GFDRR

Risk Assessment and Mitigation Training Workshop

Exercise 1:

Cyclones, storm surges, floods, landslides

NGI

26-30 September 2011

Introduction

- Cyclones and flood risk in Bangladesh (regional and local scale)

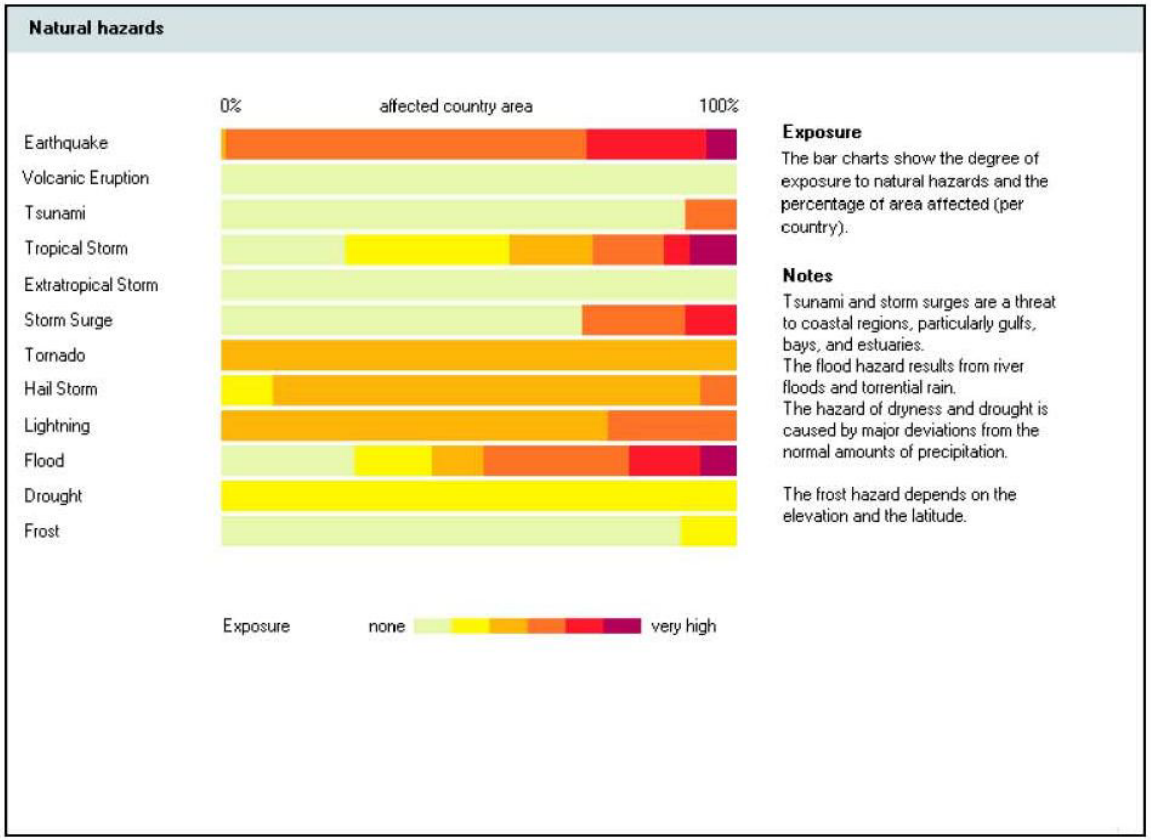
- Rainfall and Landslide in Bangladesh (regional and local scale)

Study area

- Bangladesh is almost every year affected by a natural disaster
- Coastal population over 1,000 persons per sq km
- Delta: high fertility and agricultural productivity

Source: Government of Bangladesh (2008): Cyclone Sidr in Bangladesh Damage, Loss and Needs Assessment For Disaster Recovery and Reconstruction

Natural hazard profile Bangladesh



Source: Munich RE (2009)

Cyclones – storm surges - flooding

Cylone disasters

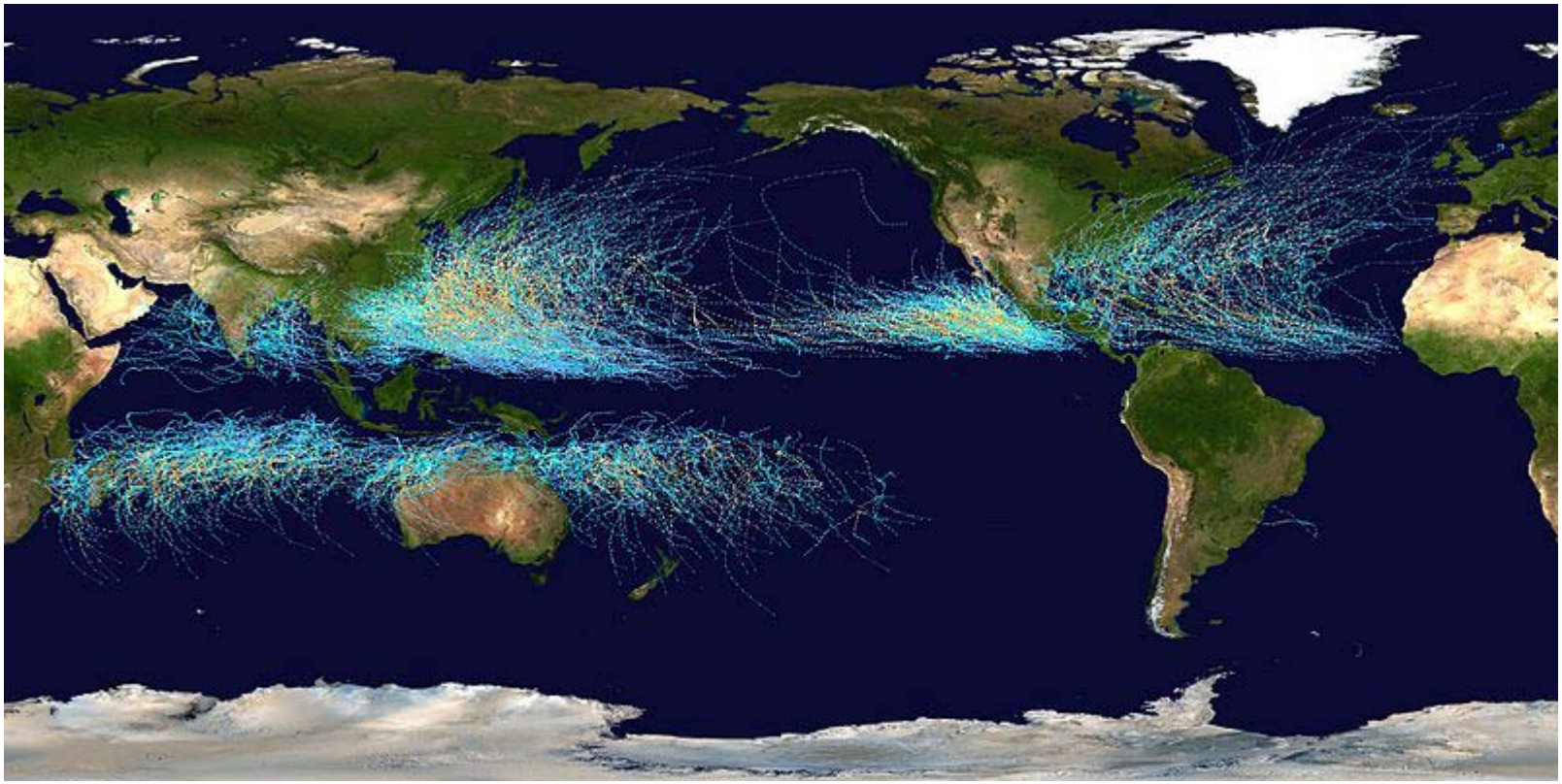
Table 4: Deaths Associated with Noteworthy Tropical Cyclones in the World

