ABSTRACT BOOK

9th International Conference on Operations and Supply Chain Management (OSCM)

15 – 18 December 2019
Ho Chi Minh City, Vietnam

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The 9th International Conference on Operations and Supply Chain Management (OSCM) is hosted by the collaboration of RMIT University, Vietnam and Institut Teknologi Sepuluh Nopember (ITS), Indonesia

RMIT UNIVERSITY VIETNAM

ITS Institut Teknologi Sepuluh Nopember

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Message from the conference chairs

The 9th International Conference on Operations and Supply Chain Management (OSCM) is hosted in Vietnam by RMIT University, Vietnam in collaboration with the Institut Teknologi Sepuluh Nopember (ITS), Indonesia. The previous 8 conferences were held in Bali, Indonesia (2005), Thailand (2007), Malaysia (2009), Maldives (2011), New Delhi, India (2013), Bali, Indonesia (2014), Phuket, Thailand (2016), and Cranfield, UK (2018). "Emerging Technologies in Supply Chain: Opportunities and Challenges" is the theme for this year conference. As we all know, the development of new technologies has major impacts on operations and supply chain management. Technologies such as advanced robotics, drone, driverless trucks, cloud computing, 3D printing, Internet of Things (IoT), Blockchain, and many others have tremendously changing the way the products are manufactured, and the supply chains are managed, and the way we work.

This year we attracted over 180 submissions representing authors from almost 40 countries. Of these, 100 papers have been selected for presentations. This demonstrates a strong international network of the conference that has been maintained since 2005. The reviewers and the scientific committee also noted that many submissions are of high quality. A substantial number of them were recommended for journal publication with revisions. With a wide range of topics and authors coming from many different institutions, this conference will stimulate enriching discussions as well as productive networking environment.

We are also pleased to have two renowned keynote speakers. Professor Shuo-Yan Chou is the Director of the Center for Internet of Things Innovation and a distinguished professor at the Department of Industrial Management, National Taiwan University of Science and Technology (NTUST). Professor Chou will be presenting a topic on Smart Transformation Enabled by Digital Fusion and Industry 4.0, a highly relevance to the conference theme. The second one is Professor Kannan Govindan, who is the Head of the Center for Sustainable Supply Chain Engineering, University of Southern Denmark who will be presenting a topic on supply chain sustainability.

Finally, this conference will not be possible without the contribution of many parties, including the committee, the reviewers, the keynote speakers, the participants, and of course the host institutions and the sponsors. We would like to thank them all for their contribution.

Wishing you all a productive and enjoyable conference.

Conference Chairs,

Assoc. Professor Matthews Nkhoma, RMIT Vietnam
Professor Nyoman Pujawan - ITS, Indonesia
Asst. Professor Reza Akbari, RMIT Vietnam
Assoc. Professor Imam Baihaqi, ITS Indonesia
Professor Caroline Chan, RMIT Australia

About The OSCM Conference

The OSCM Conference was first held in Bali in December 2005, hosted by the Department of Industrial Engineering, Institut Teknologi Sepuluh Nopember (ITS), Indonesia. Subsequent OSCM conferences were successfully held in various locations: Bangkok (2007), Malaysia (2009), Maldives (2011), New Delhi (2013), Bali (2014), Phuket (2016), Cranfield (2018), and now in Ho Chi Minh (2019)

Keynote Speakers

Professor Shuo-Yan Chou

Professor Chou is the Director, Center for Internet of Things Innovation, and distinguished professor Department of Industrial Management, National Taiwan University of Science and Technology (NTUST). He has published over 60 SCI/SSCI journal papers; PI or Co-PI of more than 80 projects. His research interests are in Internet of Things Innovation, Industrial Internet of Things, Big Data Analytics, Artificial Intelligence, Smart City Applications, Blockchain Application, Intelligent Transportation Systems, Entrepreneurship, Decision Theory, Digital Manufacturing, Computational Geometry.

