

# Optimizing emergency responses: developing operations research tools for Flood response in Bangladesh

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## Abstract:

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## 1 INTRODUCTION

### Idea generation :

Brainstormed (Mahbub & Tanmoy)

1. Collect data (GIS map, and
2. Information needed on depo, warehouse storage location (supply), affected area, and population (demand)
3. Build the conceptual and mathematical models
4. Column generation to solve the optimization problem

Relief distribution model

5 million people, ++

Proposal 1: Proof of Concept.. focus on one district (shelter house, disrupted transportation network), shelter house, NGO.

### Brainstorming (Sep 01)

1. Project aim & scope
2. VRP
3. Data intro (Riad)

Optimization model

1. Objective: maximizing coverage of shelter (demand) points
2. DV: no. of vehicles (# of drone, helicopter, truck), capacity of these vehicle
  - a. Vehicle level:  $x_{ijk}$ , from where to where
  - b. Routing level: road selection (disrupted, non-disrupted routes)
3. Input parameters: packages.
  - a. Disrupted vs non-disrupted networks
4. Constraint
  - a. Travel each demand points only once
  - b. Capacity constraints: for each vehicle
  - c. Travelling distance: helicopter (max coverage), every vehicle (truck refuel), other practical limits
  - d. Time-window
  - e.

## 2 METHOD

### 2.1 Data:

#### 2.1.1 Summary of the case study (present situation)

As of today (Aug 25, 2024), more than 500,000 people have taken refuge in around 3,500 shelters in the 11 flood-hit districts, where nearly 750 medical teams are on the ground to provide treatment (ReliefWeb 2024; Paul 2024). Most affected communities are from Feni, Noakhali and Khagrachhari districts; 193,864 people are in 3170 shelters.

Challenges (Brainstormed with **Riad**):

1. Most Bangladesh Army base locations are NOT open-source
2. Emergency response in Bangladesh is often at community level (getting data at national level is almost impossible, partly due to security reasons)

Working on:

1. Collecting GIS map & .json/.shp files of flood impacted regions ++

#### Some useful links (ref. everyone):

1. <https://protirodh.net/flood> (you need to drag the map to the right). Note: view is different in Safari vs Chrome.
2. <http://biwta.port-log.net/live/Map.php>
3. Flood Forecasting & Warning Centre <http://www.ffwc.gov.bd>
4. Water level [data](#)

