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DETERMINING THE CRITERIA FOR RESOURCES ALLOCATION IN DISASTER RISK MANAGEMENT BASED ON MULTI CRITERIA DECISION MAKING: A REVIEW

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Abstract: The objective of this study is to determining the criteria to be considered in allocate limited resources in Disaster Risk Management (DRM) through mitigative adaptation and preparedness phase in order to save lives, reduce property losses and build disaster resilient communities based on Multi Criteria Decision Making (MCDM) that will be used to compare, select or rank multiple disaster risk reduction alternatives that involve incommensurate attributes in DRM. Making a decision in DRM implies that there are alternatives choices to be considered and in this case we want not only to identify as many of these alternatives as possible but choose the one that best fits with our goals and values taking into account the vulnerability influence and resilience of the system.

Keywords: *Disaster, Risk, Vulnerability, Resilience, Multi-criteria Decision Making*

1 Introduction

A disaster happens when a hazard impacts on the vulnerable population and causes damage, casualties and disruption. Any hazard which is a triggering event along with greater vulnerability (inadequate access to resources) would lead to disaster causing greater loss to life and property. Resources such as human resources, natural resources, technical resources, organizational resources, construction equipment, professional personnel and materials are exceedingly needed during and after disaster. DRM aims to avoid, lessen or transfer the adverse effects of hazards through activities and measures for prevention, mitigation and preparedness. MCDM can be exploited to minimize hazards adverse effects through effective precautionary measures that ensures timely, appropriate and efficient organization and delivery of response and relief action. The decision making process is made complex because DRM is of dynamic and adaptative nature, may have multi-level completeness which involve tens of thousands of decision variables, multi-level confidences from different preferences of stakeholder, and may be inconsistent. Through the hazard identification and its description, in terms of risk analysis and assessment processes, MCDM can be used to discover not only which hazards are applied on the system but also how they affect it, and be used to prioritize them by need for emergency condition.

2 The global context of Disaster Risk Management (DRM)

The United Nations International Strategy for Disaster Reduction (UN/ISDR 2004) has adopted a notion concept of DRM that can be summarised into four mutually interconnected phases, being : mitigation, preparedness, response and recovery and reconstruction planning as following described :

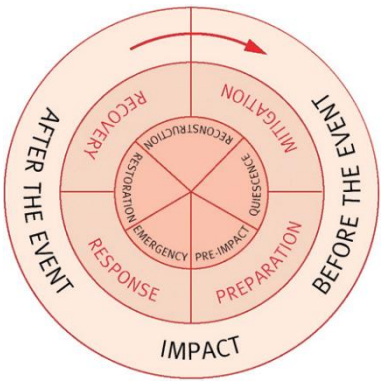

Figure 1. The Disaster Management Cycle (Alexander, 2002) [2]

DRM can be defined as the systemic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impact of hazards and the possibility of disasters. Mitigation is defined as the lessening or limitation of the adverse impacts of hazards and related disasters. Preparedness is defined as the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions. DRM includes sum total of all activities, programmes and measures which can be taken up before, during and after a disaster with the purpose to avoid a disaster, reduce its impact or recover from its losses. A disaster can be more precisely defined as a serious disruption in the functioning of the community or a society causing wide spread material, economic, social or environmental losses which exceed the ability of the affected society to cope using its own resources. A hazard may be defined as a dangerous condition or event, that threat or have the potential for causing injury to life or damage to property or the environment.

3 Resource allocation in DRM based on MCDM

Multi criteria resource allocation problems involve allocation of limited resources to different activities in DRM keeping in mind many conflicting criteria. They have been effectively solved using MCDM techniques. The goals of resource allocation in DRM based on MCDM are to know what to do in a disaster's aftermath. How to mitigate it and to define the right resource allocation to be equipped with to do it effectively ? It is a question of optimization under stochastic constraints and objectives. Disaster management challenges are complex and ill-structured multiple criteria decision processes characterized by extreme uncertainty, multi-faceted negotiations between stakeholder and high decision stakes. Moreover DRM is a multi-disciplinary field, there may be hundreds of conflicting criteria that must be considered, including tangible factors such as infrastructure facility damage and intangibles such as social vulnerability variables. While disaster risk management decisions must often be made under pressure and high uncertainty, the effects of such decision may have far reaching consequences (including loss of life, property damage and large scale evacuation).

