



Smart Flood Response with Drones: Who Gets Help First and How Fast?

Floods are one of the most frequent and destructive disasters globally. It will affect millions of people's livelihoods, properties and their ordinary life. Figure 1 refers the summary of disasters that occurred in Sri Lanka during the 21st century. In the Sri Lanka's context, floods account for 68% of the disasters that occurred during 2000 – 2024. Most of the populated urban spaces are affected by flood hazards [1].

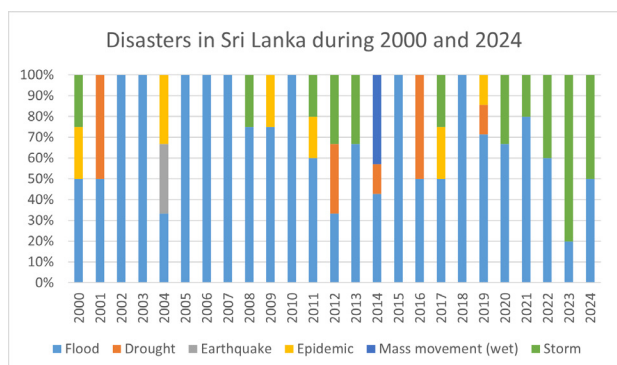


Figure 1 Disasters occurred in Sri Lanka during 2000 – 2024 Source - EM-DAT, CRED / UCLouvain, Brussels, Belgium <https://www.emdat.be>

Sudden occurrences of floods, their persistent duration and severe impact often make it challenging to predict and control. In such situations, people urgently need essential aid to survive. Therefore, ensuring the effective delivery of humanitarian aid such as dry foods, water, and medical kits becomes vital. Nowadays, flood response mechanisms often face challenges that limit the effectiveness of Search and Rescue (SAR) operations. Providing timely SAR support in current disaster scenarios remains highly complex and demanding.

The core issue is providing timely emergency supplies to affected people in the vast flooded area.

Floods often damage the road infrastructure and bridges due to extensive water. Due to the damaged transportation infrastructure, the land transportation rescue operation often faces delays and is unable to fulfil the requirements of victims on time. As well as conventional rescue and delivery

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options such as boats, trucks, or helicopters are not always a feasible option to do a SAR operation [2] , especially if urban areas get flooded, it's very difficult to do the SAR operation. This widens the gap between disaster onset and response.

To overcome these limitations, Unmanned Aerial Vehicles (UAVs) generally known as drones, can be deployed. UAVs can navigate narrow spaces and can carry moderate payloads, making them suitable for reaching inaccessible areas. On the other hand, UAVs offer exceptional speed, flexibility, and accessibility to unreachable areas which can't be delivered by traditional transportation methods [3].

The integration of UAVs into SAR operation has significantly increased in recent years, which im-

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proves capability and efficiency in rescue operations in various disaster contexts. UAVs can deliver relief supplies to disaster areas on time and avoid the effects of land traffic disruption. From a cost standpoint, drones offer more economically advantageous options, using less energy than conventional transport like boats and manned aircraft in the way of operational cost [4]. This not only makes economic benefit and SAR operations more sustainable but also improves the reaches and timely aid distribution. UAVs enables faster delivery of medical supplies to be affected areas by reducing the response time and significantly saving the lives. UAVs are used in SAR situations worldwide as practical applications. However, when only a limited number of UAVs are available, it becomes difficult to cover the vast flooded area, the relief team may lack data on victims' locations, and drones can be misallocated. So, for the above gaps and problems to be addressed and provide a technology-driven solution, which involves a limited number of UAVs, the affected areas are categorized into several boundaries and prioritized areas to provide aid distribution.

The allocation of UAVs in flood response might urgent and complexity, for this kind of scenario, Analytic Hierarchy Process (AHP) was chosen as the most suitable Multi Criteria Decision Making (MCDM) technique for prioritizing the affected areas in flood zones based on crucial criteria. Such as severity of floods, urgency of humanitarian needs, and population density, therefore giving priority to places with greatest need for immediate help with limited available of UAVs. The goal of the priority requirements of the flood affected areas received timely humanitarian relief support.

