Matrik: Jurnal Manajemen, Teknik Informatika, dan Rekayasa Komputer
Vol. 22, No. 1, November 2022, pp. 105∼116
ISSN: 2476-9843, accredited by Kemenristekdikti, Decree No: 200/M/KPT/2020
DOI: 10.30812/matrik.v22i1.2095

Model Dynamic Facility Location in Post-Disaster Areas in Uncertainty

Lili Tanti[1], Syahril Efendi[2], Maya Silvi Lydia[3], Herman Mawengkang[4]
[1]Potensi Utama University, Medan, Indonesia
[2,3,4]Sumatera Utara University, Medan, Indonesia

Article Info

Article history:

Received July 05, 2022
Revised September 26, 2022
Accepted November 20, 2022

Keywords:

Dynamic
Emergency Facility Location
Model
Machine learning
Post-disaster
Uncertainty

ABSTRACT

Indonesia has many disaster-prone areas, natural disasters that occur in Indonesia in 2021 are 5,402 disasters. For disaster management in post-disaster areas, logistical planning is needed in the distribution of logistical assistance, it is estimated that the logistics costs of disaster assistance reach approximately 80% of the total costs in disaster management so that logistical assistance is an expensive activity of disaster relief. However, so far the process of distributing logistical assistance to disaster posts has not been evenly distributed. One of the causes of the unequal distribution is the inappropriate selection of distribution post locations. The facility location model is dynamic and has the objective function of minimizing the distance between emergency posts and refugee posts in terms of distribution of disaster relief goods in one cluster group. For grouping unsupervised learning data using a machine learning clustering algorithm, k-means. Model validation has been carried out using max run and max optimization 1000 times with results reaching 90%. This proves that the emergency facility location model can be used to determine the location of the emergency center, where the determination of the location of the emergency center has the closest distance to the request point/post shelter for disaster victims.

Corresponding Author:

Lili Tanti,
Faculty of Computer Science and Computer science study program,
Sumatera Utara University, Medan, Indonesia,
Email: lilitanti82@gmail.com

How to Cite: lili Tanti, S. Efendi, M. Lydia, and H. Mawengkang, Model Dynamic Facility Location in Post-Disaster Areas in Uncertainty, MATRIK : Jurnal Manajemen, Teknik Informatika dan Rekayasa Komputer, vol. 22, no. 1, pp. 105-116, Nov. 2022.

1. INTRODUCTION

Indonesia has many areas that are prone to disasters, both natural and man-made disasters. Disasters can be caused by several factors such as geographical, geological, climatic conditions as well as other factors such as social, cultural and political diversity [1, 2]. According to BNPB (National Disaster Management Agency), natural disasters that occurred in Indonesia in 2021 were 5,402 disasters. The impact of natural disasters took 7,645,694 lives and caused 163,103 damage (https://gis.bnpb.go.id). For disaster management in post-disaster areas, good logistical planning is needed in terms of distribution of logistical assistance. Logistics is the most important element in efforts to help victims of natural disasters and how to manage the logistics of humanitarian aid will determine the success of the disaster management operation [3, 4]. The obstacle faced is that the disaster has an uncertain nature so that it can affect the performance of humanitarian logistics planning. In the humanitarian logistics literature, various parameters have been considered under an uncertain environment i.e. demand, facility capacity, transportation time costs and others, based on this it is necessary to make a dynamic or multi-period decision in determining the location of the facility to reduce these impacts by creating management reliable logistics. According to Van Wassenhove, it is estimated that the amount of logistics costs for disaster relief reaches approximately 80% of the total costs in disaster relief so that logistical assistance is the most expensive activity of any disaster relief. However, so far the process of distributing logistical assistance to disaster posts from the government and other parties is still uneven, while there are still many other victims who have not received assistance [5]. One of the causes of the uneven distribution of logistical assistance is due to the selection of the location of the post for collecting logistical assistance that is not appropriate. Determination of the location of emergency facilities in post-disaster areas as distribution centers for collecting logistical assistance which will have an impact on appropriate and fast logistics aid distribution routes. The closer the distance between the distribution center and the point of demand (disaster victims), the faster the aid process will be received at the disaster site and the greater the life expectancy of the disaster victims.