3.1 Resilience identification

Resilience is the ability of a social system to respond and recover from disasters and includes those inherent conditions that allow the system to absorb impacts and cope with an event. Since the built environment and urban infrastructure provide the core framework for most human activity, it is crucial to develop them with an effective measure of resilience so they can withstand and adapt to the threats of natural and human induced hazards. Realising a resilient and sustainable built environment can predictable from result of interactions among three major systems: the physical environment, which includes hazardous events; the social and demographic characteristics of the communites that experience them; and the buildings, roads, bridges and other components of the constructed environment. A summary of the built environment systems at risk from natural and human induced hazards and the actions required to mitigate these hazards is provided in table 1. This built environment system at risk can take into account as influence factors for determine criteria as well as alternatives on resource allocation in DRM problems.

Table 1. Summary of the built environment systems at risk from a range of hazards, their associated impacts and the actions required [7]

Built environment systems at risk:	Need to reduce impact of:	Actions required:
Residential buildings	Flood risk to structures	Review land use planning policy
Municipal buildings	Terrorist risk to structures	Consider design changes
Commercial / industrial buildings	Poor conditions in internal environment	Integrate construction professions with emergency planning
Transport infrastructure	Subsidence and heave	Broach sustainability and the contradiction between low cost and quality housing
Utilities infrastructure	Slope instability	Research alternative options regarding resilient materials and practices
Healthcare infrastructure	Damage to the structure and fabric of buildings / infrastructure	Integrate emergency planning with urban planning
Sustainable working practices	Over burdened urban drainage systems	Retrofit at risk buildings and infrastructure
Insurance availability	Inappropriate planning consent	Learn from and adopt best practice
Heritage buildings / infrastructure	Poor practice and lack of integrated approach	Embrace the sustainability agenda

3.2 Vulnerability assessment

Vulnerability has been defined by the International Strategy for Disaster Reduction of the United Nations (UN/ISDR 2004: Annex 1:7) as the conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. Vulnerability may be also defined as the extent to which a community, structure, services or geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardous terrains or a disaster prone area. A disaster is a result from the combination of hazard, vulnerability and insufficient capacity or measures to reduce the potential chances of risk. The vulnerability is calculated on the basis of a multicriteria decision-aiding approach. On a given spot of the environment, the vulnerability is thus charcterised by the number of potential targets and their relative vulnerability to different phenomena. Mitchell (2004) conceptualizes hazards as a multiplicative function of risk, exposure, vulnerability and response;

Hazard = f (risk x exposure x vulnerability x response) (1)

where risk is the probability of an adverse effect, exposure is the size and characteristics of the at risk population, vulnerability is the potential for loss and response is the extent to which mitigation measures are in place. Olivier Salvi (2006) defines;

Vulnerability = Hazard x Risk x Deficiencies in Preparedness (2)

The global vulnerability (V_{global}) is a linear combination of each target vulnerability [5];

$$V_{global} = \alpha V_H + \beta V_E + \gamma V_S \quad (3)$$

Then each type of vulnerability is a linear combination of the vulnerability to each type of effect;

$$V_H = \alpha_1 V_H^{dth} + \alpha_2 V_H^{inj} + \alpha_3 V_H^{tox} + \alpha_4 V_H^{poll} \quad (4)$$

For each effect, the vulnerability is a linear combination of vulnerabilities on different types of impact (health, economical, psychological impact)

$$V_H^{dth} = x_1^H V_H^{dth,hth} + y_1^H V_H^{dth,eco} + z_1^H V_H^{dth,psy} \quad (5)$$

For each type of impact, the vulnerability is also a linear combination of the numbers of different types of target components. For example, the human target is composed of staff onsite (H_1), local population (H_2), population in an establishment receiving public (H_3),users of transportation ways (H_4)

$$V_H^{dth,hth} = a_1^{H\,dth,hth} H_1 + b_1^{H\,dth,hth} H_2 + c_1^{H\,dth,hth} H_3 + d_1^{H\,dth,hth} H_4 \quad (6)$$

The quantification factors H_i are normalized to fit into a 0 to 1 scale.