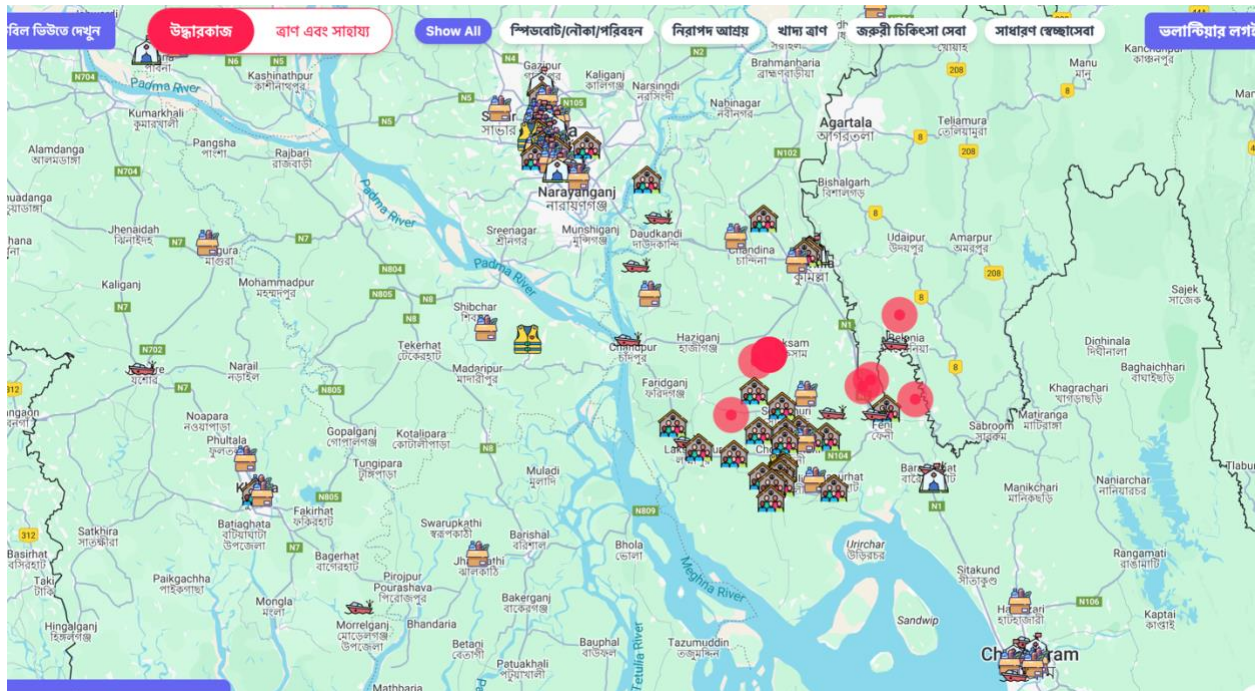


Figure 1 Affected regions in Bangladesh (Source: protirodh.net 2024)

## 2.1.2 Data needed for the optimization model

Table 1 Metadata and database schema

Category		Specifics	Data points/ type
Affected region	Road Network Data	Traffic Data: Real-time or historical traffic patterns, congestion data, and road closures. Accessibility: Information on road conditions, including roads that may be flooded or inaccessible.	
		<b>Shelters:</b> Locations of emergency shelters and their capacities. <b>Hospitals:</b> Locations, capacities, and current status (operational or flooded). <b>Locations of communication towers,</b> especially in areas with poor signal coverage.	Geolocation of shelters (& their capacity) Note: Current occupancy in this shelters are location of demand points for our model.
Supplier		<b>Depots/Warehouses:</b> Locations of resource storage facilities.	Geolocation of depot
	Resource Data	<b>Resource Type:</b> Types of resources available for distribution (e.g., food, water, medical supplies). <b>Stock Levels:</b> Current stock levels of each resource at different locations.	

		Resource Requirements: Demand for resources at various locations.	
Affected people (demand)			

Hypothetical table summarizing some of the GIS data elements, shown in Table 2. We may not be able to obtain or produce such precise information for our problem, but this can be a good starting point for our data collection.

Table 2 Hypothetical datatable (for our brainstorming), produced using ChatGPT

Data Type	Attributes	Example Values
<b>Road Network</b>	Road ID, Type, Condition, Traffic Level, Closure Status	R123, Highway, Good, High, Open
<b>Bridges</b>	Bridge ID, Location, Condition, Flood Risk	B456, (38.8977, -77.0365), Fair, High
<b>Elevation</b>	Location, Elevation (m)	(38.8977, -77.0365), 50
<b>Flood Zones</b>	Zone ID, Flood Risk Level, Last Flooded Date	FZ789, High, 2024-08-20
<b>Shelters</b>	Shelter ID, Location, Capacity, Occupancy	S101, (38.8977, -77.0365), 200, 150
<b>Hospitals</b>	Hospital ID, Location, Status, Bed Capacity	H202, (38.8977, -77.0365), Operational, 100
<b>Population Density</b>	Location, Density (people/km <sup>2</sup> )	(38.8977, -77.0365), 2000
<b>Weather</b>	Location, Temperature (°C), Rainfall (mm), Wind Speed (km/h)	(38.8977, -77.0365), 25, 50, 10
<b>Resource Stock</b>	Resource ID, Type, Location, Stock Level	R303, Water, Depot 1, 5000 liters
<b>Resource Requirement</b>	Location, Resource Type, Required Quantity	(38.8977, -77.0365), Food, 1000 kg
<b>Communication Towers</b>	Tower ID, Location, Signal Strength	C404, (38.8977, -77.0365), Strong

