ISSUES AND STRATEGIES FOR CLIMATE CHANGE ADAPTATION IN COASTAL AREAS OF BANGLADESH

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INTRODUCTION

Bangladesh is a disaster prone country that is affected almost every year by some form of natural disaster, be it floods, torrential rains, erosion, or cyclones. Of the 508 cyclones that have originated in the Bay of Bengal in the last 100 years, 17 percent have hit Bangladesh, amounting to a severe cyclone almost once every three years. Of these, nearly fifty three percent have claimed more than five thousand lives.

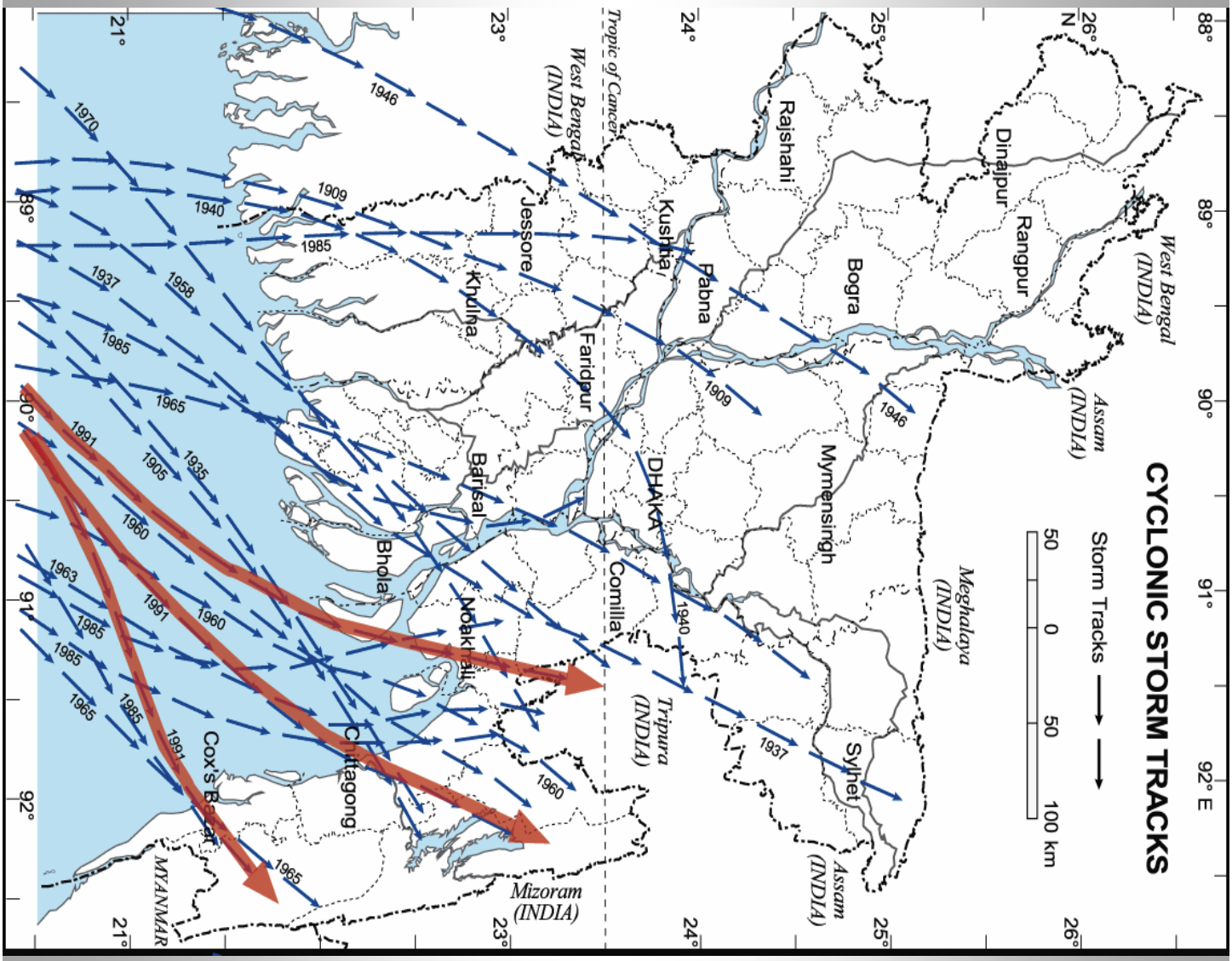
CYCLONE RECORDS AND AFFECTS

Name	Year	Wind speed (km/hr)	Surge height (m)	Death	Other loss
	29-30 Apr, 1991	240	8	150000	70000 cattle, loss of property was estimated at about Tk 60 billion.
	29-3 May, 1994	210		400	8000 cattle
	21-25 Nov, 1995	210		650	17000 cattle
	16-19 May, 1997	225	3.05	126	
	25-27 Sep, 1997	150	2.44	70	
	19-22 Nov, 1998	90	2.44		
Akash	12-15 May, 2007	37	3	53	205 houses and left an additional 845 damaged,including 2 ha (4.9 acres) of destroyed lands of shrimp farms
Sidr	11-16 Nov, 2007	260	5	3363	$450 million (2007 USD)
Bijli	14-17 Apr, 2009	75	3	4	
Aila	23-26 May, 2009	110	3	179	500 fishermen had gone missing since the storm made landfall, 58,950 animals were killed by the storm with up to 50,000 deer missing

