The Prediction of Logistic Needs of Emergency Response for Victims of Merapi Volcano Eruption in Regency Sleman, Yogyakarta

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The Prediction of Logistic Needs of Emergency Response for Victims of Merapi Volcano Eruption in Regency Sleman, Yogyakarta

N U Handayani[1], D I Rinawati[1], D P Sari[1] and P M Rifa'i[1]

[1]Department of Industrial Engineering, Faculty of Engineering, Diponegoro University, Indonesia

Email: naniekh@ft.undip.ac.id

Abstract. This research aims to predict the logistic needs for natural disaster victims of Merapi Volcano in Regency Sleman. Merapi volcano is chosen as the object of the research since it has been the most active volcano in Indonesia. The effort to maintain the logistic in times of emergency response by the authority has still been in responsive mode. It causes its ineffectiveness in maintaining the logistic for disaster. Frequently, there have been oversupply for a certain item, however, other items could not meet the demand. This research view in detail the needs of the victim based on the category of age and gender where there are 6 categories namely age of 0-2 years old, male aged 3-5 years old, female aged 3-5 years old, male aged 6-59 years old, female aged 6-59 years old and elderly aged >60 years old. The prediction is done in each refugee camp established in Regency Sleman. The result of the prediction logistic support for victims of Merapi eruption could become a facility of information for the government as well as for the community within the affected area so that the handling of logistic support for disaster at the time of emergency response could be maintained effectively and efficiently.

1. Introduction

Yogyakarta is one of the provinces in Indonesia located in the area of prone to volcano eruptions. Merapi volcano is located in Regency Sleman in Yogyakarta which is one the most active volcanoes in Indonesia [1]. The frequency of Merapi Volcano eruption is 6-7 years within the las 100 years. The level of danger in the affected area is very high, since the population in the slope of Merapi Volcano. It is proven by the number of victims affected by the Merapi eruption in 2010 was 353 people. According the the chief of BPBD of Regency Sleman, Merapi eruption in 2010 caused an open lava dome headed to the East, so that the future case of Merapi's lava eruption was predicted to head Gendol River in Sleman.

The Preparedness is an important step that must be met to reduce the risk of disaster. Action of the preparedness may include the logistic availability in the storage for both primary and secondary needs, either in time of emergency response or in time of recovery. The existence of logistic storage enables the supply of support is based on what is needed and is distributed accurately and quickly. The location of logistic storage must be optimal in order to evaluate the decision on various aspects, such as the close distance to the disaster area, the value of area's vulnerability, and the change of vulnerability value from

time to time. The close distance of the logistic storage to the disaster area would fix and improve the institution's performance related to the disaster handling [2] [3] [4].

Based on the interview with the victims of Merapi volcano in 2010, it was obtained that the handling of disaster in the period of emergency response of Merapi Volcano had not been optimal just yet. The frequent issue that occurs during the emergency response period has been the lateness of the aid sending for about 2 to 3 days, the suitability of the types and numbers of the supported items delivered and the ones needed, the characteristics of the items did not match with the characteristic of the refugees in each camp - there had been oversupply for certain items and vice versa – [5]. The characteristics of the victims mentioned there were age (toddler, kids, teenage, adult, elderly), gender (male, female), and etc.

Based on such issue, this research aimed to predict the logistic needs of the victim of eruption of Merapi Volcano in Regency Sleman. The prediction of the logistics needs has an advantage in providing information to the government, community, and the related parties about the logistic needs for the victims so that everything needed in time of emergency response could be distributed on time, at the right place, with the right amount, the right quality, matched with the need and on target, based on the priority scale and the service standard. The existence of information about the need of the item supplied for the victims of the disaster is expected to be able to improve the preparedness of the Government in handling the logistic for disaster in times of emergency response effective and efficient.

2. Methodology

2.1. The Definition of Disaster

Disaster is an event or a series of event that threats and disturbs the lives of the people caused by it, either by natural or non-natural factors or even human factors so that it causes the lost of lives, environment damage, the lost of properties, and psychology effect [6] [7]. The types of disaster are [6]:

1. Natural disaster is the disaster caused by an event or a series of event caused by nature, such as earthquake, tsunami, volcano eruption, dry, hurricane, and landslide.
2. Non-natural disaster is the disaster caused by an event or a series of event which are non-natural, such as technological fail, modernisation fail, epidemic and disease.
3. Social disaster is the disaster caused by an event or a series of event caused by human including social conflict among the communities and terror.

