Determination of Flood Logistics Command Posts and Humanitarian Logistics Vehicles in Jakarta

Joventri Chandra, Rienna Oktarina
Industrial Engineering Department
Faculty of Engineering
Bina Nusantara University
Jakarta, Indonesia, 11480
joventri.chandra@binus.ac.id, rienna.oktarina@binus.ac.id

Abstract

This research aims to determine reducing the adverse impact from flood by deciding strategic location point of flood logistics command posts, calculating the number of victim handling in every flood logistics command post and determining the number of humanitarian logistics vehicles that need to be prepared. Research method uses the mathematical model calculation and linear programming supported by Microsoft Excel software. The criteria use as variables to be factor in making decision are total population, flood prone area per district and distribution time. The first conclusion is location point of flood logistics command post in Central Jakarta is Tanah Abang, in North Jakarta are Tanjung Priok and Pademangan, in West Jakarta are Grogol Petamburan and Kembangan, in South Jakarta are Mampang Prapatan, Kebayoran Baru and Cilandak, in East Jakarta are Durensawit, Jatinegara and Makasar. The second conclusion is the number of victim handling in each flood logistics command post that need to be considered before it is bulit in Central Jakarta, North Jakarta, West Jakarta, South Jakarta and East Jakarta each are 24, 68, 105, 177, 188 people. The third conclusion is the number of humanitarian logistics vehicles that need to be prepared in Central Jakarta, North Jakarta, West Jakarta, South Jakarta and East Jakarta each are 7, 4, 5, 6, 8 vehicles.

Keywords
Humanitarian Logistics, Flood, Jakarta, Linear Programming, Flood Logistics Command Posts.

1. Introduction
Flood in Jakarta has become an annual problem that always occurs in the beginning of the year. Jakarta as the capital city of Indonesia has a population of 10,562,088 in 2020 and Jakarta is one of the most populous cities in Indonesia (Badan Pusat Statistik Provinsi DKI Jakarta, n.d.). The number of districts in Jakarta is 44 districts which 30 of them were declared flood prone area in 2014 (KOMINFO, 2015).

Flood in Jakarta gives a negative impact on the people of Jakarta both in the terms of economy and health such as the damage to houses, vehicles, public transportation, public facilities, disrupting community mobility and causing potential flood victims. Major floods in Jakarta occurred in 2002, 2007 and 2013 where Jakarta suffered losses of Rp 5.4 trillion in 2002, Rp 5.2 trillion in 2007 and Rp 7.5 trillion in 2013 (Ratriani, 2021). The Jakarta government stated that there were 5 flood victims consisting of children and elderly (Tim detikcom – detikNews, 2021).

One of the important mitigations during flood in Jakarta is the implementation of flood logistics command posts, flood logistics command posts in Jakarta are able to ease the burden on the community when floods in Jakarta occur by providing resting place, health checking, food and drink distribution center and other useful items (Badan Nasional Penanggulangan Bencana, 2020). This study provides solution which it become mitigation to reduce the bad impact of flood by finding the best location for flood logistics command posts based on population of Jakarta per district and flood prone area per district with the smallest distribution time and calculating the maximum handling of flood refugees carried out by each flood logistics command posts per administrative city in Jakarta and calculating the number of humanitarian logistics vehicles that need to be prepared for each flood logistics command post.

The general objective of this research is to find solution to reduce the bad impact of flood in Jakarta by determining the strategic location of flood logistics command posts, calculating the number of victims handling at each flood

logistics command post and determining the number of humanitarian logistics vehicle that need to be prepared. The main objective of this research is to support flood victims by planning strategic location of flood logistics command posts and planning the number of humanitarian logistics vehicles based on distribution time of one district to other districts and number of victims handling at each flood logistics command post. The specific objectives of this research are as follow.

1. Identify strategic location of flood logistics command posts per administrative city in Jakarta.
2. Identify the maximum number of flood refugees handling per administrative city in Jakarta.
3. Identify the number of humanitarian logistics vehicle that need to be prepared per administrative city in Jakarta.

2. Literature Review

2.1 Flood

According to Kompas.com news article that is written by Arum, Flood is a natural disaster in which the volume of water on land is high at a certain time. Floods can be caused by clogged drain, rain, reservoir leak and others. Climate change is also one of the factors that causes the occurrence of flood to be higher than previous year. Climate change causes the melting of ice at the north and south poles which it is causing an increase the volume of water so that water level increases can give impact to Indonesia and other countries that have many islands which the increasing of sea level makes it has a high chance of causing flood. Flood can give bad impact in terms of economy, social, infrastructure, environment and others (Putri, 2020).

2.2 Humanitarian Logistics

According to an article at the Universitas Surabaya, humanitarian logistics are activities that is related to logistics that has a function to reduce the adverse effects of disaster. The analysis of humanitarian logistics includes good distribution, types of good, number of goods, distribution time, distribution cost, number of humanitarian logistics vehicle, number of victims that can be served and others. The success of humanitarian logistics are humanitarian logistics activity can be carried out quickly, the goods need by disaster victim can be used quickly and in large quantity which it can help to reach the goal of humanitarian logistics which it is ti reduce the adverse impact experience by disaster victim because of the occurrence of natural disaster (Universitas Surabaya, 2018).

According to the research that is conducted by Dominik and Karin (2015) with the title “Legitimation Work Within a Cross-Sector Social Partnership”, humanitarian logistics is supply chain management that is distributed to area of disaster experience that is caused by both nature and human, one of the activities in supply chain management in humanitarian logistics is the response of disaster where the response to disaster can be in form of goods distribution and service based on the number of victim affected and number of victim needed when disaster occurs in the area (Rueede & Kreutzer, 2014).

2.3 Linear Programming

According to Techopedia, linear programming si a mathematical method that uses linear relationships to obtain solution from predetermined criteria (Techopedia, n.d.). The use of linear programming is suitable for determining flood logistics command post where the constraints that are used are the number of populations, flood prone area location and distribution time. The use of linear programming is supported by using software solver in Microsoft Excel.

According to the research that is conducted by Kenny and Iwan (2018) witn the title “Optimasi Jumlah Produksi Baja Tulangan Dengan Metode Linear Programming”, linear programming is one of mathematical calculation that has function to find solution from various bariables that become an obstacle in organization (Kenny & Santoso, 2018).

2.4 Flood Logistics Command Posts, Humanitarian Logistics, Flood and Other Natural Disaster Related Research

Previous studies that discuss about flood logistics command post, humanitarian logistics, flood and other natural disaster will be discussed in the literature review which they are as follows:

The research that is conducted by Rajali, Yashaswi, Biplob, Saurav, Jurgen and Shinya (2020) with the title “Mobile logistics hubs prepositioning for emergency preparedness and response in Nepal” discusses the determination of

mobile logistics hubs in Nepal which it is used for the preparation and response in the event of emergency from natural disaster in Nepal. The determination of mobile logistics hubs in Nepal uses 2 approaches which they are quantitative approach that is using a mathematical model supported by software that functions to optimize a model and qualitative approach using focus group discussion which is supported by humanitarian experts who participate in focus group discussion. The similarity between this study and the research that is conducted by author is to determine a center that helps disaster management such as flood. The difference is the mathematical model that is used, location where the research is carried out is different and there is no quantitative approach such as focus group discussion (Maharjan, et al., 2020).