Year	Location	Deaths	Year	Location	Deaths	Year	Location	Deaths
1584	Bangladesh	200,000	1897	Bangladesh	175,000	1963	Bangladesh	11,520
1737	India	300,000	1900	Texas, USA	6,000	1963	Cuba-Haiti	7,196
1779	India	20,000	1906	Hong Kong	10,000	1965	Bangladesh	19,279
1780	Antilles	20,000	1912	Bangladesh	40,000	1965	Bangladesh	12,000
1822	Bangladesh	40,000	1919	Bangladesh	40,000	1970	Bangladesh	500,000
1833	India	50,000	1923	Japan	250,000	1971	India	10,000
1839	India	20,000	1937	Hong Kong	11,000	1977	India	10,000
1854	India	50,000	1941	Bangladesh	7,500	1985	Bangladesh	11,069
1864	India	50,000	1942	India	40,000	1988	Bangladesh	5,708
1876	Bangladesh	100,000	1960	Bangladesh	5,149	1989	India	20,000
1881	China	300,000	1960	Japan	5,000	1991	Bangladesh	138,000
1895	India	5,000	1961	Bangladesh	11,468			

Not the strongest but the deadliest tropical cyclone ever recorded

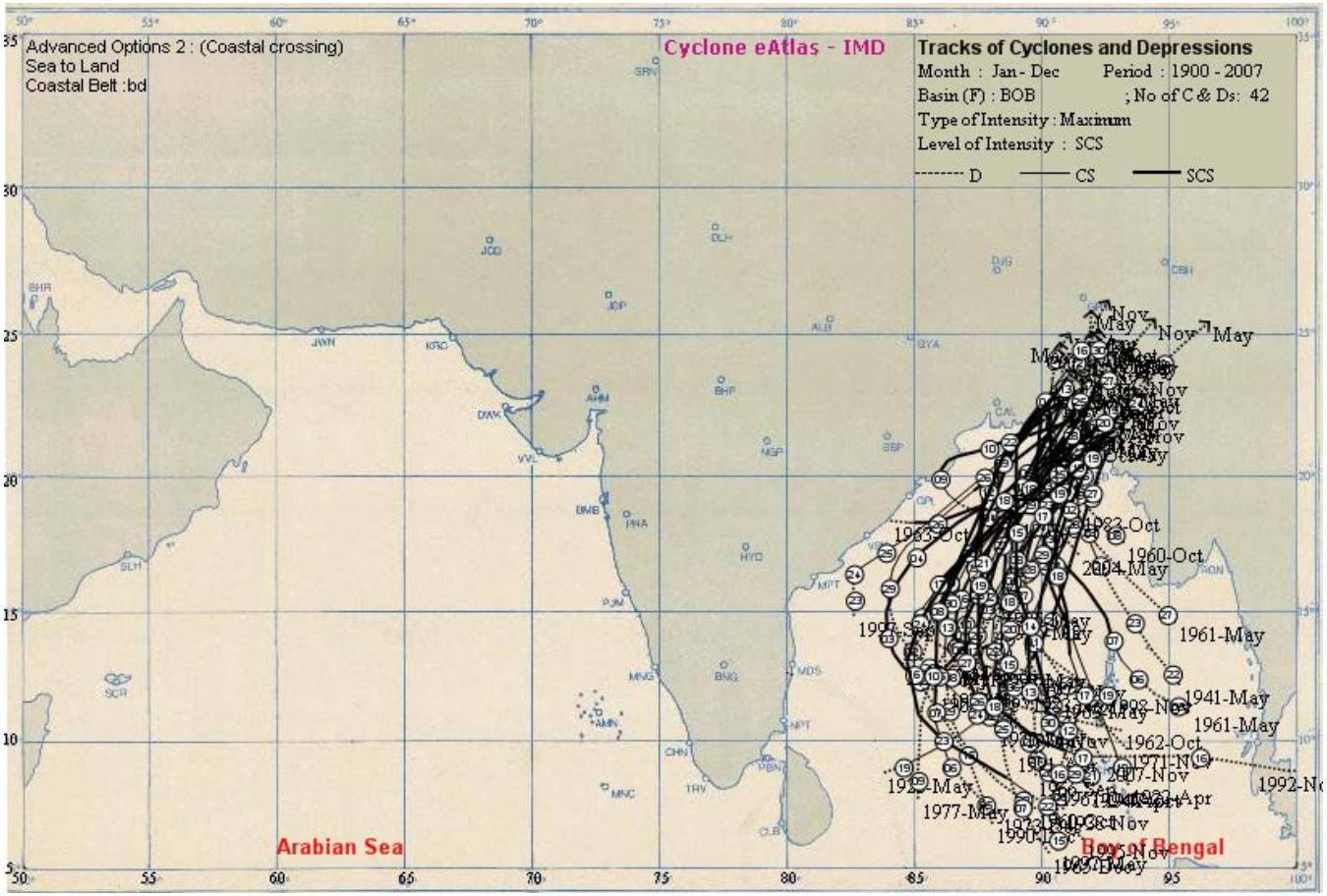
Source: Government of Bangladesh Assisted and GFDRR (2008): Cyclone Sidr in Bangladesh Damage, Loss and Needs Assessment For Disaster Recovery and Reconstruction

