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Locations of Temporary Distribution Facilities for Emergency Response Planning

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Resource planning in emergency response phase is challenging primarily because the resources have to be delivered to the affected regions in a timely manner and in right quantities. Disasters such as the hurricanes, epidemics and chemical explosions in general impact large regions and emergency supplies are needed for several days. Demand for the resources in one location at a period may not exist in the next period; or, a particular location may have a very high demand in the subsequent period. This dynamic change in the demand patterns adds further challenges in the planning process. The change in demand both in terms of the location and the quantity is usually tackled through allocation of resources at the prepositioned facilities. However, prepositioned facilities may be small in numbers and distribution of resources to the affected area may require additional funds for transportation and other overhead costs. In such a case, distribution of resources through a number of temporary facilities, located near the demand centers can significantly improve the distribution process thereby decreasing the supply response time. Therefore, in this paper, we propose a network flow model for emergency response planning which provides location and allocation plans of temporary distribution facilities for short distribution periods in the planning horizon. We assume that the individual demands in close vicinity are grouped at so-called aggregated demand points (ADPs). The distribution process initiates from a central supply point (CSP) which is a collection point that continuously acquires the resources and prepares them for distribution. In each distribution period, resource available at the CSP is allocated to the temporary distribution centers (TDCs) to distribute to the ADPs. The model considers periodically changing demands at the ADPs and supply availability at the CSP. Therefore, the decision on location and allocation are the dynamic decisions carried out in each distribution period, and the TDCs located in a period are functional temporarily only for the period. The model allows delayed satisfaction of demand when resources in a planning period are insufficient, and allows transfer of excess resources from a relief facility to another in the next time period.

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The consideration of the dynamic decision, transfer of excess resources and provision of delayed satisfaction of demand make the proposed model unique and more representative to the actual relief distribution. The objective is to minimize the total social cost which is sum of the logistics and the deprivation costs of all distribution periods. The logistics cost consists of the fixed set up costs and the transportation costs. The deprivation cost is the penalty cost associated with the delayed satisfaction of the supplies. The model is tested in a network for numerical analysis. The analysis shows that the location of TDCs in a time period influences the total cost of response. The results show that relief response can be more effective if movement of excess resources from one period to next is allowed. When such a movement is not allowed, it can increase shortage cost and eventually the total cost of emergency response. The analysis also shows solvability of the model in large and complex problem instances within a short computation time which shows the models' robustness and applicability to solve practical size distribution problems.

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