Some researchers have used heuristic methods [6] and exact [7] However, to solve the location of emergency facilities, there are still obstacles, namely the exact method takes a long time to solve large disaster cases and the heuristic method still sacrifices accuracy. Determination of the location of emergency facilities from research [8] determined based on a safe area, and served as a place to store aid goods and distribute demand points (reservation posts), so that the location of the emergency facility that was built would be tasked with distributing all demand points and a combination of routes was needed for each transportation route to be traversed, thus requiring long time to get optimal route [9]. The position of the help post is modeled in research [8] to overcome the current linear programming problem, the model includes expenses for transportation use, opening of post locations, and inventory costs. The purpose of this study was to determine the ideal allocation of aid, the ideal location for the post, and the ideal number of the post. To assess the amount of relief supplies that must be stored in each distribution center to meet the needs of disaster victims, as well as the number and location of distribution in the aid network, a model was made [9]. This model, which is a variant of the maximum coverage location model, combines facility placement and inventory decisions, takes into account multiple items, and recognizes financial and capacity constraints. The purpose of this research problem is to maximize the overall anticipated demand from the distribution center by considering a number of constraints. The problem is formulated as a mixed integer programming problem. Hill climbing, annealing simulation, tabu search, genetic algorithm, ant colony optimization, and memetic algorithm are some of the concepts that utilize heuristic techniques [10].

According to this study, the opening of the Command Post is still decided arbitrarily by decisions made by related parties without taking into account the location of the point of request, so that it still sacrifices time and accuracy for computerity tests. Future studies are recommended by some scientists to address the problem where emergency facilities should be placed in the system [11] [11,12]and disaster relief operations by using machine learning strategies to maximize the objective function [12, 13] [13-16]. As a new model to overcome the difficulty of location of disaster relief commodity facilities in logistics management, the state-of-the-art in this study is a model of dynamic location facility problems in post-disaster locations in uncertainty with deep learning techniques.

2. RESEARCH METHOD

The research stages in making a dynamic facility location model in post-disaster areas in uncertainty with a machine learning approach are shown in Figure 1.

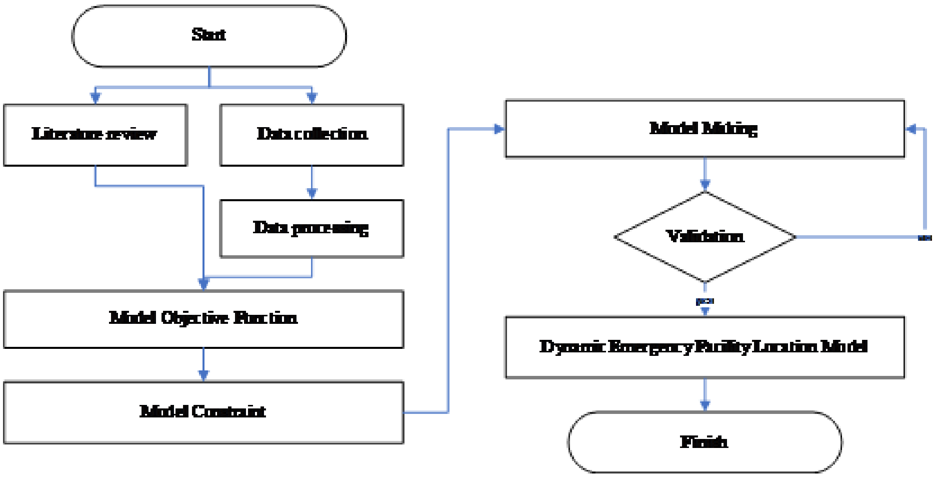

Figure 1. Research stages

The following describes the stages of the research carried out (Figure 1) including a literature review of similar research as a renewal of the plan that is owned if there are difficulties, namely machine learning, clustering, k-means, location of emergency facilities with uncertainty parameters.

2.1. Data Collection

Data collection includes disaster data obtained from the National Disaster Management Agency (BNPB) and Regional Disasters (BPBD) of North Sumatra. Disaster data in the form of a map of the population, refugee posts and posts for the eruption of the Sinabung volcano, Karo Regency, North Sumatra Province (Figure 5) with a total of 38 shelter posts with a total number of 25,516 victims from 4 sub-districts, namely Simpang Empat sub-district, Namantran sub-district, Tiganderket sub-district. and Umbrella sub-district as well as 26 villages from Karo district, North Sumatra province.

2.2. Data Processing

The data that has been collected will be processed into a graphical form to get the coordinates of x, y through the google earth application can be seen in Figure 2.

