Analyses of Vulnerability to Flood Risk in Bangladesh: Bridging Scientific Research and Policy Development

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BANGLADESH: A Disaster Prone Country

Catastrophic Disaster

(Flooded Area)

- **2004 (65%)**
- **1998 (67%)**
- **1991 (Cyclone; Death toll 138,000)**
- **1988 (60%)**
- **1987 (40%)**
- **1974 (47%)**
- **1970 (Cyclone; Death toll 300,000)**

The Impact of Flooding

- Human casualties
- Economic losses
- Health and environment

Background of the Study

One-fifth of the country hardly cross 1.5 m above mean sea-level. And, therefore, the country is more vulnerable due to sea-level rise and climate condition.

To make awareness and to comprehend the people against flooding consequences, it is essential to have the flooding information in advance based on scientific analyses of flood susceptibility

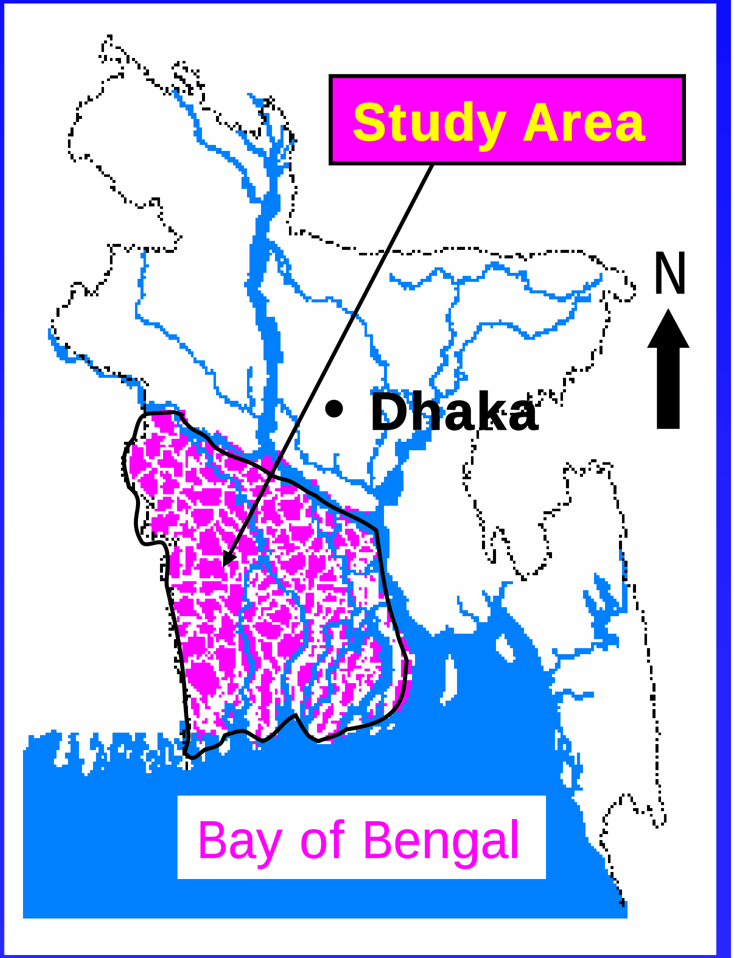
Risk-based zoning of flood prone area is crucial when budget is limited.

In this study, a methodology is described for the risk based zoning of floodplain in order to identify priority areas.

Description of the Study Area

Study Area: Ganges Floodplain

- Administrative units: 21 out of 64
- Land units (Thana): 128
- Area: 42,577 km^2
- Major rivers: Gorai, Arial khan
- Land slope: 1.6×10^{-5} to 2.0×10^{-4}
- Average land elevation: 3 m MSL
- Landuse: Agricultural, Aquaculture

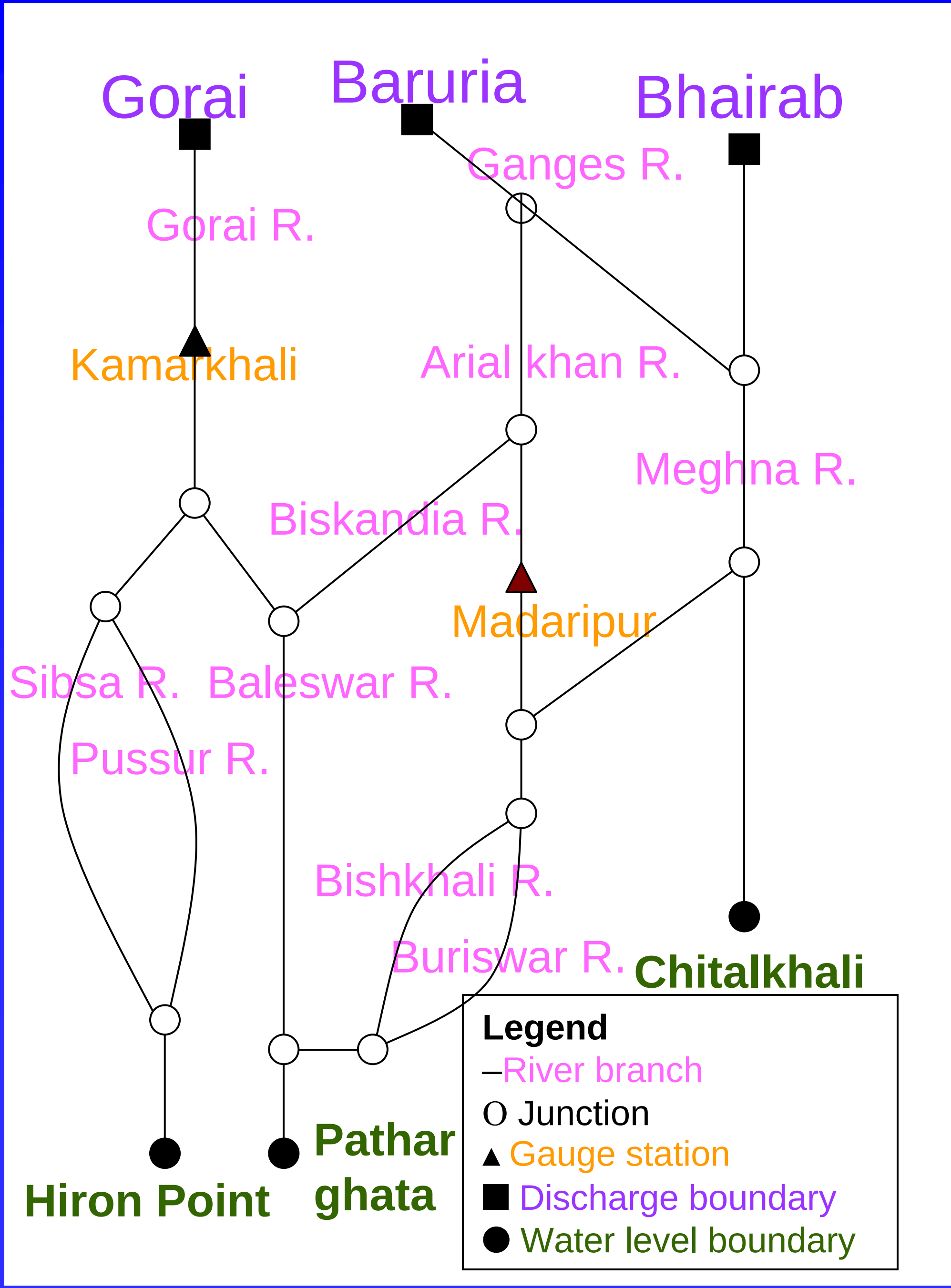


Objectives

- Simulation of flooding parameters using numerical model
- Assessment of flood hazard
- Risk-based zoning map