Global cyclone tracks



Source: Wikipedia

Cyclones in Bangladesh



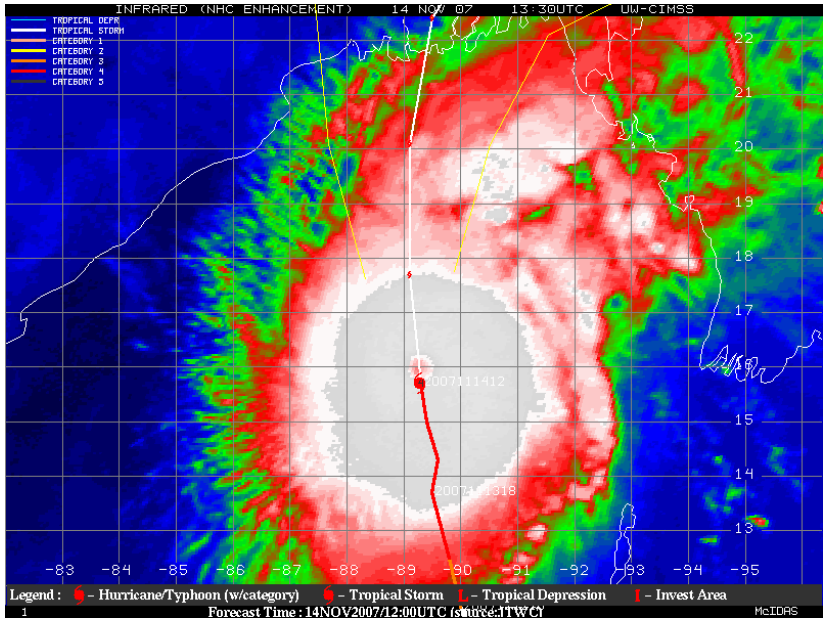
Tropical cyclone scale - IMD

Scale according to the Indian Meteorological Department

Types of Disturbances	Wind speed knots	Wind speed km/h
Depression	22 – 27	< 27
Deep depression	28 – 33	52– 61
Cyclonic storm	34 – 47	62 – 87
Severe Cyclonic storm	48 – 63	88 – 117
Veryu Severe Cyclonic storm	> 64	> 118-221
Super Cyclonic Storm	> 120	> 222

Cyclone Sidr 2007

- Category 5 cyclone (SSHS), very severe cyclonic storm (IMD), 2007
- Storm surges (3 -6 m), rainfall, winds up to 245 km/h
- 4,000 fatalities, 55,0000 injured, 2.3 million households affected
- More fatalities would have been expected, but: EWS, shelters, mangroves
- $ 1.7 billion USD

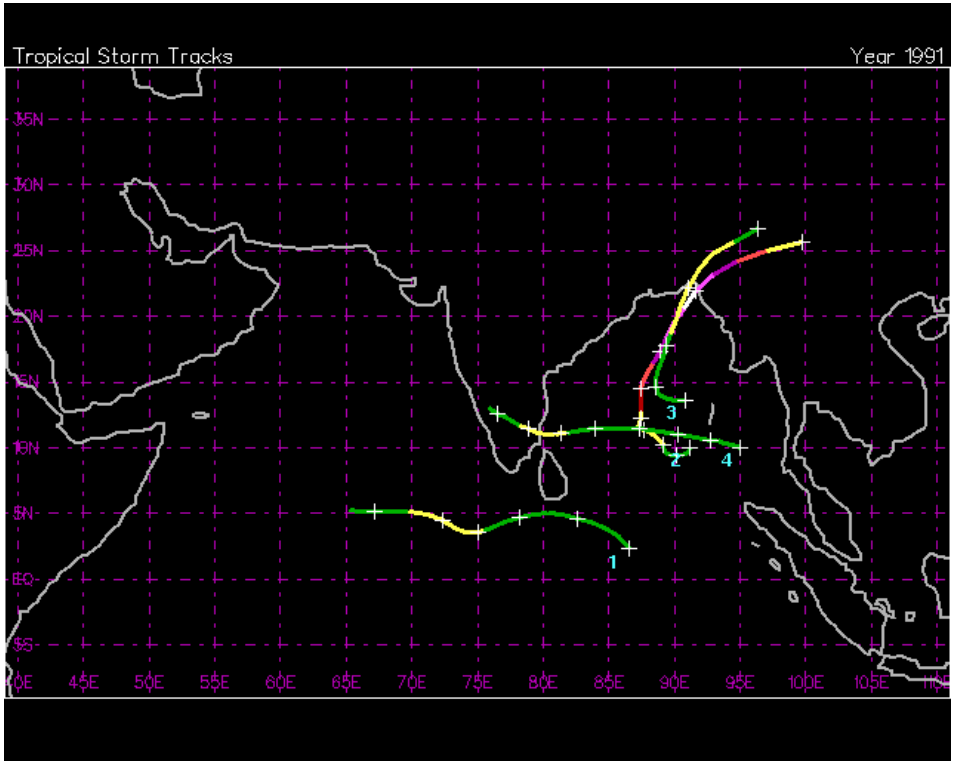


Source: Wikipedia

Source: Government of Bangladesh Assisted and GFDRR (2008): Cyclone Sidr in Bangladesh Damage, Loss and Needs Assessment For Disaster Recovery and Reconstruction