The research that is conducted by Nancy, M. Dirhamsyah and Eldine (2015) with the title "Model Distribusi Bantuan Logistics Kemanusiaan pada Saat Bencana Banjir dengan Memperhitungkan Data Iklim" discusses forecasting the number of commodity data in Aceh province and determining commodity distribution routes based on rainfall data using mathematical model. The similarity between this study and the research that is conducted by author is to design a model based on humanitarian logistics.The difference is not using commodity data for an aera, rainfall data and there is different in the using of mathematical model (Damanik, Dirhamsyah, & Fatimah, 2015).

The research that is conducted by Chawis and Chompoonoot (2020) with the title "The Multi-Objective Fuzzy Mathematical Programming Model for Humanitarian Relief Logistics" discusses about determining the location of humanitarian warehouses to mitigate the impact caused by flood disaster based on response time and budget planning using several mathematical models that is supported by LINGO software. The similarity between this study and the research that is conducted by author is that the natural disaster used as research is flood, the determination of the center that helps to mitigate the impact of flood and the using of mathematical model in finding solution. The differences are the types of mathematical model used, type of software used, and mathematical model calculations are not based on response time and budget planning (Boonmee & Kasemset, 2020).

The research that is conducted by Wapee, Keisuke and Takashi (2014) with the title "Humanitarian Relief Logistics with Time Restriction: Thai Flooding Case Study" discusses about the determination of distribution center and warehouse to mitigate the impact from flood based on logistics cost and time constraint using a mathematical model that is supported by Gurobi software. The similarity between this study and the research that is conducted by author is to reduce the impact from flood by determining the center that helps to mitigate the impact from flood with mathematical model based on time constraint and the study is flood. The differences are the using of mathematical model, software and the location study is different (Manopiniwes, Nagasawa, & Irohara, 2014).

The research that is conducted by Sonny, I Gede and Tanti (2015) with the title "Model Matematis Penentuan Lokasi Potensial Pos Bantuan atau Depo Bencana Banjir di Kabupaten Gresik" discusses about the determination of relief post or depot using mathematical model supported by solver in Microsoft Excel based on number of victim and delivery time. The similarity between this study and the research that is conducted by author are the using of mathematical model from linear programming using solver in Microsoft Excel to find solution, the using of data on number of refugees and product distribution time. The differences are the study location and the equation of mathematical model that is used to find solution (Sugiarto, Widyadana, & Octavia, 2015).

3. Methods

Mathematical model to determine the location of flood logistics command post, calculate number of victim handling at each flood logistics command post and calculate the number of humanitarian logistics vehicle need to be prepared are as follows:

3.1 Determination of The Location of Flood Logistics Command Post (1)

Objective Function: minimize distribution time from origin district (flood logistics command post candidate) to destination district (all district per administrative city in Jakarta).

$$\text{Min Z} \sum_{a=1}^{n} X$$

Constraints:
Limit of flood logistics command post in Central Jakarta = 1
Limit of flood logistics command post in North Jakarta and West Jakarta = 2

Limit of flood logistics command post in South Jakarta and East Jakarta = 3

Information:
X = Distribution time from origin to destination district

3.2 Calculation of The Number of Handling Victim at Each Flood Logistics Command Post (2)

Objective function: maximize the number of victim handling at each flood logistics command post per administrative city in Jakarta.

$$\text{Max} \sum_{i=1}^{n} y_i a_i$$

Information:
y_i: The location of flood logistics command post district i can or cannot meet the needs of flood refugee victim
a_i: Number of flood refugee victim in location i

y_i
- 1 (if the location of flood logistics command post district I can meet the needs of flood refugee victim)
- 0 (if it is not)

The assumption used in this research is that all location of flood logistics command post i can meet the needs of flood refugee victim.

Source of equation and information on calculation the number of handling victim at flood logistics command post: (Sugiarto, Widyadana, & Octavia, 2015).

3.3 Calculation of The Number of Humanitarian Logistics Vehicle Need to be Prepared (3)

The calculation will be used to compare the average distribution time with the number of humanitarian logistics vehicle that must be prepared for each flood logistics command post.

$$\frac{\sum_{a=1}^{n} (K_a + L_a)}{V} = \overline{T}$$

Information:
K_a: Time from origin to destination
L_a: Time from destination to origin
V: Number of humanitarian logistics vehicle
$\overline{T}$: Average distribution time

4. Data Collection

Data collection for determination the location of flood logistics command post, calculation number of victim handling at each flood logistics command post and calculation the number of humanitarian logistics vehicle need to be prepared are as follows:

4.1 Determination of The Location of Flood Logistics Command Post

The total population of Jakarta per district and flood prone area in Jakarta as Table 1 and Table 2 are as follow.

Table 1 Jakarta Population Data per District in 2018

Jakarta Population Data			
No	**City**	**District**	**Total Population**
1	Central Jakarta	Gambir	100916

2		Sawah Besar	134387
3		Kemayoran	262419
4		Senen	128547
5		Cempaka Putih	101051
6		Menteng	91821
7		Tanah Abang	181417
8		Johar Baru	145011
9	North Jakarta	Penjaringan	308945
10		Tanjung Priok	409271
11		Koja	335312
12		Cilincing	420714
13		Pademangan	166060
14		Kelapa Gading	140419
15	West Jakarta	Cengkareng	550522
16		Grogol Petamburan	237321
17		Taman Sari	129035
18		Tambora	271495
19		Kebon Jeruk	350278
20		Kalideres	427252
21		Palmerah	228552
22		Kembangan	290769
23	South Jakarta	Tebet	238323
24		Setia Budi	115945
25		Mampang Prapatan	156574
26		Pasar Minggu	321233
27		Kebayoran Lama	320729
28		Cilandak	218948
29		Kebayoran Baru	154681
30		Pancoran	170700
31		Jagakarsa	343826
32		Pesanggrahan	253820
33	East Jakarta	Matraman	187413
34		Pulo Gadung	302049
35		Jatinegara	321327
36		Kramat Jati	305291
37		Pasar Rebo	225407
38		Cakung	546823
39		Duren Sawit	356594
40		Makasar	217868
41		Ciracas	300939
42		Cipayung	274149