River Network Model

- river branches: 21
- junctions: 12
- boundaries: 6
- x-sections: 185
- length: 1106 km
- Δx: 5 to 10 km
- width: 500 to 5000m



Governing Equations

Continuity Equation

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} - q = 0$$

Momentum Equation

$$\frac{\partial Q}{\partial t} + \frac{\partial}{\partial x}\left(\alpha \frac{Q^2}{A}\right) + gA\frac{\partial h}{\partial x} + \frac{gQ|Q|}{C^2 AR} = 0$$

Solution Technique

- **Above equations are solved numerically using an implicit finite difference scheme known as 6-point Abbott scheme.**

Model Calibration

Conditions:

Period: 1998 flood

Time step: 15 min.

C. Time: 107 days

Starting time: 16th July

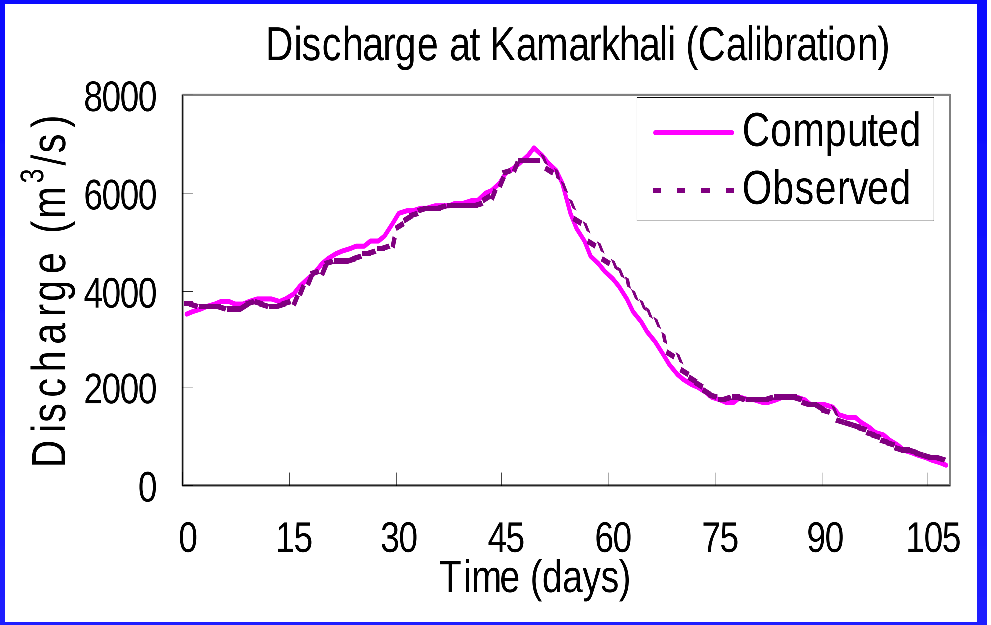
Results:

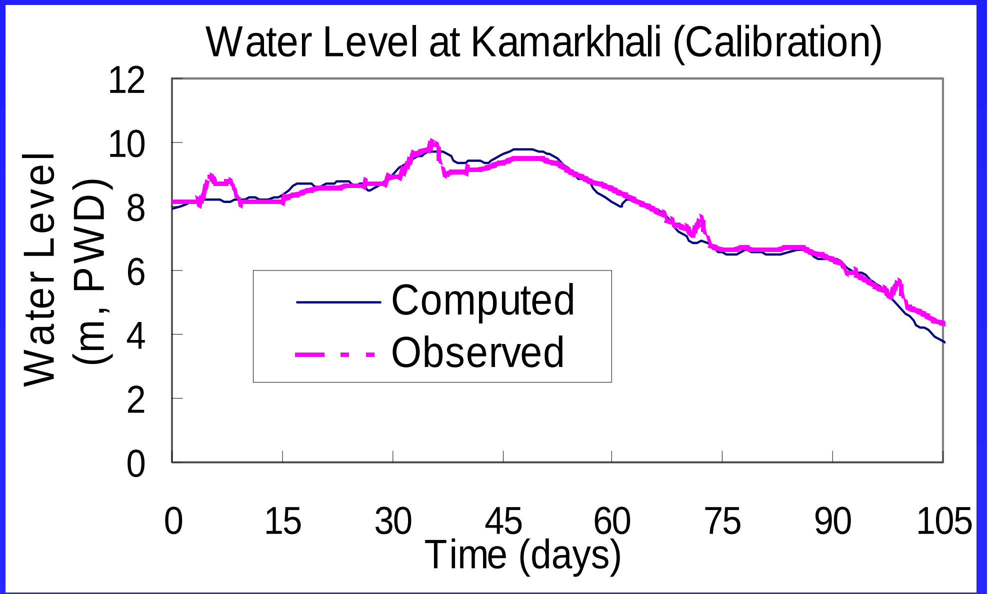
Variation in mean values:±2%

Correlation coefficient: 0.98~0.99

Efficiency coefficient: 0.92 ~0.96

Relative error: ± 0.002 ~0.02





Flood Flow Simulation

- **Conditions:**

Return Period: 100 years

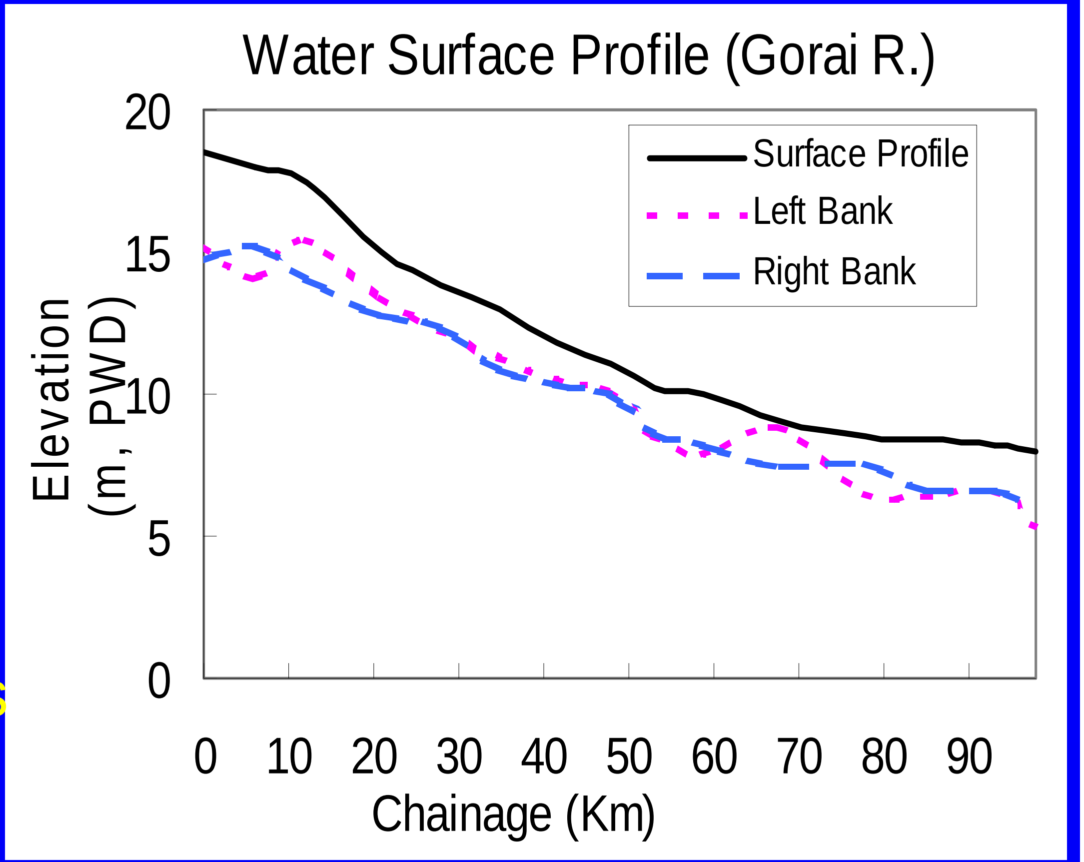
Boundary data: Synthetic time series

Time step: 15 min.

