POSSIBILITIES OF EFFECTIVE USE OF EMERGENCY LOGISTICS APPLYING THE INCEPTION PHASE IN DISASTER MANAGEMENT

Daniel CHAMRADA, Tomáš ŠUBRT

Czech University of Life Sciences in Prague, Prague, Czech Republic, EU,
chamrada@pef.czu.cz, subrt@pef.czu.cz

Abstract

This research paper deals with the possible logistics measures in the inception phase of disaster management model. The inception phase is a potential new element of the disaster management model and could be specified as a significant time range between the emergence of disaster and its impact. The limited time range offers a wide spectrum of emergency logistics activities during disaster (e.g. activation of warning systems, evacuation of the population, distribution of goods, activation of flood control measures, …).

In the introduction, theoretical bases of disaster management and emergency logistics are presented. Then the possibility of disaster management model innovation and the benefits of its extension to the inception phase are examined. This chapter is followed by the analysis of more than 300 catastrophic events (since 2000) that are examined in terms of time course. Based on this information, it is possible to determine the usual duration of the inception phase in each type of disaster. Proposed approach should be applied especially in the case of giant tsunami tide waves (due to the ideal time length minutes to hours), that arise as a side effect of an underwater earthquake and, exceptionally, during volcanic activity. Chapter Results & Discussion then cover list of activities that should be implemented (in specific time, order, …) when Tsunami events occur. Conclusion of our paper deals with comparison of often current inefficient use and our ideas. about of mentioned time range and future possibilities.

Keywords: Disaster, earthquake, inception phase, model, tsunami

1. INTRODUCTION

Disaster management same as Emergency logistics is relatively new and modern discipline that is continuously evolving with crisis management. Centre for Research on the Epidemiology of Disasters (CRED organization deals with disaster research and humanitarian crisis situations.) (CRED) defines disaster [1] as „*a situation or event that overwhelms local capacity, necessitating a request at the national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering.*" According to Coppola [2] disasters can have few different causes and can be divided into natural, technological and intentional disasters. The following text is focused only on most common natural disasters. Acording to CRED [1] several types of classification of natural disasters have been presented. In this paper catastrophes will be devided purely by type into (1) Floods; (2) Storms; (3) Earthquakes; (4) Extreme temperature; (5) Landslide; (6) Drought; (7) Wildfire; and (8) Volcanic activity. However, this division is complemented by (9) Tsunami tidal waves, which arise as a side effect of other events (for example underwater earthquakes, landslides, volcanic activity).

Emergency logistics is a specific branch of logistics that focuses on organizing of the warehousing and relief distribution during natural and other disasters. It may also include other rescue activities carried out under time pressure and leading to the achievement of the mentioned main goals [3]. According to Jiang [4] emergency logistics differs from conventional commercial logistics mainly in a different objective - minimization of looses instead of maximization of profit but also highly variable demand, unknown location with usually poor infrastructure, and minimal support of system technologies during intervention.

2. MATERIALS AND METHODS

According to Coppola [2] the number of occurrences of natural disasters is increasing and even has a growing impact on human society. Based on this idea, strategies to improve preventive operations and rescue work are being developed to reduce the consequences of these disasters. Disaster management and emergency logistics techniques contribute to improvements in this area. The steps of these disciplines are described by Kovács and Spens [5] through the three follow-up phases, which are: preparation phase, immediate response phase and reconstruction phase.

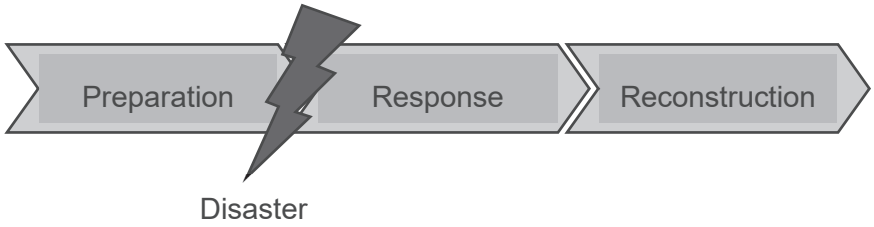

Figure 1 Phases in disaster management [Kovács and Spens, 2007]

As shown in **Figure 1** the preparation phase prevents a natural disaster, while response and reconstruction phases follow the previous one after the disaster. The individual components of the model are described in the following paragraphs.