Figure 2. Processing of request point location data with google earth

In Figure 2, in the process of processing the request point location data so as to produce data in the form of latitude (x) and longitude (y) using google earth, the results of the data processing can be seen in Table 1, which consists of 38 shelter points for disaster victims. Latitude (x) and longitude (y), are used as inputs to get the location of the distribution center that is opened using the built model.

Table 1. Data demand point location

Demand Point	Latitude	Longitude	Demand
N_1	3,071	98,250	2805
N_2	3,137	98,301	715
N_3	3,142	98,301	366
N_4	3,119	98,270	805
N_5	3,114	98,504	210
N_6	3,132	98,504	122
N_7	3,153	98,145	479
N_8	3,135	98,454	190
N_9	3,103	98,487	386
N_{10}	3,104	98,488	1107
N_{11}	3,095	98,487	415
N_{12}	3,096	98,489	207
N_{13}	3,117	98,505	81
N_{14}	3,096	98,483	1095
N_{15}	3,122	98,074	736
N_{16}	3,099	98,493	503
N_{17}	3,101	98,491	221
N_{18}	3,099	98,485	650
N_{19}	3,101	98,500	258
N_{20}	3,132	98,504	232
...	...	...	...

2.3. Formulating the objective function of the model

Formulating the objective function of the model, the objective function of the built model is to minimize the distance between the emergency post and the refugee post in terms of distribution of disaster relief goods in one cluster group.

$$min \Sigma_{ij} x_{ij} y_{ij} \tag{1}$$

Equation (1) is to minimize the distance between the emergency post I and the request point j, where xij is to find the distance between the request point j and the distribution center i formed and yij is to ensure that the request point j is in a distribution center cluster j.

2.4. Formulating Model Constraints

Formulating model constraints, namely formulating constraints so that in How to determine the selected emergency center, where the selected emergency center is the minimum distance from the emergency center closest to the point of request after post-disaster

2.5. Emergency Facility Location Model

Facility location problem modeling using machine learning clustering algorithm, namely k-means. The dynamic emergency facility location model in the post-disaster area is solving the problem of determining the emergency center to be opened by using a machine learning clustering algorithm, namely k-means, where the determination of the emergency center to be opened is the one that has the objective function of minimizing the distance between the emergency center and the request point at the location. post-disaster. The dynamic emergency facility location model in post-disaster areas can be seen in Figure 3, with the notation specifying the number of emergency centers (m), the number of demand points (n) and coordinates (x, y). The decision variable in the model is to determine the coordinates (x, y) of the emergency center, the distance between the emergency center and the request point, if the demand point is in the cluster or emergency center it will be worth 1 and vice versa, it is worth 0. The number of clusters is to determine the number of emergency centers. to be opened in the post-disaster area of uncertainty. The objective function of this model is to minimize the distance from the opening of the emergency center to the point of demand, namely the post for connecting disaster victims. The result of this model is a clustering of demand points that have the same classification as emergency centers.