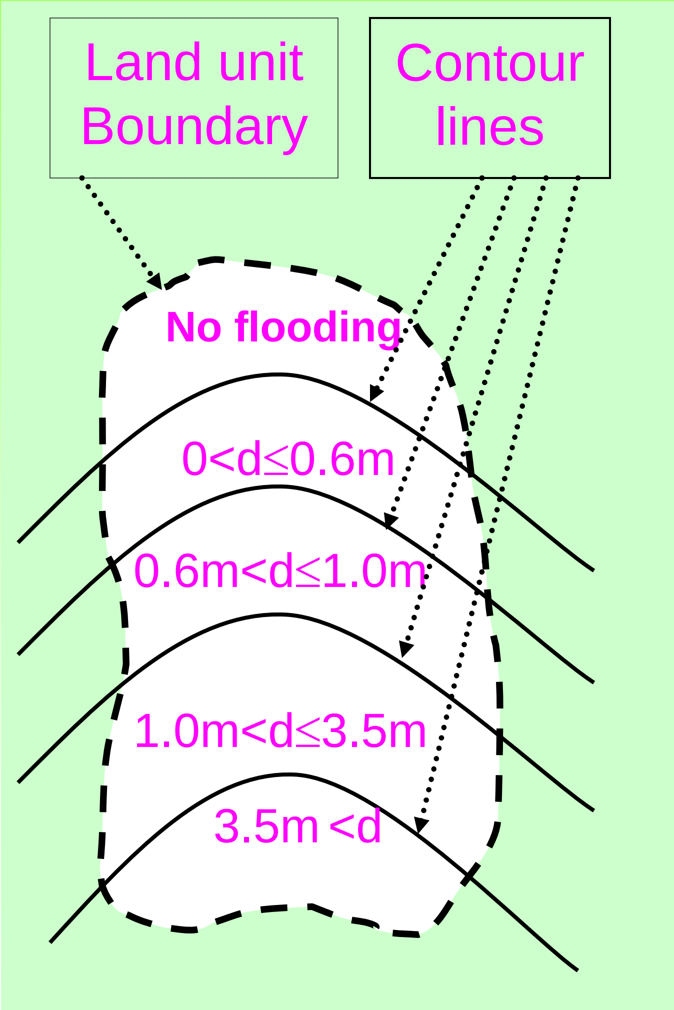
Simulation Time: 120 days

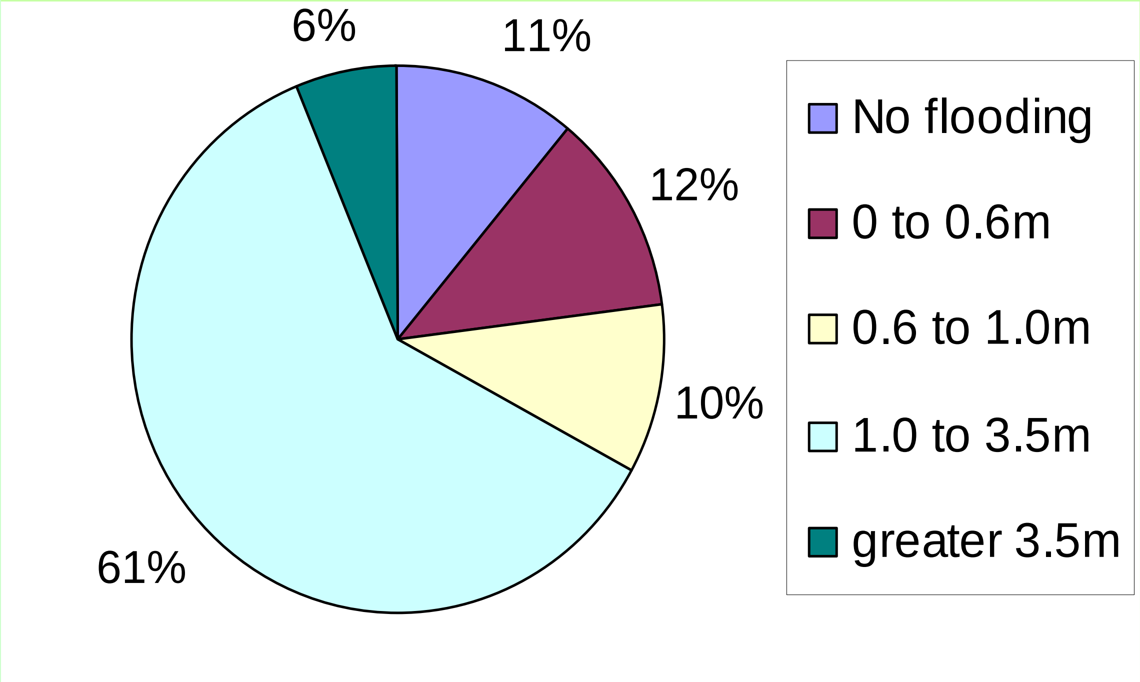
Flooding depth=

Maximum WL - Land level

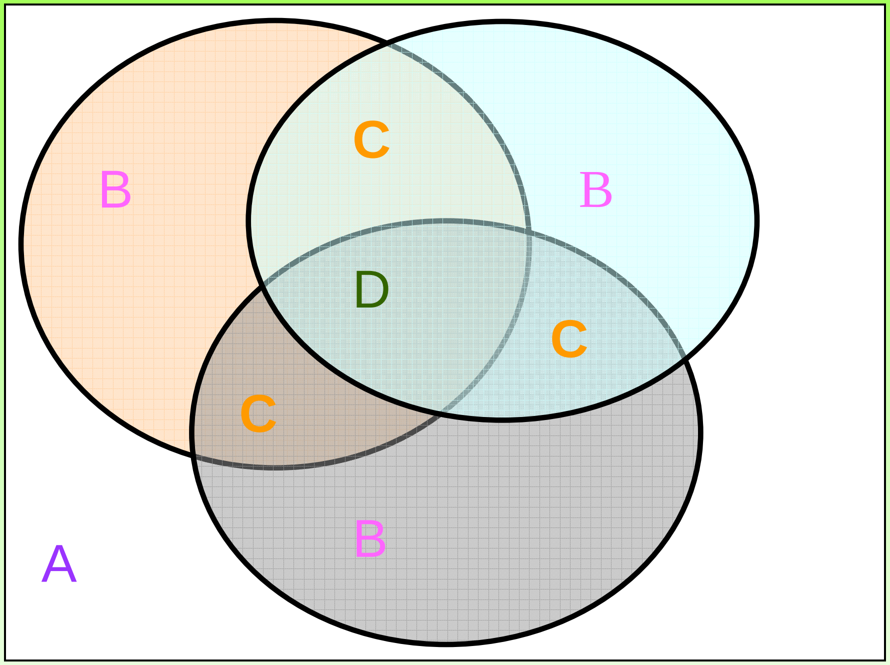


Flood Depth Analysis

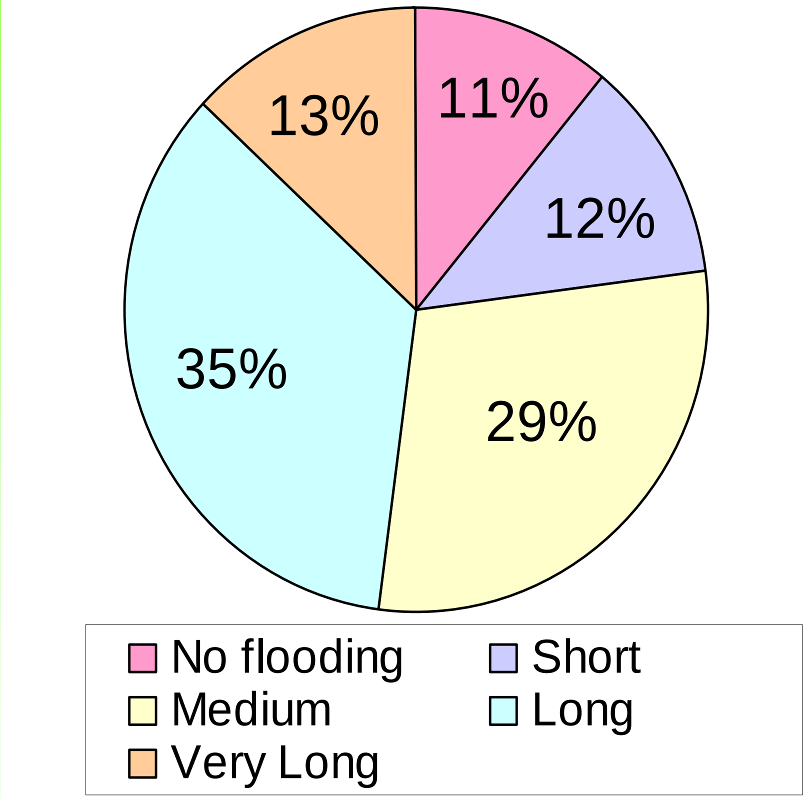




Flood Duration Analysis



□ Study Area
O Sat. images
A: Short
B: Medium
C: Long
D: Very Long



Flood Hazard Assessment

What is flood hazard?

Estimation of overall adverse effects of flooding