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Professor Kannan Govindan

Professor Govindan is the Head of the Center for Sustainable Supply Chain Engineering, University of Southern Denmark. He has published over 350 peer-reviewed research articles in journals, conferences and books. His h-index is 66 and total citation 15482 (until 26 March 2019). His research areas, among others, are Sustainable Supply Chain Management, Sustainable Circular Economy, Corporate Social Responsibility, Sustainable Consumption and Production, Extended Producer Responsibility, Industry 4.0 with Sustainable Supply Chain focus.

Operations and Supply Chain Management: An International Journal.

In addition to organizing regular conferences, we also publish an international journal called ***Operations and Supply Chain Management: An International Journal***, as the main outlet of the extended papers presented at OSCM conferences. The journal publishes high quality refereed articles in the field of operations and supply chain management. The journal is indexed in Scopus and Web of Science (Emerging Science Citation Index, by Clarivate Analytics).

We invite original contributions that present modelling, empirical, review, and conceptual works. For more information please visit the journal's website: http://journal.oscm-forum.org/

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Contents

MULTI-OBJECTIVE RELIEF DISTRIBUTION SYSTEM MODEL FOR VOLCANO DISASTER VICTIMS

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ABSTRACT

Because of its location in the ring of fire, Indonesia has around 30% of all volcanoes in the world. After the volcano erupted, the area around the volcano was damaged and many people lost their houses, jobs, and possibilities to live in there. Before the volcano erupts, people who live around the volcano must be evacuated as soon as possible to one of the available shelters. In the shelters, drinking water, food, and medicine are needed by victims who were evacuated to survive aftermath of a disaster. To distribute reliefs to all shelters effectively, we developed a multi-objective relief distribution model. This distribution system model aims to determine the allocation of various types of relief items to several shelters with a minimum total cost and balanced service level between locations. This multi-objective relief distribution model considered multi-item, multi-period, multi-vehicle, and multi-trip by using a pre-emptive goal programming approach. This optimization model was applied to the numerical example based on Semeru Mount as the highest active volcanoes in Indonesia, which is located in Lumajang, East Java.

Keywords: relief distribution model, multi-objective optimization, pre-emptive goal programming

1. INTRODUCTION

Indonesia is an archipelago, located in the Pacific Ring of Fire and also in the meeting of four tectonic plates, i.e., the Asian continental plate, the Australian continental plate, the Indian Ocean plate, and the Pacific Ocean plate (CFE-DM, 2018). Because of its location, Indonesia geographically is a vulnerable country facing natural disasters (Van Rossum and Krukkert, 2010). Natural disasters, such as earthquakes, volcanic eruptions, and tornados, are catastrophic events caused by nature and cannot be controlled by men (Shaluf, 2007). In Indonesia, volcanic eruptions frequently occurred because Indonesia has around 30% of all volcanoes in the world. According to the Indonesian National Board for Disaster Management (BNPB), during the last 5 years, Indonesia has 78 volcanic eruptions; thus, this paper focuses on the impacts of volcano eruptions.

Natural disasters have caused damage and destruction of property, infrastructure, and assets; people lost their jobs and the possibilities to live (Sahay et al., 2016). To reduce or minimize the impact of natural disasters, a disaster management planning is needed. According to Perez-Gallarce (2017), the disaster management cycle contains four phases, namely, mitigation, preparedness, response, and recovery as shown in Figure 1. Habib (2016) categorized mitigation and preparedness into pre-disaster phases, whereas response and recovery phases are categorized into post-disaster phases. Mitigation phase is the first phase of disaster management that includes the activity steps to reduce vulnerability to disaster impacts, either economy or human (Camacho-Vallejo, 2015). Preparedness phase refers to design activities or procedures to minimize the disaster impacts to people and property. Response phase is a phase of aftermath disaster that includes all activities or operations to save lives and prevent further damage, whereas the recovery or reconstruction phase is a phase of aftermath disaster that includes rehabilitation activities (Altay and Green 2006).

