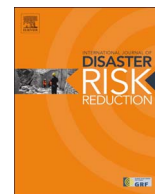




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Review Article

Emergency decision making for natural disasters: An overview

Lei Zhou^a, Xianhua Wu^b, Zeshui Xu^{c,*}, Hamido Fujita^d^a School of Applied Meteorology, Nanjing University of Information Science & Technology, Nanjing, Jiangsu 210044, China^b Collaborative Innovation Center on Forecast and Evaluation of Meteorological Disasters, School of Economics and Management, Nanjing University of Information Science & Technology, Nanjing, Jiangsu 210044, China^c Business School, Sichuan University, Chengdu, Sichuan 610064, China^d Fac. of Software and Information Science, Iwate Prefectural University, 020-0193 Iwate, Japan

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ABSTRACT

With the increasing trend of global warming, the frequent occurrences of natural disasters have brought serious challenges to the sustainable development of the society. Therefore, emergency decision making (EDM) for natural disasters plays an increasingly significant role in improving the capability to respond disasters. In this paper, we first elaborate the concept and characteristics of EDM for natural disasters and briefly expound emergency decision contents in different stages of natural disasters. Then, an overview is provided for the EDM theory and methods of natural disasters from the methodological perspective. After that, we give a detailed illustration of the construction of emergency decision support system. Finally, we summarize the main conclusions of the paper and point out the prospect of future researches.

1. Introduction

In the latest years, the frequent occurrences of destructive natural disasters in the world have caused serious damages to social construction and economic development, such as Indonesia tsunami in 2004, “5.12” Wenchuan earthquake in 2008, freezing rain disaster in southern China in 2008, devastating 2011 earthquake in Japan, flood disaster in India in 2013 and hail disaster in Yancheng in 2016, Jiangsu. Especially in July 2016, heavy rain continues to strike the north of China, with severe flood in southern China at the same time.

Natural disasters refer to the natural processes that occur in the ecosystem, which can lead to the loss of stability of the social-economic system, and serious imbalance between supply and demand of social resources. Natural disasters can be divided into six categories: geological disasters, meteorological disasters, environmental pollution disasters, fire, marine disasters, and biological disasters [1]. At present, natural disaster research is drawing extensive attention in current society and researching fields with the characters of great varieties, high frequencies, wide coverage and big intensity.

Confronted with the stringent situation of flood relief, Comrade Xi, General Secretary of the Communist Party of China and Chairman of the People's Republic of China, addressed the issue of flood relief three times a month and put forward six requirements of “highlighting the defense focus”, which provides succinct and specific instructions for disaster emergency management. As is shown above, in the face of the

test of natural disasters to the bearing capacity of social and economic system, the governments of all levels, the masses and the scholars have shown great solicitudes for major issues concerning how to quickly and accurately respond to natural disasters, implementation EDM, construct emergency decision support systems, improve the capabilities of disaster prevention and emergency rescue, and provide scientific basis for disaster prevention and relief.

EDM is one of the key issues in the field of emergency management and it needs to propose a scientific and reasonable method for analyzing the effectiveness of EDM and building emergency decision support system for information sharing and cooperative service. Up to now, numerous reviews on EDM have been conducted from the perspective of unexpected disasters [2–4], but a few have been carried out in terms of EDM for natural disasters. In order to figure out the existing developments, challenges, trends of EDM for natural disasters, we try to exploit what to do and how to do it. Roughly, the first aspect concentrates on analyzing the concept and characteristics of EDM for natural disasters, whereas the second aspect focuses on the methods and systems of EDM for natural disasters.

In this paper, we further the study of EDM for natural disasters, and makes significant contributions on EDM in existing developments.

- (1) The literature is structured and analyzed the EDM model types, and analyzed the detailed content and advantages and disadvantages in practical application.

* Corresponding author.

E-mail addresses: 20141262750@nuist.edu.cn (L. Zhou), wxxhua_77@nuist.edu.cn (X. Wu), xuzeshui@263.com (Z. Xu).<http://dx.doi.org/10.1016/j.ijdr.2017.09.037>

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- (2) We give a detailed illustration of the construction of emergency decision support system. Although with some foundation, there have been no systemic researches and conclusions on the system techniques for EDM for natural disasters.
- (3) Through the content analysis framework, several research Resource constraints in EDM for natural disasters are identified and future research directions are proposed.

The paper is organized as follows: Section 2 systematically analyzes the concept and characteristics of EDM for natural disasters and the decision content in different stages. The theory and methods of EDM for natural disasters are summarized in Section 3. Then Section 4 elaborates the construction and development of emergency decision support systems. On this basis, challenges and possible directions are depicted in Section 5. It enriches the existing literature and further provides reference for other researchers.