SAR operations may be better with prioritization but if not proper routing model, it will end up in failure, energy losses and even life losses. Capacitated Vehicle Routing Problem (CVRP) could apply for this scenario to perform better and effective humanitarian relief support. The CVRP structure is designed to determine the most efficient set of routes for UAVs to deliver essential supplies from a central depot to multiple affected locations. The model ensures that the total demand of visited sites does not exceed each UAV's predetermined carrying capacity. The aim is to ensure all delivery sites are reached within a short period, therefore reducing the total distance or time, which is crucial in emergency scenarios. This routing approach ensures maximizing the effectiveness of limited UAV resources by timely and efficient humanitarian aid distribution during the disaster relief operations. "Conventional rescue and delivery options such as boats, trucks, or helicopters are not always a feasible option to do a search and rescue operation"

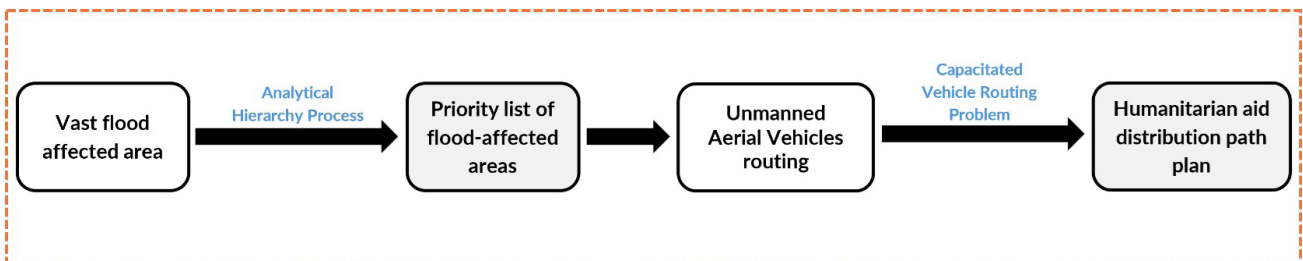


Figure 2 Flow chart of the process

To evaluate the effectiveness of the routing model combining AHP and CVRP. Kolonnawa was selected as the study area. The most affected 8 GN divisions were selected to execute the routing among the areas. Figure 3 shows the AHP priority weight of the criteria. Based on these criteria, prioritization was executed and those 8 GN divisions got ranked. Figure 4 shows the routing for those GN divisions with emphasizing first and last prioritization. Table 01 shows the comparison of the scenarios with prioritization and without prioritization. Here, the outcomes show prioritization brings reduction on energy consumption. Eventually,

the routing with prioritization gives priority to the most affected areas while reducing energy consumption.

Based on these evaluations, prioritized routing results in lower energy and time consumption compared to non - prioritized routing. Moreover, it ensures that the most affected areas receive relief more rapidly.

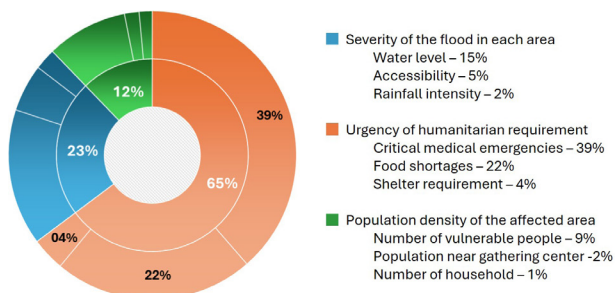


Figure 3 Priority weight of criteria

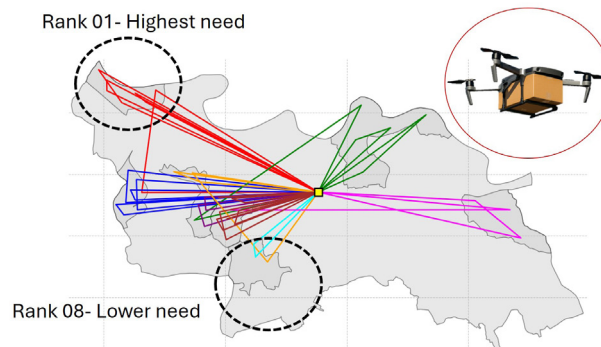


Figure 4 Ranking & Drone dispatch route

Table 1 Comparison of the routing

Comparison of the routing with prioritization and without prioritization			
	Distance (m)	Energy consumption (Wh)	Flight time (Min)
Routing with no Prioritization	48732.42	2339.16	146.20
Routing with Prioritization	20138.32	966.64	60.41

Average speed 20Km/h
Power consumption 950W

Drones can deliver relief supplies to disaster areas on time and avoid the effects of land traffic disruptions

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