# Multicriteria Models for a Humanitarian Logistics Problem: An Integral Approach







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INTEGRAL APPROACH, METHODOLOGY AND RESULTS



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# PROJECT SUMMARY

### **MAIN OBJECTIVE**

To propose an integral approach to the problem of determining shelter and distribution center location, prepositioning humanitarian aid, evacuation plans of the population and distribution of the aid to shelters in case of floods through a multicriteria optimization model in the preparedness phase and a metaheuristic in the response phase.

### **MAIN QUESTIONS**

- How to coordinate different humanitarian operations in an integral approach during the preparedness and the response phases of a disaster?
- Which methodologies are useful to plan and to respond during disasters (especially during floods)?

# **Major Activities and Findings include:**

- A multicriteria model and metaheuristic that integrates the main humanitarian operations is proposed
- The solutions found by the model/heuristic are based on scenarios obtained by the use of GIS
- Efficient sets are built combining exact methods or using SSPMO heuristic (Molina et al, 2007)
- The models are validated considering the worst flood scenario occurred in Mexico and a set of scenarios is built from three key factors in humanitarian logistics

# Recovery Research tested in Mexico: Response Response

EM-DAT. The OFDAICRED International Disaster Database - www.emost.be - Université Catholique de Louisin, Brussels - Bergluin

### The integral approach **Transportation Assignments to** and cost To define the To generate shelters To fix a zero level layers and to candidate policies and to generate stock by project maps facilities and the flood maps in connectivity → different heights Floyd-Warshall reference system Evacuation **Distribution Demand of items from** Scarce vehicles **EVACUATION** SUPPLY Methodology Define area to study Gathering input Information (Geographical information and Parameters) GIS process Multicriteria optimization model /metaheuristic algorithm Output analysis: Case of study, instances and discussion Case of study: Villahermosa, (2007) One of the worst floods in Mexico GAMS-CPLEX™ **Exact** model Phase: **Planning** Koski, (1985) Criteria Min Maximum evacuation flow-time Analysis of key factors $\min z_1 = \max \left\{ (1 + \alpha_{Esc}) \cdot \left( \sum_{k} \sum_{n} \sum_{m} dison1_{kn} \cdot ship1_{knm} + \sum_{n} \sum_{i} \sum_{m} dison2_{nj} \cdot ship2_{njm} \right) \right\}$ Spatial distribution of facilities (Apte, Evacuation equity $\min z_2 = \max \left\{ (1 + \alpha_{Esc}) \cdot \left( \sum_i \sum_j disa_{ij} \cdot \sum_m shipSum_{ijm} + \sum_i \sum_j disa_{ij} \cdot \sum_m uh_{ijm} \right) \right\}$ Metaheuristic Campbell et al, (2008) $\min z_3 = \sum_i fc_i \bullet w_i + \sum_i faAlb_j \bullet Alb_j + \sum_i faPar_n \bullet yPar_n$ Number of facilities (Van Wassenhove, Phase: Distribution + $\sum_{k}\sum_{m}\sum_{m}(ce1_{knm}+cc_{m} \cdot dison1_{kn}) \cdot ship1_{knm}$ equity Response Campbell et + $\sum_{n} \sum_{i} \sum_{m} (ce2_{njm} + cc_m \cdot dison2_{nj}) \cdot ship2_{njm}$ al, (2008) $\sum_{i}\sum_{j}\sum_{i}(ct_{ijm}+cc_{m} \cdot disa_{ij}) \cdot shipSum_{ij}$ Cost variations (Van Wassenhove, 2006) MOAMP = TS + P sampl $+\sum_{l}\sum_{j}\sum_{m}(cth_{ijm}+cc_{m} \cdot disa_{ij}) \cdot uh_{ijm} + \sum_{l}\sum_{l}ca_{l} \cdot Q_{il}$ (Caballero et al, 2004) Results Example of trip assignments **Efficient frontier Max Evacuation Flow-Time VS Total Cost** z1 = Maximum Evacuation flow-time (Weighting method + ε-constraint) vs SSPMO

z2 = Maxim um Distribution flow-tim e

z3 = Total cost

\$11.280,00

\$11.275,00

\$11.270,00

\$11.260,00

\$11.255,00

\$11.250,00

\$11.245,00

\$11.240,00

(63491,\$112.706M)

Maximum Evacuation Flow-Time (Flow-min)

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### HIGHLIGHTED RESULTS

- •As spatial distribution increases (Factor 1), the higher is shelters utilization
- •As the number of facilities increases (factor 2), criteria 1 (MINMAX evacuation), and criteria 2 (MINMAX distribution) decrease
- •An increase of the number of facilities (factor 2), generates an increase of the total cost (criteria 3)
- •A decrease of total cost (criteria 3), produces an increase on the number of required buses
- •The lower total travel time, the higher is the use of faster vehicles (helicopters and cars)
- •Number of utilized cars in the evacuation is sensitive to cost variations (factor 3)
- •The quality of the solutions in SSPMO is worse but the computational time is better than the exact models
- •Average evacuation flow-time (z1) → SSPMO: 14.2 minutes per vehicle VS Exact: 12 minutes per vehicle
- •Average distribution flow-time (z2) → SSPMO: 9.1 minutes per vehicle VS Exact: 8.3 minutes per vehicle
- •The less Planning Budget (PB), the model forces higher facilities utilization and less quantity of opened facilities
- •The more PB, higher capacity facilities are opened although they have lower utilization rates
- •Streets capacities are not enough for the analyzed scenarios. Isolated regions were detected
- •Villahermosa Downtown is a main bottleneck

## CONCLUSIONS/CONTRIBUTIONS

- An integral approach based on GIS and optimization models/metaheuristic are proposed to the planning/response phases of Humanitarian Logistics
- Scenarios with real information based on GIS and with mathematical models allow the authorities to anticipate needs during a flood in any of the humanitarian operations
- The proposed methodology improves the actions performed by the authorities for the (2007) Villahermosa case of study and the test problems give additional insight to decision makers
- The methodology can easily extended to another hydrometeorological phenomena that will ocurr in other regions