There are to main types of disaster namely natural disaster and technological disaster [8]. Natural disaster consists of:

1. Hydro-meteorological disasters such as flood, hurricane, flash flood, drought, and landslide.
2. Geophysical disasters such as earthquake, tsunami, and volcanic activity
3. Biological disasters such as epidemic, diseases that attacks plans and animals.

Technological disasters are divided into three groups [8], they are:

1. Industrial accident such as a leak of chemical substances, industrial infrastructure damage, gas leak, intoxication and radiation.
2. Transportation accident such as air crash, rail accident, road accident and water accident.
3. Miscellaneous accident such as domestic structure or non-industrial structure, explosion and fire.

2.2. Disaster Management

The conduction of disaster prevention consists of three stages [6], they are:

a. Pre disaster

The conduction of disaster handling on this pre disaster stage includes, a situation where the disaster has not yet happened and the situation has a potential for disaster to happen. Within the situation of not occurring disaster, it consists of the plan of disaster maintenance, the disaster's risk reduction, prevention, and integration in the planing of establishment, analytical requirements of disasters' risks, implementation and the establishment of spatial planning, education and training as well as technical standard requirements in handling disasters. Meanwhile, in conducting the disasters' handling in the

situation where there is a potential of disasters consists of preparedness, early warning and disasters' mitigation.

b. When the Disaster occurs (Emergency Response)

The conduction of disasters handling at the time of emergency response includes: quick and accurate study towards the location, damage, and resources; the determination of status of being in an emergency response; rescue and evacuation of the people affected by the disaster; basic needs fulfilment, protection to the vulnerable groups as well as quick recovery of the facilities and vital objects.

c. Post Disaster (Rehabilitation and Reconstruction)

Rehabilitation is an activity aiming to repair and recover all aspects of public or community service to an adequate level in the area of post disaster with the main target of normalizing all government aspects and the lives of the people on the affected area. Reconstruction is an activity to rebuild various facilities in the area of post disaster, from the level of government to the community with the main target of running back their economy, social and cultural activities, stable law and order, as well as the recovery of the role of the community in all aspects of live of the community on the affected area.

2.3. Humanitarian Logistics (Humanitarian Supply Chain)

The definition of humanitarian logistics could be separated from the definition of commercial logistics management. The difference appears on its maintenance where humanitarian logistics is more responsive, delivery of supply chain in sufficient amount and the similar treatment to the refugee without disregarding the cost minimizing [9]. Besides, other significant difference is that humanitarian supply chain has a short-term existence and unstable with inadequate relationship between the emergency aid and sustainable development [10].

Humanitarian logistics is activities that includes planning, implementation and cost controlling of the flow and the item storage effectively and efficiently from the origin point to the consumption poin aiming to reduce the number of very vulnerable victims [11]. Humanitarian logistics as a process and system to mobilize people, resources, and knowledge to help the vulnerable victims affected by the disaster [12]. Resisting factor in humanitarian logistics which does not occur on the process of commercial supply chain is the effort to repair the services related to the uncertain number of demand, costs which only focuses on the short term aid, and the lack of investment on technology and coordination.

Summary about the characteristics of humanitarian logistics that separates it from the commercial supply chain is presented in Table 1. However, most of those characteristics could change depends on the types of emergency situation especially the one caused by the level of severity of the disaster effect and the amount of logistics needed [13].

Table 1. Characteristic of Supply Chain / Humanitarian Aids Logistics

Characteristics	Explanation
Main objective	Relieve the suffering of the people affected by the disaster
Structure	Stakeholders' focus does not have clear relationship one to another, the domination from the organization other than the government and the role of the government.
3 Phases of Preparation	Pre disaster, emergency response, and recovery
Basic Features	The variation of the supply and supplier, big scaled activities, uncertain demands, and the force majeur situation within big emergency situation
Philosophy of Supply Chain	The supply is emphasized more on the location of disasters at the stage of emergency response and also applied to the stage of reconstruction.
Transportation and Infrastructure	Stable infrastructure will make quality assurance food and medical possible.
The effect of Time	Slower response time will affect to the adding number of dead victims.
Knowledge Limitation	Natural disasters naturally demands quick response, hence the supply chain needs to be planned and established at one time even though the knowledge about the situation is very limited.
Supplier Structure	Selecting on the limited supplier, it even occurs that the selection fall to the unwanted supplier.
Controlling Aspect	The control on the operation of aid is lack because of emergency situation.