OBSERVATIONS FROM PREVIOUS RECORDS

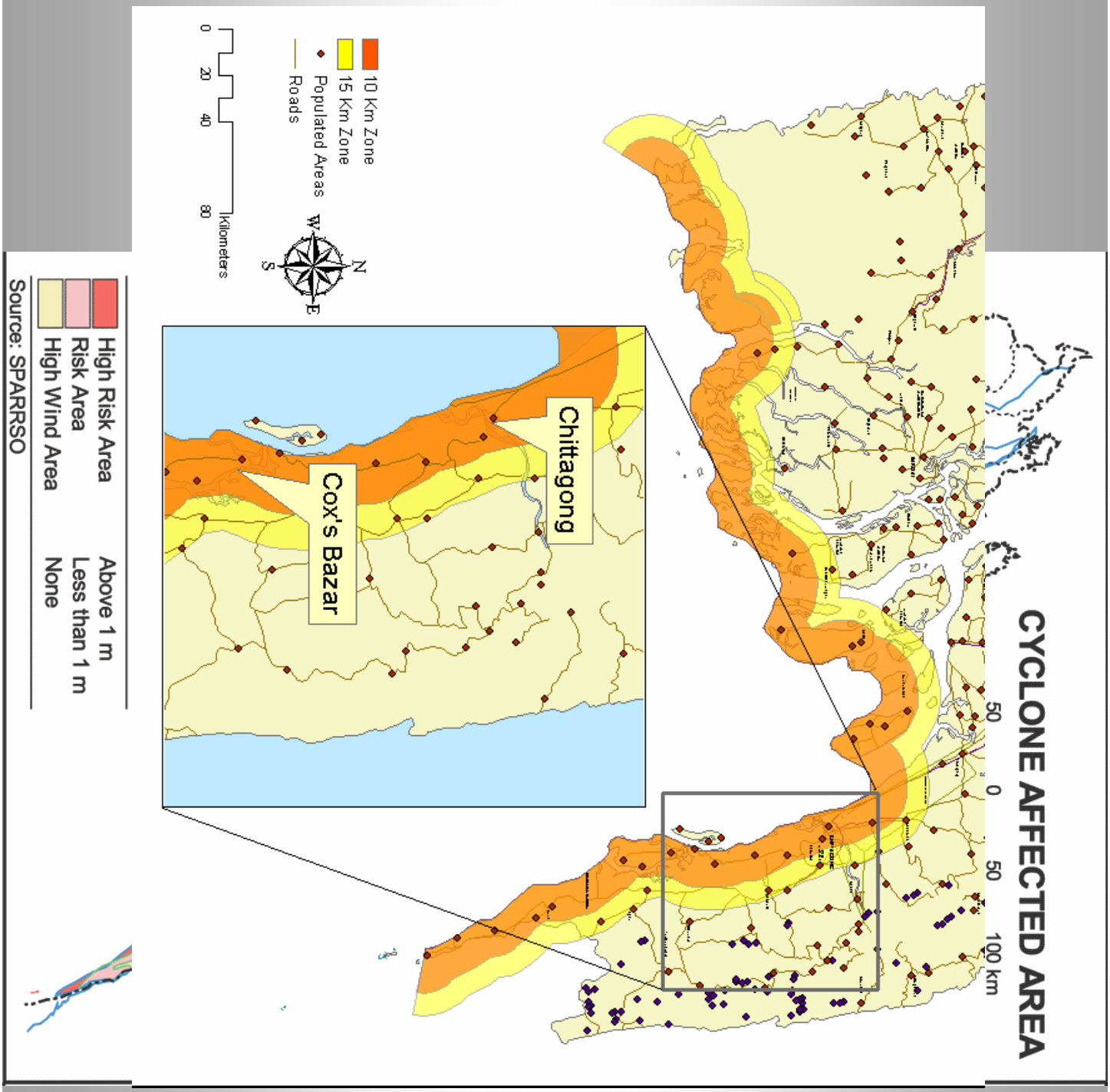
- **Number of occurrences of major cyclones has drastically increased**
- **Number of cyclones was**
  - **3 during the period of 1795-1845 and 1846-1896 respectively**
  - **13 during 1897-1947**
  - **51 during the period of 1848-1998.**