Table 2 Flood Prone Area in Jakarta in 2018

Flood Prone Area Data in Jakarta			
No	**City**	**Ward**	**District**
1	Jakarta Pusat	**Karet Tengah/Karet Tengsin***	Tanah Abang
2		Petamburan	
3	Jakarta Utara	Cilincing	Cilincing
4		Marunda	
5		Semper Barat	
6		Semper Timur	
7		Suka Pura	

8		Gading Timur	Kelapa Gading
9		Pegangsaan Dua	
10		Tugu Selatan	Koja
11		Pademangan Barat	Pademangan
12		Kamal Muara	Penjaringan
13		Kapuk Muara	
14		Pejagalan	
15		Penjaringan	
16		Pluit	
17		Tanjung Priok	Tanjung Priok
18	Jakarta Barat	Cengkareng Barat	Cengkareng
19		Cengkareng Timur	
20		Duri Kosambi	
21		Kapuk	
22		Kedaung Kali Angke	
23		Rawa Buaya	
24		Jelambar Baru	Grogol Petamburan
25		Wijaya Kesuma	
26		Semanan	Kalideres
27		Tegal Alur	
28		Duri Kepa	Kebon Jeruk
29		Kedoya Selatan	
30		Kedoya Utara	
31		Joglo	Kembangan
32		Kembangan Selatan	
33		Kembangan Utara	
34		Pinangsia	Taman Sari
35	Jakarta Selatan	Cilandak Barat	Cilandak
36		Lebak Bulus	
37		Pondok Labu	
38		Cipete Utara	Kebayoran Baru
39		Petogogan	
40		Cipulir	Kebayoran Lama
41		Kebayoran Lama Utara	
42		Pondok Pinang	
43		Bangka	Mampang Prapatan
44		Kuningan Barat	
45		Mampang Prapatan	
46		Pela Mampang	
47		Tegal Parang	
48		Kalibata	Pancoran
49		Pengadegan	
50		Rawajati	
51		Cilandak Timur	
52		Jati Padang	
53		Pejaten Timur	Pasar Minggu
54		Bintaro	Pesanggrahan
55		Petukangan Selatan	
56		Ulujami	
57		Bukit Duri	Tebet
58		Kebon Baru	
59		Manggarai	
60	Jakarta Timur	Cakung Timur	Cakung

61		Pulo Gebang	
62		Rawa Terate	
63		Cibubur	Ciracas
64		Kelapa Dua Wetan	
65		Rambutan	
66		Pondok Bambu	Duren Sawit
67		Bidara Cina	Jatinegara
68		Cipinang Besar Selatan	
69		Cipinang Muara	
70		Kampung Melayu	Kramat Jati
72		Cililitan	
73		Dukuh	
74		Karamat Jati	
75		Cipinang Melayu	Makasar
76		Halim Perdana Kusuma	
77		Kebon Pala	
78		Makassar	
79		Pinang Ranti	
80		Kebon Manggis	Matraman
81		Kalisari	Pasar Rebo
82		Pekayon	

Information:
*= Maybe there is some word error from source
Tabel 1 is designed based on source: (Portal Data Terpadu Pemprov DKI Jakarta, 2019).
Tabel 2 is designed based on source: (Definati, 2020).

Table 1 and Table 2 are designed in map at Figure 1 is as follows.

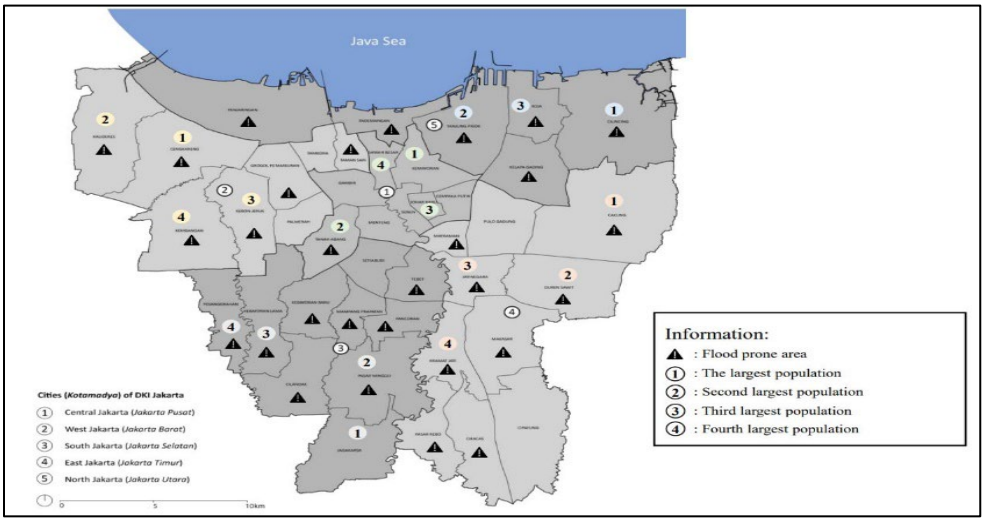

Figure 1 Jakarta Map Based on Population and Flood Prone Area

From Figure 1, it needs to find flood logistics command post candidate subjectively based on total population, flood prone area, distribution time per administrative city in Jakarta which it displays in Figure 2 is as follows.

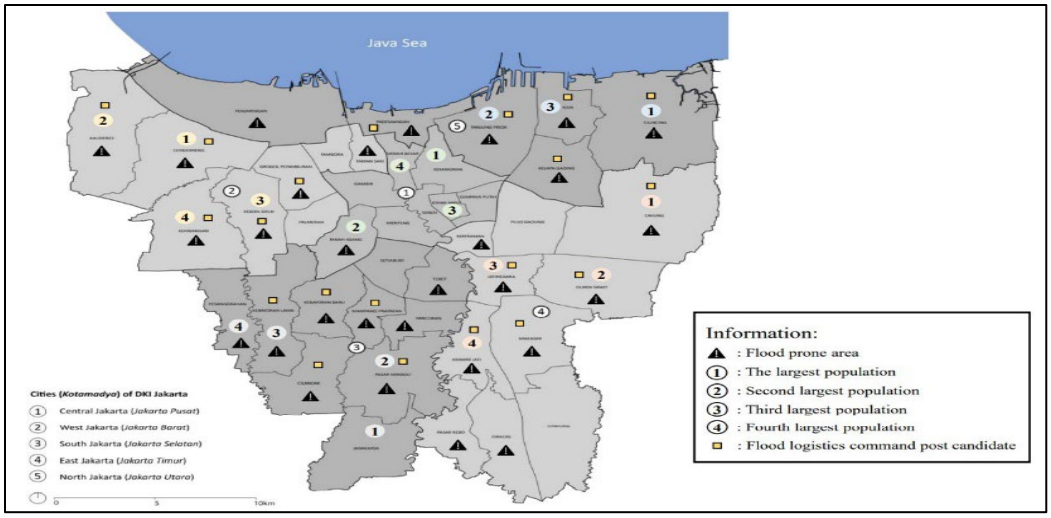

Figure 2 Jakarta Map Based on Population, Flood Prone Area, and Flood Logistics Command Post Candidates

