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► **To cite this version:**

Polina Lemenkova. Flood Hazard and Natural Risk Assessment: A Case Study of Bangladesh. Doctoral. Course 24S796912 'Disaster Risk Management with Geoanalytics', Salzburg (Austria), Austria. 2024, pp.10. hal-04620677

HAL Id: hal-04620677

<https://hal.science/hal-04620677v1>

Submitted on 21 Jun 2024

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Flood Hazard and Natural Risk Assessment: A Case Study of Bangladesh

Assignment 4 for the Course 24S796912
'Disaster Risk Management with Geoanalytics'

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June 7, 2024

Introduction

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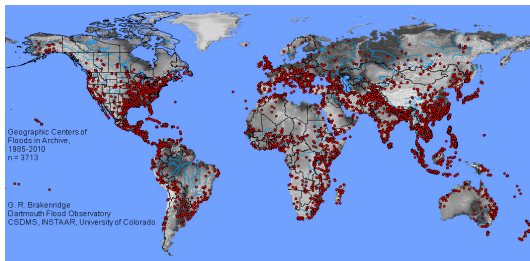
Major Floods in Bangladesh

Mapping flood hazard and
shelter suitability in
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Mapping flood hazard in
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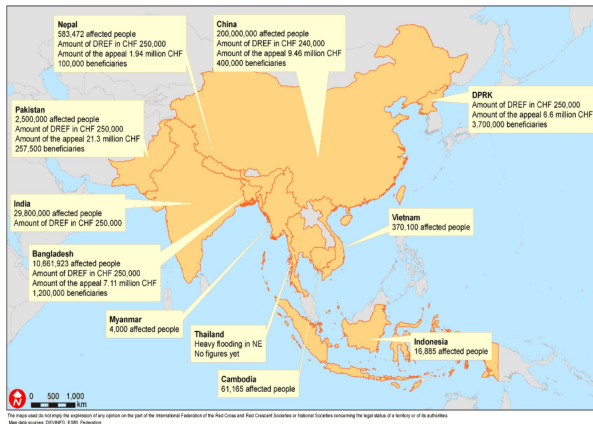
Floods in the world

Figure: Source: Dartmouth Flood Observatory. Global Active Archive of Large Flood Events, 1985-Present



- ▶ Water is a resource but also can be a threat: flood risk management involves segments of water use (potable water, industrial use, irrigation, recreation, energy production)
- ▶ Flood risk analysis in terms of the risk equation: hazard, vulnerability, exposure and capacity.
- ▶ Flood correlates with large-scale events and climate change => multi-hazard scenarios.
- ▶ Flood reasons: heavy rainfall when land surface lacks the capacity to convey excess water.
- ▶ Flooding can also result from other phenomena, storm surge, tropical cyclone, tsunami, high tide.
- ▶ Flood types: riverine floods, flash floods, urban floods, glacial lake outburst floods and coastal floods (climatic and non-climatic processes cause these different types of floods)
- ▶ Globe coverage: Floods are the natural hazard with the highest frequency and the widest geographical distribution worldwide.
- ▶ Scale: although most floods are small events, monster floods are not infrequent.
- ▶ The human and economic losses caused by floods are impressive (Thousands of life losses + up to dozens of US \$ billions)

Floods in Asia



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- ▶ Flood magnitude depends on precipitation intensity, volume, timing and phase.
- ▶ Hydrogeological parameters increasing flood force: riverbed structure and drainage basins (frozen or not or saturated soil moisture or unsaturated) and status.
- ▶ Climatological parameters: precipitation (intensity and period), windstorms, storm surges and sea-level rise.
- ▶ Climate change has a prominent role when assessing flood risk
- ▶ Environmental factors increasing floods: deforestation, relief (topography),
- ▶ Human factors and interactions : collapsed dams and land-use activities such as urbanization which increases run-off volume and rate

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Key points on Bangladesh:

- ▶ Bangladesh is among the countries that are the most affected by climate change
- ▶ Frequent natural disasters, loss of life, damage to infrastructure and economic assets, impacts on lives and livelihoods
- ▶ Floods, tropical cyclones, storm surges and droughts are likely to become more frequent and severe in the coming years
- ▶ Lies in the delta of three of the largest rivers in the world – the Brahmaputra, the Ganges and the Meghna
- ▶ Mostly low and flat topography, susceptible to river and rainwater flooding
- ▶ More than 50 million of people still live in poverty
- ▶ Many people live in remote or ecologically fragile parts of the country, e.g. river islands
- ▶ Approximately one quarter of the country inundated each year
- ▶ The poorest and most vulnerable living in the exposed areas suffer the most
- ▶ High population density and poverty
- ▶ Nature-dependant traditional agriculture
- ▶ Population at risk: elderly, women, disable, children and poor people