CYCLONE STORM TRACKS

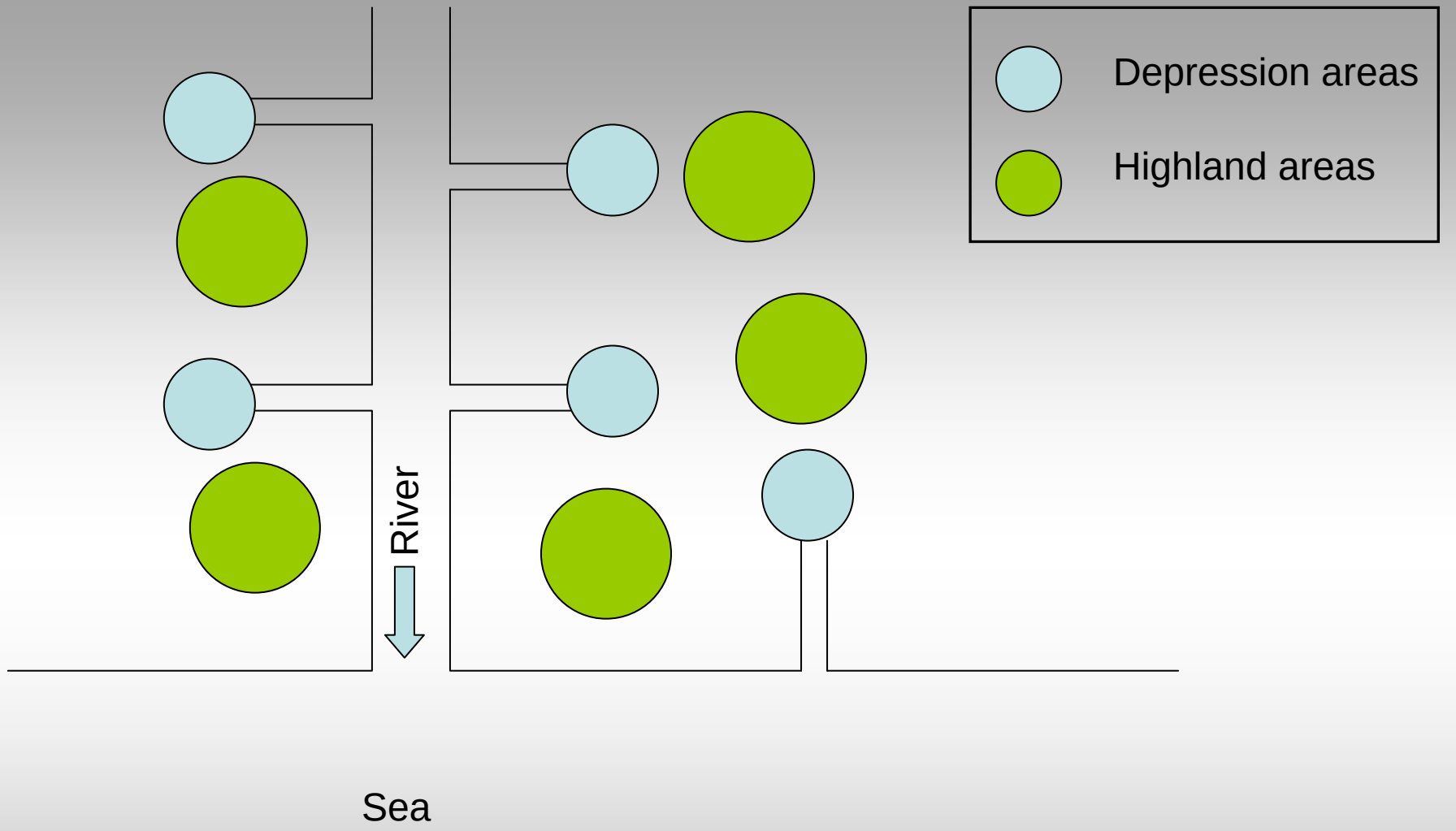


http://www.uwec.edu/jolhm/EH2/Molnar/path.htm

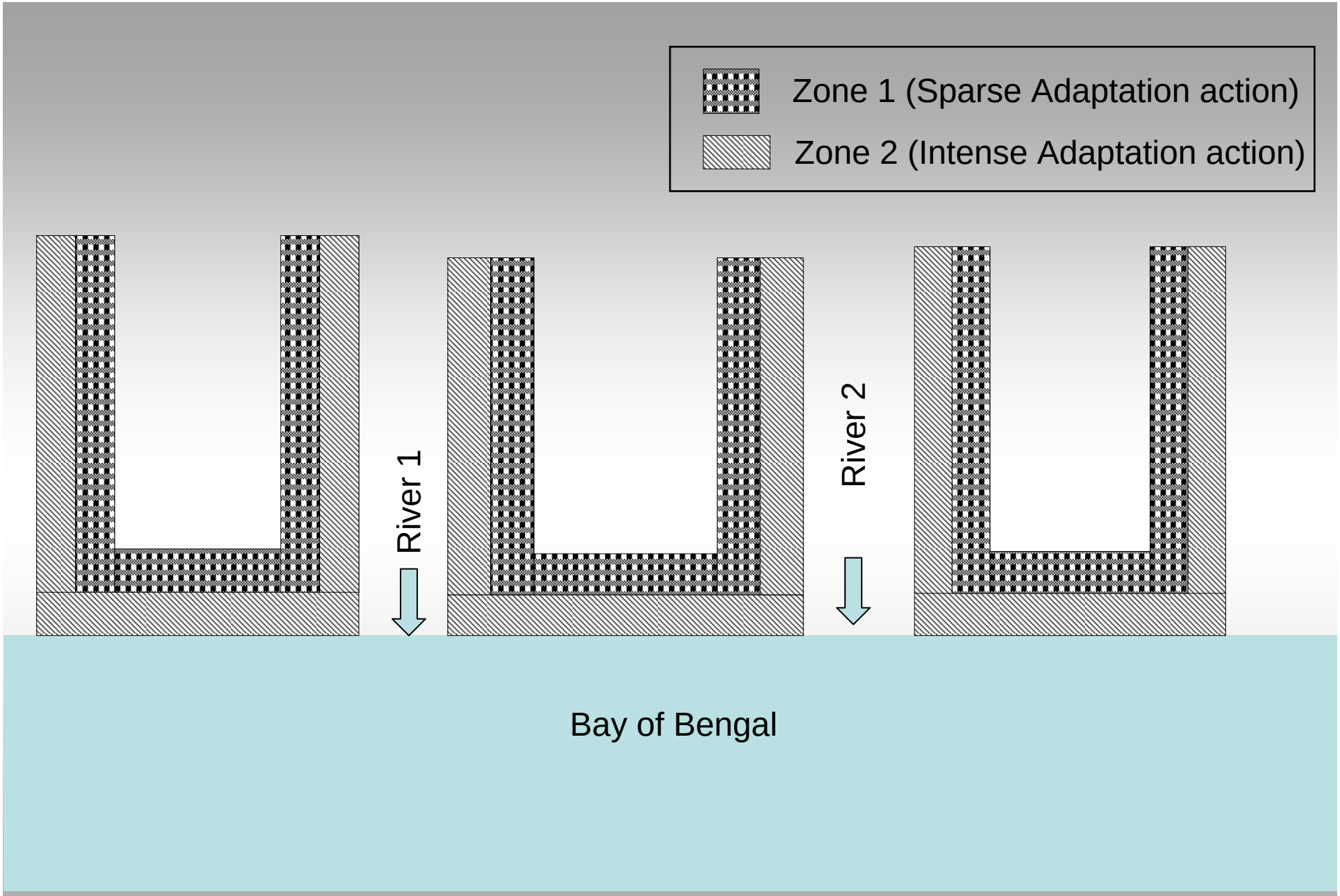
MOST VULNERABLE AREAS



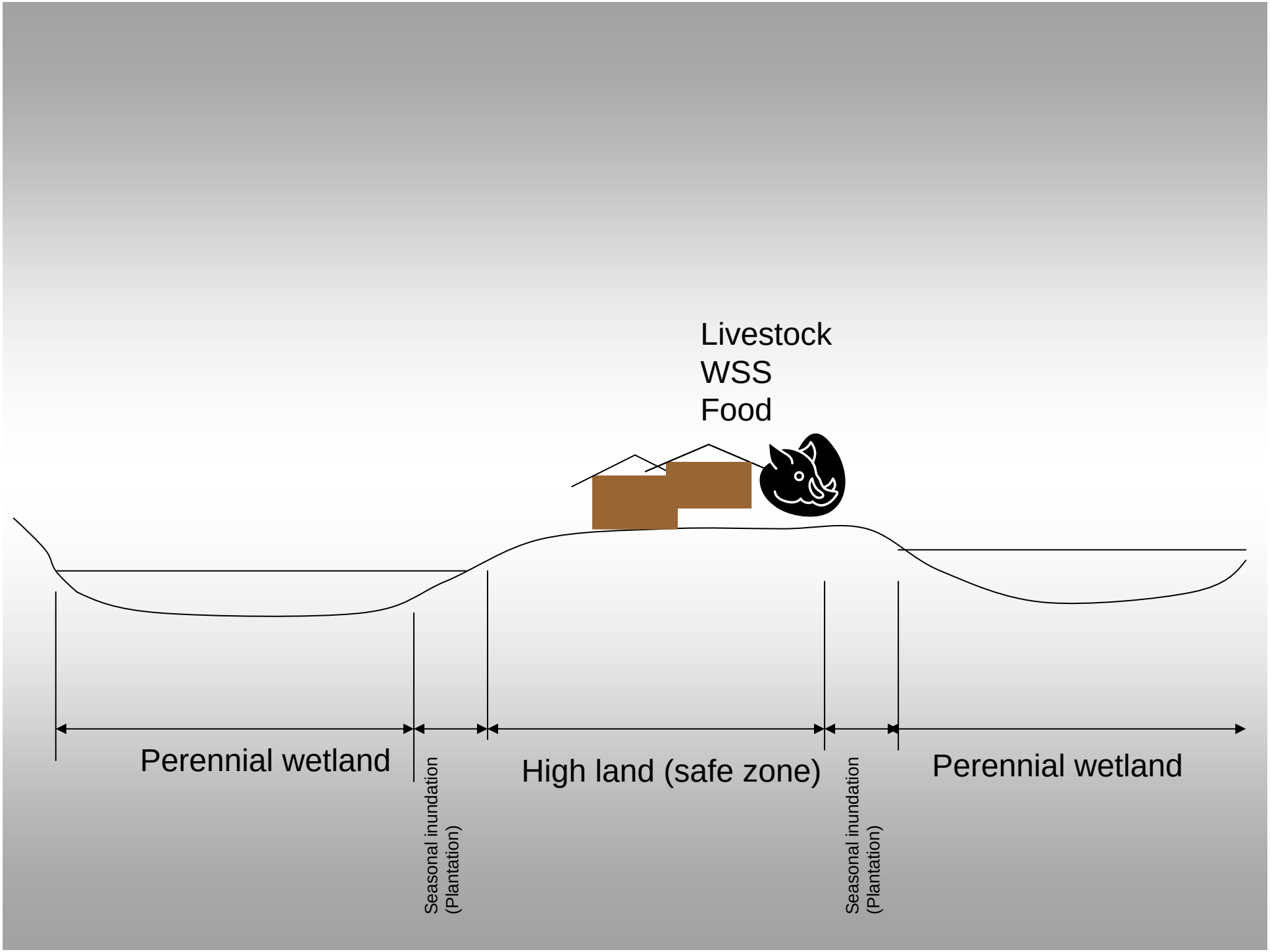
http://www.uwec.edu/jolhm/EH2/Molnar/map.htm



PLAN VIEW OF THE AREA UNDER ADAPTATION



PRIORITY OF AREA UNDER ADAPTATION


Livestock
WSS
Food
Perennial wetland
Seasonal inundation (Plantation)
High land (safe zone)
Seasonal inundation (Plantation)
Perennial wetland

OPTIONS OF LANDSCAPE

- **Wetlands**
- **Forests**

} **Multi-Species Shelterbelts**

- **Embankment/ Stabilized elevated land**
- **Floodplains**

WHY LANDSCAPING?

- For energy dissipation
- Surge height reduction
- Minimization of erosion, mudslides and flooding
- Protection against Wind and Salt Spray
- Attenuation of distress, damage and death

EFFECTIVENESS OF WETLAND

- Seaward wetlands absorb incoming wave energy,
- provide protection of roots of trees reducing land erosion.
- Inland wetlands function like natural tubs, store flood waters that over-flood riverbanks and surface areas.
- A one-acre wetland can typically store about three-acre feet of water, or one million gallons
- Act as primary coastal barrier, increase roughness and capture sea spray