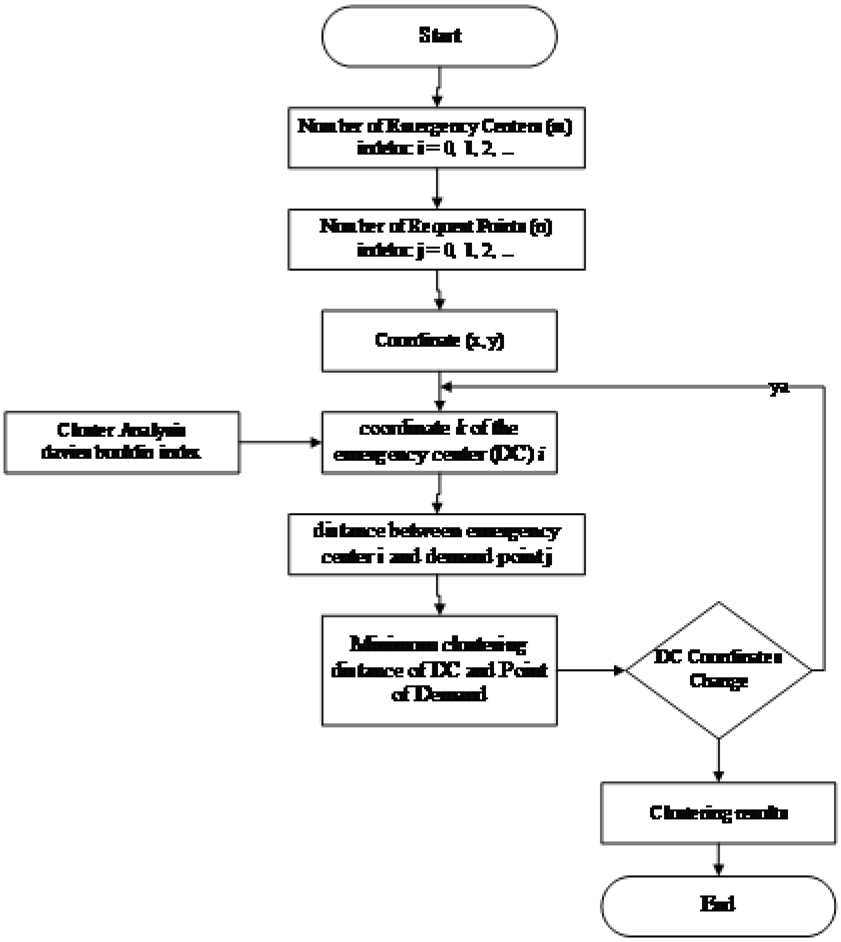

Figure 3. Emergency Facility Location Model

After building a dynamic model of the location of the emergency facility, the next step is to validate the model, namely entering disaster and refugee data into the model to see if the objective function has been achieved.

3. RESULT AND ANALYSIS

This study discusses the determination of the location of emergency facilities in the post-disaster area, namely determining the opening of the location of emergency facilities that are used as a place to store disaster relief goods from donors/suppliers both regionally, nationally and internationally.

3.1. Problem Description

As for planning to solve the problem of facility location, where the problem of facility location considers disaster relief operations with the opening of the location of emergency facilities, where the decision on the problem of opening the location of emergency facilities in post-disaster areas in uncertainty is determined as follows:

1. How to determine the chosen emergency center, where the selected emergency center is the minimum distance from the emergency center closest to the point of request after post-disaster.
2. How to determine the decision of the emergency center to be established, where the distribution center should be open after a disaster occurs (because not all emergency centers need to be opened with consideration of opening costs and demand).

3.2. Facility Location Problem Planning

Planning in dealing with facility location problems is shown in Figure 4, namely in making decisions on facility location problems, namely how to determine the location of emergency facilities in post-disaster areas.

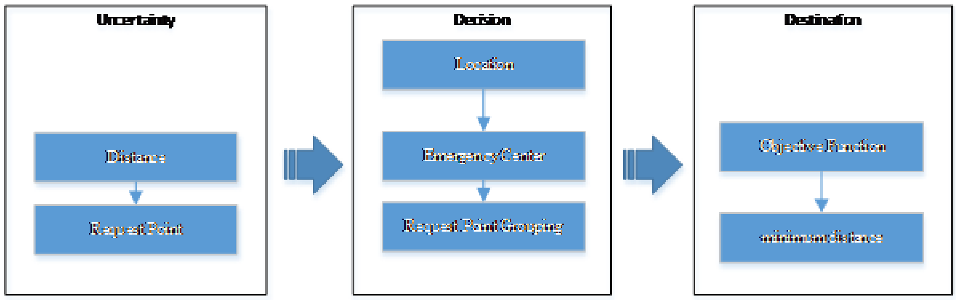

Figure 4. Roadmap for Planning the Location of Emergency Facilities in Post-Disaster Areas

The roadmap for planning the opening of emergency facilities in post-disaster areas in uncertainty (Figure 4) includes the variable distance and demand points from the location of the disaster victim shelter. Uncertainty variables are used for decision making in determining the opening of emergency centers and grouping demand points based on clusters of opened emergency centers.

3.3. Assumption

The modeling assumptions used to model the location of emergency facilities in post-disaster areas are shown in Figure 5, including:

1. Determination of the opening of an emergency center based on the shortest distance from the grouping of demand points.
2. Grouping of demand points based on the similarity characteristics of the opened cluster/emergency center.
3. The emergency center should be open after a disaster occurs, because not all emergency centers need to be opened considering the cost of opening and demand.

