Drone Based Emergency Supplies with Prioritization of Severely Flood Affected Areas

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I. INTRODUCTION

Floods are deadliest disaster among the natural disasters. Especially sudden occurrences of flood events, they can be devastating to a country or region, affecting the communities [1]. Between 2000 and 2025, floods occurred most frequently in Asia, about more than 50% of the disasters. In the Sri Lankan context, floods account the 68% of the disasters that occurred during 2000 – 2024. Since most of the populated urban spaces like Colombo are being affected by flood hazards. Kolonnawa is one of the suburbs within Colombo district which is the worst affected city due to 2016 flood. Kelani river is along the Kolonnawa DS. There are several GN divisions most affected by the 2016 flood and Wellampitiya, Kelanimulla, Gothatuwa, Udumulla North, Egoda Kolonnawa, Megoda Kolonnawa, and Singhapura are the heavily affected GN divisions during the 2016 floods [2].

The Search and Rescue (SAR) operations are crucial in disaster zones to provide emergency supplies within the shortest period. During the flood, conventional rescue and delivery options such as boats, trucks, or helicopters are not always a feasible option to do a search and rescue operation [3]. However, with emerging technologies, SAR operations can be more effective. Especially if urban areas get flooded, it's very difficult to do the SAR operation. Boats can't reach if any broken trees, electrical posts, or any kind of barriers restrict the way of approaching the victims. Helicopters can't reach the victims if anyone is stuck in their houses and has no way to exit. It will increase the significant gap between the time of the disaster and the time of the rescue operation.

For these limitations and restrictions, Drones can be employed. It could fly in between small spaces and can carry huge weights. However, with limited drones unable to cover the vast flooded area, the relief team may lack data on victims' locations, and drones can be misallocated.

To sort out these issues, this research explores the gap by prioritizing target areas for drones-based aid delivery based on the severity of impact, especially within urban flood affected zones.

II. LITERATURE REVIEW

SAR operations are very crucial due to high risks of drowning, immediate health hazards, and isolation of affected populations. Humanitarian logistics involves the process of mobilizing people, resources, skills and knowledge to help the victims who suffer from disasters. In the humanitarian process, logistics is the central because of it's a bridge between disaster preparedness and response, procurement and distribution [4]. Effective SAR operations during floods not only saved lives but offering services immediate evacuation, sheltering and distribution of critical supplies, which are extremely important in the early stage of the response .

As mentioned earlier, SAR operations in flooded scenarios often face various logistical and operational challenges. To ensure effective SAR responses, need to the robust logistics networks that can quickly deploy the supplies to disaster zones, which are critically considered [5]. By improving the strength of these networks and including real time data will help SAR operations to be more responsive, flexible, and able to reduce the negative effects of floods on at risk populations.

These days, drones are the essential player in the SAR operations. It has several advantages but still their deployment is restricted by several factors that diminish the operational efficiency. drones have their own limitations including battery life and payload capacity [6], which make relief operations more complex. But a best planning and effective allocation helps to do more efficient relief operations.

Flood disaster response is complex procedure consists of several conflicting priorities, multiple stakeholders, and decision making with uncertainties. For this kind of complex scenario, Multi Criteria Decision Making (MCDM) provides structured approach for analysing. Decision makers can evaluate multiple alternatives against the diverse criteria [7].

III. METHODOLOGY

This research focuses on developing an overall framework for prioritization for affected target zones with developing DRONES routes for prioritized areas. To achieve this objective, two steps are involved in the framework. In the first step, Analytical hierarchy Process (AHP) is equipped for prioritizing the affected areas based on criteria such as Severity of the Flood, the Urgency of Humanitarian Needs, and the Population Density of the Affected Regions. Several sub criteria follow each criterion. In the second step, drones routing model was developed with Capacitated Vehicle Routing Problem (CVRP) while considering the constraints of drones such as payload capacity and battery capacity [8]. Fig 01 shows the methodology framework of this study.

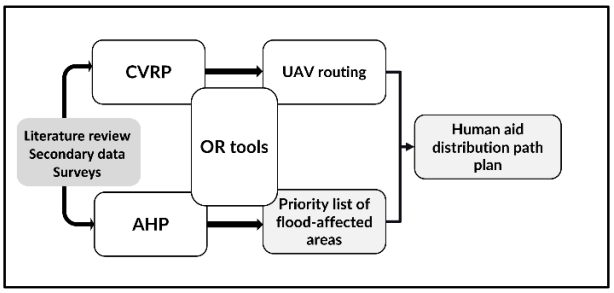

Fig. 1. Flow chart of methodology

IV. Discussion

In the first step, AHP is helping to create a hierarchy of criteria, sub-criteria and alternatives which are extracted from the literature review. Which helps to decompose the problem into a hierarchical model. Under each criterion, there are several criteria defined. Those criteria helped to prioritise the alternatives. In the Kolonnawa, the 8 frequent vulnerabilities of flooding areas were selected as alternatives for this study. The pairwise comparison was executed using expert judgement with SAR experts and Local government executives (GN). To maintain consistency and accuracy of results, the consistency ratio was calculated and ensured that the priority order is consistent. Table I shows the priority order of target areas. Based on this priority order the disaster response will be taken.

In the second step, a CVRP model was developed for drones to deliver emergency supplies in an efficient manner. The drones must visit the target areas to deliver and come back to the depot to refill the emergency supplies or recharge batteries. Based on the priority order got from step 01, the routing was defined based on the severity of the urgency. The most urgent and severe areas were distributed and followed by less severe areas. Table II shows the distance travelled for each GN division and the number of trips needed to fulfil. The routing model serves with central depot has facility with charging and refilling stations to facilitate the several trips. So, the drones can do multiple trips to until fulfil the overall affected area.

TABLE I. PRIORITY LIST OF THE GN DIVISIONS

GN Divisions	Preference score	Priority order
Wellampitiya	0.4361	5
Kelanimulla	0.5518	3
Gothatuwa	0.3258	6
Udumulla North	0.3175	7
Sedawatta	0.9125	1
Megoda Kolonnawa	0.2355	8
Singhapura	0.4376	4
Meethotamulla	0.8417	2

TABLE II. NUMBER OF SIMULATED TRIPS AND DISTANCE TRAVELLED FOR EACH GN

GN Divisions	No of trips	Total distance [m]
Wellampitiya	3	4,421.55
Kelanimulla	5	2,431.58
Gothatuwa	3	629.68
Udumulla North	3	3,294.44
Sedawatta	2	2,758.49
Megoda Kolonnawa	2	3,106.78
Singhapura	2	2,806.92
Meethotamulla	6	688.88

V. Conclusion

This research supposed to develop the drones routing model incorporates with AHP for prioritization. The overall strategy of the research was achieved by two steps. This research limited by the constraints of the drones such as battery life and payload capacity. Also, wind resistance and weather impacts and obstacles are didn't consider in this study. In future, these factors will be considered. To improve the applicability of model, the various kinds of disasters will be simulated.

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