Figure 1. Four phases of the Disaster Management Cycle
(Perez-Gallarce, 2017)

This paper focuses on the response phase of the disaster management cycle, a phase aftermath a volcanic eruption. Cozzolino (2012) divided the response phase into two sub-phases, namely, immediate response and restore, as shown in Figure 2. The immediate response sub-phase deals with how to rescue people, whereas the restore sub-phase deals with how to supply relief goods (medical attention, food, water, and shelter) to the refugees. Shaluf (2007) states that the worst consequence of volcanic eruption is when people have to be moved (evacuated) to shelters. Therefore, this paper deals on how to supply or distribute the relief goods to refugees in every shelter, especially to those who were affected by volcanic eruptions.

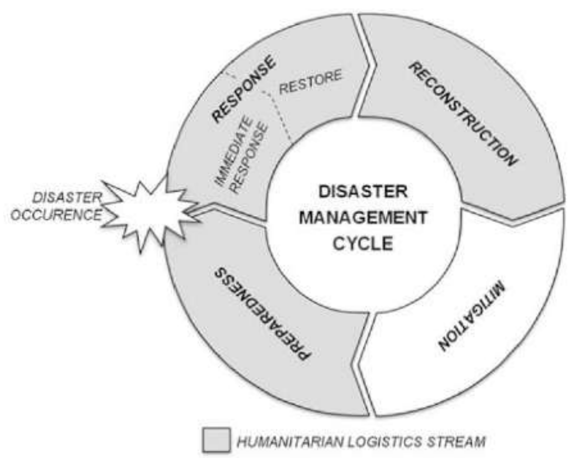

Figure 2. Response sub-phases in Disaster Management Cycle
(Cozzolino, 2012)

Each shelter needs various relief (multi-item) and regional and provincial agencies (BNPD) have to distribute multi-relief to multi-shelter using multi-vehicle. Each vehicle can have multi-trip per period to supply a similar or a different shelter. Therefore, this paper proposed a model of distributing multi-reliefs to multi-shelters using multi-vehicle, in which each vehicle can have many trips in a period. The proposed relief distribution system model has multi-objectives. The objectives are, first, to minimize the total cost of relief distribution and, second, to balance the service level of each shelter. Pre-emptive method is used to solve the multi-objective relief distribution system model. The pre-emptive methods solve the proposed model by completing each objective function in sequence (Winston, 2004).

2. RESEARCH FRAMEWORK

The research objectives can be achieved through systematic and structured steps. We started by defining the problem of distributing relief goods to each shelter. After the second step, which was to review literature, we began to develop the proposed model, which is a multi-objective distribution system model by considering multi-item, multi-vehicle, and multi-trip for each vehicle and multi-shelter. The next step was to create a scenario that consists of some actual data obtained in the field and some data assumptions. After completing the model using a pre-emptive approach and analyzing it, finally, conclusions and suggestions were done.

3. MODEL DEVELOPMENT

In the aftermath of a disaster, the basic needs of refugees must be met so the government through the BNPD distributes relief goods to each shelter where the refugees live. The proposed multi-objective distribution system model developed based on Lin et al. (2011) consists of two echelons, namely, the regional and provincial agency (BNPD) and multi-shelters. Regional and provincial agency (BNPD) is a government agency tasked to distribute the relief goods to multi-shelters. In each shelter, a lot of items are needed to be fulfilled during a certain period, and a corresponding penalty cost is imposed when the demand cannot be fulfilled within that period.