The previous researcher has done a research on the comparison between commercial supply chain and humanitarian logistics from various perspectives. The basic difference between commercial logistics and the humanitarian logistics is on its strategic purpose, characteristics of the customers and demands, environmental factor, and motivation in the process of logistic's effectiveness and efficiency [14] [15]. Commercial Supply chain and humanitarian logistics rules various kinds of activity including preparedness, planning, design, supply, transportation, inventory, storage tracking and tracing, distribution, customer satisfaction, reporting and accounting, as well as administration of custom and excise [11] [12]. The basic principles of maintenance of the flow of goods, information, and finance constituted within the commercial logistics, also apply in humanitarian logistic [13].

The main objective of humanitarian logistics is to distribute the supply based on the need, either the number of the demand, location, or the time to minimize the number of dead victims and reduce the sufferings of the victims considering the cost limitation [14] the difference between commercial supply chain and humanitarian logistics [17] is presented in Table 2.

Table 2. The Comparison of Commercial Logistic and the Humanitarian Aids Logistics

Criteria	Commercial Supply Chain	Humanitarian Logistic
Source of Income	Source of income comes from the product and service selling to the customers	Source of income comes from the government funds, and donation
Objective	To earn profit and provide satisfaction financially to the stakeholder	To reach social mission and objective Crucial financial stability towards the mission and the life of the organization
Motivating item	Profit	It is not related to the profitability in its efforts to relieve the suffering of the community caused by the disaster
Coordination	Well coordinated	Coordination is not running well
Strategic purposes	Cost reduction, capital, service improvement	It goes more on the effectiveness of the mission Financial stability
Stakeholders	Depends on the owner of the organization, tends to be homogeneous	Consist of various constituent who have heterogeneous purposes and needs
Demands	It constitutes the product and service The receiver is individual or organization, and it is predictable.	It constitutes goods and human (human resources) The time, location, type and numbers are not predictable No actual demand Lack of pressure from the customer's side
Lead Time	Lead time varied from day, week to months from the time of order until the goods are received by the customer	Lead time = 0 (no warning) between the demand and the time when the goods are needed
Performance measurement	Profit is easily measured and is the competence parameter in translating market satisfaction and the capability to operate efficiently	The service offered does not have any forms, unmeasurable, the output is unknown, the standard determined by the stakeholders is different one another so the performance measurement would hardly be carried out.

2.4. Research Design

This research adopted the model [18] about the prediction of logistics needs for earthquake victims, as shown at Figure 1. The object of the research was the eruption of Merapi Volcano. The process of predicting the logistic for eruption victim was started by the process of collecting the data of the people in the affected area. There had been 14 villages in 5 Sub-regencies in Regency Sleman including the area prone to volcano eruption. From the data of the people it could be estimated the proportion of the

people from each refugee camp. The estimation of such proportion used the technique of cut and fit. Furthermore, the prediction of the victim in each camp was done by multiplying the proportion of the people with the predicted number of victims. The database details the basic need of the refugee based on the age and gender laid on the guidance of logistic handling for refugee. Once the number of predicted victim is obtained in each refugee camp, the next step is to process the predicted logistics for the victim by multiplying the result of the predicted refugee in each refugee camp with the item of logistics based on the group of age and gender.

To obtain the proportion of the number of victims from the volcano eruption in Regency Sleman, victim's demography data must first be found out. This demography data consists of data of the number of the people based on the category of age and gender projected who will occupy the refugee camps as a preparation to face the disaster with different rate of severity. The scenario is Scenario A to face the condition of effusive eruption to the affected areas of Umbulharjo, Kepuharjo and Glagaharjo. Scenario B to face the effusive eruption with affected area of the extension area of the previous area of village Umbulharjo, Glagaharjo, Kepuharjo, Girikerto, Wonokerto, and Purwobinangun. Scenario C to face the type of explosive eruption with the affected area of villages in five sub-regencies around the slope of Merapi Volcano and Scenario D to face the huge eruption where the scenario is of evacuation of refugee was conducted to the distance of > 15 km from Merapi summit.