Cyclone BOB 01,1991

- 138.000 fatalities
- Maximum Wind speed: 160 km/h
- Category five (SSHS), Super cyclonic storm (IMD)
- Surge heights **Chittagong**: ~ 5 m above ground close to the shore
- Rainfall: ca 200 mm during landfall

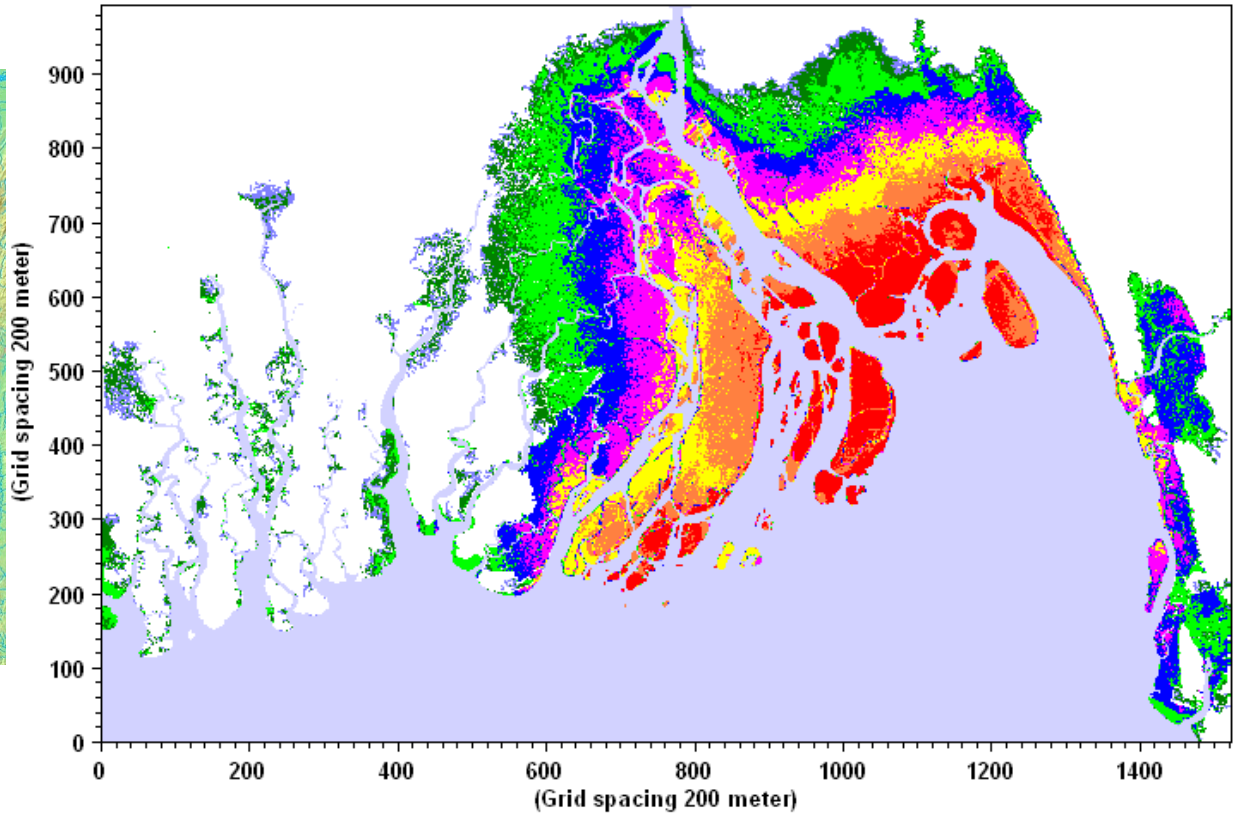


Source: http://weather.unisys.com

Cyclone BOB 01, 1991

Source: Wikimedia

Inundation 1970 cyclone



Source: Institute of Water Modelling, Bangladesh, 2009

Exposure to cyclones

- Large parts of the country are only very few meters above sea level
- One of the largest deltas in the world (Ganges-Brahmaputra- Meghna river system) - increased flood risk even far in the hinterland
- High exposure in the flood prone areas, due to fertile land -> high population density

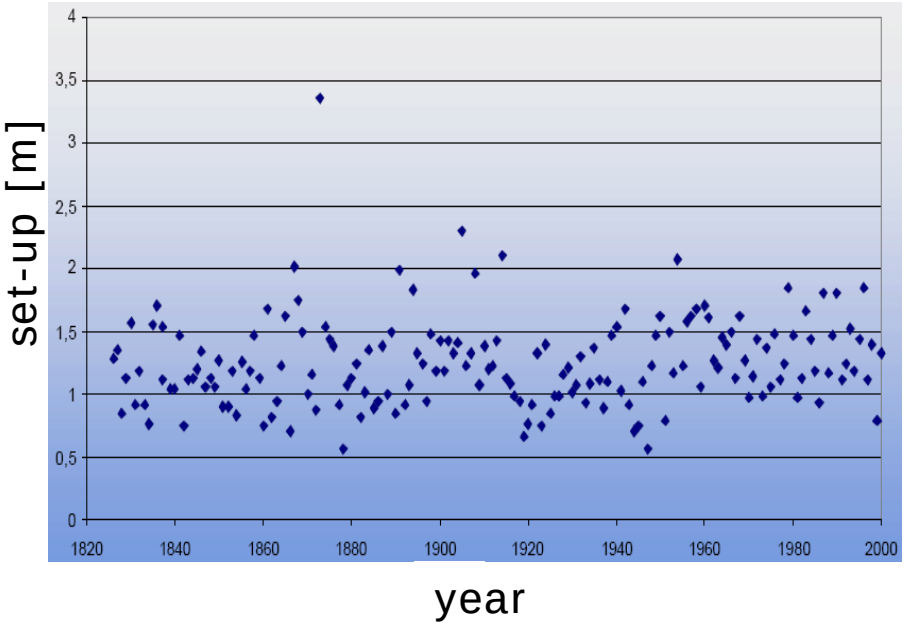
Risk assessment – flooding from cyclones