In the proposed distribution system model, one BNPD distributes relief items to many shelters. BNPD has multi-homogeneous vehicles to transfer multi-relief to shelters. In one period, vehicles can have many trips to the same or different shelter during a period as long as they have available time to transfer relief. At the same time (in one trip), a vehicle can only send multi-relief goods to one shelter, but the shelter can be visited by more than one vehicle that sends all requests for shelter in the same period. Each vehicle has weight and volume capacity restrictions. Certain relief demand at certain shelters in a period can be fulfilled by multiple vehicles and multiple trips using the same vehicle or not. This proposed model determined the number of reliefs that are distributed to a certain shelter using a certain vehicle in a certain trip at a certain period in order to minimize the total cost to meet the demand for relief goods and to minimize the gap in service level between shelters.

3.1. Mathematic Notation

Several mathematical notations that are used in this proposed multi-objective relief distribution system model can be classified become indexes, parameters, and decision variables as follows:

Index

i = Type of relief
j = Shelter location
l = Vehicle
t = Period
k = trip

Parameter

ξ_j	=	Transportation time to shelter location *j*
C_{jl}	=	Transportation cost to location *j* using vehicle *l*
H	=	Total of available work time per period
W	=	Maximum load weight capacity of vehicle *l*
V	=	Maximum load volume capacity of vehicle *l*
M	=	A large number
D_{ijt}	=	Demand of relief *i* at location *j* in period *t*
FP_i	=	Penalty cost of relief *i* if there is remaining unsatisfied demand
a_i	=	Unit weight of relief *i*
b_i	=	Unit volume of relief *i*

Decision Variable

X_{ijltk}	=	Amount of relief *i* delivered to shelter location *j* using vehicle *l* in period *t* trip *k*
w_{ijt}	=	Unsatisfied demand for relief item *i* at shelter location *j* in period *t*
S	=	Maximum difference of service level between two shelter locations
s_j	=	Service level of shelter location *j*
Y_{jltk}	=	Equal to 1 when relief are delivered to shelter location *j* using vehicle *l* at period *t* trip *k*, and 0 otherwise

3.2. Mathematic Formulation

This proposed aid distribution model has two objective functions. The first objective function (equation 1) is to minimize the total cost to meet the demand for relief goods, consisting of penalty cost and transportation cost. The penalty cost is the cost incurred because there is a demand for relief items that cannot be met. The second objective function (equation 2) is to minimize the gap of service level between shelters. This objective function aims to balance service level among shelters. Both objective functions are formulated as follows:

$$\min \sum_i \left(\left(\sum_j \sum_t D_{ijt} - \sum_j \sum_l \sum_t \sum_k X_{ijltk} \right) FP_i \right) + \sum_j \sum_l \sum_t \sum_k C_{jl} Y_{jltk} \tag{1}$$

$$min.\ S \tag{2}$$

This proposed model has several constraints as follows:

$$s_p - s_q = S^+ - S^- \quad \forall p, q \in \boldsymbol{J}, p \neq q \tag{3}$$

$$s_j = \frac{\sum_i \sum_l \sum_t \sum_k X_{ijltk}}{\sum_i \sum_t D_{ijt}} \qquad \forall j \tag{4}$$