Information:
Figure 1 and Figure 2 are designed based on source: (Rochelimit at en. Wikipedia, 2010) for map design, (Portal Data Terpadu Pemprov DKI Jakarta, 2019) for population data per district and (Definati, 2020) for flood prone area data in Jakarta.
Information about distribution time from flood logistics command post candidate to all district per administrative in Jakarta to find best flood logistics command post are as follows. (Tables 3 – 7)

Table 3 Flood Logistics Command Post Candidate and Distribution Time in Central Jakarta

District	**Destination (minute)**							
Origin	Gambir	Sawah Besar	Kemayoran	Senen	Cempaka Putih	Menteng	Tanah Abang	Johar Baru
Tanah Abang	17	29	27	21	24	14	0	25

Table 4 Flood Logistics Command Post Candidate and Distribution Time in North Jakarta

District	**Destination (minute)**					
Origin	Penjaringan	Tanjung Priok	Koja	Cilincing	Pademangan	Kelapa Gading
Cilincing	44	36	23	0	38	34
Tanjung Priok	20	0	23	36	14	15
Koja	26	25	0	24	23	18
Pademangan	13	19	26	43	0	24
Kelapa Gading	41	36	26	33	35	0

Table 5 Flood Logistics Command Post Candidate and Distribution Time in West Jakarta

District	**Destination (minute)**							
Origin	Cengkareng	Grogol Petamburan	Taman Sari	Tambora	Kebon Jeruk	Kalideres	Palmerah	Kembangan
Cengkareng	0	29	37	35	31	25	27	25

Grogol Petamburan	34	0	18	17	26	38	10	24
Kalideres	22	37	52	52	37	0	43	30
Kebon Jeruk	34	24	35	36	0	38	19	13
Kembangan	25	23	34	35	11	28	19	0

Table 6 Flood Logistics Command Post Candidate and Distribution Time in South Jakarta

District	**Destination (minute)**									
Origin	Tebet	Setia Budi	Mampang Prapatan	Pasar Minggu	Kebayoran Lama	Cilandak	Kebayoran Baru	Pancoran	Jagakarsa	Pesanggrahan
Mampang Prapatan	25	18	0	27	37	22	21	24	37	41
Pasar Minggu	28	35	28	0	36	24	31	27	26	38
Kebayoran Lama	41	36	35	41	0	33	22	49	45	15
Kebayoran Baru	27	23	15	26	19	16	0	27	30	23
Cilandak	39	33	24	23	28	0	16	42	20	30

Table 7 Flood Logistics Command Post Candidate and Distribution Time in East Jakarta

District	**Destination (minute)**									
Origin	Matraman	Pulo Gadung	Jatinegara	Kramat Jati	Pasar Rebo	Cakung	Duren Sawit	Makasar	Ciracas	Cipayung
Cakung	34	21	36	43	49	0	23	40	47	45
Duren Sawit	22	20	14	33	37	25	0	27	36	33
Jatinegara	20	20	0	26	31	30	17	28	30	26
Kramat Jati	31	32	30	0	23	47	36	26	21	27
Makasar	30	31	28	21	28	38	34	0	27	27

Information:
Table 3, 4, 5, 6 and 7 are designed based on source: (Google Maps, n.d.).

4.2 Calculation of The Number of Handling Victim at Each Flood Logistics Command Post

The number of people affected by flood in 2020 as Table 8 is as follows.

Table 8 The Number of People Affected by Flood in 2020

City	**District**	**Number of People Affected by Flood (a_i)**
Jakarta Pusat	Johar Baru	2
	Kemayoran	4
	Sawah Besar	3
	Tanah Abang	15
Jakarta Utara	Cilincing	17
	Kelapa Gading	22

	Koja	1
	Penjaringan	23
	Pademangan	5
Jakarta Barat	Cengkareng	15
	Grogol Petamburan	7
	Kalideres	17
	Kebon Jeruk	17
	Kembangan	24
	Palmerah	25
Jakarta Selatan	Cilandak	23
	Jagakarsa	17
	Kebayoran Baru	27
	Kebayoran Lama	27
	Mampang Prapatan	20
	Pancoran	20
	Pasar Minggu	14
	Pesanggrahan	9
	Setia Budi	5
	Tebet	15
Jakarta Timur	Cakung	20
	Cipayung	22
	Ciracas	18
	Duren Sawit	14
	Jatinegara	17
	Kramat Jati	21
	Makasar	17
	Matraman	21
	Pasar Rebo	18
	Pulo Gadung	20

Information:
Table 8 are designed based on source: (Portal Data Terpadu Pemprov DKI Jakarta, 2021).

4.3 Calculation of The Number of Humanitarian Logistics Vehicle Need to be Prepared

Calculation of the number of humanitarian logistics vehicle is based on map which displays about route of humanitarian logistics vehicle as Figure 3 is as follows.

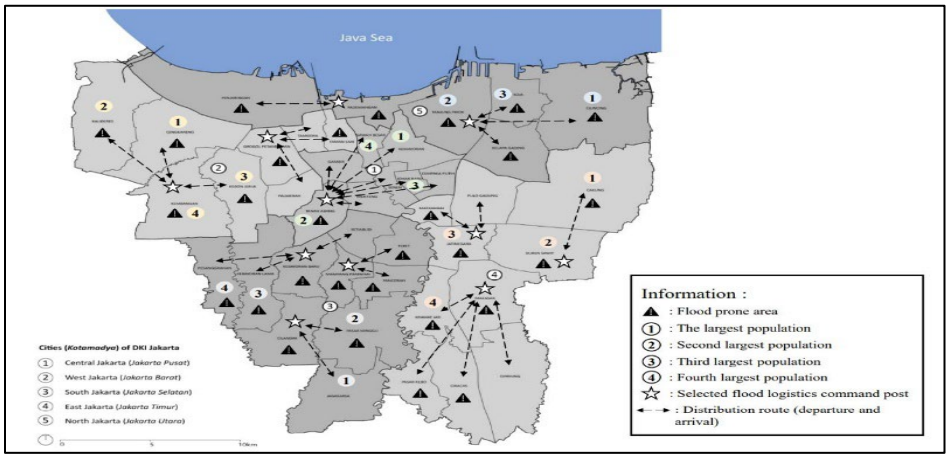

Figure 3 Jakarta Map Based on Population, Flood Prone Area, Selected Flood Logistics Command Post and Distribution Route

Information:
Figure 3 is designed based on source: (Rochelimit at en. Wikipedia, 2010) for map design, (Portal Data Terpadu Pemprov DKI Jakarta, 2019) for population data per district and (Definati, 2020) for flood prone area data in Jakarta.