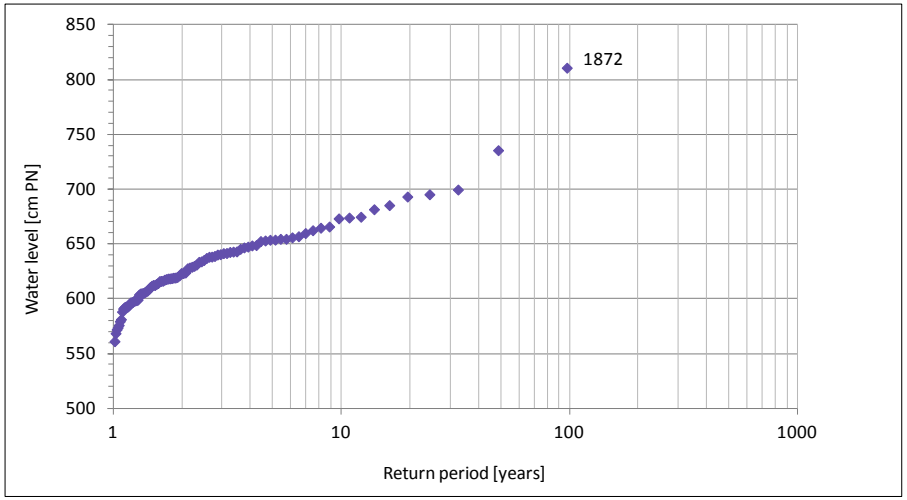
1. Wind intensities
2. Inundation modelling or mapping –> water depth and flow velocities, probability of scenario
3. Exposure analysis – people, assets, environment
4. Vulnerability assessment – which factors or conditions make the communities vulnerable
5. Probability * consequences = risk

Risk assessment - scales

Scale	Dimension – Data	Application
Global	Macro-scale Coarse resolution data sets (GRUMP, SRTM, etc.) fast and ”cheap” methods	Global risk studies Comparison of countries or regions International funding
Regional	Meso-scale medium resolution data sets for regions, settlement structures, population data	Transnational management
Local	Micro-scale Object-based studies high resolution data, detailed information on values and people	Local flood risk maps, evacuation planning, single protection measures

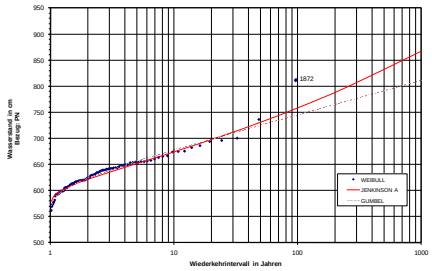
Hazard analysis
Calculation of the return period



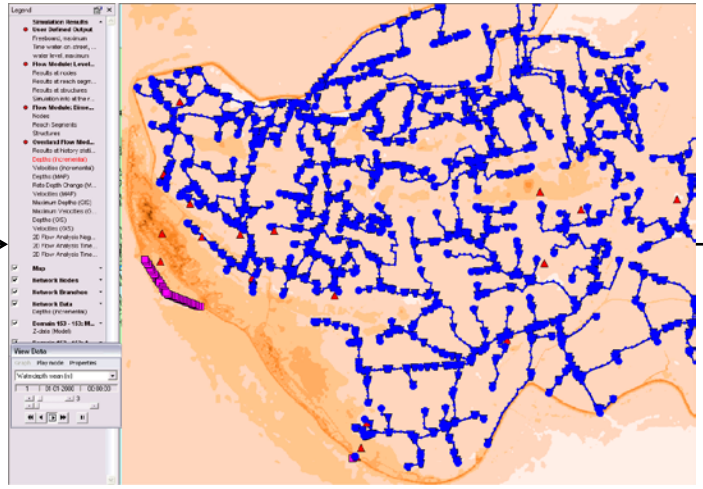


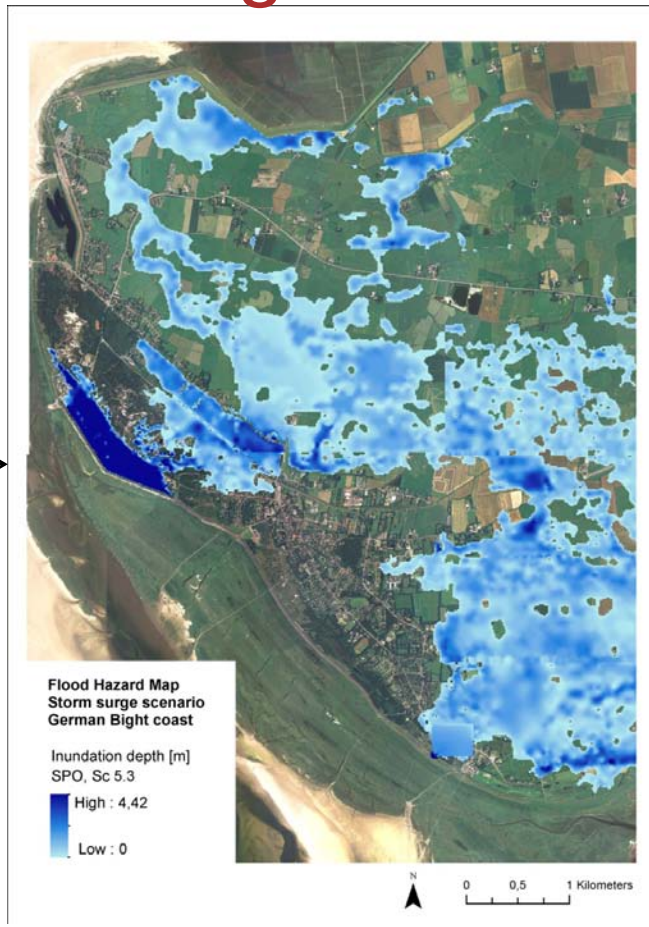
Hazard map – storm surge modeling

Scenario



Inundation modeling





Hazard map

Exposure

- people
- buildings
- harbors, airports, roads, companies/industry
- critical infrastructure (hospitals, schools, etc.)
- ecosystems

Vulnerability criteria

People *(loss of life models, depending on social characteristics)*

- e.g. demography (age, poverty, education, etc.)