$$\sum_l \sum_k (X_{ijltk} + w_{ijt}) = D_{ijt} \qquad \forall i, j, t \tag{5}$$

$$X_{ijltk} \leq M Y_{jltk} \qquad \forall i, j, l, t, k \tag{6}$$

$$\sum_j \sum_k \xi_j Y_{jltk} \leq H \qquad \forall l, t \tag{7}$$

$$\sum_i \sum_j a_i(X_{ijltk}) \leq W \qquad \forall l, t, k \tag{8}$$

$$\sum_i \sum_j b_i(X_{ijltk}) \leq V \qquad \forall l, t, k \tag{9}$$

$$\sum_j Y_{jltk} \leq 1 \qquad \forall l, t, k \tag{10}$$

$$Y_{ltk} = \sum_j Y_{jltk} \qquad \forall l, t, k \tag{11}$$

$$Y_{ltk} \geq Y_{jlt(k+1)} \qquad \forall l, t, k; k < \bar{k} \tag{12}$$

$$S^+, S^- \geq 0 \tag{13}$$

$$S^+, S^- \leq S \tag{14}$$

$$w_{ijt} \geq 0 \qquad \forall i, j, t \tag{15}$$

$$X_{ijltk} \geq 0 \qquad \forall i, j, l, t, k \tag{16}$$

$$Y_{jltk} \in \{0,1\} \qquad \forall j, l, t, k \tag{17}$$

Equations (3) and (4) are used to determine the gap in service levels to meet the needs of all relief items at the shelter. The level of service for fulfilling all relief items at the shelter is calculated from the ratio between the total demand for all relief goods that are fulfilled at the shelter and the total demand for all relief goods at the shelter. Equation (5) ensures that the total demand for each item of relief goods in a period is fulfilled within that period. Equation (6) guarantees that the relief goods are delivered using the assigned vehicle, whereas equation (7) ensures that in each period, each vehicle can be used only in the available working hours in that period. Equations (8) and (9) limit the total weight and total volume of loading of relief goods to not exceed the capacity of the vehicle. Equations (10) and (11) ensure that each vehicle on the same trip only sends relief goods to one shelter, whereas equation (12) guarantee that all trips of each vehicle are done in sequence order. Equations (13) and (14) guarantee that the values of the gap are absolute. Equations (15) and (16) guarantee non-negative decision variables, whereas equation (17) ensures binary decision variables.

4. RESULTS & DISCUSSION

The proposed multi-objective distribution system model is implemented using Mount Semeru data. Mount Semeru is one of the most active volcanoes in East Java, Indonesia, exactly located in Lumajang city. The height of Mount Semeru is 3,676 m above sea level, making it the highest mount in East Java. In the aftermath of a disaster, relief goods are distributed to the victims. Distributed relief goods have to be suitable for their needs. Mount Semeru data can be obtained from BPBD Lumajang. All data are collected as shown in Table 1. - Table 4.

Table 1. Shelter Location and Number of Refugee

Location	Capacity (person)	Number of Refugee (person)	Breastfeeding mothers (person)	Toddler (kid)
GOR Wira Bakti & Lapangan	20,000	18,413	3,995	1,149

Location	Capacity (person)	Number of Refugee (person)	Breastfeeding mothers (person)	Toddler (kid)
Stadion Semeru	30,000	29,642	5,640	1,209
Barak/Aula Yonif 527	7,500	6,826	700	-
Asrama Nakertrans	1,000	808	428	272
Kantor Diklat	1,000	809	429	273
Total	**59,500**	**56,498**	**11,192**	**2,903**

Table 2. Amount of Relief Sent For Each Location Each Period

Relief goods	Dimension	Location of shelter				
		GOR Wira Bakti & Lapangan	Stadion Semeru	Barak/Aula Yonif 527	Asrama Nakertrans	Kantor Diklat
Mineral water 600 ml	box	2,878	4,739	1,423	90	90
Prepared food	box	864	1,422	342	27	27
Medicine	box	185	297	68	8	8
Toddler food	pack	575	605	-	136	137
Sanitary napkins	pack	160	226	28	18	18

Table 3. Weight, Volume and Penalty Cost of Each Relief

Relief good 1	Weight (kg) 2	Volume (m^3) 3	Penalty cost (Rp) 4
Mineral water 600 ml	15	0.0239	1,500,000,-
Prepared food	3	0.0217	1,500,000,-
Medicine	5	0.006	1,500,000,-
Toddler food	0.12	0.0008	1,500,000,-
Sanitary napkins	1.5	0.0078	1,500,000,-

Table 4. Parameters

Parameter 1	Amount 2
Number of vehicle	3 units
Weight capacity of vehicle	5,895 kg
Volume capacity of vehicle	13 m^3
Travel time to each shelter location	0,5 hour
Loading and unloading time of relief	1 hour
Number of trips	6 trips
Operation time	10 hours
Planning periods	7 days

Using a pre-emptive approach, relief goods sent to the shelter location can be shown in Table 5 and the unfulfilled demand can be shown in Table 6.