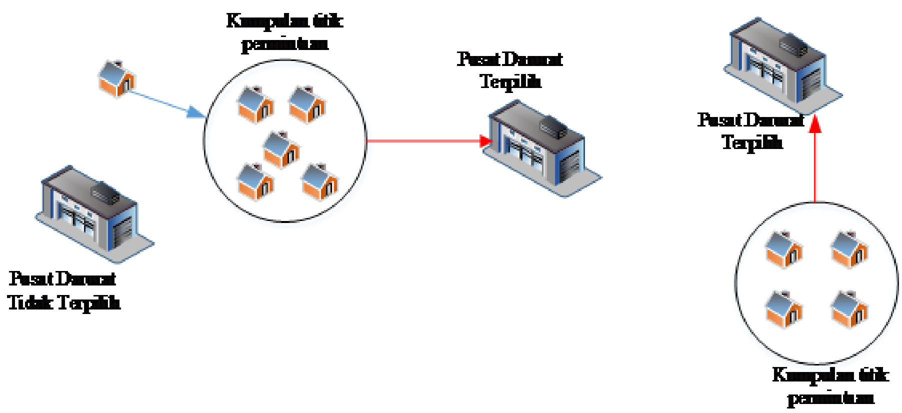

Figure 5. Illustration of Dynamic Emergency Facility Location Model in Post-Disaster Areas in Uncertainty

3.4. Model Validation

Model validation is used to validate the dynamic emergency facility location model with disaster data and refugee data in the event of a disaster, namely determining the location of emergency facilities in post-disaster areas in uncertainty.

1. Disaster Data

Disaster data were obtained from the National Disaster Management Agency (BNPB) and the North Sumatra Regional Disaster Management Agency (BPBD). Disaster data in the form of a map of the population, refugee posts and posts for the eruption of the Sinabung volcano, Karo Regency, North Sumatra Province (Figure 6) with a total of 38 shelter posts with a total number of 25,516 victims from 4 sub-districts, namely Simpang Empat, Namantran, Tiganderket sub-districts. and Umbrella sub-district as well as 26 villages from Karo district, North Sumatra province.

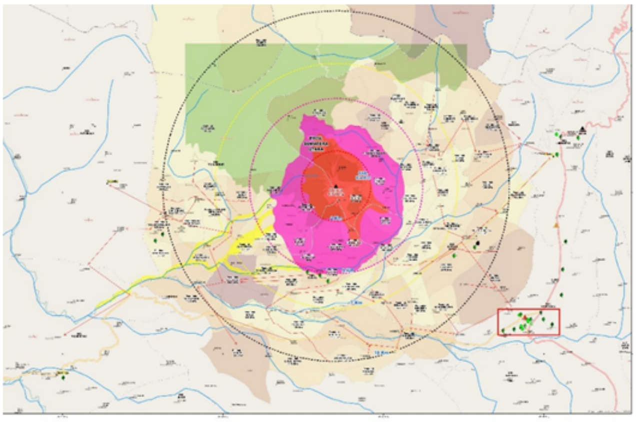

Figure 6. Map of Disasters and Refugees of the Sinabung Volcano Eruption

2. Emergency Facility Site Opening Experiment

Experiments on opening emergency facility locations using a machine learning clustering algorithm, namely k-means. The results of the grouping of the disaster data are based on the distance variable and the point of request (disaster victim shelter post) using a dynamic emergency facility location model.

1. Location of the request point /shelter post
   The location of the request points is based on disaster data in the form of a map of the population, refugee posts and the Sinabung volcanic eruption post, Karo Regency, North Sumatra Province (Figure 6) with a total of 38 shelter posts with a total of 25,516 victims from 4 sub-districts, namely Simpang Empat sub-district, Sub-district Namantran, Tiganderket and Umbrella sub-districts as well as 26 villages from Karo district, North Sumatra province as shown in Figure 7.

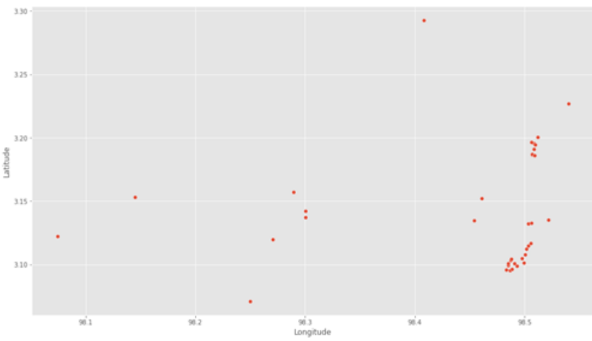

Figure 7. Graphics of the location of shelter points / shelter posts

2. Opening of the location of emergency facilities/emergency posts
   The validation of the emergency facility location model resulted in four (4) clusters formed based on 38 demand points/posts for sheltering disaster victims. The results of the cluster formed are used as a decision to determine the location of the emergency post construction as shown in Table 2 and Figure 8.