- Preparation Phase - Based on the Coppola [2] the preparation phase covers steps that lead to reducing the risk and overall impact of natural disasters. During preparation phase first aid supplies and pre-positioning strategies for relief distribution should be made [6].
- Response Phase - Takes place shortly after a disaster, includes first aid to injured people and creation of crisis plans. Response phase usually lasts 12 hours [7] up to few days [8] based on activities alocated.
- Reconstruction Phase - Comes with a quietening of the situation after response phase. Reconstruction phase has strategic goals and covers reconstruction works that leads to get back to normality as soon as possible [9]. Özdamar [6] states that this phase closes disaster cycle because alocated activities proceed to the first phase.

3. RESULTS

We have described in chapter 2 that disaster management model does not include a significant part. Its range begins when a disaster occurs (explosion, eruption, gaining power, earth tremor, ...) and ends in the moment of the first impact on human society and/or nature. This fact leads to creation of a very short time gap. Usually, this time span lasts only a few minutes or hours in case of natural disasters, but in exceptional situations it can takes up to days and months. None of the models in the previous chapter involved this idea. We assume, that this time range is ideal to start some rescue operations and we decided to name this time span an “Inception“ phase - it presents begining and origin of the situation. Major advantages of operations processing in this time are unchanged conditions of the immediate surroundings of disaster - human behavior is rational, it is possible to use a fully functioning infrastructure and area is less chaos. Suitable activities are: (1) Beginning of evacuation; (2) Informing about escape roads; (3) Relief distribution; (4) Request support from other rescue services - especially major global organizations (UNICEF). **Figure 2** shows the modified version of the model, which illustrates the original Kovács and Spens model and includes the described “Inception“ phase.

Figure 2 (unlike **Figure 1**) contains Inception phase in its process. Using this model, it is already possible to clearly define which activities are carried out before disaster, after its origin, and after the disaster impact. Now it is also possible to allocate emergency logistics activities exclusively to the two middle phases of the model which clarifies the current concept of disaster management and emergency logistics.

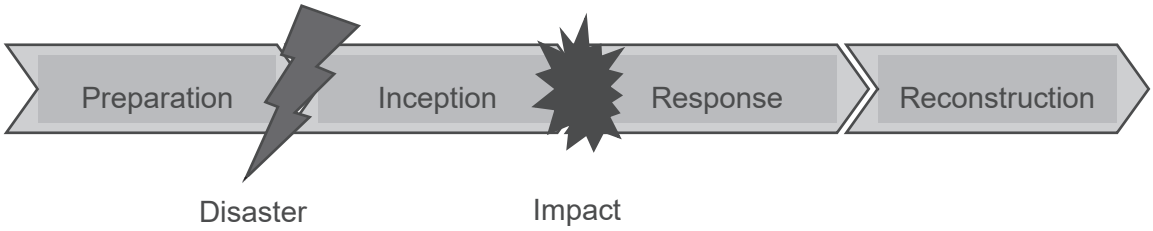

Figure 2 Disaster management model, supplemented with the inception phase [own study]

4. ANALYSIS - LENGTH OF INCEPTION PHASE

Based on the results obtained (shown in chapter 3), it is now appropriate to consider what type of disasters it is appropriate to monitor (and improve) trend of the inception phase. In order to this idea, an analysis of 323 catastrophic events since 2000 up to 2018 was carried out and the time sequence was monitored. The types of disasters were categorized according to the distribution indicated in the introduction. The **Table 1** below lists all types of natural disasters in chronological order according to the length of the inception phase - from the average longest duration to the shortest.

Table 1 Overview of analyzed events and length of its inception phase [own study]

Type of disaster	Usual time range (emergence to impact)	Number of events analyzed
Volcanic activity	1 - 4 months	61
Droughts	1 or 2 weeks	36
Extreme temperatures	2 days to 1 week	38
Storms	2 - 3 days	64
Floods	6 hours to 5 days	43
Wildfires	4 - 12 hours	27
Tsunami	**10 minutes to 2 hours**	**25**
Land earthquakes	5 seconds to 2 minutes	29

Each of the analyzed catastrophic events in **Table 1** is traceable in the CRED database and its progress has been monitored. Relevant timeline data has been obtained from (1) detailed CRED data; (2) data from other professional databases (eg. GVP*, ITIC*, ...); (3) research articles; (4) from unofficial sources - only in extreme cases. Major disasters with high impact on a larger part of the world could be analyzed multiple times, monitoring the impact on different regions. (The Indian Ocean Tsunami in 2004 were analyzed four times with an impact on Indonesia, Thailand, Sri Lanka and South Africa.). Shown data of usual time ranges always contains at least 70 % of the total inception phase time of analyzed events within each category, although in some cases the category covers more than 80 % of the observed values. So, the reason is often the wide statistical variance of inception phase length.

