Integrated Humanitarian Logistics System for Developing Countries

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Abstract

The purpose of this research is to develop an integrated humanitarian logistics system for post-disaster relief response in developing countries, which includes a measure of the suffering of affected people into the formulations of humanitarian logistics. This will allow a better distribution of social costs among those affected, and the timely delivery of critical commodities according to deprivation time, starting with the neediest people. In consequence, this framework leads to more effective and coordinated strategies for delivering critical supplies in developing countries.

Objectives

- To develop humanitarian logistic models capable of explicitly considering the impacts of delivery actions on deprivation costs in developing countries.
- To propose an emergency management system for disaster relief agencies in order to improve their response.

Hypothesis

The suffering of affected people due to disasters

Our hypothesis is that the costs associated to human suffering, due to the occurrence of a disaster, can be assessed based on the time of supply shortages experienced by affected people and their socioeconomic characteristics.

The structure and nature of such suffering should be considered as a function of wellness, which is monotonically increasing, non-linear and convex (Holguín-Veras et al., 2013) with respect to deprivation time, as shown in Figure 1.

The assignment of humanitarian aid

We believe that incorporating deprivation costs into the objective function of humanitarian logistic models allows to reach the optimal assignment and the timely delivery of scarce resources, during the aftermath of a disaster.

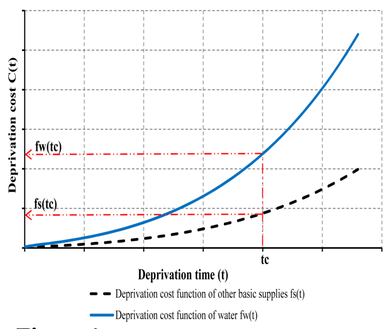


Figure 1. Deprivation cost functions representation

Figure 2. Affected due to Haiti earthquake 2010

Methods and Instruments

Microeconomic approach

The welfare of an affected individual for a natural disaster can be treated through the random utility theory, using stated preference surveys. (Ortúzar and Willumsen, 2011).

$$U_{nj} = V_{nj} + \varepsilon_{nj} \qquad V_{nj} = \sum_{k=1}^{K} \beta_{jk} . x_{njk} + \beta_{jt} . f_{jt}(t_{nj})$$

The benefits for timely supply are obtained as a measure of welfare change arising from the change in consumer surplus (Train, 2009).

$$\Delta E(EC_n) = \frac{1}{\alpha_n}\left[ln\left(\sum_{j=1}^{J^1} e^{V_{nj}^1}\right) - ln\left(\sum_{j=1}^{J^0} e^{V_{nj}^0}\right)\right]$$

Experimental design

The design consisted on choice situations that were presented to respondents, describing hypothetical scenarios of being a disaster survivor where they had to decide whether or not to buy a kit of life-sustaining items (water and foods). The variables used in this experimental design were: Shortage time (no delivery), expected delivery time, budget, purchase amount and total cost of the purchase.

The samples

Two surveys were applied in several cities of Colombia where socioeconomic information was gathered from households affected by natural disasters, and from others who were not.

Figure 2. shows the towns (in red) were the first surveys were conducted and the level of impact of floods in the Colombian Caribbean Region in 2010 and 2011. This sample was formed by 240 respondents.

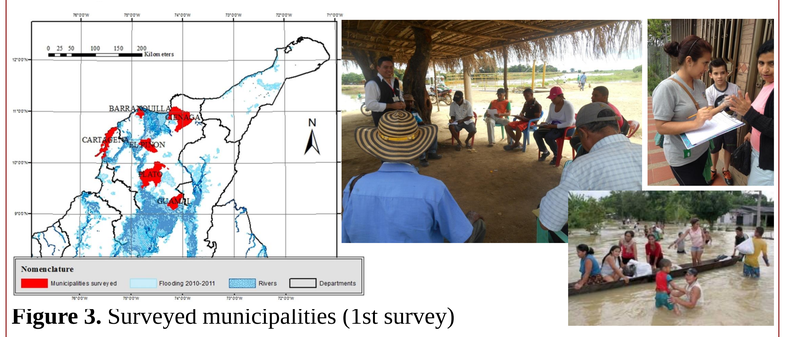


Figure 3. Surveyed municipalities (1st survey)

The second survey was applied to 560 people from different cities and towns affected by disasters in Colombia.

Results

The assessment of the economic benefits and deprivation cost function for the estimated models are presented below.