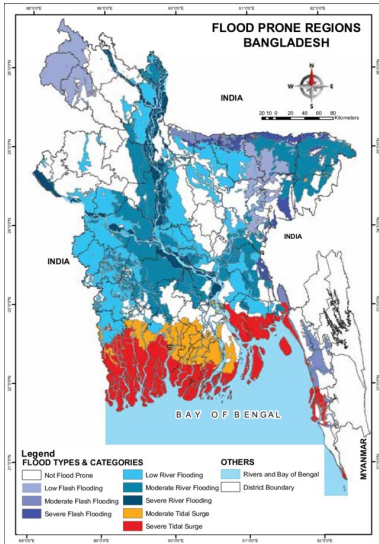


Figure: Flood-prone regions of Bangladesh and areas vulnerable to flooding. Source: Based on BCA Drought Maps

Factors of flood risks in Bangladesh

Factors of risks in Bangladesh increasing vulnerability to flood hazards:

▶ Geographic location

- * long coast line: floods more affect coastal and rural areas
- * effect of saline water intrusion in the estuaries
- * vast low-lying landmass
- * extremely dynamic coastal geomorphological processes

▶ Socio-demographic and economic features

- * Initial economic conditions (poor / non-poor)
- * One of the poorest and the most flood-prone areas worldwide and in Asia
- * Gender and general health condition (capacity to resist illnesses, stresses)
- * Poorer segments of society live closer to the river: residents are mostly farmers cultivating rice, wheat, vegetables, oil seeds

▶ Environmental facts

- 📄 Bangladesh - one of the highest flood hazard area in the world;
- 📄 Location: coastal, Ganges River Delta, rural or urban
- 📄 Floods => reduced livelihood options, e.g. loss of agriculture, restriction of movement



In April 1991, a cyclone struck Bangladesh, claiming lives and leaving destruction in its path. The satellite image on top shows the eye of the catastrophic storm. The worst cyclone in recorded history on mortality count struck Bangladesh in November 1970.
Image source: NOAA



Flood in rural Bangladesh. Source: CNRS, Dhaka.



River Bank Erosion after Flood in Bangladesh. Source: CNRS, Dhaka.

Bangladesh: Socio-Economic Vulnerability

Repeatability of hazards:

- ➔ Population suffered from devastating floods over the past 20 years in 1988, 1996, 1998 and 2004
- ➔ Inundation levels significantly higher for poorer households
- ➔ Impoverished face a higher risk of flooding and are more vulnerable

Inequality of diverse social groups and their exposure to flood hazards:

- ⇒ The higher the exposure level and income inequality, the less access to a natural resources
- ⇒ Average damage costs and coping capacity higher for wealthier households
- ⇒ Households with higher income take preventive measures and have significantly lower damage costs
- ⇒ Unequal income distributions in villages with higher risk exposure
- ⇒ The least well prepared at household- and community level face the highest risk of flooding

Table 2. Causes of Impacts, Vulnerable Areas and Impacted Sectors in Bangladesh:

Climate and Related Elements	Critical Vulnerable Areas	Most Impacted Sectors
Sea Level Rise and Salinity Intrusion	Coastal Area Island	Agriculture (crop, fisheries, livestock) Water (water logging, drinking water) Human settlement Energy Health
Floods	Central Region North East Region Char land	Agriculture (crop, fisheries, livestock) Water (urban, industry) Infrastructure Human settlement
Temperature rise and drought	North-west	Agriculture (crop, livestock, fisheries) Water Energy Health

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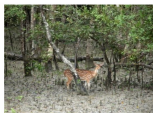
Impacts of the Flood Hazards in Bangladesh

Impact of Event = \sum Intensity of Event * \sum Baseline Conditions * \sum Adaptive Capacity

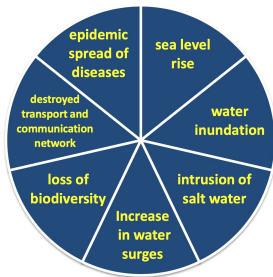
In the coastal areas of Bangladesh communities are impacted by the following factors:



Destructions in Bangladesh after flood.
Photo: Dev Jain, *Saint Martin's Island*
Saint Martin's Island station by SIDR, source: web



The Sunderbans - the world's largest tropical mangrove forests - is already losing islands from climate change impacts including coastal erosion and sea level rise. The forest has a unique ecosystem and rich in biodiversity.