EFFECTIVENESS OF FOREST

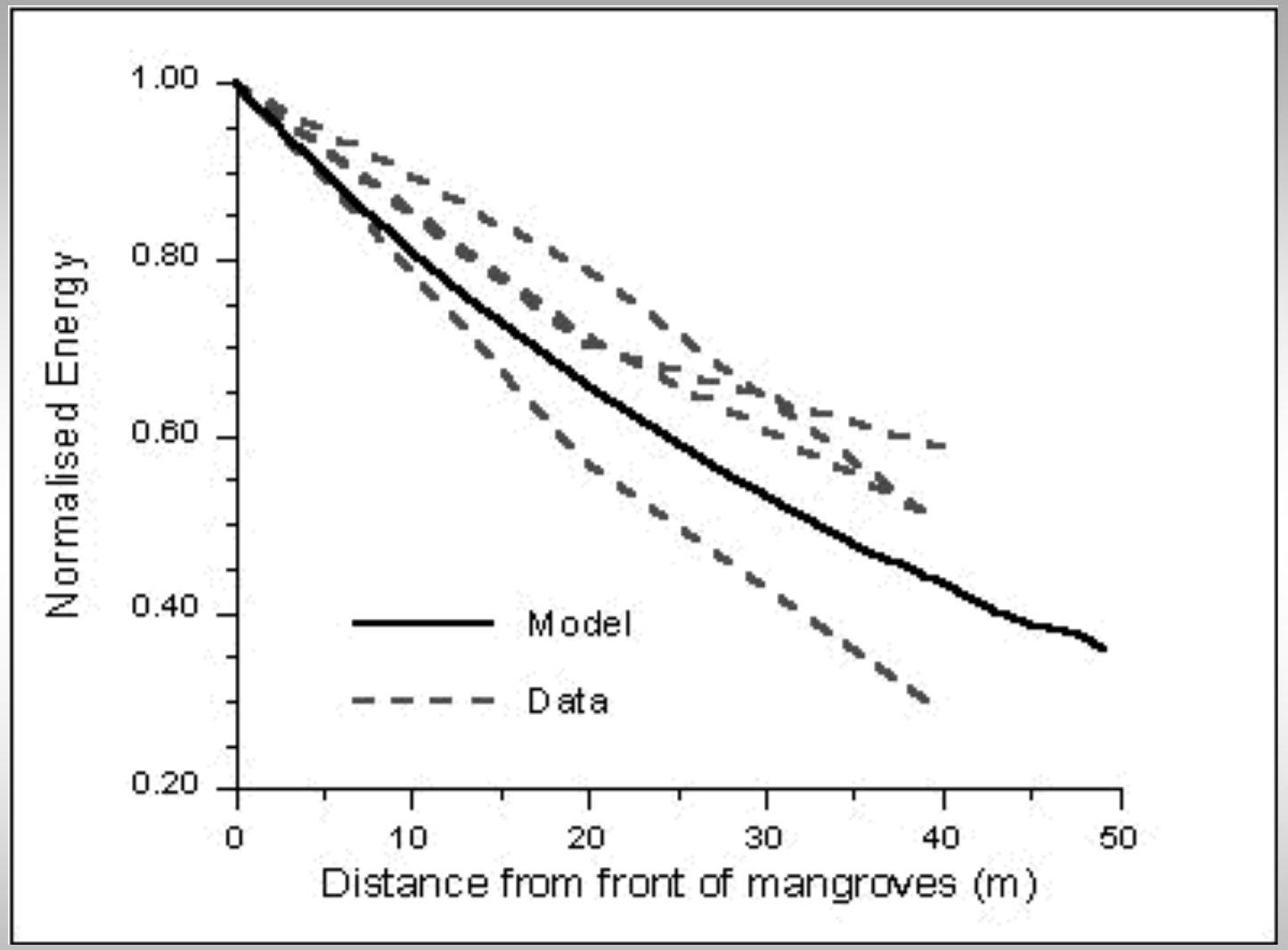
- **Mangroves trap and stabilize sediment and reduce the risk of shoreline erosion**
- **Typically, wave energy is attenuated by a factor of 2 within 50 meters of the front of the mangrove forest.**
- **Deflection of wind direction and wind speed reduction**
- **Stabilization of soil**
- **Act as protective shade of house and other structures**

CASE STUDY

Variables	*Description*	*Villages*		
		Singdi	*Bankual*	*Bandhamal*
DR	Damage to houses (0–19 scale)	9.40	5.34	10.44
PTD	Tree damage (%)	21.0	3.3	15.5
DPP	Damage to other personal property (INR)	108.11	0.00	2375.00
DL	Damage to livestock in money terms (INR)	54.05	127.63	1044.37
FP	Flooding in premises (m)	0.34	0.29	0.58
FF	Flooding in fields (m)	1.99	1.09	1.39
WLF	Water logging in fields (days)	9.46	5.63	12.87
CR	Cost of repair and reconstruction (INR)	996.97	682.86	973.21
Y99	Yield for the year 1999 (kg ha^{-1})	531	1479.5	335.9
LFS	Loss of fish seedlings (fingerlings) released prior to cyclone (INR)	310.81	69.74	260.94
TML	Total quantifiable variables (INR)	1983.3	61454.13	6918.62