Assets, buildings, infrastructure

e.g.

- building material
- insurance
- dependencies

Environment

e.g

- Environmental degradation
- Recovery potential

Risk management

Many capacity building and disaster mitigation programmes in place, e.g.:

- Multipurpose Cyclone Shelter Program
- Bangladesh Urban Disaster Mitigation Program (BUDMP)/ADPC/USAID/OFDA/CARE
- Storm Warning Center
- Reforestation

Cyclones, storm surges, floods, landslides

Group 1:	Scenario: *Cyclone -> storm surge, flooding –> cascading effects* Scale: regional
Group 2:	Scenario: *Cyclone -> storm surge, flooding –> cascading effects* Scale: local
Group 3:	Scenario: *Monsoon -> rainfall -> flooding -> landslides -> cascading effects* Scale: regional
Group 4:	Scenario: *Monsoon -> rainfall -> flooding -> landslides -> cascading effects* Scale: local

Group 1

Group 1: Cyclone – regional (national) scale, Bangladesh

Group 2: Cyclone – local scale, City of Chittagong

1. Return period and impacts?
2. Exposure?
3. Vulnerability?
4. Short- and long-term impacts, cascading effect?
5. Risk mitigation?

GFDRR

Risk Assessment and Mitigation
Training Workshop

Precipitation-induced landslides: introduction to exercise

Dr. José Cepeda DIC MSc PhD

NGI

26-30
September
2011

Importance of rainfall-induced landslides

Significant in total number of landslides:

~ 80%

Numerous transform in debris flows:

~ 90%

Debris flows:

Long runout distances: several kilometres

High velocities: > 18 km/h, but often > 100 km/h

www.unicaen.fr

www.usgs.gov

Landslides

Landslide types based on material and movement (most common are named)

Type of movement → Material ↓	Fall	Topple	Slide	Spread	Flow
• Rock	Rock fall	Rock topple	Rock slide		Rock flow (*rock avalanche*)
• Soil			Soil slide	Soil spread	Soil flow
Earth			Earth slide		Earth flow
Debris			Debris slide		Debris flow

What happens after a landslide is initiated?

www.usgs.gov

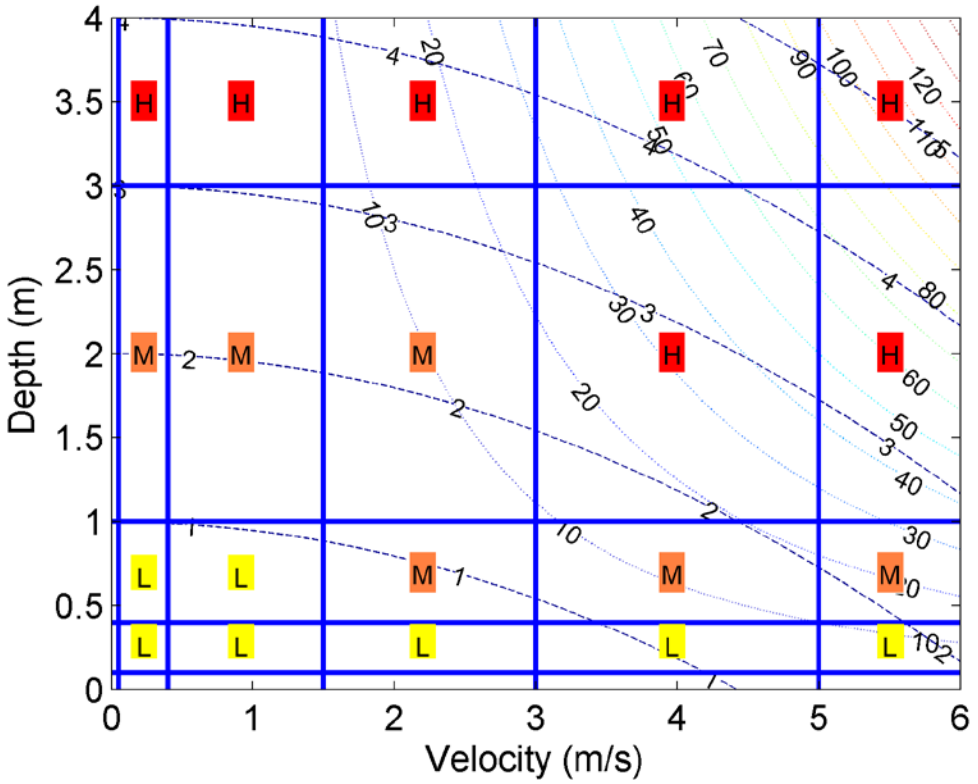
Casita landslide (Nicaragua, 1998): 2500 people killed 6 km away from release area

- Characteristics of landslide propagation:
  - Maximum distance (runout distance)
  - Thickness or depth
  - Velocity
- Landslide intensity (potential for destructiveness) is directly related to propagation characteristics.

Landslide intensity

The spatial distribution of:

- velocity of sliding coupled with slide volume, or
- kinetic energy of the landslide, or
- total displacement.



