Proceedings of the 2015 Winter Simulation Conference
L. Yilmaz, W. K. V. Chan, I. Moon, T. M. K. Roeder, C. Macal, and M. D. Rossetti, eds.

AN AGENT-BASED MODELING APPROACH TO IMPROVE COORDINATION BETWEEN HUMANITARIAN RELIEF PROVIDERS

Megan Menth and Jessica L. Heier Stamm

Kansas State University
Manhattan, KS 66506 USA

ABSTRACT

Logistical coordination between humanitarian organizations is crucial during the response effort to a disaster, as coordinating aid improves efficiency, reduces duplication of effort, and ultimately leads to better outcomes for beneficiaries. One challenge in particular is making facility location decisions, where makeshift homes, medical tents, or other aid-related facilities need to be placed in a way that provides fair service to all in need. This research aims to improve upon the current practices of facility placement coordination by drawing on data from the 2015 earthquake in Nepal. We develop an agent-based simulation model with data from this event, and extend our findings to provide new insights about humanitarian decision making and coordination in regard to the facility location problem.

1 INTRODUCTION

In the humanitarian field, the response effort following any natural or man-made disaster is highly complex given the large number of actors involved along with high uncertainty in regard to supply, demand, and potentially infrastructure. There could also exist social, technological, organizational or many other barriers that hinder coordination among relief providers. Several studies have shown that increasing coordination among relief actors can mitigate the uncertainty that comes with a disaster and ultimately lead to a better response effort (Balcik et al. 2010, Muggy and Heier Stamm 2015). Overcoming coordination barriers has also been emphasized in the literature and could lead to better outcomes for disaster victims (Kabra et al. 2015). Increasing collaborative efforts in the humanitarian field is the central motivation behind this study.

2 RESEARCH OBJECTIVES

The objective of this research is to increase understanding of effective coordination mechanisms for the facility location problem (FLP), particularly in post-disaster situations where temporary child protection facilities need to be established. This area of research is relatively new in the humanitarian field, as the FLP usually involves creating a long-term solution such as where to pre-position inventory before a disaster strikes. Facility location effectiveness is often measured using some type of efficiency metric. In this case, the most efficient implementation could be the placement of facilities that provides service to the greatest number of people in need given limited initial resources.

Another important measure of effectiveness in the humanitarian context is that of equity or fairness among beneficiaries. Given that post-disaster problems are time sensitive, aid providers need to quickly consider facility locations that will not only be efficient, but equitable as well. Both efficiency and equity can suffer in environments where the facility location decisions of many organizations are not well-coordinated. Therefore this research also aims to contribute to the already well-established discussion of efficient vs. equitable methods, although by means of simulation modeling rather than traditional mathematical optimization methodology.

978-1-4673-9743-8/15/$31.00 ©2015 IEEE

3 METHODS

Humanitarian relief is a complex area of study and therefore requires complex modeling methods, such as agent-based modeling (ABM) or simulation. As a relatively new modeling tool to the humanitarian field, there are many facets where ABM can be applied, including coordination in regard to facility location. In this context, ABM is more practical than traditional modeling choices such as optimization, as it can directly account for the often imperfect nature of autonomous decision makers. By modeling agents that have their own individual behavior and strategies, the emergent behavior can be observed on a global scale. Just as ABM is used in the public health realm to inform decision making, results could potentially be used to influence future coordination decisions or policies in the humanitarian sector (Smith, 2012).

We propose a model in which the agents are the organizations that are involved in the response effort. The agents decide with which organization they will coordinate, as well as where and when to operate a facility. To create an accurate and reliable model, agents' decision rules will be informed through an extensive literature review as well as through interview findings from experienced humanitarian logisticians. The model itself will include geospatial maps from a case study both before a disaster strikes and during the response and recovery phases. Input data used will include lists of organizations involved, the role they play in aid relief, and where they are located.

4 CASE STUDY

We apply our ABM approach to a case study from the Nepal earthquake response. On April 25, 2015, a deadly earthquake hit a rural region of Nepal leaving 14 districts affected overall, and nearly 9,000 dead. Given the location and damaged or initial lack of infrastructure, the response effort became a logistical nightmare as over 400 humanitarian organizations flooded into Kathmandu, the capital of Nepal, which houses the country's sole international airport (Page, 2015). Given these conditions, there are several situations for which the facility location problem must be solved, including temporary housing camps, safe spaces for children, and makeshift medical treatment facilities.

Much can be learned from this case study by employing agent-based simulation. With ABM different coordination mechanisms can be compared, including what actually happened during the response in Nepal and other possible actions that could have been taken. This study will help identify opportunities missed due to lack of coordination and inform improved strategies for future relief efforts.

5 CONCLUSIONS AND ONGOING RESEARCH

Coordination in the humanitarian field is essential to the health and quality of life of those that are affected by a disaster. Those that lost their homes or needed emergency medical care following the 2015 Nepali earthquake specifically relied on (or continue to rely on) temporary housing or clinics, both of which are products of the facility location problem. The agent-based models we develop in this case study are expected to produce generalizable insights to improve coordination in facility placement for future disasters.

REFERENCES

Balcik, B., et al. "Coordination in Humanitarian Relief Chains: Practices, Challenges and Opportunities." International Journal of Production Economics 126.1 (2010): 22-34. Web.

Kabra, Gaurav, et al. "Identification and Prioritization of Coordination Barriers in Humanitarian Supply Chain Management." International Journal of Disaster Risk Reduction 13 (2015): 128-38. Web.

Muggy, L. and J. L. Heier Stamm. "Dynamic, robust location models to quantify the impact of decentralization on service accessibility." In preparation. (2015).

Page, Paul. "Nepal Eathquake Response Challenges Logistics Experts." The Wall Street Journal. 29 April 2015. Web. 23 August 2015.

Smith, Dianna M., "Simulating spatial health inequalities." In Heppenstall, Alison J. et al. Agent-Based Models of Geographical Systems (2012) 499-510.