Table 2. Emergency center location data

Centroid	Emergency Post Name	Latitude	longitude
0	DC-01	3.129	98.232
1	DC-02	3.103	98.493
2	DC-03	3.136	98.491
3	DC-04	3.205	98.501

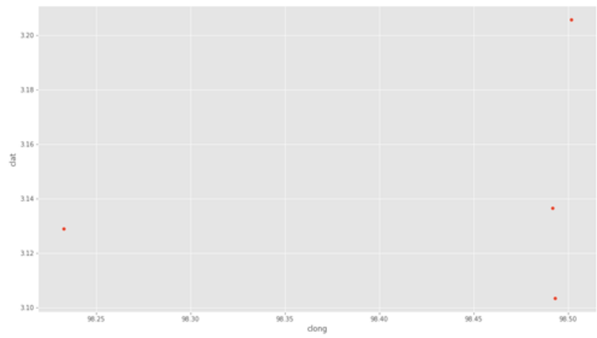

Figure 8. Graph of emergency post locations

In Figure 8 it can be seen that the centroids generated based on the location of 38 demand points resulted in the 4 most optimum clusters, where k=0, k=1, k=2, k=3 were used as the location for the opening of the emergency post. The emergency post that has been opened is tasked with distributing relief items to the shelter post. The results of the location of the emergency center are presented in the form of latitude and longitude coordinates according to the graphic conditions of the area.

3. Grouping of request points / shelter posts by emergency center
After the location of the emergency center has been established, the next step is to classify the demand points/posts for sheltering disaster victims that have data in common with the resulting cluster, in this case the location of emergency facilities/emergency centers. The results of the grouping are shown in Table 3.

Table 3. Demand point grouping data

ID	Distribution Center	Number of Request Point
DC0	Distribution Center-1	1,2,3,4,7,15,33
DC1	Distribution Center-2	5,9,10,11,12,13,14,16,17,18,19,21,22,23,38
DC2	Distribution Center-3	6,8,20,30,36,37
DC3	Distribution Center-4	24,25,26,27,28,29,31,32,34,35

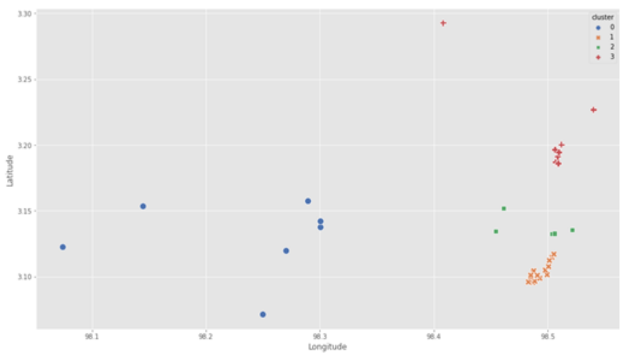

Figure 9. Demand point grouping graph

The request point grouping data based on the similarity to the three clusters shown in Figure 9 consists of 4 clusters, where cluster 0 consists of 7 request points, cluster 1 consists of 15 request points and cluster 2 consists of 6 request points and cluster 3 consists of 10 request points. . Each cluster has a centroid, the centroid of each cluster is used as the distribution center. centroid 0 (DC-01) functions as a post for disaster relief goods storage which is tasked with distributing these items to 7 demand points / disaster victim shelter posts, centroid 1 (DC-02) is tasked with distributing these items to 15 request points / victim shelter posts disaster and centroid 2 (DC-03) is tasked with distributing these items to 6 demand points/disaster shelter shelters and centroid 3 is tasked with distributing these items to 10 demand points/disaster shelter shelters as can be seen in Figure 10.

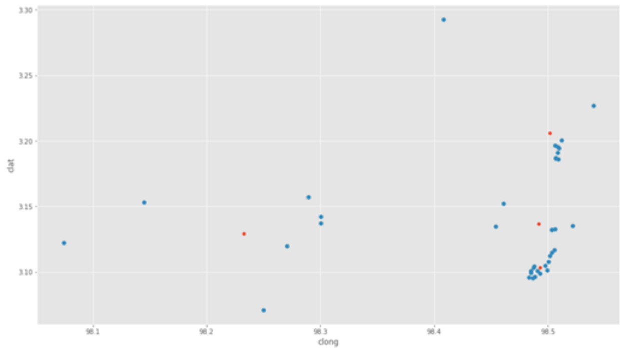

Figure 10. Graph of demand point grouping based on emergency post cluster

3. Analysis of the number of Clusters (k)/location of emergency facilities

Analysis of the number of clusters (k) was performed using the Davies Bouldin index. The Davies Baouldin index is used to see two forms of performance distance, namely the first is used to analyze the performance distance between members in the cluster, the closer the distance between members in the cluster is, the more optimal it is and the second is to analyze the performance distance between the resulting clusters, the farther the distance between the clusters, the more optimal [14, 15].