2. Concept and stage analysis of EDM for natural disasters

2.1. The concept of EDM for natural disasters

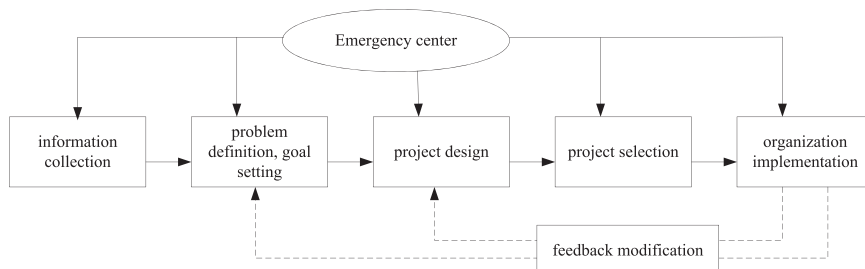
Decision-making is a process of selecting the optimal scheme among numerous alternatives to achieve the objective of organizations, and EMD process can be divided into six stages: problem definition, goal setting, project design, project selection, organization implementation and feedback modification [5], as is shown in Fig. 1. In a broad sense, EDM for natural disasters refers to all kinds of prepared measures for the effective control of hazards in the event of disasters, including forecasting, monitoring, early warning and emergency planning, collection of information for emergency transferring, dispatching and rescuing, and disaster recovery after the occurrences of natural disasters [6,7]. In a narrow sense, EDM refers to the process of the timely collection of relevant information, succinct emergency objectives, the development of feasible programs, implementation, coordination and control, and dynamic adjustment according to the specific situation [8–10].

Under the unexpected accidents with high time pressure, high information indeterminateness and insufficient conditions, EDM for natural disasters exhibits the following characteristics:

From the perspective of decision subject: Multi-sectoral participation in disaster prevention and mitigation is crucial in EDM for natural disasters. Besides, decision coordination plays an essential part in EDM, which contributes to the construction of highly centralized decision core and powerful organizational executive departments.

From the perspective of decision making environment: The decision object presents great complexity in dynamic change of environment, short reaction time, information asymmetry, inadequate protection of resources, which will lead to the urgent and high demand for EDM.

From the perspective of decision objective: Great importance should be attached to humanism – the primary objective in EDM for natural disasters for the purpose of minimizing the loss of life [11]. Then other factors come second such as avoiding or reducing property losses and environmental damage, rescue time, costs and impacts among the public.



Research on Disaster Operations Management (DOM) has also been given great attention in the past decades. Rawls and Turnquist [12] define DOM as the sequence of operations damages resulting from a disaster; and to facilitate the recovery from such an event. As it can be seen, EDM is similar to DOM in considering all the actions taken to reduce the disaster impact, from the minimization of vulnerability and mitigation of risk, to the reconstruction procedures and the implementation of programs to return to normalcy. However, EDM gives more attention to the urgency of disasters, and focused on an organization with clear subject and definite goal, it pays more attention to developing communication systems to reduce the severity of damage. While DOM applies Operation Research (OR) techniques to improve the decision making process in response to the catastrophic impact of disasters [13].

2.2. Emergency decision contents in different stages for natural disasters

In terms of making timely and effective response to natural disasters, we should first understand why natural disasters occur and how emergency decision works [14], in order to reduce disaster losses. The occurrence, development and evolution of disasters are usually divided into mitigation, preparedness, response, recovery in responding natural disasters [15]. The four stages are a closed cyclic process, which runs through the latent period, formation period, stalemate period and extinction period of unexpected disasters. According to the evolution law of natural disasters, the corresponding decision contents should be formulated at different stages of disaster evolution. In the stage of disaster mitigation, the main content of EDM is disaster prevention. Effective measures can be taken such as real-time monitoring, prepared emergency plan, hunt of hidden hazard and emergency rehearsal. The emergency decision content of the disaster preparedness stage puts much emphasis on disaster identification, release of early-warning information, risk prediction and emergency support, etc. The main content of EDM in the third stage is disaster response, including environmental analysis, the determination of emergency priorities, emergency preparedness, scheme design, implementation and feedback adjustment. In the stage of disaster recovery, close attention should be paid to the development of recovery plan, post-disaster restoration and reconstruction, assessment of emergency effect and final conclusion.

Generally speaking, EDM refers to the enhancement of the prediction and prevention capabilities before disasters, the emergency rescue capability in disasters and the handling capability after disasters by optimizing the allocation of resources and making timely and effective response. The process of EDM for natural disasters includes the following steps, as is shown in Fig. 2.

The present paper retrieves the published literature by means of searching titles or keywords of EDM and natural disaster EDM in Chinese, and EDM, emergency decision support, decision support system, disaster EDM and disaster EDM in English. The literature in Chinese is based on CNKI, while Elsevier Science, Springer LINK and SCIE are used to search for literature in English. The keyword disaster EDM was searched in any place of the documents corresponding to journal articles published in English and Chinese. Conferences proceedings, book chapters, books, working papers, and these were not

Fig. 1. General process of EDM.

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