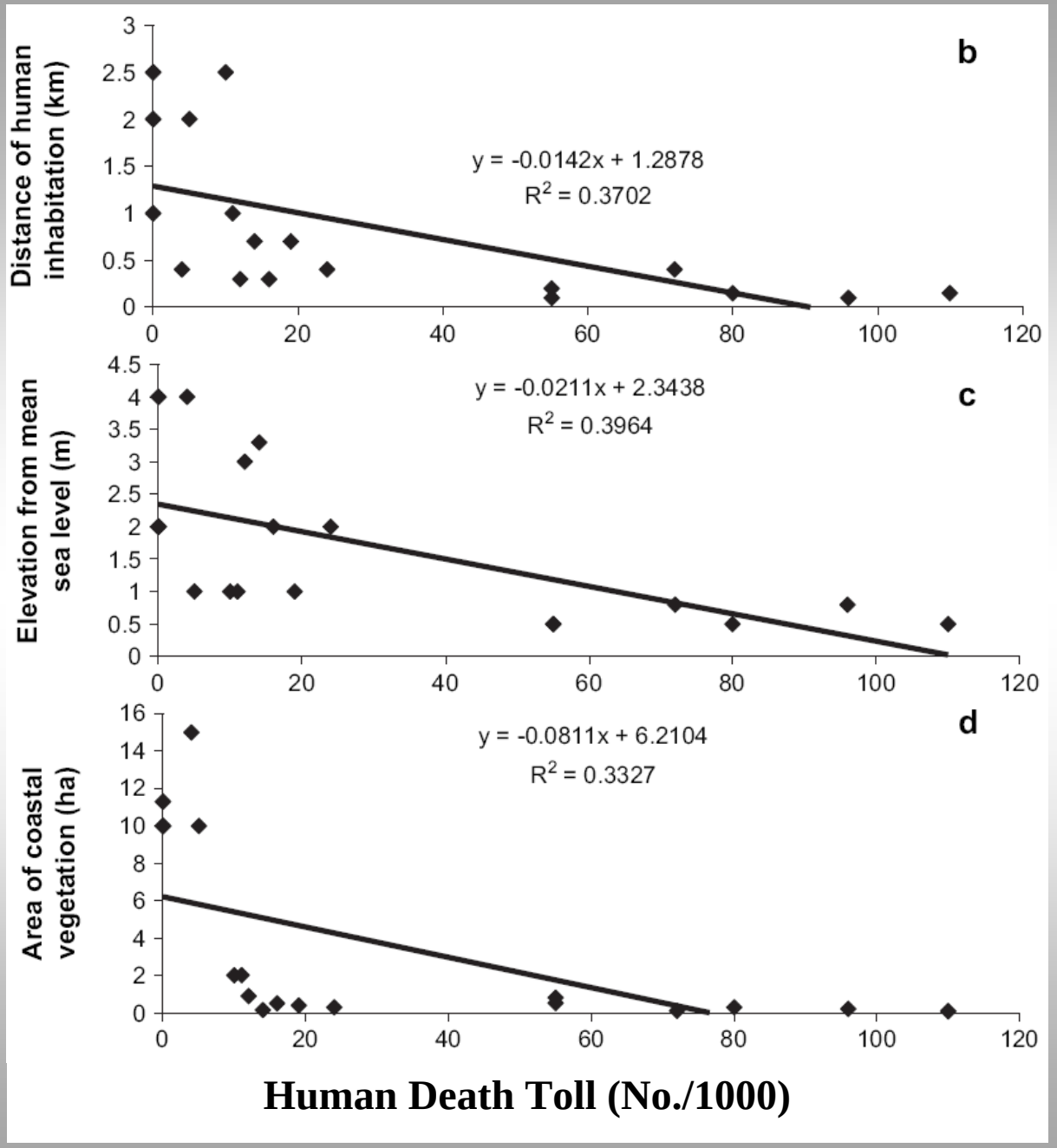
Summary of computed storm surge reductions by mangrove bands of various widths (Kabir *et al.*, 2006)

Mangrove Forest			*Maximum Surge Level (m) at Locations (local co-ordinates)*		
Nota-tion	*No. of Rows*	*Total width (m)*	*(104, 57)*	*(166, 67)*	*(198, 102)*
Mg0	0	0	6.186	5.74	5.685
Mg2	2	133	6.01	5.708	5.73
Mg3	3	200	5.976	5.765	5.79
Mg4	4	267	5.906	5.674	5.737
Mg5	5	333	5.866	5.664	5.739
Mg6	6	400	5.846	5.653	5.727
Mg8	8	533	5.765	5.617	5.71
Mg9	9	600	5.738	5.599	5.717

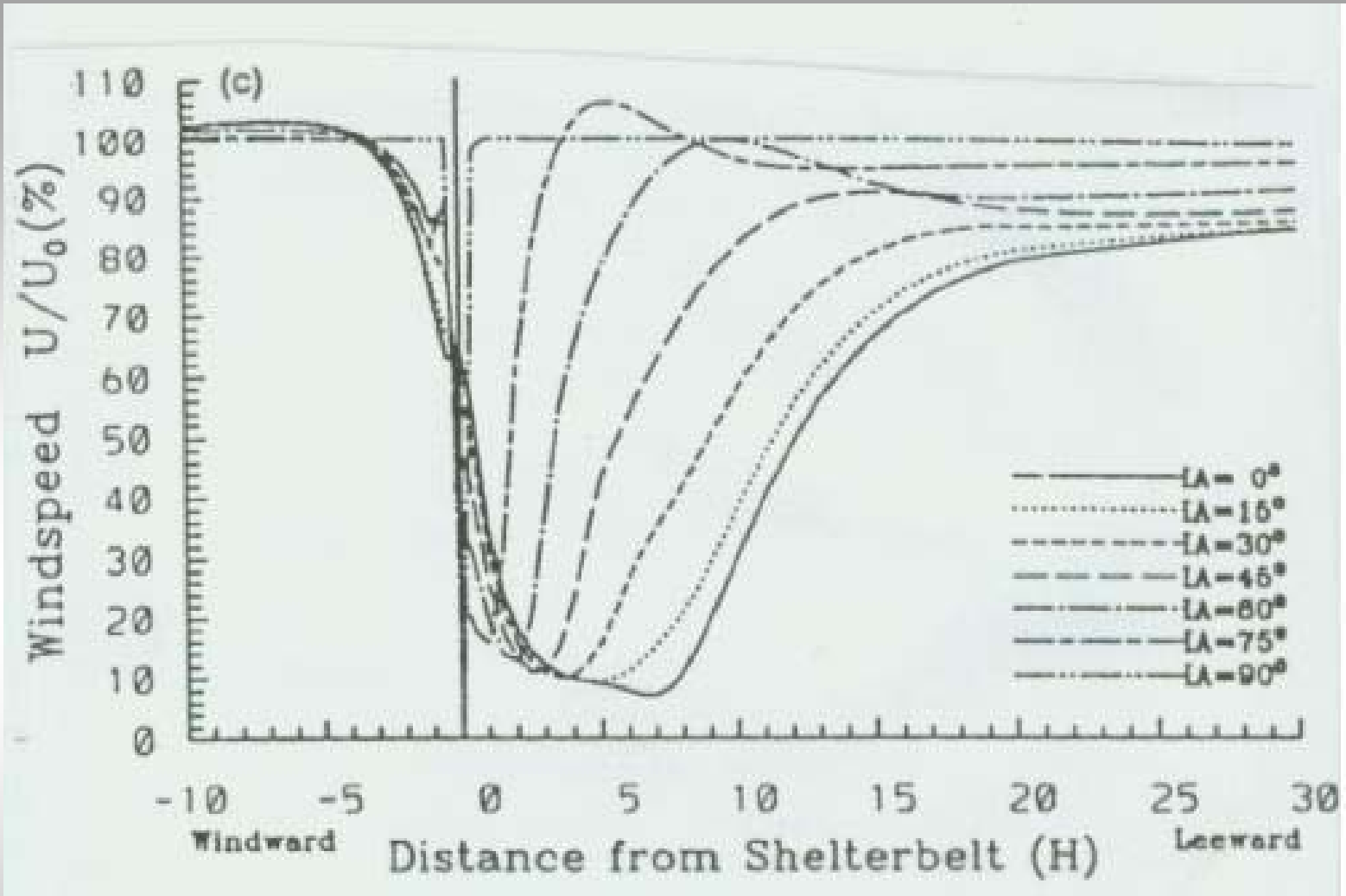


Comparison between field data and numerical simulations

(http://www.aims.gov.au/ibm/pages/news/mangwave.html)