The results of grouping with the number of clusters (k) based on the same data characteristics based on clusters (k). The cluster (k) formed will be used as a decision to open the location of the emergency facility. Where this emergency post will be used as a shelter for disaster relief items that will be distributed to each point of request based on the results of grouping the location of the request point with clusters that have the same characteristics in this case, namely the location of emergency facilities (emergency posts). The cluster analysis formed is analyzed using the Davies Bouldin index to see the most optimal number of clusters (k) based on the disaster data shown in Table 1 and the rarity between members in the cluster that has been formed is shown in Table 3.

Table 4. Analisis cluster dengan davies bouldin index

Cluster (k)	Max runs	Max optimization steps	Performance Vector
2	1000	1000	-0,473
3	1000	1000	-0,736
4	1000	1000	-0,339
5	1000	1000	-0,329
6	1000	1000	-0,278

Figure 11. Graph of Emergency Center (DC) analysis with davies bouldin index

Based on the graph shown in Figure 11, where the analysis of the number of clusters (k) formed using the Davies Bouldin index analysis as shown in table 1 produces the most optimal number of clusters (k) is cluster (k) = 4 with a performance vector value. -0.329 with max runs 100 and max optimization steps 1000. The number of clusters is three (4) generated by using a dynamic emergency facility location model using a machine learning clustering algorithm, namely k-means, which is used as a decision to open an emergency facility location (posko emergency) disaster relief goods storage.

Table 5. Cluster member distance analysis with davies bouldin index

Centroid distance	Score	items
Avg. within centroid distance_cluster_0	0,184211	7
Avg. within centroid distance_cluster_1	0,394737	15
Avg. within centroid distance_cluster_2:	0,157895	6
Avg. within centroid distance_cluster_3:	0,263158	10
Avg. within centroid distance	0,25	38

Analysis of the distance (table 4) members in the cluster with the number of clusters (k) is four (4) as shown in table 4 has an average value in cluster 0 is -0.18 has 7 members, cluster 1 is 0.39 which has 15 members and cluster 2 is 0.15 which has 6 members, based on the average value of each cluster, the results of the analysis of the distance between the centroids are 0.25. Model validation has been carried out using max run and max optimization 1000 times with results reaching 90%.

4. CONCLUSION

The facility location model in the post-disaster area in uncertainty uses a machine learning clustering algorithm, namely k-means, which has the objective function of minimizing distance. The results of the emergency facility location model resulted in decisions in the form of the location of the emergency center and the grouping of demand points that had a minimum distance from the location of the emergency center from 38 demand points resulting in the 4 most optimal emergency facility locations with Avg. within centroid distance 0.25 with 90% achievement. The emergency facility location model is dynamic, namely the opening of the emergency center location can move according to the conditions of the number of shelter posts. This model, in addition to providing the results of the opening of the location of the emergency post, can also be used for grouping demand points based on the emergency post. This makes it easier to plan the route of distribution of aid goods. The results of this model can be used to determine the distribution of disaster relief goods to disaster victims quickly and accurately. This proves that the emergency facility location model can be used to determine the location of the emergency center, where the determination of the location of the emergency center has the closest distance to the request point/post shelter for disaster victims. The contribution of this research is to produce a problem model for the location of emergency facilities, where this model has an objective function, namely to minimize the distance between the location of the emergency center opening based on the point of request from the disaster victim shelter post so as to produce a decision or recommendation for the opening of an emergency center that aims to minimize costs by using algorithms in machine learning.

The direction of future research is to develop a model for the location of emergency facilities by collaborating the distribution route for relief items from the emergency center to the point of request with a Deep Learning approach based on the emergency facility location model that has been developed in this study.

5. ACKNOWLEDGEMENTS

This research has received financial support from the Medan Potential Utama Foundation and the University of North Sumatra which have provided support to the implementation of this research. Based on that, we thank you very much for the support.

6. DECLARATIONS

AUTHOR CONTIBUTION

Lili Tanti as a model maker, data collector, analyzes and writes articles. Dr. Syahril Efendi, S.Si, M.IT as the promoter in directing this research. Dr. Maya Lydia Silvi, M.Sc as co-promoter 1 and Prof. Herman Mawengkang as co-promoter 2 in directing this research.

