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Housing recovery in the aftermath of a catastrophe: *Material resources perspective*

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ABSTRACT

Background/purpose: The occurrence of catastrophic events proves disastrous as they cause significant physical damages, both at the human and material levels. Depending on the magnitude of the event, a natural phenomenon can potentially lead to loss of life, home destruction and alter the economic and social structures of the affected community. The purpose of this study is to gain a deeper insight into the housing recovery process following a catastrophic event from the material resources perspective.
Method: A System Dynamics (SD) model is developed in this paper to study the problem at the reconstruction/repair material supply level in an affected area. The model describes the behavior of material resources in the housing reconstruction and recovery planning a catastrophic event.
Results: It enables deeper understanding of the implications of the occurrence of a disaster on the housing material fluctuations. This model considers, due to the resources shortage created, the amount of material adjustments to make in the aftermath of a highly disruptive event. Theoretical results show satisfaction as the model displays expected results, reflecting the importance of timing in decision making for supplies, in the housing recovery progress.
Contribution: The proposed model brings more insight into the types of the housing recovery and the material demands over time. It provides a means to anticipate the demand requirements and alleviate the population's suffering, considering the uncertainties associated with disaster.

1. Introduction

Natural disasters constitute a major cause of significant death toll and grief when they hit a populated region. Besides the loss of human lives, the destruction or deterioration of belongings and properties is devastating. This brings about the critical need to lay out a preparedness plan in order to limit casualties and damages as much as possible. This planning eases the process of recovery in the aftermath of the disaster and eases the change in situations the population experience before and after a disaster.

After the disaster, actions are taken to recover and help the affected population. Given the uncertain nature and different degrees of a hurricane (Bell, Montgomery, & Lee, 2012), the needs in supplies likely differs from one area to another and the variation in magnitude of the disaster calls for a prioritization of certain locations over others. Some populations may be affected in a higher degree than others. The resilience of the zone is tested as the capacity to rebuild/repair is affected and the massive displacement experienced by the victims requires solutions. The construction materials represent the resources much needed to meet the demands from the population. The supply of these resources is critical to the success of the reconstruction through efforts made by the local and governmental authorities. The exceptional nature of the situation renders the predictions quite complex since many decisions have to be made on the effective usage of materials in order to minimize any type of delay in activities. As the construction activities progress in time, a clear idea of the material inventory is necessary. The variation of the quantity of material resources and their availability in stock determine the housing production rate. Modeling provides a clear direction to decision makers and construction workers on the improvement in resources management, identifying bottlenecks and risky actions to avoid. The stakeholders and construction labor can thus understand the critical factors which impact the resources, quantities and availability over time in a post-disaster situation. The modeling contributes to the enhancement of management skills, necessary in disaster recovery projects. The simulation model suggested in

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this paper presents these projects, from the material resources standpoint. It addresses the resourcing challenges and lays out the appropriateness of responses to overcome those issues. The success of the recovery projects implies stakeholder collaboration and policies allowing market flexibility for an effective supply chain of materials (Barroso, Machado, & Machado, 2011). The use of System Dynamics (SD) modeling in this paper demonstrates the desire to provide an accurate picture of the housing reconstruction process. The structure evoked is the stock management structure suggested by Sterman (2000), exploring the behavior of the material for construction and its implications on the reconstruction process. This structure establishes the relationship between the production capacity (production and inventory of the material) and the decision rule used by decision makers to control the flow of material.

The paper is organized as follows. First, a brief review of the literature is presented. This section is followed by an outline of the research approach used in this study. Next, a detailed description of the model and the interpretation of the simulation results are offered. The last portion is the managerial implications, and conclusion with options for eventual future work.

2. Literature review

In the aftermath of a natural disaster, actions are taken to recover, with the objective of helping the populations in despair and reestablishing the services damaged during the event. The housing reconstruction can only begin effectively if the stock of material is sufficient and their inventory remains at an appropriate level. Authorities and decision makers ought to be aware of supply chain rules in order to avoid lengthy recovery process and discomfort of the victims. Research has been performed in this domain, described in the rest of this section, to emphasize the need for efficient inventory material planning and emergency management projects.