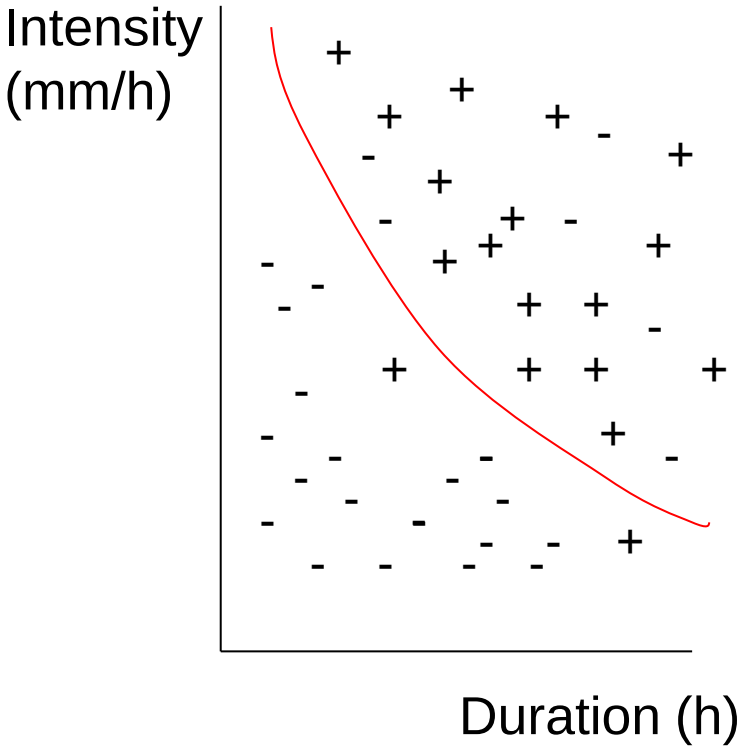
Intensity ➔

H	High
M	Medium
L	Low

Susceptibility factors

- Slope (+): steeper slopes, higher susceptibility.
- Geology (-): lower resistance of geological materials, higher susceptibility.
- Ground water (+): higher moisture and water pressures, higher susceptibility

Triggering factors: precipitation



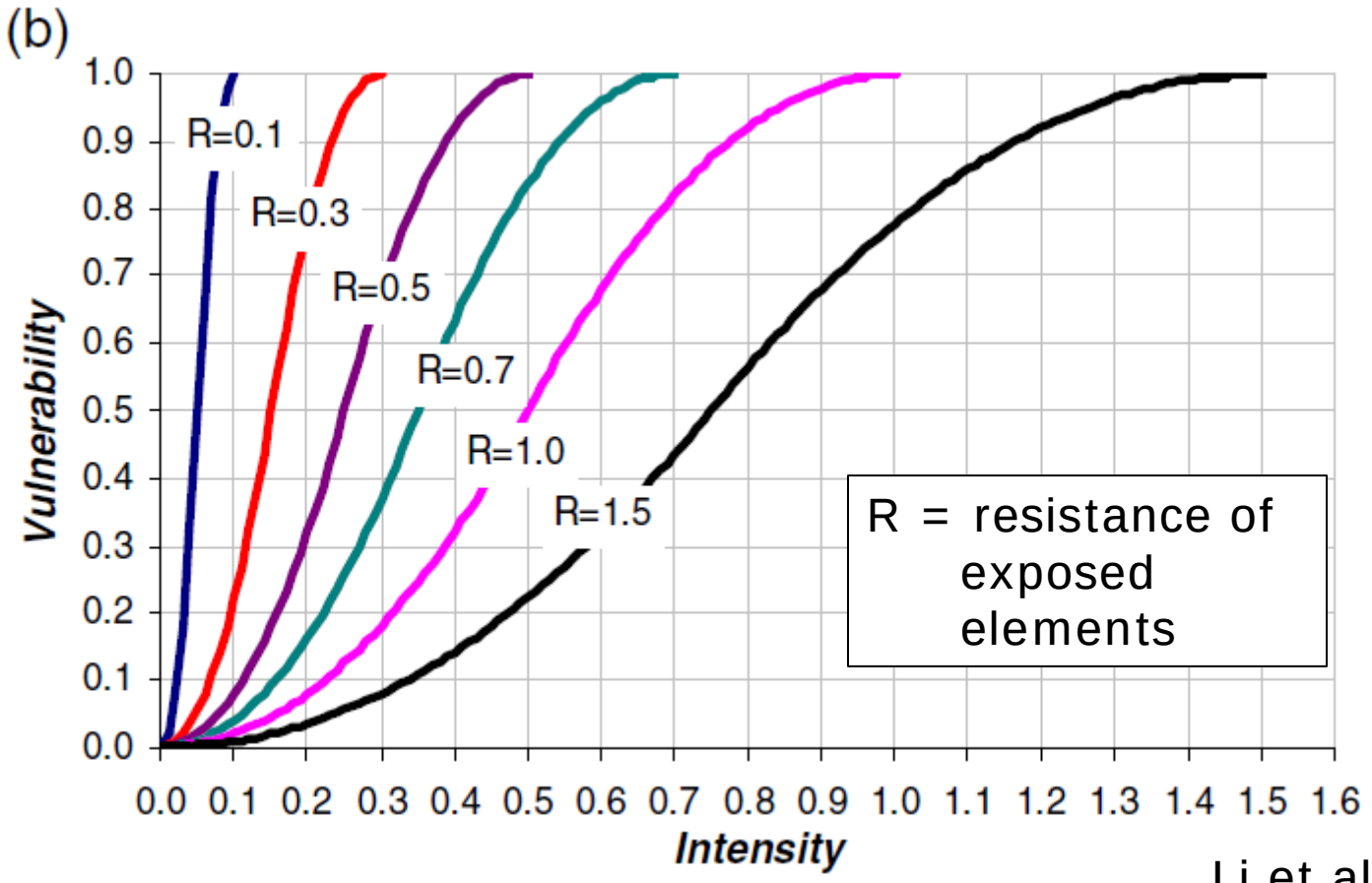
Rainfall threshold for landslide triggering

Boundary curve or surface separating triggering and non-triggering rainfall events.