FUNDING STATEMENT

Researchers would like to express their deepest gratitude to the Medan Potential Foundation and the Main Potential University for providing funding support for this research.

COMPETING INTEREST

The future research direction is to develop a model for the location of emergency facilities by collaborating on transportation routes in humanitarian logistics by using the Deep Learning model based on the emergency facility location model that has been developed in this lesson so as to produce optimization of transportation routes in the field of Vehicle Routing Problem (VRP).

REFERENCES

[1] I. Hanna Sawalha, "A contemporary perspective on the disaster management cycle," *FORESIGHT*, vol. 22, no. 469-482, 2020.

[2] A. Apriani, H. Zakiyudin, and K. Marzuki, "Penerapan Algoritma Cosine Similarity dan Pembobotan TF-IDF System Penerimaan Mahasiswa Baru pada Kampus Swasta," *Jurnal Bumigora Information Technology (BITe)*, vol. 3, no. 1, pp. 19–27, 2021.

[3] B. Sharma, M. Ramkumar, N. Subramanian, and B. Malhotra, "Dynamic temporary blood facility location-allocation during and post-disaster periods," *Annals of Operations Research*, vol. 283, no. 1-2, pp. 705–736, 2019.

[4] Z. Xiao, J. Sun, W. Shu, and T. Wang, "Location-allocation problem of reverse logistics for end-of-life vehicles based on the measurement of carbon emissions," in *Computers & Industrial Engineering*, vol. 127, no. January, jan 2019, pp. 169–181. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S0360835218306168

[5] H. Sun, Y. Wang, and Y. Xue, "A bi-objective robust optimization model for disaster response planning under uncertainties," *Computers and Industrial Engineering*, vol. 155, no. May, p. 107213, 2021.

[6] A. M. A. Alan Fuad Jahwar, "Meta-Heuristic Algorithms For K-Means Clustering : A Review," *PalArch's Journal of Archaeology of Egypt/Egyptology (Pjaee)*, vol. 17, no. 7, pp. 12 002–12 020, 2021.

[7] S. K. Das, S. K. Roy, and G. W. Weber, "An exact and a heuristic approach for the transportation-p-facility location problem," *Computational Management Science*, vol. 17, no. 3, pp. 389–407., 2020.

[8] X. Wang, W., Wu, S., Wang, S., Zhen, L., & Qu, "Emergency facility location problems in logistics: Status and perspectives," *Transportation research part E: logistics and transportation review*, vol. 154, no. Oktober, p. 102465, 2021.

[9] S. M. Shavarani, "Multi-level facility location-allocation problem for post-disaster humanitarian relief distribution: A case study," *Journal of Humanitarian Logistics and Supply Chain Management*, vol. 9, no. 1, pp. 70–81, 2019.

[10] V. Senthilkumar, K. K., Kumarasamy, K., & Dhandapani, "Approximate Multipliers Using Bio-Inspired Algorithm," *Journal of Electrical Engineering & Technology*, vol. 16, no. 1, pp. 559–568, 2021.

[11] Y. Liu, Y. Yuan, J. Shen, and W. Gao, "Emergency response facility location in transportation networks: A literature review," pp. 153–169, 2021.

[12] D. Olave-Rojas and S. Nickel, "Modeling a pre-hospital emergency medical service using hybrid simulation and a machine learning approach," *Simulation Modelling Practice and Theory*, vol. 109, no. May, p. 102302, 2021.

[13] M. Wang and X. Wei, "Research on Logistics Center Location-Allocation Problem Based on Two-Stage K-Means Algorithms," in *International Conference on Computer Science, Engineering and Education Applications*, vol. 1247 AISC, 2021, pp. 52–62.

[14] H. Santoso, H. Magdalena, and H. Wardhana, "Aplikasi Dynamic Cluster pada K-Means Berbasis Web untuk Klasifikasi Data Industri Rumahan," *Manajemen, Teknik Informatika, dan Rekayasa Komputer*, vol. 21, no. 3, pp. 541–554, jul 2022.

[15] F. B. Ashraf, A. Matin, M. S. R. Shafi, and M. U. Islam, "An Improved K-means Clustering Algorithm for Multi-dimensional Multi-cluster data Using Meta-heuristics," in *2021 24th International Conference on Computer and Information Technology (ICCIT)*, 2021, pp. 1–6.