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Humanitarian Logistics: Combining Multidimensional Risk Evaluation With Agent Based Simulation Modeling On Flood Preparedness And Response

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Due to the increasingly frequent occurrence of natural disasters worldwide, there is great interest in addressing humanitarian logistics due to the need for emergency services in the event of a disaster. Controlling operational and disruption uncertainties in emergency management is one of the most challenging topics of recent times. Therefore, there is an urgent need for local institutions to develop socio-economic transformation improvements through public policies (Paul et al., 2022). Therefore, this paper proposes a combination of an MCDM model for allocating temporary shelter sites with agent-based models (ABMs) to plan logistical improvements and new investments in mitigation and adaptation (Kim et al., 2022). Based on the concept of humanitarian logistics, emergency resource distribution centers, and hospital care rescue are two essential services during extreme events. Many studies do not explicitly consider the effects of mitigation infrastructure (i.e., emergency response resources), such as response facilities, relief supplies, and workforce, which are essential for the response (Kim & Heo, 2023). In this way, the results of this study allow decision-makers and policymakers to have more information on how to deal with a flood and thus be able to design more effective contingency plans to deal with the uncertainties generated by flood events throughout the supply chain, along with the availability of services.

Initially, this article proposes a multidimensional risk-based model to evaluate the location of urban flood risk shelters using Decision Analysis and Multi-Attribute Utility Theory (De Almeida et al., 2015). The MCDM model was built from the establishment of criterion, seeking to incorporate performance parameters of the mass queuing system of individuals (M/M/1) following roads not affected by flooding to the shelters - viability of the route, shelter capacity, and number of evacuees. In addition, the financial (economic) factor is recommended to address financial preparedness for emergency preparedness. Also, we provide a summary of the utility function formats for each criterion, thereby applying Keeney and Raiffa's protocol under DM's preference structure (De Almeida et al., 2015)

It is worth noting that the independence between the consequences is an essential point, as compensatory methods, such as MAUT, aggregate the performance between the risk dimensions into a single risk measure and need to determine the joint probabilities of the dimensions under study (Da Silva, Alencar and De Almeida, 2022).

The ranking of shelters is expressed based on the behavior and preferences of the DM, thus indicating, from the lowest to the highest risk value, the best places to implement emergency protocols due to flooding. Figure 1 shows the temporary shelters assessed according to risk, distributed on the georeferenced map.

For the humanitarian logistics operations, 12 hours of emergency assistance were simulated, assuming the occurrence of geo-hydrological disasters (landslides and floods) resulting from heavy rainfall. The parameters were configured with an initial number of 1 vehicle at each civil defense headquarters and two vehicles at each hospital, with an average interval of 20 minutes for non-urgent requests and an average interval of 40 minutes for urgent requests. The most requested type of assistance was medical assistance with 62% of requests and other

types of resources with 38%, as shown in the Figure 2 (b). Additionally, Figure 2 (a) shows the number of requests for emergency aid in each shelter (alternatives) and compares the type of aid in each. Some shelters had a higher number of medical requests, such as alternatives A1 and A8, and on the other hand, shelters such as A2, A3, A6, and A10 had a higher number of requests for other resources.

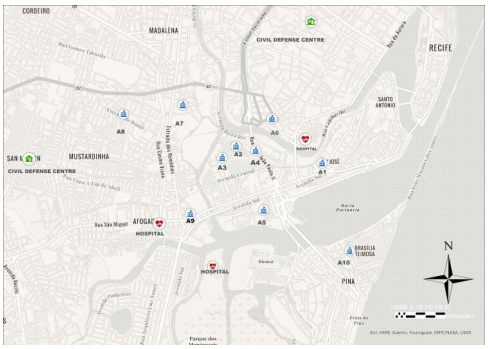

Fig. 1. Georeferenced map of logistics operations simulation.

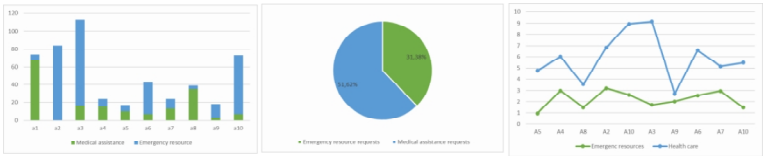

Fig. 2. Simulation Results.

In addition, in Figure 2 (c), it is possible to analyze the distribution by the shelter of the time spent on each emergency operation during the simulation, with the level of hospital service being higher than most emergency resources, such as basic supplies. This could be based on the hypothesis of a high level of people affected during the evacuation process, low efficiency in communicating the evacuation alert, or residents needing to learn how to act during the disaster. Therefore, the importance of simulations of extreme events can be seen in helping public managers to analyze the complexity of the behavior of the agents in the scenario and, consequently, to support the construction of risk-mitigating public policies, as well as to prepare in terms of measures, in response to disasters.

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