Global catalogue of precipitation thresholds:

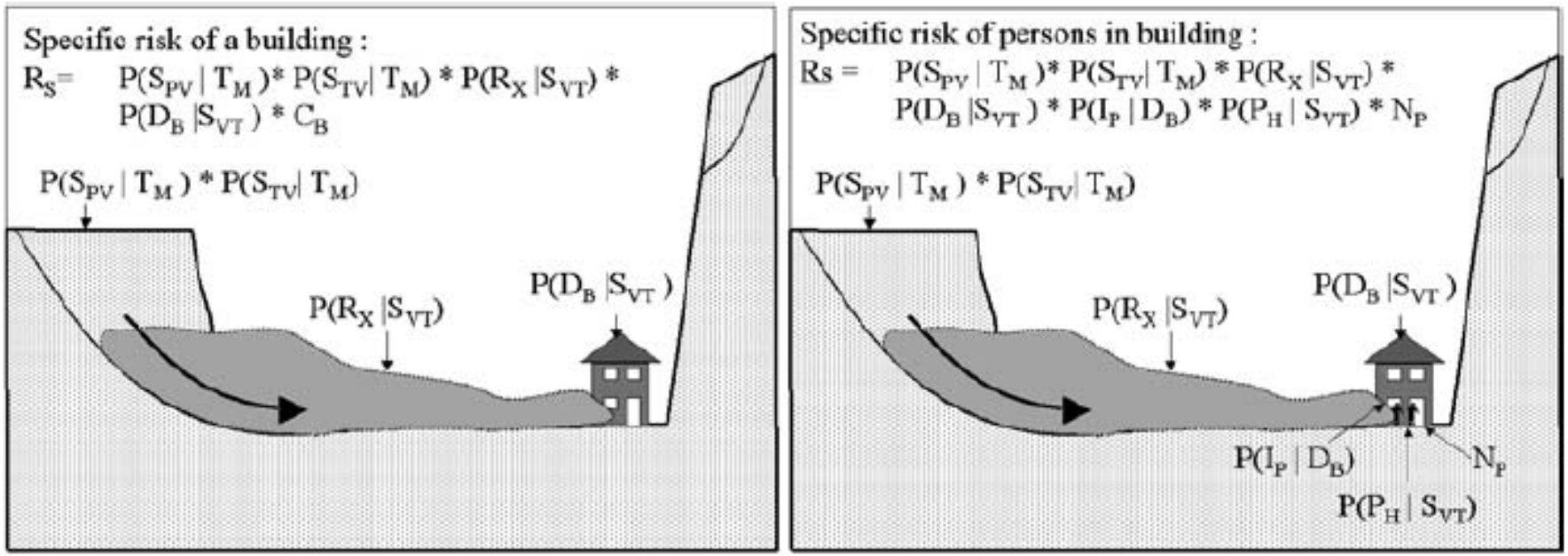
http://rainfallthresholds.irpi.cnr.it/

Vulnerability curves



Li et al. (2010)

Risk assessment



Van Westen et al. (2006)

Landslide risk reduction - some relevant aspects

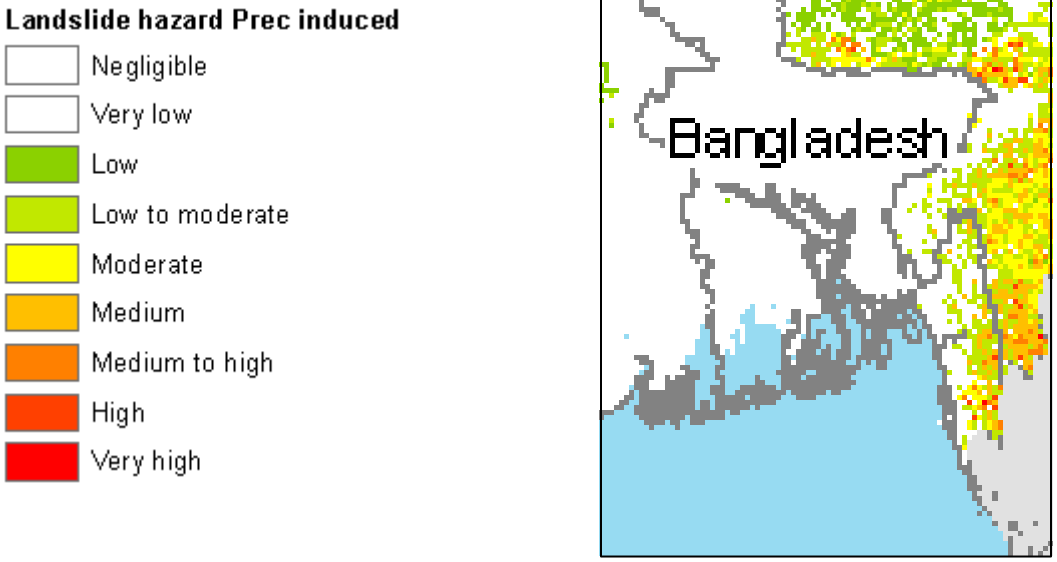
- When preventing landslide initiation (or reducing mobilisation) is feasible:
  - Slope stabilisation measures (increasing Factor of Safety to a minimum level, usually specified by building codes or country/regional guidelines)

- When preventing landslide is not feasible:
  - Deviate landslide path or trajectory away from exposed elements
  - Timely evacuation of exposed population (need for an Early Warning System, EWS)

Case study: regional

- Based on landslide hazard assesment for Bangladesh.
- Discussions on the different factors that contribute to susceptibility, hazard, exposure and risk.
- Risk-based decisions for location of new critical facilities and for changes in population exposure.
- Material (to be distributed in A4 and A3 sheets):
  - List of aspects for discussion.
  - Slope, lithology, precipitation and hazard maps.
  - Population and exposure maps.

Case study: regional



Case study: local

- Discussion on vulnerability maps in a town potentially affected by precipitation-triggered debris flows having high mobility.
- Material (to be distributed separatealy in A4 sheets):
  - List of aspects for discussion.
  - Hazard maps.
  - Vulnerability curves.
  - Vulnerability maps.

Group building

- Prepare a presentation for Thursday
- 10 min per group
- Present and discuss the outcomes of the exercise