Determine the Coordinate of Distribution Centre for Disaster Management Using Centre of Gravity

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Abstract

The purpose of this research is to determine the coordinates of the distribution center for disaster management using the Centre of Gravity by Excel and POM QM for Windows. The final result in each island for both Excel and POM QM for Windows is the same as -2.562623, 140.692633 for Papua located in Jayapura City, -8.841546, 121.64332 for Nusa Tenggara located in Ende, 0.482722, 101.457393 for Sumatra located in Pekan Baru, Java has two distribution centers with coordinates -6.942854, 107.647912 and -7.600916, 111.921028 located in Bandung and Nganjuk, -3.018673, 120.179055 for Sulawesi located in Palopo, -1.726377, 114.837564 for Kalimantan located in South Barito.

Keywords
Centre of Gravity, Distribution Center, Disaster Management, Excel, POM QM for Windows

1. Introduction
Indonesia is the world's largest archipelago and straddles the equator, between the continents of Asia and Australia. Its major islands include Sumatra, Java, Kalimantan, Sulawesi, Maluku and Papua (Garschagen, 2017). As the most fourth most populous country in the world, Indonesia's location on the Pacific Ring of Fire and proximity to the equator makes the country prone to natural disasters. Disaster is a natural phenomenon that cannot be avoided (Kane et al., 2016). Natural disasters that occur in Indonesia such as earthquakes, tsunamis, volcanic eruptions, floods, drought, tornadoes, landslides, abrasion, forest and land fires, which are caused by its geological, geographical, demographic and sociological condition (Kamaluddin et al., 2019).

According to the Indonesia National Agency for Disaster Management, disaster is an event or series of events that disrupt people's lives, both natural, non-natural and social disasters, resulting in human casualties, environmental damage, property loss, and psychological impact. Non natural disaster that occurs in Indonesia are fire and transportation accidents. Social disasters include conflict and acts of terror. Based on the data from Indonesia National Agency for Disaster Management, disaster in Indonesia increased from 1.945 cases in 2010 become 3.814 cases in 2019. The increase number of disaster can damage to health facilities, educational facilities, religious facilities, missing victims, injured victims, displaced victims, dead victims, affected victims, and house with severely damaged, minor and moderate damage. However, unfortunately, they are often experiencing a slow reaction to help. Meanwhile, there are still many victims who need immediate help (Haribowo et al., 2022).

Identify the best location to build the logistic warehouse for disaster management is needed for have a quick response to the victim of disaster. According to Indonesia National Agency for Disaster Management, disaster management logistic warehouse should be established in a very low risk area. Each region in Indonesia has different risks. These

risks consist of very high risk, high risk, medium risk, low risk, and very low risk. So, it is necessary to identify a safe area for build a logistics warehouse. Besides that, the logistic warehouse should be in Centre of Gravity, that means the location is the point where it reflects balance and equal weight to all area based on the location and the number of population in that area. Center of Gravity method is a mathematical technique to determine the ideal or center location for distribution point that serve several regions (Margana et al., 2021). So, this research utilizes the clustering of risk in each cities at Indonesia with the main purpose finding the best location based on Centre of Gravity method by using Excel and POM QM for Windows that have very low risk.

1.1 Objectives

The objectives of this research is determine the coordinates of distribution center for disaster management using Centre of Gravity by Excel and POM QM for Windows.

2. Literature Review

The logistics infrastructure play a vital role in increasing the capacity that leads to improved resilience against disaster (Hakim & Kusumastuti, 2018). Disaster relief logistic management is categorized into three phases such as preparation, immediate response and reconstruction. The objective of disaster relief logistic management is to improve rapid response facilities so as to deliver in emergency situations timely (He et al., 2017). Distribution center is responsible for storage, processing, distribution and coordinates the supply (Shen et al., 2020).

The techniques for determining the distribution center is Centre of Gravity. Centre of Gravity Techniques is a mathematical technique used to find the best location for a single distribution point that serves several location (Irwanto et al., 2018). The Centre of Gravity (COG) seeks to minimize the total distance that a load will travel and also provide the x and y coordinates for the location (Chenikwi, 2016).Centre of Gravity (COG) is considered in the study that generates a geographic points that (Arivalagan, 2019):

- Considers the relative size (measured by weight, volume, or quantity of product) of each supply or demand point.
- Minimizes the distance travelled to reach all the points in a supply or demand network to produce a point of equilibrium.