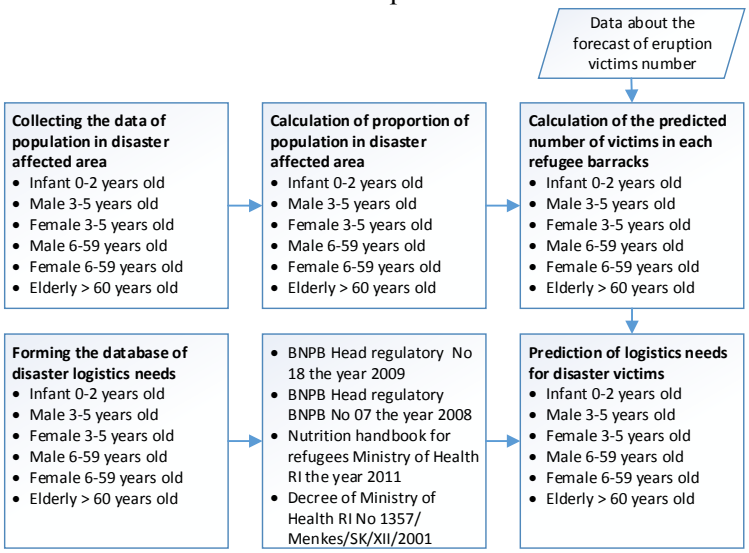

Figure 1. The Conceptual Model

3. Results and Analysis

3.1. Determining the Proportion

This stage determines the proportion of the number of victims in each refugee camps in Regency Sleman. Such proportion determining was executed using technique of cut and fit. The technique of cut and fit is generally used by the company to try many variation of product capacity allocation in a certain group until it reaches a satisfactory combination. On this research, determining the proportion is used to recognize the estimation of the number of victim in each refugee camps so that later, logistics need of the victims is predictable.

From the demographic data, the proportion of the number of the people in each refugee camps is recognized so that later the estimation of the number of victims could be counted. The proportion calculation is implemented using the technique of cut and fit by comparing the number of people in each camps and the total number of people living in the zone of affected area. Such proportion calculation is done based on the category of age and gender. The formulation of proportion calculation using the technique of cut and fit could be seen on the equation 1.

People's proportion: $\frac{Numberofpeople}{\sum numberofpeopleinzoneofaffected\ area}$ …… (1)

For example, the calculation of proportion for the age group of 0-2 years in Scenario A. In such scenario, the area affected were 3 villages namely Umbulharjo, Kepuharjo, and Glagaharjo. All refugee at the group age of 0-2 years from the three villages was 496 people, while for the Plosokerep camp had 206 people, so the proportion of the refugees in Plosokerep was:

People's proportion: $\frac{206}{496} = 0.42$

The following is the result of the calculation of the people's proportion in each refugee camp.

- Scenario A
  Scenario A is a plan prepared to implement the evacuation the refugee for the type of effusive eruption with the affected area of village Umbulharjo, Kepuharjo, and Glagaharjo. In this scenario, the proportion counted was only the number of victim for disaster-prone areas (DPA) 1 since the village affected was only on DPA 1.
- Scenario B
  Scenario B is a plan prepared to implement the evacuation of refugee for the effusive type of eruption with affected area wider than Scenario A, they were village Umbulharjo, Kepuharjo, and Glagaharjo, Girikerto, Wonokerto and Purwobinangun. In this scenario, the proportion counted was only the number of victim for DPA 2 since the village affected was only on DPA 2.
- Scenario C
  Scenario Cis a plan prepared to implement the evacuation of refugee for the explosive type of eruption with affected area wider than Scenario B, they were villages located in five sub-regencies, they are Cangkringan, Pakem, Tempel, Turi, and Ngemplak. In this scenario, the proportion counted was only the number of victim for DPA 1 and DPA 2 since the villages affected were on those to area of prone to disaster.
- Skenario D
  Scenario Cis a plan prepared to implement the evacuation of refugee for the explosive type of eruption with affected area wider than Scenario C, where the eruption was the biggest compared to other eruption. In this scenario, the proportion counted were the number of victim for DPA 1 and DPA 2 since the villages affected were on those to area of prone to disaster.

3.2. The Calculation of Prediction of the Number of Victim in Each Refugee Camp

Once the proportion of the number of the people in each refugee camp was obtained, the next step was to count the predicted number of victims in each camps. The calculation of such prediction was conducted based on the category of age and genders by multiplying the prediction result of the number of victims [19] with the proportion number of people in each refugee camp. The following is a formula to calculate the prediction of the number of victims in each refugee camp.