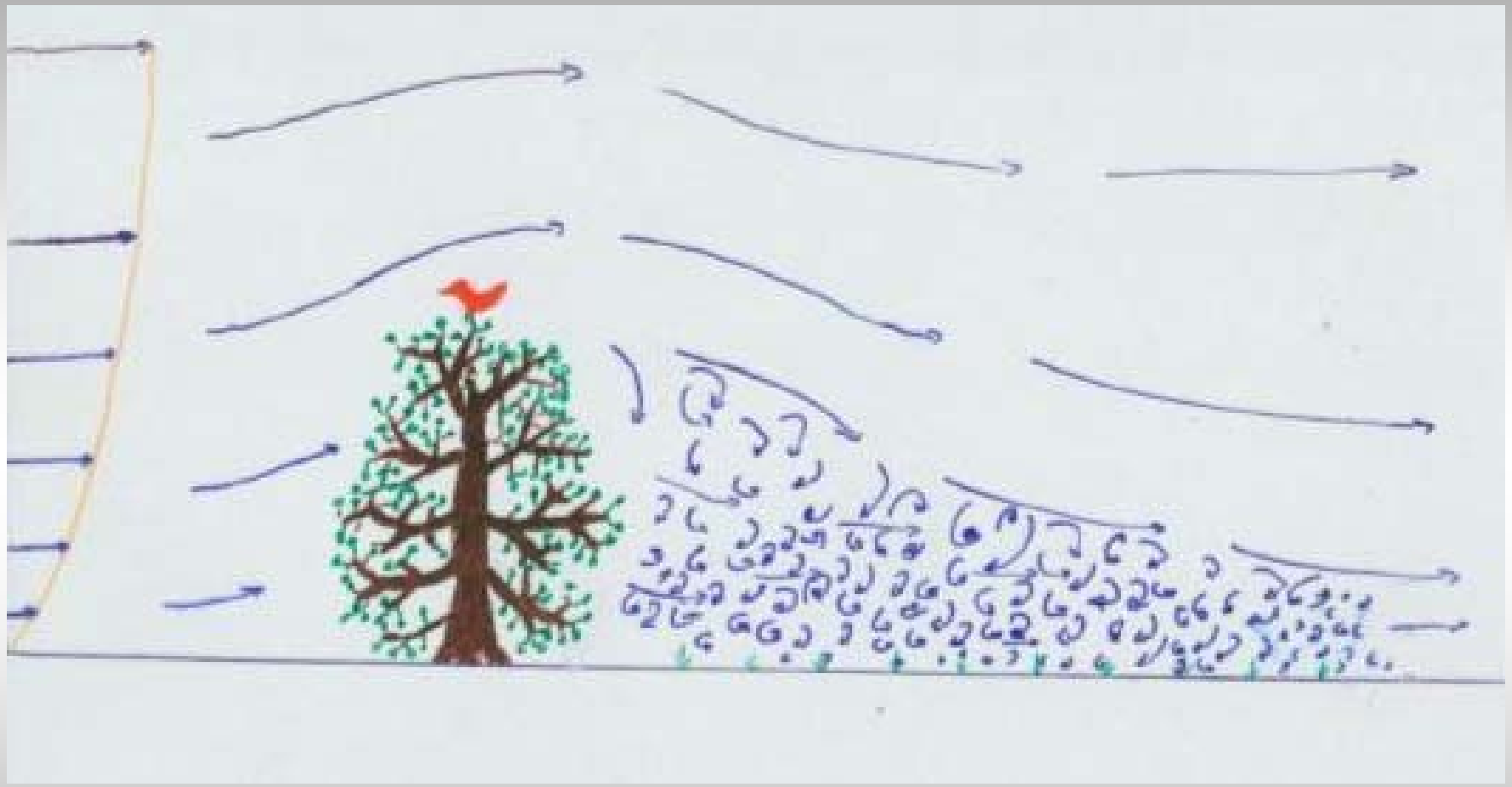


(Kathiresan and Rajendran, 2005)