*Global Volcanism Program / National Museum of Natural History of Smithsonian Institution

*International Tsunami Information Center, database of National Centres for Environmental Information

Based on the observations and data obtained, it is clear that tsunami with a time range of 10 minutes to 2 hours is an ideal type of disaster for further investigation. Land earthquake has a short duration of the inception phase. Current technologies do not allow the initiation and execution of rescue operations with an effective result. Wildfires, in particular, affect mainly economically developed parts of the world and current systems allow for fast reaction.

5. DISCUSSION

Emergency logistics (also called humanitarian logistics) is a significant part of disaster management. Its importance increases with population density of the endangered area. Emergency logistics includes a number of steps to mitigate the effects of catastrophic events. Its effective use can lead to rapid stabilization of the affected area.

In accordance with the present concepts it can be mentioned that emergency logistics activities currently cover five major areas in general. According to Celic [10] who specified these subjects as criteria in his mathematical model are listed activities related to information system, warehousing, organization, transportation & distribution and management & planning. It is appropriate to use mentioned distribution also in the specific case of tsunami. However, it is necessary to adapt the individual points to the situation of often highly populated coastal sites in less economically developed countries.

Emergency logistics activities based in the information system

- Triggering an early warning siren in vulnerable areas to inform the population.
- Announcing the evacuation of the area using appropriate communication channels & communication language. The communication shall not affect the nationality, culture or language of the population.
- Providing on-line informations about vulnerable areas, expected magnitude and strength of wave and time of intervention. Providing additional information about evacuation corridors.

Emergency logistics activities based in warehousing

- Informing the public about the availability of warehouses with medical supplies and food in selected locations.
- Preparation warehouses to stock draw and create orders for re-supply.
- Occupation of warehouse personnel for controlled use of stocks. Their allocation adapted to the most vulnerable areas.

Emergency logistics activities based in organization

- Setting up communication and cooperation of mutual information between emergency services and key international organizations (UNICEF, UNHRD, WFP, ...) (UNICEF = originally United Nations International Children's Emergency Fund, UNHRD = United Nations Humanitarioan Response Depots, WFP = World Food Programme)
- Reduce impact through artificial or natural coastal barriers. Activation of mobile breakwaters.

Emergency logistics activities based in transportation and distribution

- Allocation of paramedics and rescue teams to the most vulnerable areas.
- Closure of traffic (complete public infrastructure) at transit points of vulnerable areas.
- Informing the public about possible escape routes.

Emergency logistics activities based in management and planning

- Creating of a plan for deploying relief distribution channels.
- Use of the operational decision plan.

First of all, it is important to warn in a universal way as soon as possible. The corresponding communication channel and communication language must be selected. The communication shall not affect the nationality, culture or language of the population at risk. Emergency logistics activities are tied to human capacity, which is usually limited in time and place. Effective realization of mentioned activities requires utilization of time

capacity. Then it is also important to note that implementation of each activity requires the use of the total time capacity of the inception phase and the execution of each activity reduces the impact of the disaster.

The most common measures are related to warning the population and subsequent evacuation. However, operations are not efficiently carried out.

In this research paper, it is appropriate to make a cursory comparison. For this purpose, we chose the two most devastating tsunami waves in the last 20 years - the earthquake and tsunami in the Indian Ocean (2004) [11] and the earthquake and tsunami in Japan (2011) [12]. Both of these events are well known, including their course and impact. They can thus be credibly compared with a potentially effective solution that we designed in **Table 2**.

Table 2 Realized and possible activities during tsunami 2004 in SE Asia and 2011 in Japan [own study]

Areas of activities	**Use of rescue activities**			
	Tsunami 2004 (SE Asia)		**Tsunami 2011 (Japan)**	
	Possible activities	**Realized**	**Possible activities**	**Realized**
ELA* based in the information system	Sirens, providing online information, evacuation	No	Sirens, providing online information, partial evacuation	Yes
ELA based in warehousing	Warehouses preparing and opening	No	Distribution od medical supplies	Partly
ELA based in organization	Activation of barriers; Joining international organizations	No	Activation of barriers on the coast	Yes
ELA based in transportation and distribution	Allocation of paramedics, Closure of traffic	No	Allocation of paramedics, Closure of traffic	Partly
ELA based in management and planning	Deploying relief distribution channels, Oper. decision plan	No	Operational decision plan	Yes
Lenght of inception phase	**1 hour, 45 minutes**		**17 minutes**	

* ELA = Emergency logistics activities

Tsunami in Southeast Asia (2004) is one of the worst organized disaster of all time. The reason for this failure was a poor assessment of the situation, as the earthquake information was considered a system error. Minimal information about incoming waves between SE Asia countries increased the overall impact. Japan's earthquake and tsunami (2011) was different [12]. In the organizational point of view, the inception phase was perfectly managed. Just 7 minutes after beginning of the earthquake, a crisis staff met in Tokyo. Information about tsunami warning were in all online media and on TV just two minutes later.