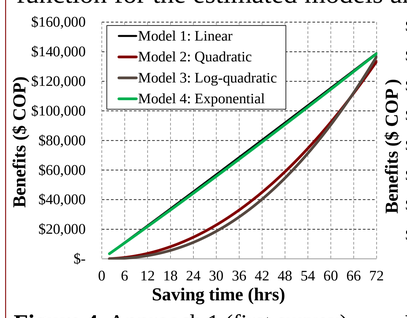


Figure 4. Approach 1 (first survey)

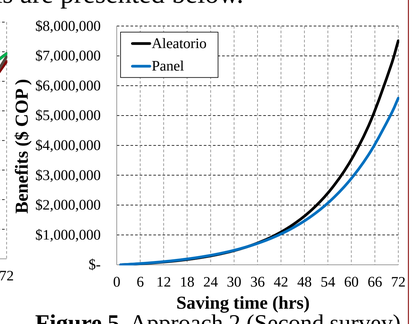
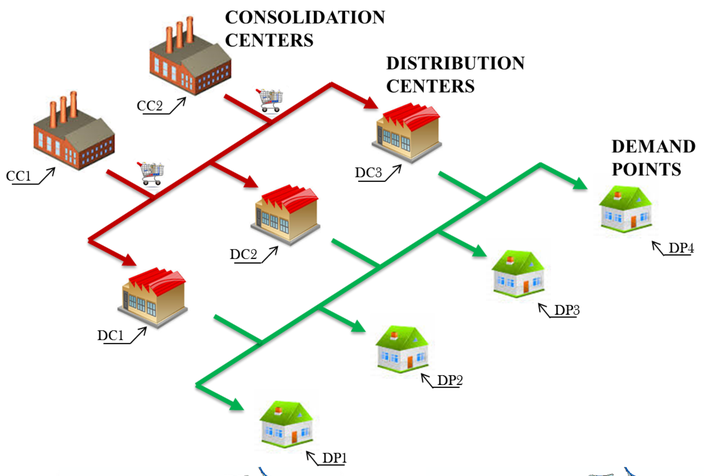


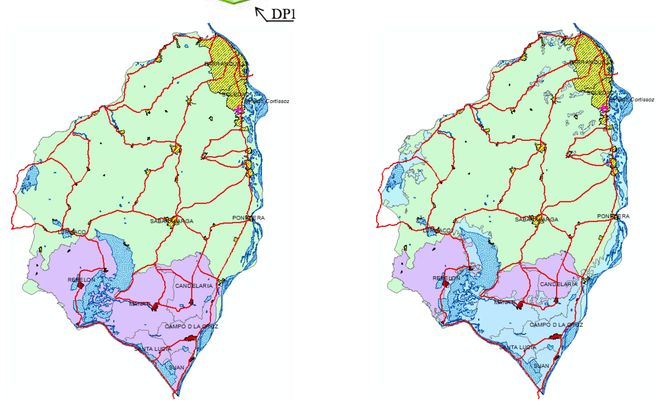
Figure 5. Approach 2 (Second survey)

Incorporate DC into humanitarian logistics models

We have treated the facility location problem for pre-positioning supplies, allowing to serve the areas affected by disasters. The formulation proposed considers deprivation costs in the objective function.

$$\text{Min} \sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{j=1}^{J} C_{jk}^{m} \cdot w_{km} \cdot P_{jk}^{m} + \sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{j=1}^{J}\sum_{i=1}^{I} C_{ijk}^{m} \cdot w_{km} \cdot P_{ijk}^{m} + \sum_{j=1}^{J} f_j . Y_j$$
$$+ \sum_{m=1}^{M}\sum_{j=1}^{J} s_m . A_j^m + \sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{j=1}^{J} \gamma^m(t_{jk}, Q_k) \cdot P_{jk}^{m} + \sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{j=1}^{J}\sum_{i=1}^{I} \gamma^m(t_{ijk}, Q_k) \cdot P_{ijk}^{m}$$