Green, Bates, and Smyth (2007) analyze the reconstruction phases in New Orleans one year after Katrina and point out the challenges encountered at the human and also at the material supply levels. In another disaster, Singh and Wilkinson (2008) explore the problem of availability of resources in the aftermath of the Wellington Earthquake, during the reconstruction phase. The authors propose the resource estimation method in order to determine the resources and quantities required. The results show the presence of constraints due to limitations on construction material and suggest alternative arrangements to overcome the shortage. Fu and Chen (2009) address the issue of emergency material demand, proposing the method of forecast. They use the normalization of the Euclidean algorithm to predict the material demand after the disaster and prevent resource shortage during the recovery period.

In another study, Zixue and Meiran (2010) examine the role of demand forecasting in the aftermath of a disaster. They propose a method based on Fuzzy Markov Chain aiming at predicting the emergency materials requirement and their availability. On the other hand, Yang (2010) insists on the need to initiate sufficient preparedness planning in material supply in order to mitigate the effects of a disaster. The researcher inspects the capability of a region in resources support, through the G-1 method. This technique assigns various weights to evaluating indicators, according to their importance in the supply chain. Using an improved and adapted Grey GM(1,1) model, Song, Liu, and Chang (2010) seek to model material distribution demand for the purpose of assuring material availability in disaster areas. The method assists decision makers in resource distribution, considering the demands. In a study proposed by Banomyong and Sopadang (2010), a Monte Carlo simulation model to help emergency logistics decision makers in refining their preparedness planning process. It is believed, emergency logistics decision makers can make better informed decisions based on simulation model output and can further refine their decision-making capability. In another study, Nolz, Doerner, and Hartl (2010) present a decision support system using an efficient multi-objective metaheuristic algorithm for planning water distribution tours in disaster relief. Especially in situations after a disaster occurrence, characterized by instability and the immediate need of help, high-quality decisions have to be made fast. Moreover, Said and El-Rayes (2010) investigate the elaboration of a planning model which finds optimal decisions of material supply. The objective is to minimize ordering and carrying delay, especially when shortage occurs. The researchers integrate innovative methodologies, looking to measure the impact of these decisions in the course of construction projects. Whereas, Da Silva (2010) highlight the necessity of material availability and supply in the reconstruction process. To overcome the question of shortage, the authors present a three phased program (planning, design and construction) which constitutes the recovery process. The research supports the need for an estimation of current resources as to assess limitations, identify alternative sources and minimize delays during material transfer. Further, Chang, Wilkinson, Brunsdon, Seville, and Potangaroa (2011) underline the concern posed by the lack of resources during post-disaster housing reconstruction and the consequences on the success of the recovery. An integrated planning framework is designed, allowing a more appropriate management of resources and enhancing the capacity for reconstruction. In another study, they provide a guideline to construction professionals and stakeholders and provide them with a deeper understanding of the factors impacting the supply of material resources. Chang, Wilkinson, Potangaroa, Seville (2012a, 2012b); Chang, Wilkinson, Brunsdon, Seville, and Potangaroa (2012c) perform a comparative analysis using a triangulation method. This technique leads to the identification of these factors and contributes to a project management methodology to enhance the ability to manage disaster recovery projects in a more effective manner. Also, Chang (2012) points to the challenges encountered in the housing reconstruction following a major disaster, from the resources and capacity standpoint. The study examines the inventory of material resources, through an analytical model looking at the reconstruction environment, the housing reconstruction approach, the resources and their availability as well as the critical factors impacting this availability. Chang et al. (2012a, 2012b, 2012c) also seek to provide answers to the questions regarding the availability of resources. The authors make a comparative case study between Indonesia, China and Australia during their recovery phases and examine their resource availability and management policies in the construction projects. The research provides a deeper understanding of material resourcing and explores the practical and social implications of resourcing issues. In another study, the same authors examine the shortage of material resources as well as the increase of costs attached. Chang et al. (2012a, 2012b, 2012c) propose a longitudinal study exploring the relationship between material requirements and construction advancement, caused by the escalation of material costs. The research suggests that strong post-disaster reconstruction planning and good monitoring of material demands are key in controlling the resources fluctuation costs and their effects on the recovery process. Liu, Hu, and Li (2012) explore the shape of the demand predictions on material resources in the aftermath of a catastrophe. The authors indicate the case-based reasoning (CBR) method and present the characteristics of resource demand prediction in an emergency situation. The model provides an effective resource allocation over a given recovery time period. In another study, Kun-Peng, Yu, and Li (2013) attack the issue of the shortage in construction material and waste in emergency management. The method used is the Index Screening based on Rough Set Theory