Centre of Gravity method is used to determine the pin location for new placing the warehouse or distribution center. The Centre of Gravity method is an accurate method in resolving distribution center locations that have minimal distances (Sutaji & Hasibuan, 2021). Data collection is done by determining the location of the sample from google maps to find out the coordinates of the location (Syam et al., 2018). The output of the Centre of Gravity method will be in the form of weighted distance of the origin and destination city distance with respect to weight in that flow. Formula for calculating Centre of Gravity is given below references (Gehrlein & Pasic, 2009):

$$COG = \frac{x_1 w_1 + x_2 w_2 + x_3 w_3 + \cdots + x_n w_n}{w_1 + w_2 + w_3}$$

Where:

COG = Centre of Gravity

x_n = Location n

w_n = Weight n

The center of gravity method is a method used to determine the location of a distribution center that will minimize transportation costs (Irwanto et al., 2018). The method treats shipping cost as a linear function of the distance and quantity shipped. A good starting point is the center of gravity of the target area. This location usually is not optimal one for the Euclidian or rectilinear distance measures, but it still is an excellent starting point. Using center of gravity as a starting point, managers can now search in its vicinity for the optimal solution. But, we need took other factors into considerations such as the fact that transport rates are not linear with distances and the real location of the center of gravity (Chenikwi, 2016).

The center of gravity, or weight center, technique is a quantitative method for locating a facility such as warehouse at the center of movement in a geographic area based on weight and distance. The center of gravity method takes into account the location of markets, the volume of goods shipped to those markets, and shipping costs in finding the best location for a distribution center (Gehrlein & Pasic, 2009).

3. Methods

The data that used in this study are the list of clustering each cities in Indonesia that have very high risk, high risk, medium risk, low risk and very low risk. The flowchart is as in figure 1