- **Threat to life and limb**
- **Difficulty of evacuating people and their possessions**
- **Potential damage to the properties and productions**
- **Social disruption**

Parameters of flood hazard?

- **Depth of flooding**
- **Duration of flooding**

Hazard index for case studies

Depth of Flooding

Hazard Index

Duration of Flooding

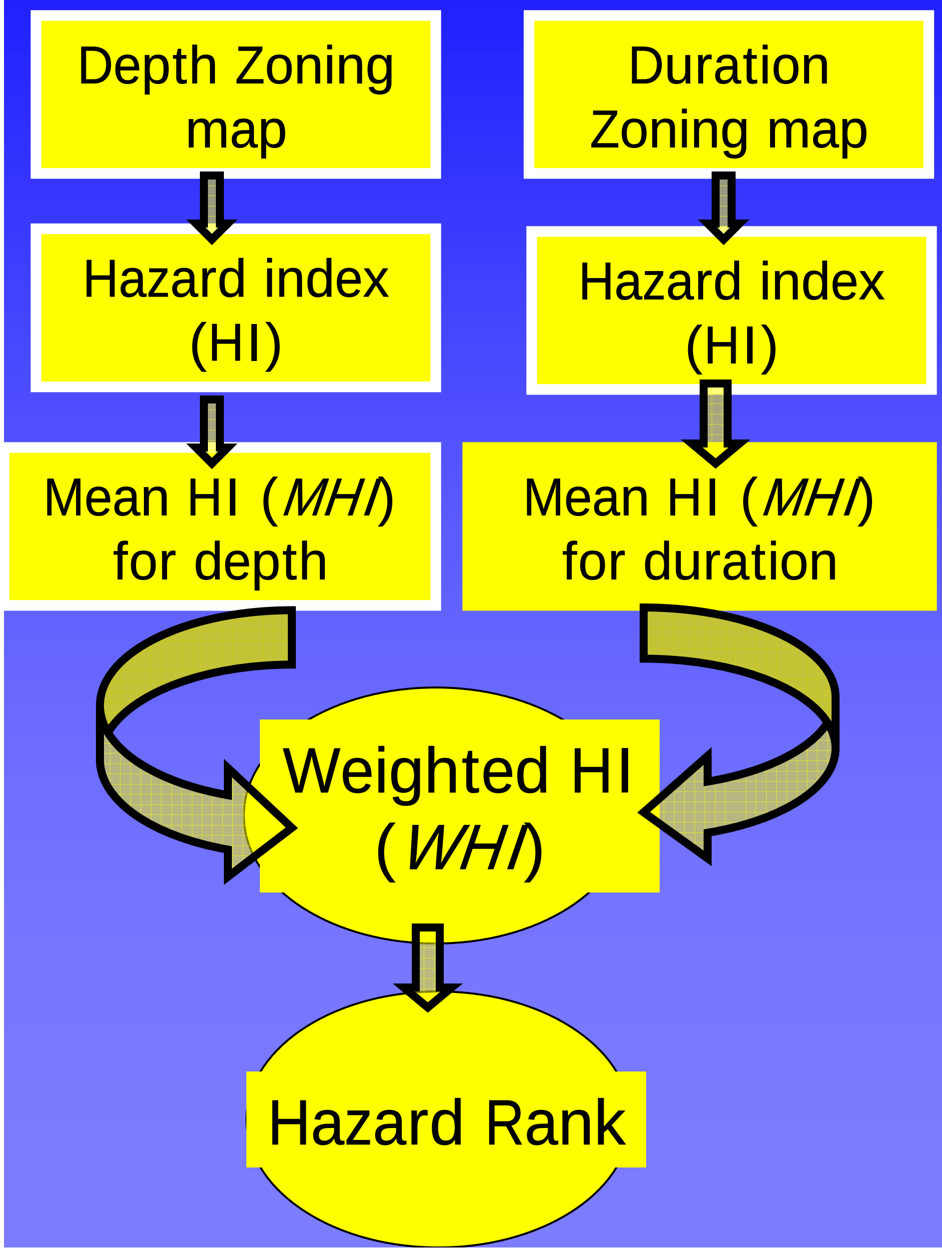
Depth (m)	Hazard Index	
	Alt.1	Alt.2
$0<d\le 0.6$	1	2
$0.6<d\le 1.0$	2	3
$1.0<d\le 3.5$	3	4
$3.5<d$	4	5