For further research it is necessary to supplement the presented theory with techniques of quantitative methods. These can be applied in a variety of cases. Transportation problem could be used for searching for escape routes from the vulnerable zone with regard to the danger of overloading these corridors. Techniques of turnaround project management could be applied during the both Inception and Response phase. Knapsack problem could be helpful during sorting and prioritization of activities with limited time availability. Multicriterial programming is conducive to relief distribution centers and relief distribution channels deployment in the affected area.

6. CONCLUSION

Disaster management same as emergency logistics is a modern science discipline that deals with reducing of the impact in crisis situations by using and adhering selected relief procedures. However, the time span

between the occurrence and impact of a disaster in vulnerable area is used inefficiently in these situations. Especially in cases of tsunami and earthquakes. For these cases, we proposed inception phase to which it is possible to allocate activities to reduce the impact. Then we focused more on tsunami cases and compared our suggested approach with tsunami in SE Asia (2004) and Japan (2011). These ideas and procedures should be now supplemented with a mathematical part through operational research methods.

REFERENCES

[1] YAGHMAEI, Nima. *Disasters 2018: Year in Review*. Centre for Research on the Epidemiology of Disasters, Louvain, 2019. 8 p.

[2] COPPOLA, Damon P. *Introduction to international disaster management.* 3rd ed. Boston: Butterworth-Heinemann, 2015. p. 760

[3] CAUNHYE, Aakil M., NIE, Xiaofeng and POKHAREL Shaligram. Optimization models in emergency logistics: A literature review. *Socio-Economic Planning Sciences*. 2012. vol. 46, pp. 4-13.

[4] JIANG, Yiping and YUAN Yufei. Emergency Logistics in a Large-Scale Disaster Context: Achievements and Challenges. *International Journal of Environmental Research and Public Health* 2019. vol. 16, pp. 779-802

[5] KOVÁCS, G., SPENS, M. Humanitarian logistics in disaster relief operations. *International Journal of Physical Distribution & Logistics Management*. 2007. vol. 37, pp. 99-114.

[6] ÖZDAMAR, Linet and ERTEM, Mustafa A. Models, solutions and enabling technologies in humanitarian logistics. *European Journal of Operational Research*, 2015. vol. 244, pp. 55-65.

[7] AHMADI, Morteza, SEIFI, Abbas and TOOTOONI, Behnam. A humanitarian logistics model for disaster relief operation considering network failure and standard relief time: A case study on San Francisco district. *Transportation Research Part E: Logistics and Transportation Review*. 2015. vol. 75, pp. 145-163

[8] CAO, Cejun, LI, Congdong and YANG, Qin. Multi-Objective Optimization Model of Emergency Organization Allocation for Sustainable Disaster Supply Chain. *Sustainability, MDPI, Open Access Journal*. 2017. vol. 9(1), pp. 1-22,

[9] HOYOS, Maria C., MORALES, Ridley S. and AKHAVAN-TABATABAEI Raha. OR models with stochastic components in disaster operations management: A literature survey. *Computers & Industrial Engineering*. 2015. vol. 82, pp. 183-197

[10] CELIK, Erkan and TASKIN GUMUS, Alev. An assessment approach for non-governmental organizations in humanitarian relief logistics and an application in Turkey. *Technological and Economic Development of Economy*. 2018. vol. 24, pp. 1-26

[11] SINGH, Poonam K. A decade after the 2004 Asian Tsunami: recalling the turning point for disaster management. World Health Organisation (WHO) [online]. Version 1, Last updated: 24 December 2014 [viewed 2019-11-14]. Available from: https://www.who.int/southeastasia/news/opinion-editorials/detail/a-decade-after-the-2004-asian-tsunami-recalling-the-turning-point-for-disaster-management

[12] HOLGUÍN-VERAS, José et al. The Tohoku disasters: Chief lessons concerning the post disaster humanitarian logistics response and policy implications. *Transportation Research Part A: Policy and Practice*. 2014. vol. 69, pp. 86-104