3.3 Determine criteria and alternative

In this study we propose for considering criteria in three main categories that have physical influence, social and economic against vulnerability of the site [4, 5, 6, 9, 10, 11, 12].

Tabel 2. Proposed selection criteria for resource allocation in DRM

Criteria	Subcriteria	Description
Capacity	Structure Environment	characteristic of the building, age, strength, materials used
Impact/Damage	Human Psychological	injury, death, traumatic, physically disabled
Resilience	Organization Infrastructure	social capital, income, ownership, insurance
Proximity	River Open space	distance from prone area
Population	Gender	adult, children
Education	Culture	unwillingness to changes
Poverty	Awareness	non-existen regarding prevention, poor maintenance

4 Conclusion

This study finding several main criteria that expected more realistic to be considered in allocate limited resources in DRM over phases mitigative adaptation and preparedness planning based on MCDM approach taking into account the vulnerability and resilience influence. The next step of the research is to determine characteristic of the criteria and alternative to be analyzed using the selected MCDM method.

References

[1] Bosher L.S., Dainty A.R.J., Carillo P.M., Glass J., and Price A.D.F., *Decision support for integrating disaster risk management strategies into construction practice In:* Dainty, A. (Ed) Procs. 25th Annual ARCOM Conference, 7-9 September 2009, Nottingham, UK. (2009).

[2] Damon P. Coppola, *Introduction to international disaster management*. Handbook, (2007).

[3] Han Günter Brauch, Ursula Oswald Spring, Czeslaw Mesjasz, John Grin, Patricia Kamen-Mbote, Béchir Chourou, Pál Duna., *Coping with global environmental change disasters and security: threat, challenges, vulnerabilities and risk.* Handbook p.1148, p.1153, Springer (2011).

[4] Huan Liu,Ximin Cui, Debao Yuan,Zhihui Wang ,Jingjing Jin, Mengru Wang, *Study of earthquake disaster population risk based on GIS a case study of wenchuan earthquake region.* Journal of Procedia Environmental Sciences Vol.11:1084–1091 (2011).

[5] J. Nouri, N. Mansouri, M. Abbaspour, A.R. Karbassi, M. Omidvary, *Designing a developed model for assessing the disaster induced vulnerability value in educational centers*. Journal of Safety Science 49:679-685 (2011).

[6] Jayanath Ananda, Gamini Herath, *A critical review of multi criteria decision making methods with special reference to forest management and planning*. Journal of Ecological Economics 68:2535-2548 (2009).

[7] Lee Bosher, Patricia Carillo, Andrew Dainty, Jacqueline Glass and Andrew Price, *Realising a resilient and sustainable built environment: towards a startegic agenda for the United Kingdom*. Disasters Journal compilation 31(3): 236-255 (2007).

[8] Mileti, D.M. (1999), *Disasters by design: A reassessment of natural hazards in the United States*. Joseph Henry Press, Washington DC.

[9] Olivier Salvi, Bruno Debray, *A global view on ARAMIS, a risk assessment methodology for industries in the framework of the SEVESO II directive*. Journal of Hazardous Materials 130:187-199 (2006).

[10] Roberto Miniati, Christian Iasio, *Methodology for rapid seismic risk assessment of health structures: case study of the hospital system in Florence, Italy.* International Journal of Disaster Risk reduction (2012).

[11] Syed Ainuddin, Jayant Kumar Routray, *Community resilience framework for an earthquake prone area in Baluchistan.* International Journal of Disaster Risk Reduction (2012).

[12] Talon Aurélie, Bacconnet Claude, Fabre Denis, Cespedes Xavier, Thouret Jean-Claude, *Evaluation de la vulnérabilité des constructions de la ville d'Arequipa (Pérou) face aux impacts de lahar*. XXXe Rencontres AUGC-IBPSA, Chambery Savoie France, 6-8 Juin 2012.

[13] UN/ISDR, *Living with Risk: A global review of disaster reduction initiatives*. United Nations International Strategy for Disaster Reduction, Geneva (2004).