Duration	Hazard Index	
	Alt.1	Alt.2
Short	1	0
Medium	2	1
Long	3	2
Very Long	4	3

Case Studies

No.	Hazard Index	
	Depth	Duration
Case1	Alt.1	Alt.1
Case2	Alt. 1	Alt.2
Case3	Alt. 2	Alt.1
Case4	Alt.2	Alt.2

Flood Hazard Assessment



$$MHI = \sum_{i=1}^{n} (HI)_i A_i / \sum A_i$$

$$WHI = \sum_{i=1}^{N} (MHI)_i / N$$

n: number of hazard categories

N: Number of hazard parameters

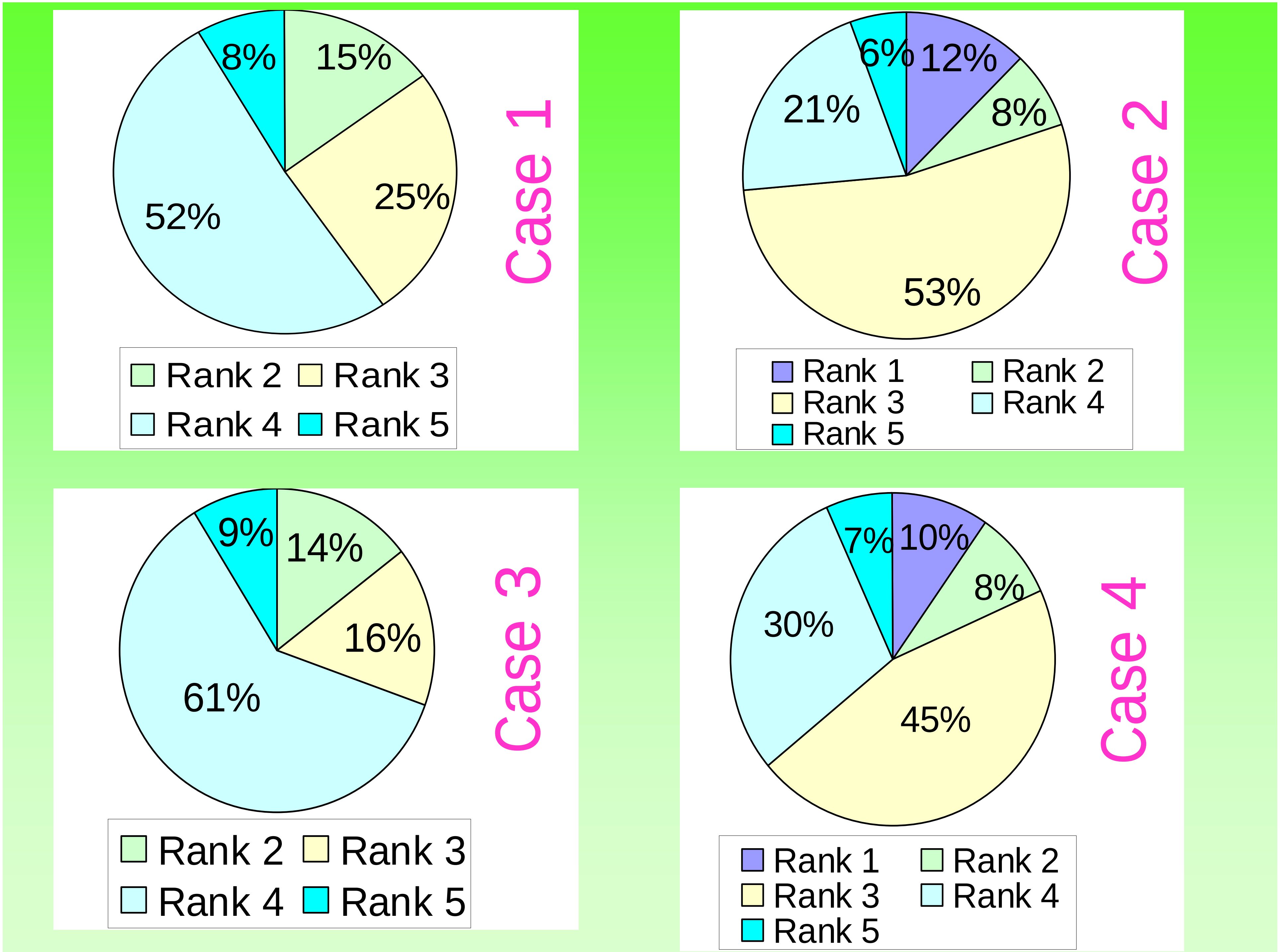
WHI= 1~20: Rank 1

WHI=21~40: Rank 2

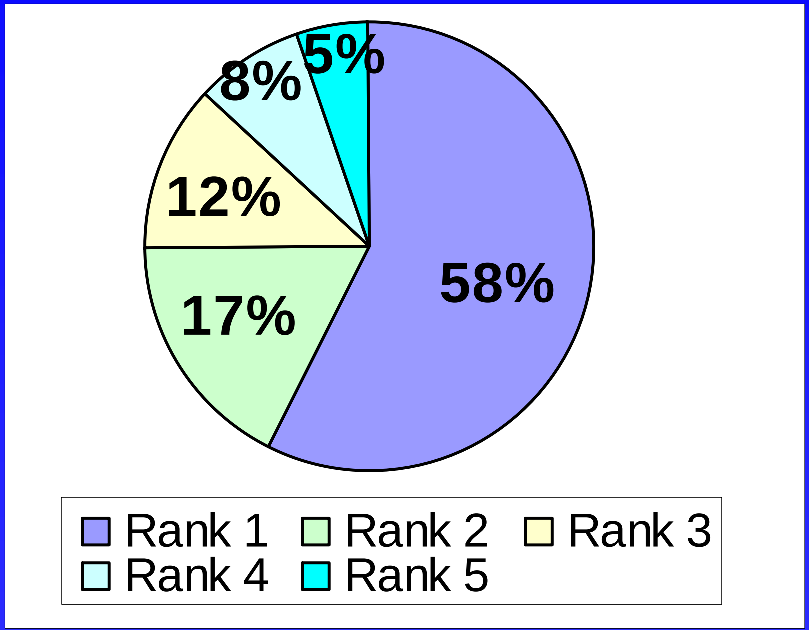
WHI=41~60: Rank 3

WHI=61~80: Rank 4

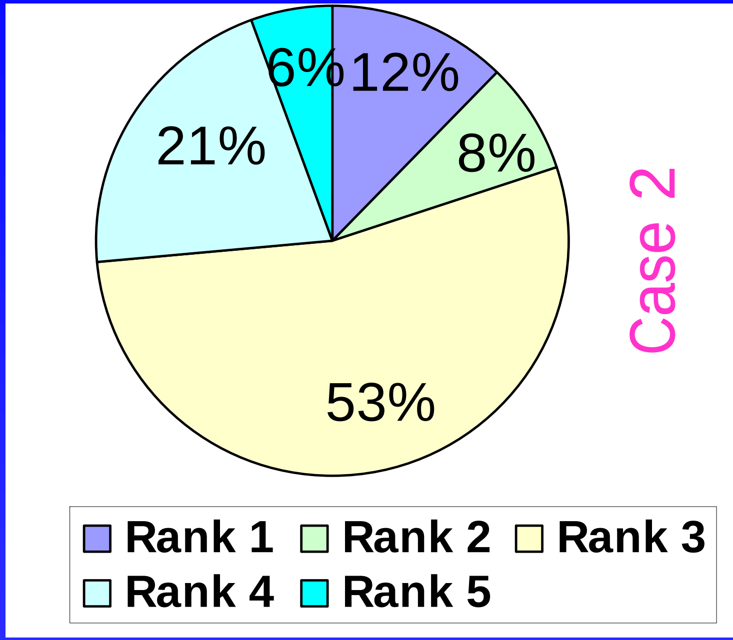
WHI=81~100: Rank 5

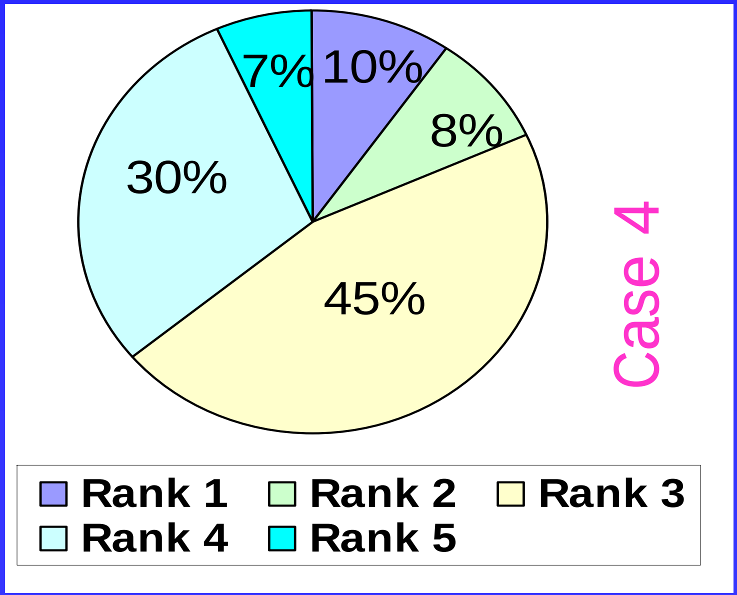

8%
15%
25%
52%
Case 1
Rank 2
Rank 3
Rank 4
Rank 5
6%
12%
8%
21%
53%
Case 2
Rank 1
Rank 2
Rank 3
Rank 4
Rank 5
9%
14%
16%
61%
Case 3
Rank 2
Rank 3
Rank 4
Rank 5
7%
10%
8%
30%
45%
Case 4
Rank 1
Rank 2
Rank 3
Rank 4
Rank 5

Comparison with Past Floods



Observed Damage Rank
(BUET, 1997)