Table 5. Number of Relief Goods Sent

Relief	Shelter Location	Period						
		1	2	3	4	5	6	7
Mineral water 600 ml	GOR Wira Bakti & Lapangan	1709.93	1709.93	1709.93	1709.93	1273.36	2102.93	1709.93
	Stadion	3126.1	2340.1	3126.1	2910.7	3126.16	2565.4	3126.16

Relief	Shelter Location	Period						
		1	2	3	4	5	6	7
	Semeru	6	6	6	4		8	
	Barak/Aula Yonif 527	692.13	1423	108.13	692.13	1423	692.13	672.15
	Asrama Nakertrans	0	90	90	0	0	57.071	90
	Kantor Diklat	90	90	0	90	90	0	90
Prepared food	GOR Wira Bakti & Lapangan	864	864	864	864	864	864	864
	Stadion Semeru	1422	1422	1422	1422	1422	1422	1422
	Barak/Aula Yonif 527	342	342	342	342	342	342	342
	Asrama Nakertrans	27	27	27	27	0	27	27
	Kantor Diklat	27	27	0	27	27	27	27
Medicine	GOR Wira Bakti & Lapangan	185	185	185	185	185	185	185
	Stadion Semeru	297	297	297	297	297	297	297
	Barak/Aula Yonif 527	68	68	68	68	68	68	68
	Asrama Nakertrans	8	8	8	8	0	8	8
	Kantor Diklat	0	8	0	0	0	8	0
Toddler food	GOR Wira Bakti & Lapangan	575	575	575	575	575	575	575
	Stadion Semeru	605	605	605	605	605	605	605
	Barak/Aula Yonif 527	0	0	0	0	0	0	0
	Asrama Nakertrans	136	136	136	136	0	136	136
	Kantor Diklat	137	99,303 61	0	137	137	137	137
Sanitary napkins	GOR Wira Bakti & Lapangan	160	160	160	160	160	160	160
	Stadion Semeru	226	226	226	226	226	226	226
	Barak/Aula Yonif 527	28	28	28	28	28	28	28
	Asrama Nakertrans	18	18	18	18	0	18	18
	Kantor Diklat	0	0	0	18	0	18	18

Table 6. Unfulfilled Demand

Relief	Shelter Location	Period						
		1	2	3	4	5	6	7
Mineral water 600 ml	GOR Wira Bakti & Lapangan	1168.067	1168.067	1168.067	1168.067	1604.645	775.0667	1168.067
	Stadion Semeru	1612.84	2398.84	1612.84	1828.26	1612.84	2173.515	1612.84
	Barak/Aula Yonif 527	730.86	0	337.87	730.87	0	730.87	750.85
	Asrama Nakertrans	90	0	0	90	90	32.93	0
	Kantor Diklat	0	0	90	0	0	90	0
Prepared food	GOR Wira Bakti & Lapangan	0	0	0	0	0	0	0
	Stadion Semeru	0	0	0	0	0	0	0
	Barak/Aula Yonif 527	0	0	0	0	0	0	0
	Asrama Nakertrans	0	0	0	0	27	0	0
	Kantor Diklat	0	0	27	0	0	0	0
Medicine	GOR Wira Bakti & Lapangan	0	0	0	0	0	0	0
	Stadion Semeru	0	0	0	0	0	0	0
	Barak/Aula Yonif 527	0	0	0	0	0	0	0
	Asrama Nakertrans	0	0	0	0	8	0	0
	Kantor Diklat	8	0	8	8	8	0	8
Toddler food	GOR Wira Bakti & Lapangan	0	0	0	0	0	0	0
	Stadion Semeru	0	0	0	0	0	0	0
	Barak/Aula Yonif 527	0	0	0	0	0	0	0
	Asrama Nakertrans	0	0	0	0	136	0	0
	Kantor Diklat	0	37.69	137	0	0	0	0
Sanitary napkins	GOR Wira Bakti & Lapangan	0	0	0	0	0	0	0
	Stadion Semeru	0	0	0	0	0	0	0
	Barak/Aula Yonif 527	0	0	0	0	0	0	0
	Asrama	0	0	0	0	18	0	0