From distribution route in Figure 3, it needs to find distribution time both departure and arrival which the tables are as follows. (Tables 9 – 13)

Table 9 Distribution Time Both Departure and Arrival in Central Jakarta

City	District	Distribution Time (minute)								
			Gambir	Sawah Besar	Kemayoran	Senen	Cempaka Putih	Menteng	Tanah Abang	Johar Baru
		Departure	17	29	27	21	24	14	0	25
Central Jakarta	Tanah Abang	Arrival	11	26	26	20	27	14	0	26

Table 10 Distribution Time Both Departure and Arrival in North Jakarta

City	District	Distribution Time (minute)						
			Penjaringan	Tanjung Priok	Koja	Cilincing	Pademangan	Kelapa Gading
North Jakarta	Pademangan	Departure	13				0	
		Arrival	19				0	
	Tanjung Priok	Departure		0	23	36		15
		Arrival		0	24	33		37

Table 11 Distribution Time Both Departure and Arrival in West Jakarta

City	District	Distribution Time (minute)								
			Cengkareng	Grogol Petamburan	Taman Sari	Tambora	Kebon Jeruk	Kalideres	Palmerah	Kembangan
West Jakarta	Grogol Petamburan	Departure		0	18	17			10	
		Arrival		0	18	19			19	
	Kembangan	Departure	25				11	28		0
		Arrival	22				13	30		0

Table 12 Distribution Time Both Departure and Arrival in South Jakarta

City	District	Distribution Time (minute)										
			Tebet	Setia Budi	Mampang Prapatan	Pasar Minggu	Kebayoran Lama	Cilandak	Kebayoran Baru	Pancoran	Jagakarsa	Pesanggrahan
South Jakarta	Mampang Prapatan	Departure	25		0					24		
		Arrival	17		0					16		
	Kebayoran Baru	Departure		23			19		0			
		Arrival		21			20		0			
	Cilandak	Departure				23		0			20	
		Arrival				31		0			25	

Table 13 Distribution Time Both Departure and Arrival in East Jakarta

City	District		Distribution Time (minute)									
			Matraman	Pulo Gadung	Jatinegara	Kramat Jati	Pasar Rebo	Cakung	Duren Sawit	Makasar	Ciracas	Cipayung
East Jakarta	Duren Sawit	Departure						25	0			
		Arrival						28	0			
	Jatinegara	Departure	20	20	0							
		Arrival	20	17	0							
	Makasar	Departure				21	28			0	27	27
		Arrival				22	38			0	31	31

Information:
Table 9, 10, 11, 12 and 13 are designed based on source: (Google Maps, n.d.).

5. Results and Discussion

Result and discussion based on data collection to determine the location of flood logistics command post, calculate the number of handling victim at each flood logistics command post and calculate the number of humanitarian logistics vehicle need to be prepared are as follows.

5.1 Determination of The Location of Flood Logistics Command Post

Determination of the location of flood logistics command post based on data calculation and using mathematical model (1) that is supported by solver in Microsoft Excel software produce results are as follows. (Tables 14 – 18)

Table 14 Flood Logistics Command Post Candidate and Distribution Time in Central Jakarta

District	Destination (minute)								
Origin	Gambir	Sawah Besar	Kemayoran	Senen	Cempaka Putih	Menteng	Tanah Abang	Johar Baru	Maximum
Tanah Abang (Selected)	1	1	1	1	1	1	1	1	8
Constraint	1	1	1	1	1	1	1	1	
Min Z	157								

Table 15 Flood Logistics Command Post Candidate and Distribution Time in North Jakarta

District	Destination (minute)						
Origin	Penjaringan	Tanjung Priok	Koja	Cilincing	Pademangan	Kelapa Gading	Maximum
Cilincing	0	0	1	1	0	0	2
Tanjung Priok (Selected)	1	1	0	0	1	1	4
Koja	0	0	1	1	0	0	2
Pademangan (Selected)	1	1	0	0	1	0	3
Kelapa Gading	0	0	0	0	0	1	1
Constraint	2	2	2	2	2	2	
Min Z	128						

Table 16 Flood Logistics Command Post Candidate and Distribution Time in West Jakarta

District	**Destination (minute)**								
Origin	Cengkareng	Grogol Petamburan	Taman Sari	Tambora	Kebon Jeruk	Kalideres	Palmerah	Kembangan	Maximum
Cengkareng	1	0	0	1	0	1	0	0	3
Grogol Petamburan (Selected)	0	1	1	1	0	0	1	0	4
Kalideres	1	0	0	0	0	1	0	0	2
Kebon Jeruk	0	0	0	0	1	0	0	1	2
Kembangan (Selected)	0	1	1	0	1	0	1	1	5
Constraint	2	2	2	2	2	2	2	2	
Min Z	227								

Table 17 Flood Logistics Command Post Candidate and Distribution Time in South Jakarta

District	**Destination (minute)**										
Origin	Tebet	Setia Budi	Mampang Prapatan	Pasar Minggu	Kebayoran Lama	Cilandak	Kebayoran Baru	Pancoran	Jagakarsa	Pesanggrahan	Maximum
Mampang Prapatan (Selected)	1	1	1	0	0	1	1	1	0	0	6
Pasar Minggu	1	0	0	1	0	0	0	1	1	0	4
Kebayoran Lama	0	0	0	0	1	0	0	0	0	0	2
Kebayoran Baru (Selected)	1	1	1	1	1	1	1	1	1	1	10
Cilandak (Selected)	0	1	1	1	1	1	1	0	1	1	8
Constraint	3	3	3	3	3	3	3	3	3	3	
Min Z	586										

Table 18 Flood Logistics Command Post Candidate and Distribution Time in East Jakarta

District	**Destination (minute)**										
Origin	Matraman	Pulo Gadung	Jatinegara	Kramat Jati	Pasar Rebo	Cakung	Duren Sawit	Makasar	Ciracas	Cipayung	Maximum
Cakung	0	1	0	0	0	1	1	0	0	0	3
Duren Sawit (Selected)	1	1	1	0	0	1	1	1	0	0	6
Jatinegara (Selected)	1	1	1	1	1	1	1	0	1	1	9
Kramat Jati	0	0	0	0	0	0	0	1	1	1	5
Makasar	1	0	1	1	1	0	0	1	1	1	7

(Selected)											
Constraint	3	3	3	3	3	3	3	3	3	3	
Min Z	610										

The result of the calculation to determine the flood logistics command post using mathematical model (1) for Central Jakarta is Tanah Abang with total distribution time is 157 minutes to reach to 8 districts. For North Jakarta are Tanjung Priok and Pademangan with total distribution time is 128 minutes to reach to 6 districts. For West Jakarta are Grogol Petamburan and Kembangan with total distribution time is 227 minutes to reach to 8 districts. For South Jakarta are Mampang Prapatan, Kebayoran Baru and Cilandak with total distribution time is 586 minutes to reach to 10 districts. For East Jakarta are Duren Sawit, Jatinegara and Makasar with total distribution time is 610 minutes to reach to 10 districts. Each administrative city has different flood logistics command post where it is based on fairness, where each administrative city in Jakarta has different number of resident and flood prone area, so it needs to be adjusted. The result of this adjustment results in 1 flood logistics command post in Central Jakarta, 2 flood logistics command post in North Jakarta, 2 flood logistics command post in West Jakarta, 3 flood logistics command post in South Jakarta and 3 flood logistics command post in East Jakarta. The Map that displays the result as Figure 4 is as follows.

