Optimization under uncertainty
Emergency help drones.

1 Presentation

A NGO sets up help centers in a region of South East Asia that is subject to frequent natural disasters. When such an event occurs, the response time to send food, emergency medical equipment and drugs to the local populations is critical to prevent starvation and the spread of diseases due to poor sanitary conditions. The area contains 80 small villages of different sizes and the NGO has 15 emergency centers, located as represented in Figure 1 (coordinates are available in file `data_drones.xlsx`).

In case of natural disaster, the NGO sends first aid kits to the villages. The weight of a kit is determined in relation with the number of inhabitants in the village (usually between 1 and 6 kg, see Table "Demand points" in file `data_drones.xlsx`). Each facility has a limited stock of 30kg of supply to be distributed to the villages when necessary. However, roads and other traditional transportation links in the area are often disrupted after a catastrophy. Therefore, the NGO decides to get a fleet of 30 drones to speed up the first aid process and offer quick supply to the inhabitants when needed. It can modify up to 5 of its help centers into drones launching sites, i.e. assign sufficient charging stations, spare parts and a drone specialist (maintenance and control) to each of the selected sites. Drone are assigned to a single help center and can only undertake one-to-one trips (from this help center to one village and back) until their available battery energy is exhausted, so it is important to respect their range constraints.

The power consumption of a given trip depends on the distance covered and on the weight carried by the drone. Based on the specifications provided by the manufacturer, the battery power necessary to carry a weight w through a given distance d_{ij} covered between points i and j is determined according to the formula $\beta w d_{ij}$, with $\beta = 2.3$. However, the NGO decides to systematically consider an over-consumption of 10% to make sure each drone can come back to its base, plus possible deviations due to weather conditions. For a given return trip i, j, the fleet managers hence decide to consider that the multiplier coefficient β in the previous formula is drawn uniformly in the interval $[2.5, 3]$ the battery consumption. Given that a return trip occurs in a limited time interval, they consider that the same coefficient applies to both the way out

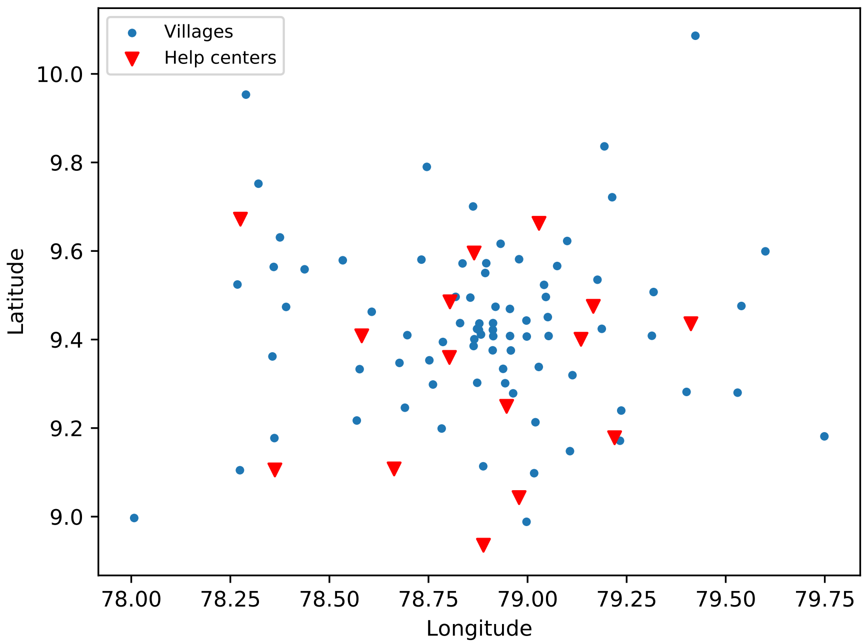

Figure 1: Map of the area

(with the emergency supply) and the return to the base (empty drone), but that each trip draws its own coefficient independently. The net weight of each drone is 10 kg, with a total battery capacity of 700 Wh (the coefficient β in the formula has the correct units to obtain Wh from the weight in kg and the distance in km).

The organization seeks to maximize the demands served while considering the uncertainties in battery consumption.