Flood in Bangladesh, June 11 2007. Photo taken from <https://us.news.riaa.us/world/21jun2007/bangladesh.html>



Likely salinity ingress in Southern Bangladesh.
Agrwala et al. (2003)

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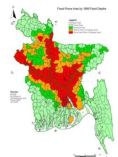
Flood in main road of Dhaka.

Source: www.poffet.net



Boats on a city road in Bangladesh.

Source: CNRS, Dhaka.



Flood-prone area in Bangladesh, 1996

Impacts of the Major Floods in Bangladesh

Major floods in Bangladesh during the last 50 years and their consequences:

Event	Impact
1954 floods	Affected 55% of country
1974 flood	Moderately severe, over 2,000 deaths affected 58% of country followed by famine with over 30,000 deaths
1984 floods	Inundated 52,520 km ² , cost estimated at US\$ 378 million
1987 floods	Inundated over 50,000 km², estimated damage US\$ 1.0 billion, 2055 deaths
1988 floods	Inundated 61% of country, estimated damage US\$ 1.2 billion, more than 45 million homeless, between 2,000-6,500 deaths
1998 floods	1,100 deaths, inundated nearly 100,000 km ² , rendered 30 million people homeless, damaged 500,000 homes, heavy loss to infrastructure, estimated damage US\$ 2.8 billion
2004 floods	Inundation 38%, damage US\$ 6.6 billion, deaths 700, affected people nearly 3.8 million

General impacts of flood hazards on the population: Particular impacts of flood hazards on human health:

- ▶ temperature rise and widespread malnutrition (due to shortage of water)
- ▶ degrading water quality and quantity => illnesses: cholera, diarrhoea, dysentery, malaria, typhoid

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Hazard assessment:

- ▶ Flood hazard assessment includes inundation and flood hazard maps
- ▶ Different methodologies are needed to define flood hazard when different scales are considered
 - ✓ Historic flood risk assessment: information on floods that have occurred in the past
 - ✓ Predictive analysis assessing the areas that could be prone to flooding
 - ✓ Modelling of the potential consequences
 - ✓ Expert opinions: locals / departments / agencies to identify areas prone to flooding
 - ✓ Probabilistic quantitative risk approaches and prognosis
- ▶ Heavy monsoon rainfall generates excessive flows in the rivers and causes floods almost every year

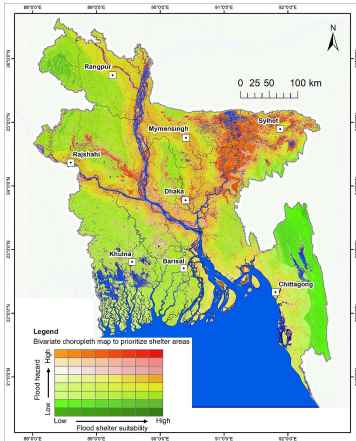


Figure: Priority area for flood shelter construction based on the bivariate choropleth analysis

Mapping flood hazard in Bangladesh using Deep Learning

Reference: Lemenkova, Polina. 2024. "Deep Learning Methods of Satellite Image Processing for Monitoring of Flood Dynamics in the Ganges Delta, Bangladesh" Water 16, no. 8: 1141. DOI: 10.3390/w16081141

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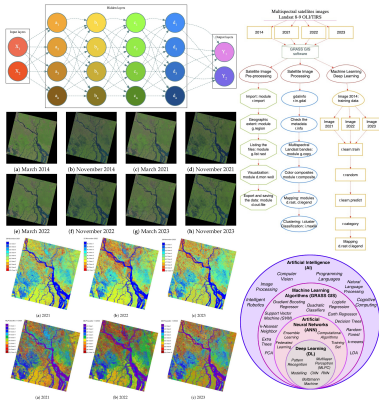


Figure: Algorithms of Deep Learning by GRASS GIS for mapping flood hazards using satellite images



Figure: Cartographic mapping of vulnerable area in Bangladesh by GRASS GIS