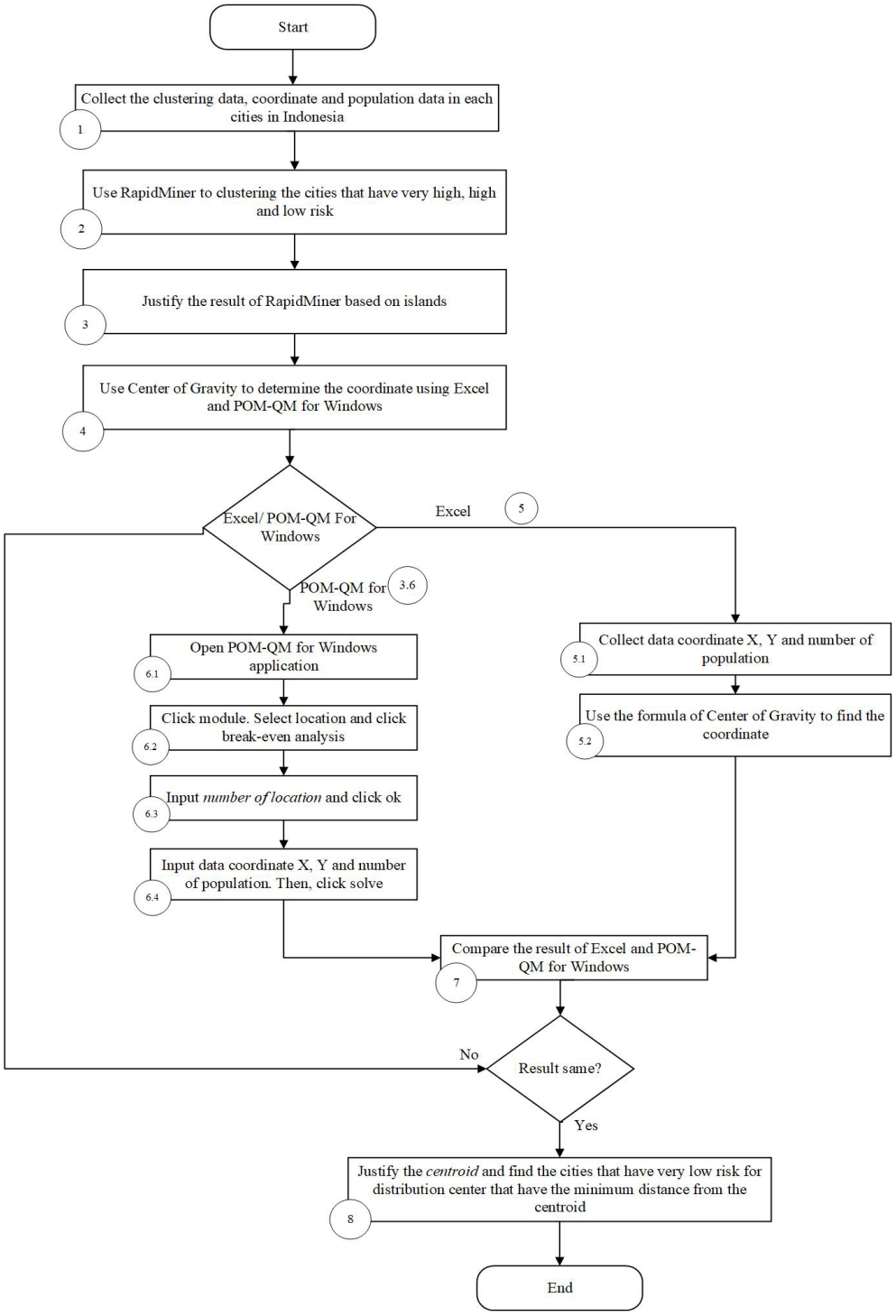

Figure 1. Methodology

The step of this research in figure 1 as below:

1. Collect the clustering risk of each cities in Indonesia that have very high risk, high risk, moderate risk, low risk and very low risk. Besides that, the data that need include the coordinate of X and Y regional disaster management agency and the population of each city in 2019 at Indonesia.
2. Use Rapid Miner to clustering the cities that have very high risk, high risk and moderate risk with the coordinate and population data to know the clustering based on location. The clustering that use is five because the data consists of six islands in Indonesia.
3. After get the result, justify the result of Rapid Miner based on islands.
4. Use Centre of Gravity to determine the coordinate of distribution center using Excel and POM QM for Windows application.
5. If Using Centre of Gravity by Excel:
    5.1 Collect the data of coordinate X, Y and number of population.
    5.2 Use the formula of Centre of Gravity to find the coordinate.
6. If Using Centre of Gravity by POM QM for Windows:
    6.1 Open POM QM for Windows application.
    6.2 Click module. Select location and click break-even analysis.
    6.3 Input number of location and click ok.
    6.4 Input the data of coordinate X, Y and number of population. Then, click solve.
7. Compare both of result in Excel and POM QM For Windows.
    7.1 The result is change so check again the calculation of center of gravity using Excel and POM QM for Windows.
    7.2 The result is same can go to next step.
8. Justify the centroid and find the cities that have very low risk for distribution center that have the minimum distance from the centroid.

4. Data Collection

The data that used in this study are the list of clustering each cities in Indonesia that have very high risk, high risk, medium risk, low risk and very low risk (Oktarina & Junita, 2021).

5. Results and Discussion

The result of Rapid Miner clustering is shown in Table 1 below.

Table 1. Result of Rapid Miner

No	Cluster	X	Y	Initial Result
		Excel & POM QM for Windows		Distribution Centre
1	Cluster 0	-2.549871	140.477109	Jayapura, Papua
2	Cluster 1	-9.235841	121.632737	Sawu Sea
3	Cluster 2	2.123048	99.889959	Labuhan Batu City, North Sumatra
4	Cluster 3	-6.462082	107.318282	Karawang City, West Java
5	Cluster 4	-7.529016	112.518046	Mojokerto, East Java
6	Cluster 5	-1.829328	117.649923	Makassar Strait

The initial results of clustering in Table 1 need justification because there are different data on islands that are categorized into one cluster.. Besides that, the result of cluster one and five is not in the city but in the sea and strait. This justification aims for the distribution process of goods can be categorized in one islands to make the deliver process quickly. In addition, shipping and handling of goods does not take a long time due to differences in transportation used due to different islands.

