	83-90	8	Pasir Bumi	Mekar Jaya	Persada Indah VII

Grouping with 3 center point groups divides each 90 communal salt ventures into three venture groups. The P-median iteration found membership distribution for each of the three venture groups with the lowest transport distance of 219.07 km. Asapok Angin venture, Mekar Jaya venture, and Usaha Bersama VII venture were selected to be the center of the first venture group, second venture group and third venture group respectively. The first venture group was centered in the Asapok Angin venture, had 13 members of ventures who were all distributed in 5 villages in the Pragaan sub-district. Mekar Jaya venture, at latitude -7.061699 longitude 113.87342, became the center of the second venture group with a membership of 61 communal salt ventures, distributed in 10 villages in sub-district of Saronggi, Gapura and Kalianget. The third group, centered on the Koperasi Usaha VII venture, at latitude -7.022103 longitude 113.95423, consists of 16 communal salt ventures, distributed in 4 villages in Gapura sub-district. It turned out that all communal salt ventures in Pragaan sub-district remained grouped in group one and remained centered in Asapok Angin venture. Communal salt ventures, which are located in Saronggi sub-district, Gapura sub-district, and Kalianget sub-district which were previously as a centralized group in Pasir Bumi venture, are now divided into two groups centered on Mekar Jaya venture and Usaha Bersama VII venture. Communal salt ventures, which are located in 5 villages in Saronggi sub-district, in 4 villages in Kalianget sub-district, and in 1 village in Gapura sub-district remains in group two. While the third group was formed from communal salt ventures which are located in 4 villages in the Gapura sub-district. Gapura sub-district is the intersection area of group two and group three in 3 grouping of communal salt ventures in Sumenep District.

Next iteration, the P-median distributes the membership of 90 communal salt ventures into four groups and generate the lowest transport distance as low as 127.82 km. The Asapok Angin venture became the center of the first group in the grouping of four groups. The first group consisted of 13 communal salt ventures which were located in 5 villages in Pragaan sub-district. The second group was centered in the Mekar Jaya venture, consisting of 41 communal salt ventures spread over 7

villages in sub-district of Saronggi and Kalianget. The third group's center is the Usaha Bersama VII venture with the membership of 16 communal salt ventures which were located in 4 villages in Gapura sub-district. The Persada Indah VII venture at latitude -7.037813 longitude 113.90590, became the center of a fourth group with a total of 20 communal salt ventures member spread over 3 villages in sub-district of Gapura and Kalianget. The division of the four groups turned out to split the previously group 2 into two group centered on Mekar Jaya venture and Persada Indah VII venture. The first group of four consisted of ventures which were located in the Pragaan sub-district. The second group of four consists of ventures which are located in Saronggi sub-district and a portion of ventures which are located in Kalianget sub-district. The third group of four consists of a portion of salt ventures in the Gapura sub-district. The fourth group of four consists of a portion salt ventures in the Gapura sub-district and a portion salt ventures in the Kalianget sub-district. Kalianget District is the intersection area of groups two and groups four. Gapura District is the intersection area of group three and group four

6. Conclusion

Grouping with 4 central points succeed in reducing transport distances to as low as 127.82 km. The first group was centered at Asapok Angin venture, consisting of 13 communal salt ventures in the Pragaan sub-district. The first group of four has a total salt evaporation pond area of 203.01 hectare and production capacity of 31,449.4 tons/year. The second group is centered at Mekar Jaya venture, consisting of 41 salt ventures. The second group of four has a total salt evaporation pond area of 435.85 hectare and production capacity of 80,086.05 tons/year. The third group is centered at Usaha Bersama VII venture, consisting of 16 communal salt ventures. The third group of four has a total salt evaporation pond area of 142.34 hectares and production capacity of 24,468.7 tons/year. The fourth group is centered on the Persada Indah VII venture, consisting of 20 communal salt ventures. The fourth group of four has a total salt evaporation pond area of 236.84 hectare and production capacity of 42,341.0 tons/year.

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