### 2.1.3 Dataset of our case-study

Table 3 Dataset of flood-affected region


Population density of Bangladesh [source link](#); [link2](#)

### 3 RESULT & DISCUSSION

The flood severity plot in Figure 2 is semi-hypothetical (I have manually put the severity after reading some local newspapers). Population density plot in Figure 3 (need to fix color++)

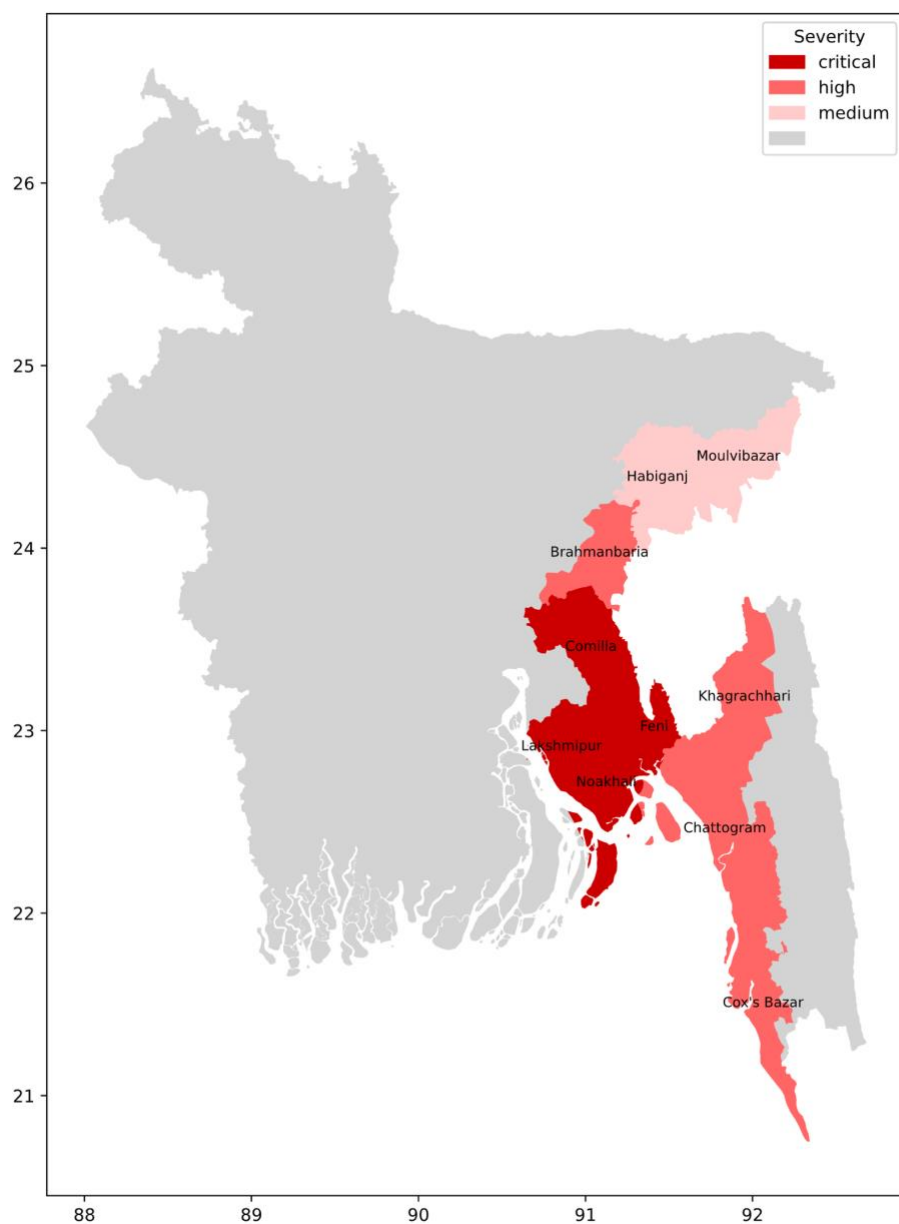


Figure 2 Floor severity in affected districts

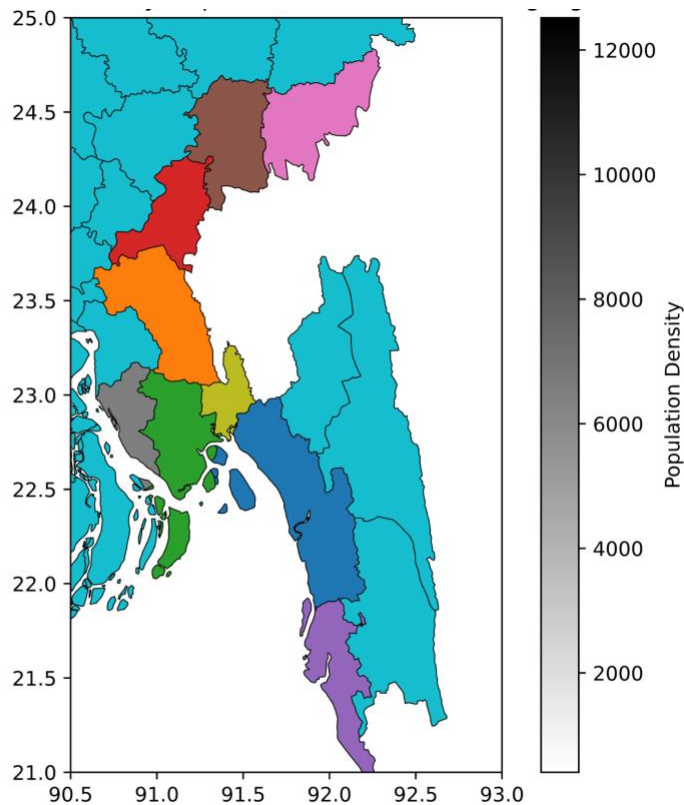


Figure 3 Population density

**Tanmoy** (Aiming to complete below tasks before Sep 01 meeting): +++

1. Feni (GIS map with shelter locations, population, severity)
2. Fix Fig3
3. POC
  - a. math model and descriptive text of VRP-TW model
  - b. brainstorm on DV, objective function
4. 1-2 idea brainstorming for webapp.
5. Optimized network (add one GIF for Github homepage)

## 4 CONCLUSION

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## SUPPLEMENTARY RESOURCES

<https://github.com/tanmoyie/Optimizing-flood-reponse-in-Bangladesh>

## AUTHORS' CONTRIBUTION

**Md Mahbubar Rahman:** original research idea, optimization model development, solution algorithm;  
**Tanmoy Das:** optimization model development, data curation and analysis; **Riad Alam:** Domain experience, data collection; **Hafizur Rahman:** model deployment, validation

## REFERENCE

- Paul, Ruma. 2024. "Twenty Dead, 5 Million Affected in Bangladesh Floods." Yahoo News. 2024. <https://au.news.yahoo.com/twenty-dead-5-2-million-145537062.html>.
- protirodh.net. 2024. "প্রতিরোধ.Net." <https://Protirodh.Net/Flood>. 2024. <https://protirodh.net>.
- ReliefWeb. 2024. "Flooding in Eastern Bangladesh (Feni, Comilla, Noakhali, Habiganj, Moulvibazar, Khagrachhari and Rangamati)." 2024. <https://reliefweb.int/report/bangladesh/flooding-eastern-bangladesh-feni-comilla-noakhali-habiganj-moulvibazar-khagrachhari-and-rangamati-briefing-note-24082024>.