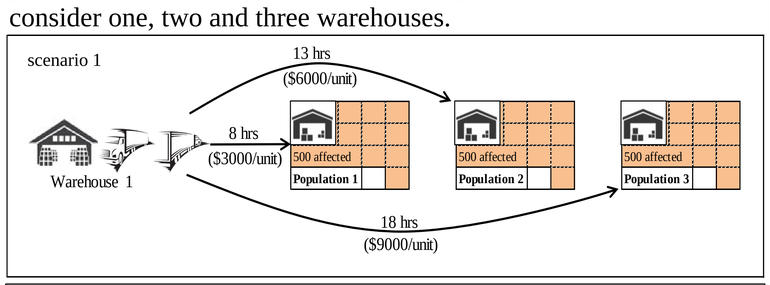
Before floods — After floods

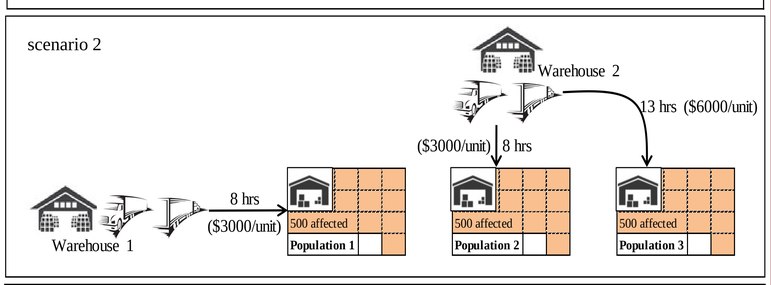
Figure 6. Floods in the Atlantic department, Colombia, 2010-2011

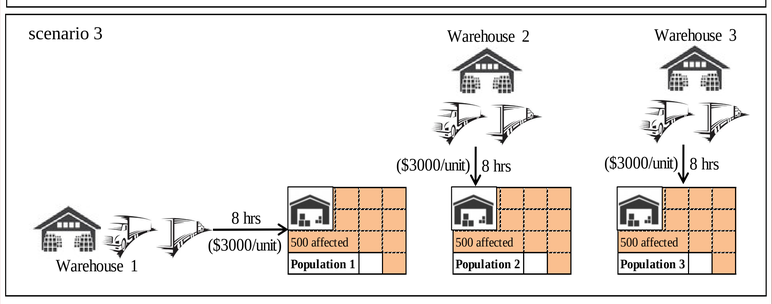
Case Study - Numerical example

The example considers three scenarios for distributing water in three towns affected by a disaster. The population of each town is 500 inhabitants.

Scenarios differ in the number of warehouses for water prepositioning to attend the impacted populations. The scenarios consider one, two and three warehouses.



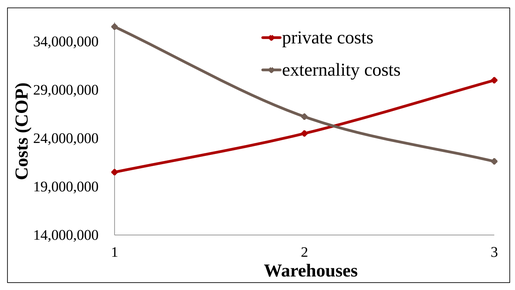


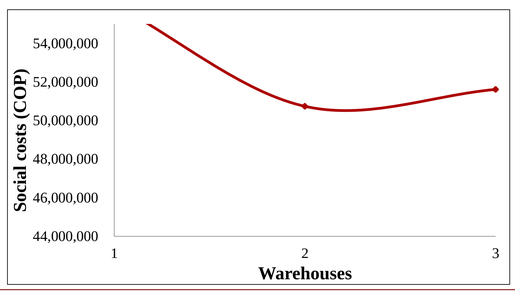


The purpose was to supply water (4 liters per capita) to people affected.

In all scenarios, the fixed cost is COP 7,000,000 for each warehouse and the inventory costs are COP 3,000 for each unit of product (4 liters).

Under humanitarian logistics perspective, social costs must be taken into account. Only under such circumstances, supplies could be fairly distributed.





Conclusions

- This research provides basis for efficient delivery strategies, ensuring the best allocation of critical commodities to affected populations.
- We estimated different econometric models of deprivation costs, that can be useful to assess humanitarian relief operations and to develop comprehensive models of humanitarian logistics.
- Progress has been made in developing a strategic logistic model, especially for pre-positioning supplies to serve the areas affected by disasters.

Future research impacts

The development of this research will minimize the negative impacts of natural disasters in terms of human suffering, especially in developing countries. The preliminary results can be briefly summarized in the fact that the estimated costs can be incorporated into comprehensive models of humanitarian logistics, both at the strategic level (facility location for prepositioning supplies) and the tactical or operational level (assistance to the affected), and they serve as support to making-decision process related for an efficient response. Results can be used for the economic and social assessment of humanitarian aid operations.

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Acknowledgements

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