The result of first iteration is shown in Table 2.

Table 2. Result of First Iteration

No	Island	X	Y	Initial Result	Risk
		Excel & POM QM for Windows		Distribution Centre	
1	Papua	-2.549871	140.477109	Jayapura, Papua	High
2	Nusa Tenggara	-9.020078	119.682963	Sawu Sea	-
3	Sumatera	0.189740	101.364517	Kampar City, Riau	Moderate
4	Java	-6.648440	107.432497	Purwakarta City, West Java	High
5	Java	-7.318987	111.800753	Bojonegoro City, East Java	Moderate
6	Sulawesi	-2.910855	120.607454	Boni Sea	-
7	Kalimantan	-0.991627	114.942291	Barito City, Central Kalimanatan	High

The results of the first iteration in Table 2 justification will be categorized based on islands so it becomes 7 clusters with the islands of Papua, Nusa Tenggara, Sumatra, Jawa (covering West Java, Central Java, DKI Jakarta, and Banten), Java (covering Central Java, East Java and DI Yogyakarta), Sulawesi and Kalimantan. Java Island consists of two clusters due to the large number of areas that have dangerous risks so that it will be divided into two clusters based on Rapid Miner. The results of the first iteration is still in high and moderate risk, and for Nusa Tenggara and Sulawesi are don't have the risk because the distribution centre in sea.

According to Indonesia National Agency for Disaster Management, distribution centre for disaster management must be in areas that have a very low risk category. So, the first iteration need to be justified to get the best or optimal distribution centre. The result of second iteration is shown in Table 3.

Table 3. Result of Second Iteration

No	Island	X	Y	Initial Result	Risk
		Excel & POM QM for Windows		Distribution Centre	
1	Papua	-2.562623	140.692633	Jayapura City, Papua	Very low
2	Nusa Tenggara	-8.841546	121.64332	Ende, East Nusa Tenggara	Very low
3	Sumatera	0.482722	101.457393	Pekan Baru, Riau	Very low
4	Java	-6.942854	107.647912	Bandung City, West Java	Very low
5	Java	-7.600916	111.921028	Nganjuk, East Java	Very low
6	Sulawesi	-3.018673	120.179055	Palopo, South Sulawesi	Very low
7	Kalimantan	-1.726377	114.837564	Barito Selatan, Central Kalimantan	Very low

The result of second iteration is already in very low risk. So, it's means that the result of distribution centre can be considered as the distribution centre for disaster management. The result of the second iteration on the maps is shown in Figure 2.

Figure 2. The Result of Second Iteration

Where:

= Pekan Baru
= Bandung City
= Nganjuk
= Barito Selatan
= Palopo
= Ende
= Jayapura City

6. Conclusion

The optimal number of iterations is two. In the initial results, there are data on different islands which are categorized as one cluster. So the first iteration is needed. The second iteration is obtained by finding a distribution center that has a low risk. The final result of the distribution center for both Excel and POM QM for Windows applications is the same as the island of Papua which has coordinates -2.562623, 140.692633 is located in Jayapura City, Nusa Tenggara island has coordinates -8.841546, 121.64332 is located in Ende district, Sumatra island has coordinates 0.482722, 101.457393 is located in Pekan Baru, Java Island has two distribution centers with coordinates -6.942854, 107.647912 and -7.600916, 111.921028 is located in the cities of Bandung and Nganjuk, Sulawesi Island has coordinates -3.018673, 120.179055 is located in Palopo, Kalimantan Island has coordinates -1.726377, 114.837564 located in South Barito.

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Biography

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Junita is student in Industrial Engineering at BINUS University, has completed her study in learning E- Supply Chain Management, Supply Chain: Logistics, Warehouse Management Systems, Transportation Modelling, Research Methodology, Production & Operation Analysis. She ever join the IOP Conference Series: Earth and Environmental Science and publish the paper with the title is Determine the Clustering of Cities in Indonesia for Disaster Management using K-Means by Excel and Rapid Miner.