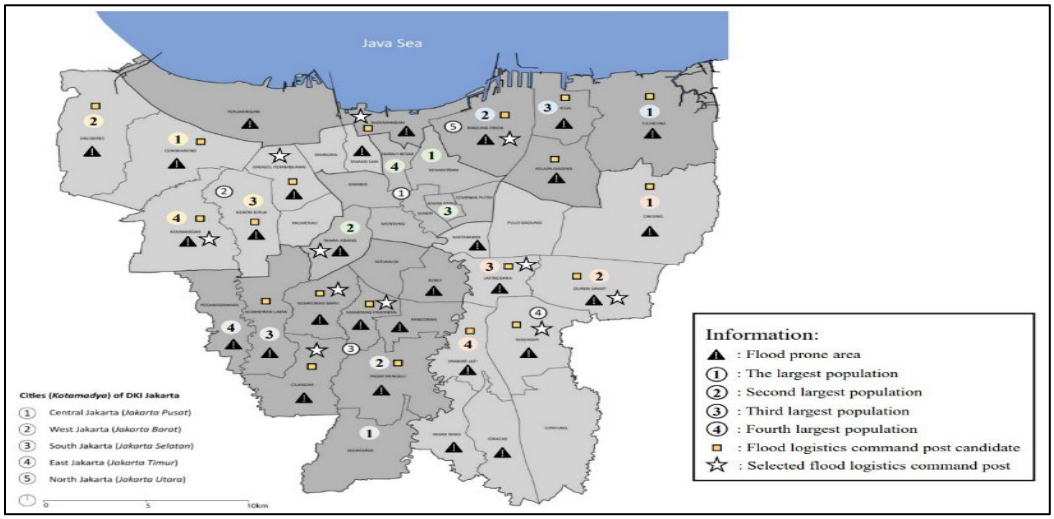

Figure 4 Jakarta Map Based on Population, Flood Prone Area and Selected Flood Logistics Command Post

Information:
Figure 4 is designed based on source: (Rochelimit at en. Wikipedia, 2010) for map design, (Portal Data Terpadu Pemprov DKI Jakarta, 2019) for population data per district and (Definati, 2020) for flood prone area data in Jakarta.

Specific location suggestion for each district of the selected flood logistics command post for each administrative city in Central Jakarta namely Tanah Abang in Bendungan Hilir, Gelora, Kampung Bali, Kebon Kacang dan Kebon Melati. For North Jakarta namely Tanjung Priok and Pademangan in Kebon Bawang, Papanggo, Sungai Bambu, Sunter Agung, Sunter Jaya, Warakas, Ancol, Pademangan Timur. For West Jakarta namely Grogol Petamburan and Kembangan in Grogol, Jelambar, Tanjung Duren Selatan, Tanjung Duren Utara, Tomang, Meruya Selatan, Meruya Utara, Srengseng. For South Jakarta namely Mampang Prapatan, Kebayoran baru and Cilandak in Gandaria Utara, Gunung, Kramat Pela, Melawai, Pulo, Rawa Barat, Selong, Senayan, Cipete Selatan, Gandaria Selatan. For East Jakarta namely Duren Sawit, Jatinegara and Makasar in Duren Sawit, Klender, Malaka Jaya, Malaka Sari, Pondok Kelapa, Podok Kopi, Bali Mester, Cipinang Besar Utara, Cipinang Cempedak, Rawa Bunga.

5.2 Calculation of The Number of Handling Victim at Each Flood Logistics Command Post

Calculation of the number of handling victim at each flood logistics command post based on data calculation and using mathematical model (2) produce results are as follows.

Table 19 Calculation the Number of People Affected by Flood in 2020

City	District	y_i	Number of People Affected by Flood (a_i)	Result
Jakarta Pusat	Johar Baru	1	2	2
	Kemayoran	1	4	4
	Sawah Besar	1	3	3
	Tanah Abang	1	15	15
Jakarta Utara	Cilincing	1	17	17
	Kelapa Gading	1	22	22
	Koja	1	1	1
	Penjaringan	1	23	23
	Pademangan	1	5	5
Jakarta Barat	Cengkareng	1	15	15
	Grogol Petamburan	1	7	7
	Kalideres	1	17	17
	Kebon Jeruk	1	17	17
	Kembangan	1	24	24
	Palmerah	1	25	25
Jakarta Selatan	Cilandak	1	23	23
	Jagakarsa	1	17	17
	Kebayoran Baru	1	27	27
	Kebayoran Lama	1	27	27
	Mampang Prapatan	1	20	20
	Pancoran	1	20	20
	Pasar Minggu	1	14	14
	Pesanggrahan	1	9	9
	Setia Budi	1	5	5
	Tebet	1	15	15
Jakarta Timur	Cakung	1	20	20
	Cipayung	1	22	22
	Ciracas	1	18	18
	Duren Sawit	1	14	14
	Jatinegara	1	17	17
	Kramat Jati	1	21	21
	Makasar	1	17	17
	Matraman	1	21	21
	Pasar Rebo	1	18	18
	Pulo Gadung	1	20	20

Table 20 The Number of People Affected by Flood in 2020 per Administrative City in Jakarta

City	Number of People Affected by Flood in Jakarta	Number of Handling Victim at Each Flood Logistics Command Post
Central Jakarta	24	24
North Jakarta	68	68
West Jakarta	105	105
South Jakarta	177	177
East Jakarta	188	188

Information:
Table 19 and Table 20 are designed based on source: (Portal Data Terpadu Pemprov DKI Jakarta, 2019)
The assumption used in this research is that all location of flood logistics command post i can meet the needs of flood refugee victim. That is why $\mathbf{y_i}$ in table 19 is 1.

The number of victim handling at Central Jakarta flood logistics command post amounting 1 must have the capacity for 24 people affected by flood. The number of victim handling at North Jakarta flood logistics command post amounting 2 must have the capacity for 68 people affected by flood. The number of victim handling at West Jakarta flood logistics command post amounting 2 must have the capacity for 105 people affected by flood. The number of victim handling at South Jakarta flood logistics command post amounting 3 must have the capacity for 177 people affected by flood. The number of victim handling at East Jakarta flood logistics command post amounting 3 must have the capacity for 188 people affected by flood. This capacity is an important basis for management to design and plan the construction of flood logistics command post to be able to provide capacity value that need to be considered so that flood victim can be handled more effectively.