The number of victims: Predicted Number of Victims x Proportion of the People…….. (2)

For example, the calculation of predicted victims for Scenario A group of age of 0-2 years. The result of the calculation of the people's proportion in Camp Plosokerep is 0.42. This proportion calculation is then multiplied by the predicted number of people in Scenario A, Group of age 0-2 Years old of 802 people. The result is:

The number of victims: 802 X 0,42 = 333

3.3. The Calculation of Prediction of Victim's Logistics Need

Once the calculation of prediction of victim in each refugee camps was conducted, then it could further be calculated the prediction of the number of logistic needs for the victim of Merapi volcano eruption by multiplying the prediction of the number of victim with the item of goods supported which had been made through the database of logistic needs for victim multiplied by the number of days. The number

of days in this prediction was 30 days. The calculation of such prediction was conducted based on the category of age and gender in each refugee camp and the scenario of evacuation of refugee.

For example, the calculation on the prediction of logistic need for victims of eruption of Merapi volcano on Scenario A group age of 0-2 years old for the items of milk. Once it is known that the number of people who were about to go to Camp Plosokerep was 333 people then the logistics need for Camp Plosokerep was:

The Prediction of the Need of Milk = 40 gr x 333 people x 30 days

The Prediction of the Need of Milk = 399.600 gr

It means that the need of milk in Camp Plosokerep was 399.600 gram or equal to 399.6 kilogram for a month.

When the disaster occurred, the main priority was the effort to rescue the victims by evacuating them from the centre of eruption, so that the survivor did not have time to carry their personal belongings. It arose the demand for the needs for the people affected by the disaster. However, the operation of supply of logistic quite often was responsive so that the handling became less effective and efficient. When the disaster occurs, the Regent would issue the status of emergency response. Once it was issued, the emergency response team would go down to implement the process of need assessment to the need of the people. Process evacuation and the first aid. Among the disastrous situation, nervousness frequently occurred in the process of the calculation of the need so that the number and the type of item donated would not match with what the people needed. Once the process of need assessment was done and reported, BPBD would further undertake the process of supplying the items needed. It caused the distribution of the donated items became late at the beginning of the disaster.

This research aims to provide information to BPBD Sleman and the people about the prediction of the logistic need of victim of disaster in the affected area. The calculation of the prediction of logistic needs of the victim will be focused on each refugee camp as supply point of the donated goods and the centre of activities of the victim of Merapi eruption. The calculation of the prediction of logistic needs was implemented by making the database of the victim of Merapi eruption. The database of the need of the victim made must concern the aspect of category of age and gender. There were six age category, they are group of age 0-2 years old, male 3-5 years old, female 3-5 years old, male 6-59 years old, female 6-59 years old, and elderly aged >60 years old. The database was then verified by the Chief of Logistic Section of BPBD Sleman. Once the database of the victim was verified the next step was to calculate the proportion number of the people in the area affected using the technique of cut and fit. This technique was used to disaggregate the number of victim in one area prone to disaster into the number of victim in each refugee camp. Based on the result of prediction of the number of victim in each refugee camp, the calculation of logistic needs for the victim was implemented by multiplying the number of victim with the database of logistic needs of the victim that had been verified based on the group of age and genders for one period of emergency response which was 30 days.

In this research, there were four scenario of victim evacuation based on the type of Merapi eruption. There were two types of eruption namely effusive and explosive eruption. Effusive eruption is a process of spurting the magma to the surface of the earth with weak pressure of gas and so it came out in some sort of melt, no eruption nor explosion. The material putting out from the effusive eruption was liquid and some solid material melted through the slope of the volcano. While explosive eruption is a process of spurting the magma to the surface of the earth by exploding from the high pressured magma. Such eruption spurting volcanic material either in solid form and liquid. The scenario made by BPBD Regency Sleman was divided into Scenario A and B for effusive eruption, and Scenario C and D for explosive eruption, each had to concern to the width of the affected area. Each scenario has its own difference in terms of the movement of the refuge occupying the refugee camp. This difference of course would affect the number of logistics needed in each refugee camp. For example, Scenario A with its affected area of Village of Umbulharjo, Kepuharjo, and Glagaharjo. The calculation of prediction of logistic need for the victim for this scenario would of course be different with scenario B which the affected area were village Girikerto, Wonokerto, Umbulharjo, Kepuharjo, and Glagaharjo. Scenario C was designed as an evacuation plan of refugee for affected area in all villages in 14 villages and scenario D was the extension

of scenario C. The calculation of prediction of logistic needs for the victim in this research, of course still had some weaknesses. One of which was the fluctuation of the number of the people in the refugee camp was not concerned. This research only provided the description of logistic needs for the victim during the period of emergency response but never paying attention to the movement of the refugee in the refugee camp. The refuges usually would go home at certain times or leave the refugee camps for some reasons that the number of the refuges in the camp would change. Further research needs to be conducted to make the process of the goods distribution more effective for.