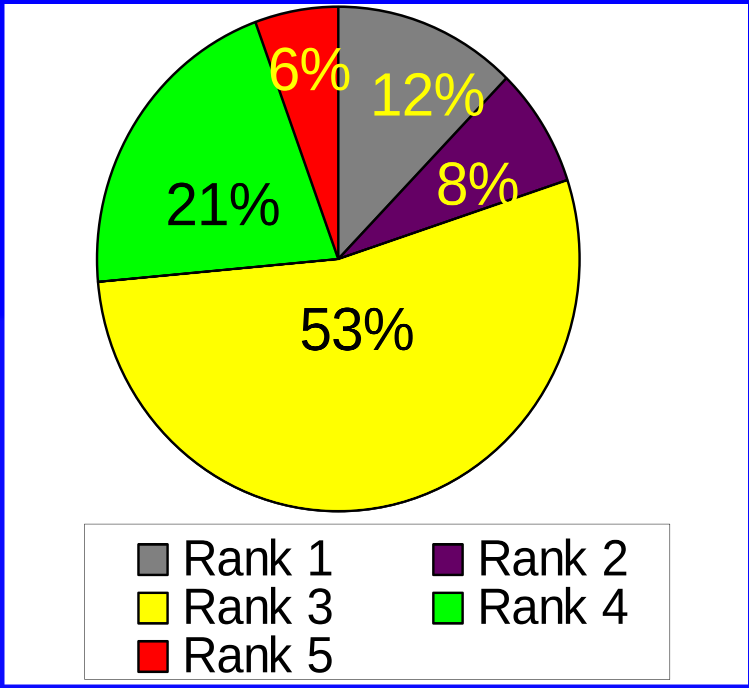




Selection criteria

- RMS value
- Consistency for higher ranks

Flood Hazard Map



Very high hazard: 2,384 km^2

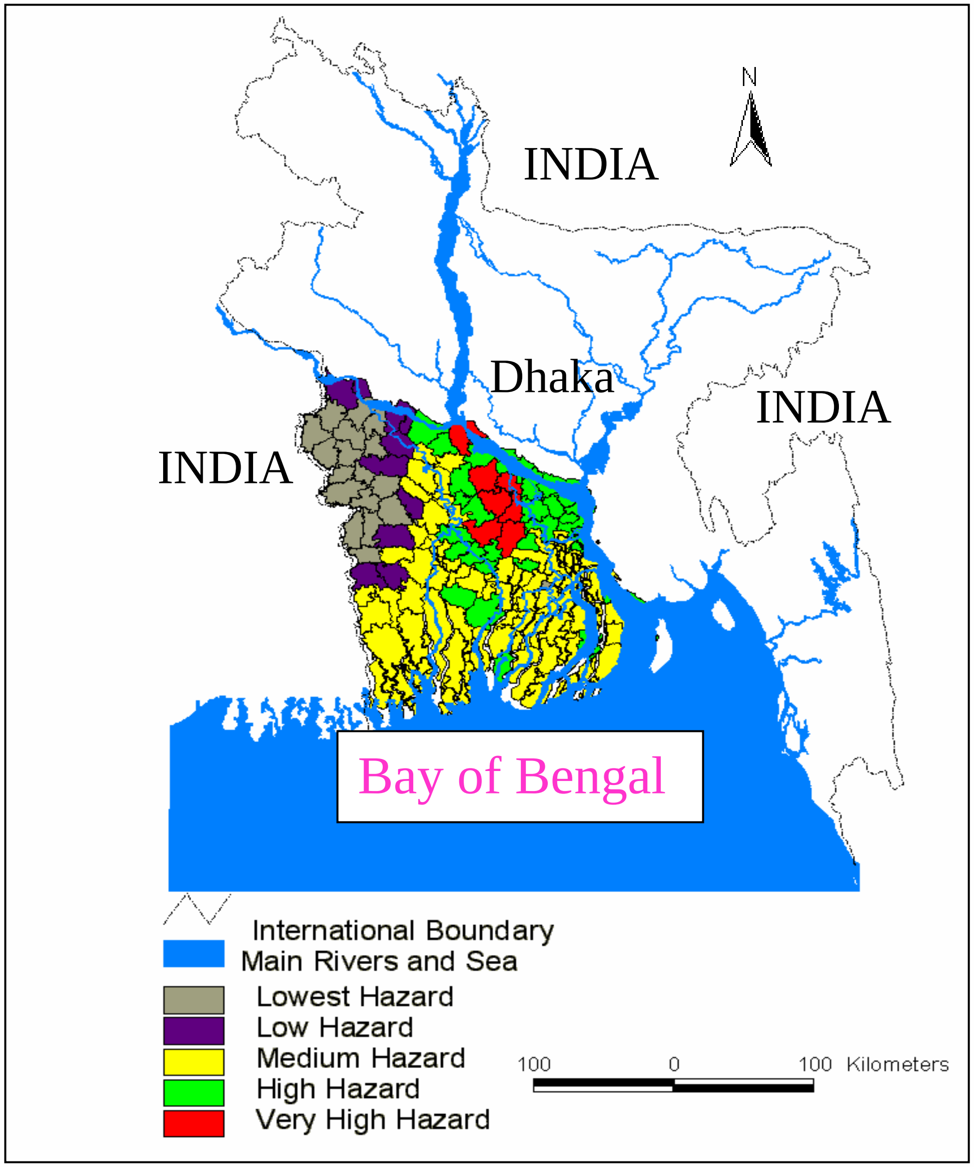
High Hazard: 8,856 km^2

Medium Hazard:22,864 km^2

Low hazard: 3,278 km^2

Lowest hazard: 5,194

Total Area: 42,577 km^2



Flood Risk Assessment

What is flood risk?

• Expected number of lives lost, person injured, damage to property and disruption of economic activity due to particular natural phenomenon

Elements at Risk?

• Population, infrastructures, economic activities, public services and utilities

Vulnerability?

• Degree of loss to a given element at risk or set of such elements resulting from the occurrence of a natural phenomenon