5.3 Calculation of The Number of Humanitarian Logistics Vehicle Need to be Prepared

Calculation of the number of humanitarian logistics vehicle need to be prepared at each flood logistics command post based on data calculation and using mathematical model (3) produce results are as follows. (Tables 21 – 26)

Table 21 Suggestion for Humanitarian Logistics Vehicle in Central Jakarta

Central Jakarta										
Total Distribution Time (minute)	307	307	307	307	307	307	307	307	307	307
Time Policy (minute)	30	40	50	60	70	80	90	100	130	160
Number of Humanitarian Logistics Vehicle	11	8	7 (Selected)	6	5	4	4	4	3	2

Table 22 Suggestion for Humanitarian Logistics Vehicle in North Jakarta

North Jakarta										
Total Distribution Time (minute)	200	200	200	200	200	200	200	200	200	200
Time Policy (minute)	30	40	50	60	70	80	90	100	110	120
Number of Humanitarian Logistics Vehicle	7	5	4 (Selected)	4	3	3	3	2	2	2

Table 23 Suggestion for Humanitarian Logistics Vehicle in West Jakarta

West Jakarta										
Total Distribution Time (minute)	230	230	230	230	230	230	230	230	230	230
Time Policy (minute)	30	40	50	60	70	80	90	100	110	120
Number of Humanitarian Logistics Vehicle	8	6	5 (Selected)	4	4	3	3	3	3	2

Table 24 Suggestion for Humanitarian Logistics Vehicle in South Jakarta

South Jakarta										
Total Distribution Time (minute)	264	264	264	264	264	264	264	264	264	264
Time Policy (minute)	30	35	50	60	70	80	90	100	110	120
Number of Humanitarian Logistics Vehicle	9	8	6 (Selected)	5	4	4	3	3	3	3

Table 25 Suggestion for Humanitarian Logistics Vehicle in East Jakarta

East Jakarta										
Total Distribution Time (minute)	355	355	355	355	355	355	355	355	355	355
Time Policy (minute)	30	40	50	60	70	80	90	100	110	120
Number of Humanitarian Logistics Vehicle	12	9	8 (Selected)	6	6	5	4	4	4	3

Table 26 Time Policy Comparison with Number of Humanitarian Logistics Vehicles in Each Administrative City in Jakarta

Time Policy Comparison with Number of Humanitarian Logistics Vehicles in Each Administrative City in Jakarta									
Central Jakarta		**North Jakarta**		**West Jakarta**		**South Jakarta**		**East Jakarta**	
A (minute)	**B (unit)**	**A (minute)**	**B (unit)**	**A (minute)**	**B (unit)**	**A (minute)**	**B (unit)**	**A (minute)**	**B (unit)**
30	11	30	7	30	8	30	9	30	12
40	8	35	5	40	6	35	8	40	9
50	7 (S)	50	4 (S)	50	5 (S)	50	6 (S)	50	8 (S)
60	6	60	4	60	4	60	5	60	6
70	5	70	3	70	4	70	4	70	6
80	4	80	3	80	3	80	4	80	5
90	4	90	3	90	3	90	3	90	4
100	4	100	2	100	3	100	3	100	4
130	3	110	2	110	3	110	3	110	4
160	2	120	2	120	2	120	3	120	3

S means selected

The results of the calculation using mathematical model (3) which it is supported by Microsoft Excel software results in the conclusion that the flood logistics command post in Central Jakarta needs to prepare 7 humanitarian logistics vehicles so that the time span of humanitarian logistics vehicles to flood logistics command post is an average of 50 minutes. The flood logistics command post in North Jakarta needs to prepare 4 humanitarian logistics vehicles so that the time span of humanitarian logistics vehicles to flood logistics command post is an average of 50 minutes. The flood logistics command post in West Jakarta needs to prepare 5 humanitarian logistics vehicles so that the time span of humanitarian logistics vehicles to flood logistics command post is an average of 50 minutes. The flood logistics command post in South Jakarta needs to prepare 6 humanitarian logistics vehicles so that the time span of humanitarian logistics vehicles to flood logistics command post is an average of 50 minutes. The flood logistics command post in East Jakarta needs to prepare 8 humanitarian logistics vehicles so that the time span of humanitarian logistics vehicles to flood logistics command post is an average of 50 minutes. The distribution time policy of 50 minutes is allocated

for all administrative cities in Jakarta so it is hoped that wherever someone is in area in Jakarta, humanitarian logistics vehicle can reach their destination and take refugees to flood logistics command post for 50 minutes. If the situation is required for flood logistics command post to distribute relief goods to flood prone area in Jakarta, the assumption that can be used is one half of 50 minutes which it is 25 minutes. It is expected wherever someone is in area in Jakarta, humanitarian logistics vehicle can reach their destination and bring relief goods for 25 minutes. The consideration of choosing the number of humanitarian logistics vehicle is based on the area, population, number of flood prone area and the number of selected flood logistics command post in Jakarta so as to create justice both in terms of time and capacity of flood logistics command post. Capacity of flood logistics command post is based on number of victim handling or humanitarian logistics vehicles. The using of humanitarian logistics vehicle in large number can reduce waiting time significantly but it is necessary to pay attention to the area, population and the ability to provide humanitarian logistics vehicles.