4. Conclusion

The making of database of logistic needs for the victims were divided into three categories, they were category of clothing, food, and others. The category of food related to the standard need of food and water for the victim. The category of clothing related to the standard need of clothing such as clothing for prayer, personal clothing based on the age and gender, uniform for schoolchildren and etc. While other needs related to the needs other the need of food and clothing. Example of other needs was tampon, diaper, spoon, fork, masker and etc. The making of database of logistics for the victim must be matched with the age and the gender of the victim where there are six age category and gender they were group of age 0-2 years old, male 3-5 years old, female 3-5 years old, male 6-59 years old, female 6-59 years old, and lastly elderly aged of more than 60 years old.

The prediction of logistic needs for victim of Merapi eruption was conducted in 33 shelters or refugee camps in Regency Sleman. The prediction of logistic needs for victim of Merapi eruption was also conducted based on the scenario of evacuation of refugee where each scenario was designed to face different type of eruption. There were two types of eruption, they were effusive and explosive eruption and there were four scenarios, they were Scenario A for effusive eruption with the affected area of village Kepuharjo, Umbulharjo, and Glagaharjo. Scenario B for effusive eruption with the affected area of the extension of scenario A of village of Girikerto, Wonokerto, Umbulharjo, Kepuharjo, and Glagaharjo. Scenario C was designed as the evacuation plan of the refugee for the affected area of all 14 villages and scenario D was the extension of scenario C.

References

[1] Sayudi D S, Nurnaning A, Juliani D J and Muzani M 2010 *Peta Kawasan Rawan Bencana Gunung Merapi, Jawa Tengah dan Daerah Istimewa Yogyakarta 2010 (*Jakarta: Pusat Vulkanologi dan Mitigasi Bencana Geologi, Badan Geologi, Kementrian Energi dan Sumber Daya Mineral).
[2] Wifqi A, Pujawan I N, and Kurniati N 2010 *Prosiding Seminar Nasional Manajemen Teknologi XII*. Surabaya.
[3] Roh S Y, Pettit S, Harris I, and Beresford A 2015 *Inter J. Prod Econ* **170** Part B 616-28.
[4] Handayani N U, Rinawati D I, and Wiguna YK 2015 *Joint International Conference on Electric Vehicular Technology and Industrial, Mechanical, Electrical and Chemical Engineering (ICEVT & IMECE)*.
[5] Patriatama A A and Bintoro A G 2013 *Seminar Nasional Mesin dan Industri (SNIM8) 2013* 520-27.
[6] Undang-Undang Republik Indonesia No. 24 Tahun 2007 Tentang Penanggulangan Bencana. Jakarta.
[7] Peraturan Kepala Badan Nasional Penanggulangan Bencana Nomor 18 Tahun 2009 tentang Pedoman Standarisasi Logistik Penanggulangan Bencana.
[8] UN-ISDR 2002 *Living with Risk: A Global Review of Disaster Reduction Initiatives*. ISDR. Geneva.
[9] Ahmadi M, Seifi A and Tootooni B 2015 *Trans Research* Part E **75** 145-63.
[10] Oloruntoba R and Gray R 2006 *Supply Chain Management: An International Journal* **11** 115-20.
[11] Thomas A and Kopczak L 2005 From logistics to supply chain management. The path forward in the humanitarian sector, Fritz Institute.

[12] Van LN and Wassenholve 2006 *The Journal of Operations Research Society (IJPDLM)* **57** 475-89.
[13] Kovacs G and Spens K M 2007 *International Journal of Physical Distribution and Logistics Management* **37** 99-114.
[14] Balcik B and Beamon B M 2008 *International Journal of Logistics Research and Applications* **11**(2) 101-121.
[15] Ernst R 2003 *Forced Migration Review* **18** 1-5.
[16] Gustavsson L 2003 *Forced Mitigation Review* **18** 6-8
[17] Roh S, Jang H and Han C 2013 *The Asian Journal of Shipping and Logistics (AJSL)* **29** 103-20
[18] Oktarina R, Bahagia S N, Diawati L and Pribadi K S 2013 *Proceedings of The International Conference on Tourism, Transport, and Logistics (IJTTL)* 221-225
[19] Rinawati D I, Sari D P, Handayani N U, and Siwi B R 2018 *MATEC Web of Conferences* **154** 01050.