Relief	Shelter Location	Period						
		1	2	3	4	5	6	7
	Nakertrans							
	Kantor Diklat	18	18	18	0	18	0	0

Table 7 shows the level of service for each number of shelters 0.74811. This value recognizes the percentage of fulfillment of 74,811% of the total shelter demand. In addition, the percentage of fulfillment of each demand is the same, and this means that each shelter is served equally. The results of model gave the first objective function, the total cost amount Rp.38,009,100 and the second objective function is no gap of service level between all shelter locations.

Table 7. Service Level of each Shelter

Shelter Location	Service Level
GOR Wira Bakti & Lapangan	0,74811
Stadion Semeru	0,74811
Barak/Aula Yonif 527	0,74811
Asrama Nakertrans	0,74811
Kantor Diklat	0,74811

5. CONCLUSION

During the restore sub-phase, BNPD distributes multi-reliefs to multi-shelters using multi-vehicles which each vehicle has multi-trips. The proposed relief distribution model gave result with minimal cost as well as balanced service level. The future research should develop metaheuristic algorithm in order to solve the proposed model faster.

6. ACKNOWLEDGEMENT

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7. REFERENCES

Altay, N. and Green, W. G. (2006)., OR/MS research in disaster operations management. *European Journal Operation Research*. Vol. 175 (1), 475-493

Habib, M.S., Lee, Y.H. and Memon, M.S. (2016)., Mathematical models in humanitarian supply chain management: a systematic literature review. Mathematical Problems in Engineering Vol. 2016, Article ID 3212095, http://dx.doi.org/10.1155/2016/3212095

Camacho-Vallejo, J.F., Gonzalez-Rodriguez, E. and Almaguer, F.J. (2015)., A bi-level optimization model for aid distribution after the occurrence of a disaster. *Journal of Cleaner Production* Vol. 105, 134-145

CFE-DM (The Center for Excellence in Disaster Management and Humanitarian Assistance) (2018), Indonesia disaster management reference book. https://www.cfe-dmha.org

Cozzolino, A. (2012), *Humanitarian logistics: cross-sector cooperation in disaster relief management*. Springer, New York.

Lin, Y.H., Batta, R., Rogerson, P. A., Blatt, A., & Flanigan, M. (2011);. A logistics model for emergency supply of critical items in the aftermath of a disaster. *Socio-Economic Planning Sciences* 45(4), 132-145.

Sahay,B.S., Menon, V.C., and Gupta, S. (2016)., Humanitarian logistics and disaster management: the role of different stakeholders, in Sahay,B.S., Gupta, S., and Menon, V.C. (ed), *Managing Humanitarian Logistics*, Springer, India.

Shaluf, I.M. (2007). An overview on disasters. *Disaster Prevention and Management: An International Journal*, Vol. 16 (5), 687-703

Perez-Galarce, F., Canales, L.J., Vergara, C. and Candia-Vejar, A. (2017). An optimization model for the location of disaster refuges. *Socio-Economic Planning Sciences* Vol. 59, 56-66

Van Rossum, J. and Krukkert, R. (2010). Disaster management in Indonesia : logistical coordination and cooperation to create effective relief operations. *Jurnal Teknik Industri* Vol. 12(1), 25-32

Winston,W.L. (2004). *Operations research applications and algorithms*, 4th Edition. Thomson Learning, Inc., Canada.