Method of Risk Zoning

$$Rt = \sum (E).(Rs)$$

$$Rs = (H).(V)$$

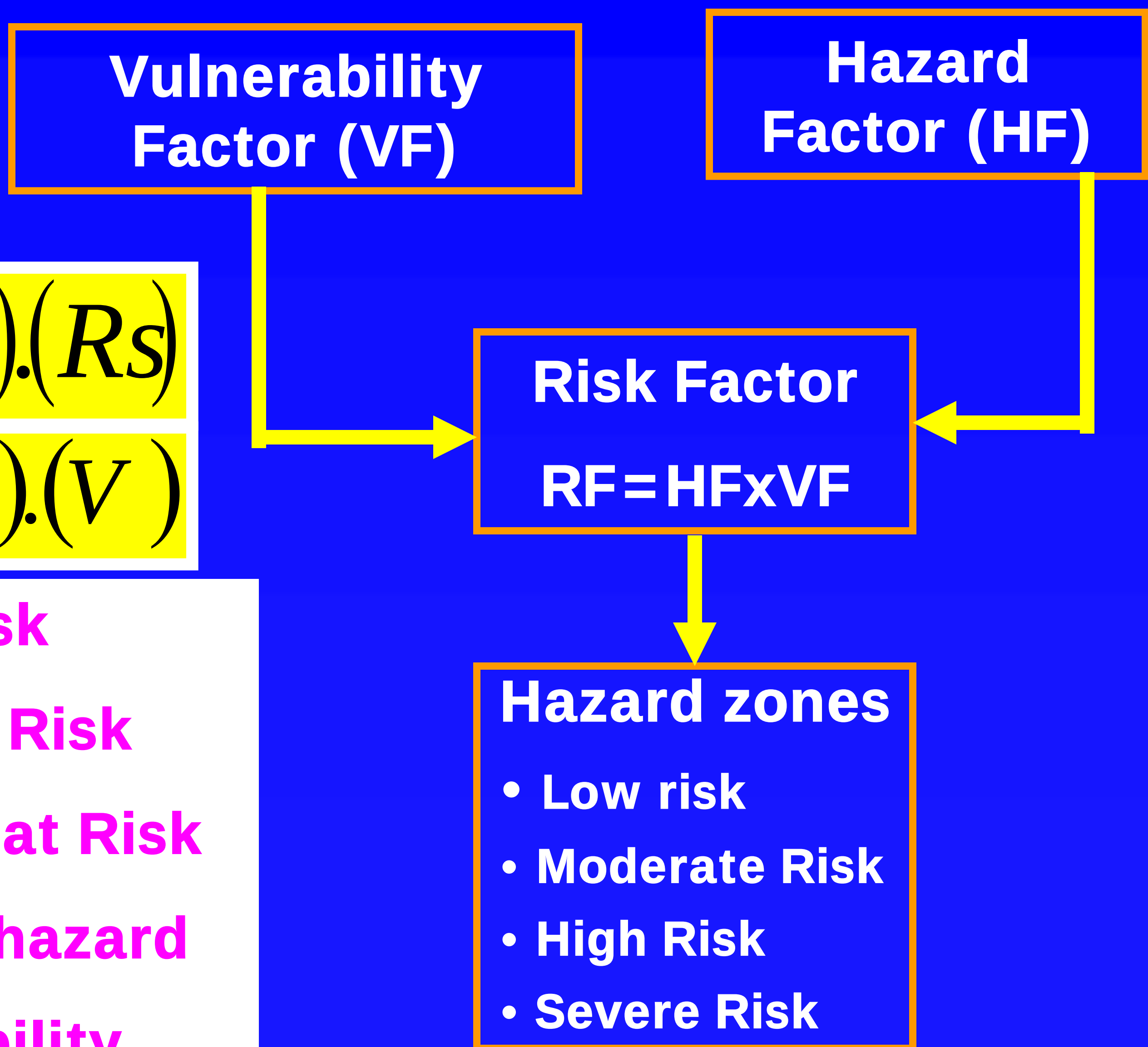
Rt **: Total Risk**

Rs **: Specific Risk**

E **: Element at Risk**

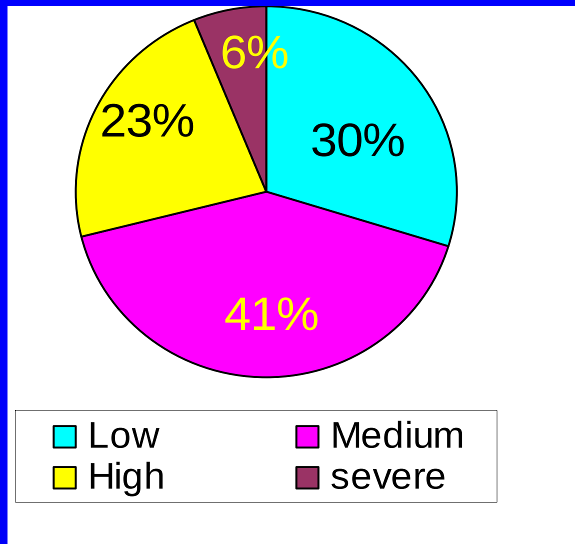
H **: Natural hazard**

V **: Vulnerability**

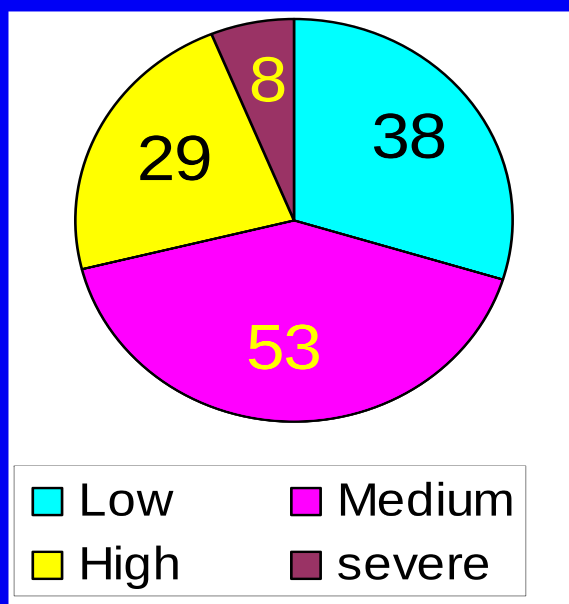


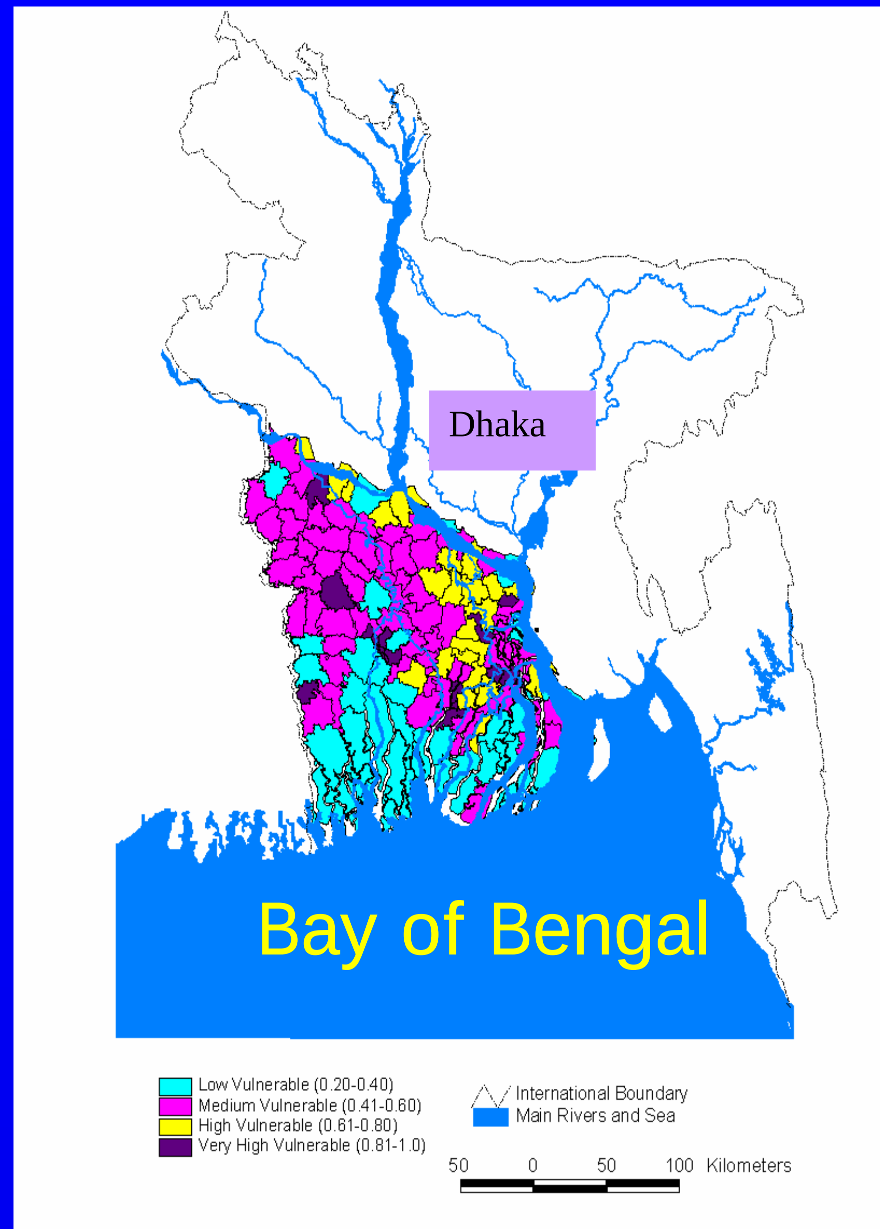
Risk-based Zoning Map

Land Area (%)



No. of Land Unit





Conclusions:

- A methodology is described for flood hazard assessment and risk analysis.
- Flooding depth and duration are the major factors for hazard.
- Land Areas with higher population density are under higher risk category though hazard rank is small
- The results provide considerable management implications for emergency preparedness including aid and relief operations.
- Residents of floodplain and concerned authorities (Government/NGOs) can share the information for adaptation and mitigation

THANK YOU FOR YOUR ATTENTION