6. Conclusion

Handling flood in Jakarta requires mitigation to reduce the bad impact of flood in Jakarta where the recommendation of mitigation is determining the strategic location of flood logistics command post in district which can also reach other district within an administrative city in Jakarta, calculating the number of handling victim at each flood logistics command post and calculating the number of humanitarian logistics vehicle that must be prepared before the flood occurs in Jakarta. Determination of the location of flood logistics command post in Central Jakarta is Tanah Abang (the wards are Bendungan Hilir, Gelora, Kampung Bali, Kebon Kacang dan Kebon Melati), the location of flood logistics command post in North Jakarta are Tanjung Priok (the wards are Kebon Bawang, Papanggo, Sungai Bambu, Sunter Agung, Sunter Jaya, Warakas, Ancol, Pademangan Timur) and Pademangan (the wards are Ancol, Pademangan Timur), the location of flood logistics command post in West Jakarta are Grogol Petamburan (the wards are Grogol, Jelambar, Tanjung Duren Selatan, Tanjung Duren Utara, Tomang) and Kembangan (the wards are Meruya Selatan, Meruya Utara, Srengseng), the location of flood logistics command post in South Jakarta are Mampang Prapatan (-), Kebayoran baru (the wards are Gandaria Utara, Gunung, Kramat Pela, Melawai, Pulo, Rawa Barat, Selong, Senayan) and Cilandak (the wards are Cipete Selatan, Gandaria Selatan), the location of flood logistics command post in East Jakarta are Duren Sawit (the wards are Duren Sawit, Klender, Malaka Jaya, Malaka Sari, Pondok Kelapa, Podok Kopi), Jatinegara (the wards are Bali Mester, Cipinang Besar Utara, Cipinang Cempedak, Rawa Bunga) and Makasar (-). The number of victims handling at each flood logistics command post in each district is served or distributed by flood logistics command post and after it is calculated, the results are that each number of victim handling at each flood logistics command post in each administrative city in Central Jakarta is 24 affected people by flood, North Jakarta is 68 affected people by flood, West Jakarta is 105 affected people by flood, South Jakarta is 177 affected people by flood and East Jakarta is 188 affected people by flood. The number of handling victim is used as the basis for designing the size of flood logistics command post in each administrative city in Jakarta. Suggestions for the number of humanitarian logistics vehicle that must be prepared are Central Jakarta is 7 humanitarian logistics vehicles with an average distribution time of 50 minutes, North Jakarta is 4 humanitarian logistics vehicles with an average distribution time of 50 minutes, West Jakarta is 5 humanitarian logistics vehicles with an average distribution time of 50 minutes, South Jakarta is 6 humanitarian logistics vehicles with an average distribution time of 50 minutes and East Jakarta is 8 humanitarian logistics vehicles with an average distribution time of 50 minutes. It is hoped that with the number of humanitarian logistics vehicles that are prepared, flood refugees can visit the flood logistics command post in 50 minutes and if it is only distribution of relief goods that is needed, it will take 25 minutes.

References

Badan Nasional Penanggulangan Bencana, Available: https://bnpb.go.id/berita/sebaran-posko-logistik-banjir-di-jakarta, Accessed on October 18, 2021.

Badan Pusat Statistik Provinsi DKI Jakarta, Available: https://jakarta.bps.go.id/indicator/12/111/1/jumlah-penduduk-provinsi-dki-jakarta-menurut-kelompok-umur-dan-jenis-kelamin.html, Accessed on October 18, 2021.

Boonmee, C. and Kasemset, C., The Multi-Objective Fuzzy Mathematical Programming Model for Humanitarian Relief Logistics, Industrial Engineering & Management Systems, Vol. 19, No. 1, pp. 197-210, 2020.

Damanik, N., Dirhamsyah, M. and Fatimah, E., MODEL DISTRIBUSI BANTUAN LOGISTIK KEMANUSIAAN PADA SAAT BENCANA BANJIR DENGAN MEMPERHITUNGKAN DATA IKLIM, Jurnal Ilmu Kebencanaan, Vol. 2, No. 1, pp. 35-43, 2015.

Definati, I., BPBD DKI: 82 Kelurahan di Jakarta Rawan Banjir, Ini Daftarnya, 8 December 2020, https://www.liputan6.com/news/read/4428461/bpbd-dki-82-kelurahan-di-jakarta-rawan-banjir-ini-daftarnya. Accessed November 19, 2021.

Google Maps, Available: https://maps.google.com, Accessed on November 19, 2021.

Kenny & Santoso, I. B., OPTIMASI JUMLAH PRODUKSI BAJA TULANGAN DENGAN METODE LINEAR PROGRAMMING, *Jurnal Mitra Teknik Sipil,* Vol. 1, No. 1, pp. 29-38, 2018.

KOMINFO, Available: https://kominfo.go.id/content/detail/6485/titik-rawan-banjir-di-jakarta/0/infografis, Accessed on October 18, 2021.

Maharjan, R., Shrestha, Y., Rakhal, B., Suman, S., Hulst J. and Hanaoka, S., Mobile logistics hubs prepositioning for emergency preparedness and response in Nepal, Journal of Humanitarian Logistics and Supply Chain Management, Vol. 10, No. 4, pp 555-572, 2020.

Manopiniwes, W., Nagasawa, K. and Irohara, T., Humanitarian Relief Logistics with Time Restriction: Thai Flooding Case Study, Industrial Engineering & Management Systems, Vol. 13, No. 4, pp. 398-407, 2014.

Portal Data Terpadu Pemprov DKI Jakarta, Available: https://data.jakarta.go.id/dataset/jumlah-penduduk-dki-jakarta-berdasarkan-kelurahan-dan-jenis-kelamin-tahun-2018/resource/2db9d370-31db-4986-9c2e-5a0824bf9252, Accessed on November 18, 2021.

Portal Data Terpadu Pemprov DKI Jakarta, Available: https://data.jakarta.go.id/dataset/data-kejadian-bencana-banjir-di-provinsi-dki-jakarta-tahun-2020, Accessed on November 20, 2021.

Putri, A. S., Apa Itu Banjir? Definisi, Penyebab dan Dampak, 3 January 2020, https://www.kompas.com/skola/read/2020/01/03/060000269/apa-itu-banjir-definisi-penyebab-dan-dampak. Accessed October 25, 2021.

Ratriani, V. R., Catatan Nilai Kerugian Banjir Jakarta, Bisa untuk Bangun 19.381 Desa di Indonesia, 3 January 2021, https://www.kompas.com/tren/read/2020/01/03/162307665/catatan-nilai-kerugian-banjir-jakarta-bisa-untuk-bangun-19381-desa-di?page=all. Accessed October 18, 2021.

Rochelimit at en.wikipedia, Available: https://id.wikipedia.org/wiki/Berkas:Jakarta_districts.png, Accessed on November 19, 2021.

Rueede, D., and Kreutzer, K., Legitimation Work Within a Cross-Sector Social Partnership, Journal of Business Ethics, Vol. 128, No. 1, pp 39-58, 2014.

Sugiarto, S., Widyadana, I. A. and Octavia, T., Model Matematis Penentuan Lokasi Potensial Pos Bantuan atau Depo Bencana Banjir di Kabupaten Gresik, Jurnal Tirta, Vol. 3, No. 2, pp. 265-268, 2015.

Technopedia, Available: https://www.techopedia.com/definition/20403/linear-programming-lp, Accessed on October 23, 2021.

Tim detikcom - detikNews, Available: https://news.detik.com/berita/d-5396443/lara-banjir-di-jakarta-telan-5-korban-jiwa, Accessed on February 7, 2021.

Universitas Surabaya, Available: https://ubaya.ac.id/2018/content/interview_detail/130/logistik-kemanusiaan--humanitarian-logistics-.html, Accessed on October 26, 2021.

Biographies

Joventri Chandra is final year undergraduate student from Bina Nusantara University majoring in Industrial Engineering with streaming in Supply Chain Engineering.

Rienna Oktarina is a Faculty Member and Subject Content Coordinator for Supply Chain Engineering at Bina Nusantara University. She earned PhD in Industrial Engineering from Institut Teknologi Bandung. Her research interests include logistics, supply chain management, humanitarian logistics, warehousing, transportation, and distribution.