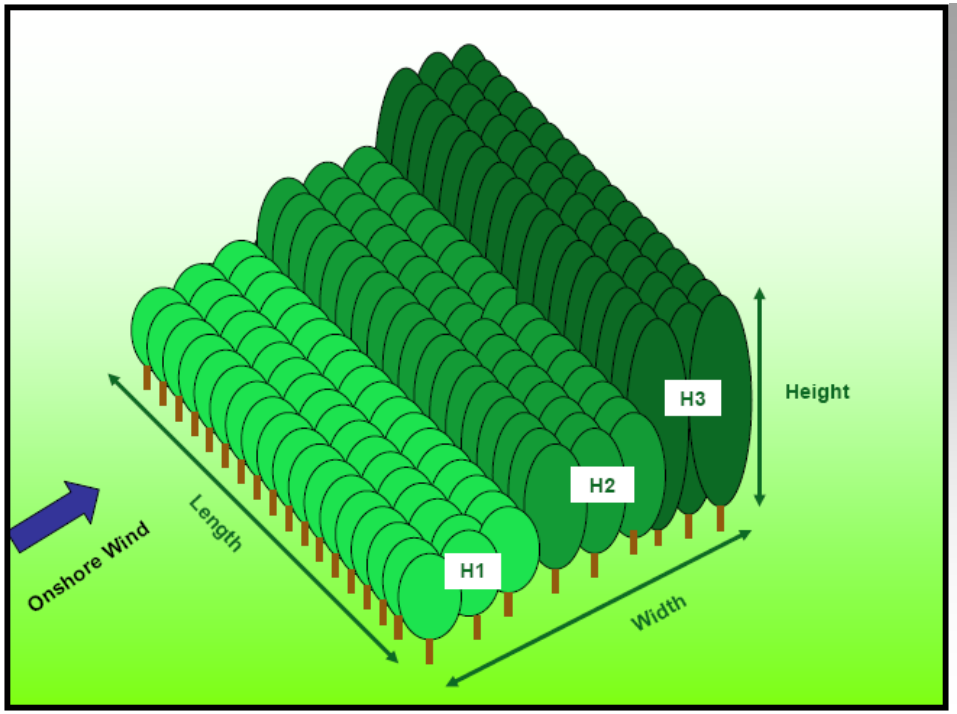


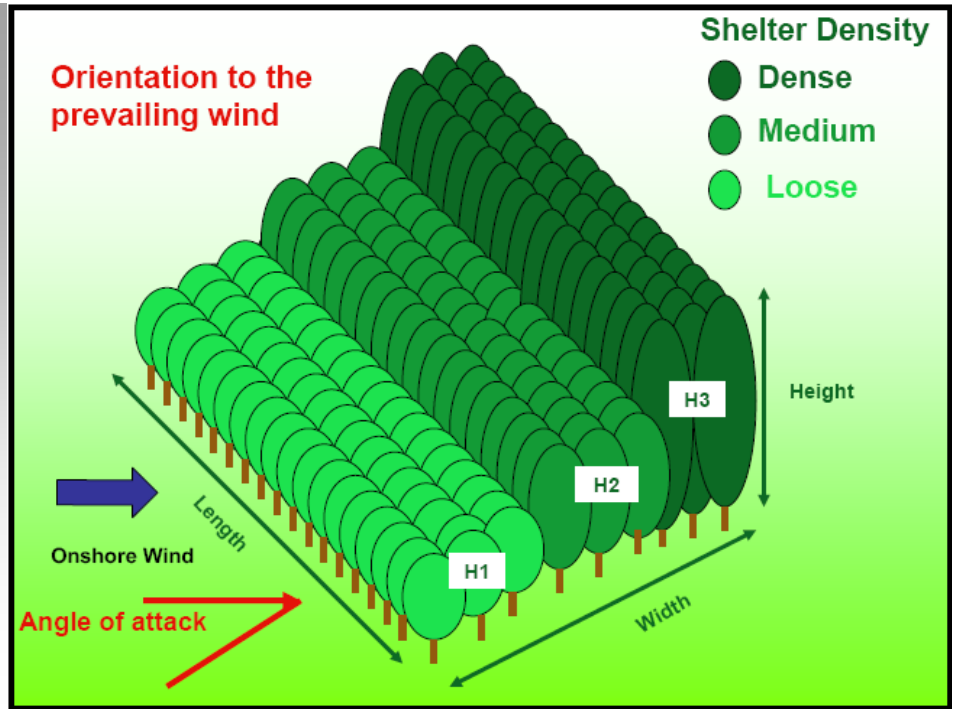
Percentage reduction in windspeed (U) upwind and downwind of a shelterbelt of width 1 H for various attack angles (IA) of the wind. Wind perpendicular to the belt has IA = 0°, and wind parallel to the belt has IA = 90°. The solid vertical line marks the downwind edge of the shelter

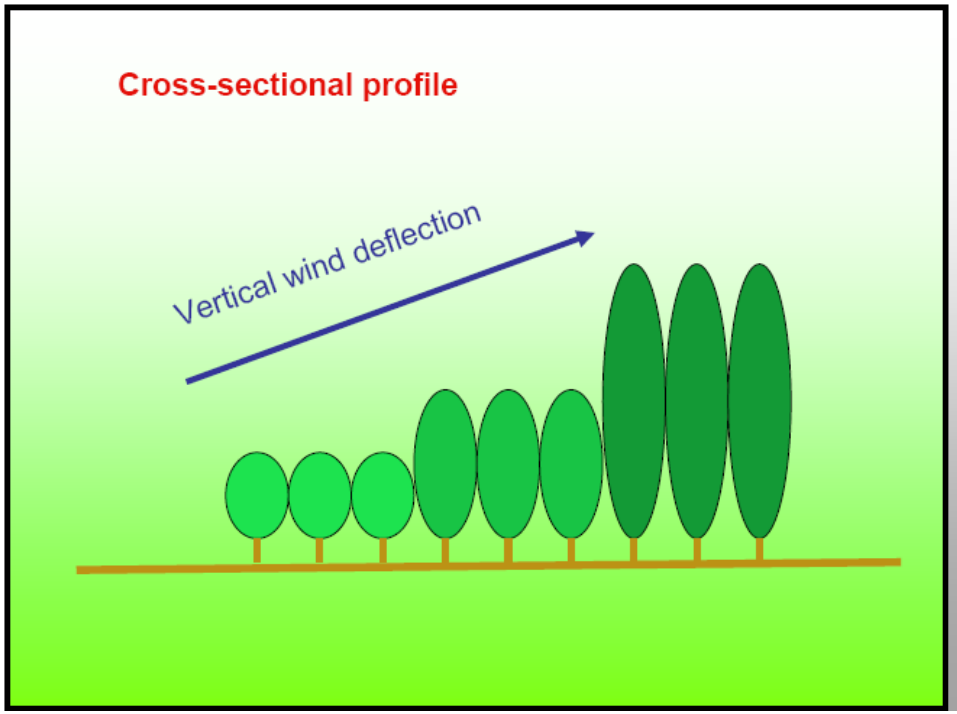
(wang et al., 2001)

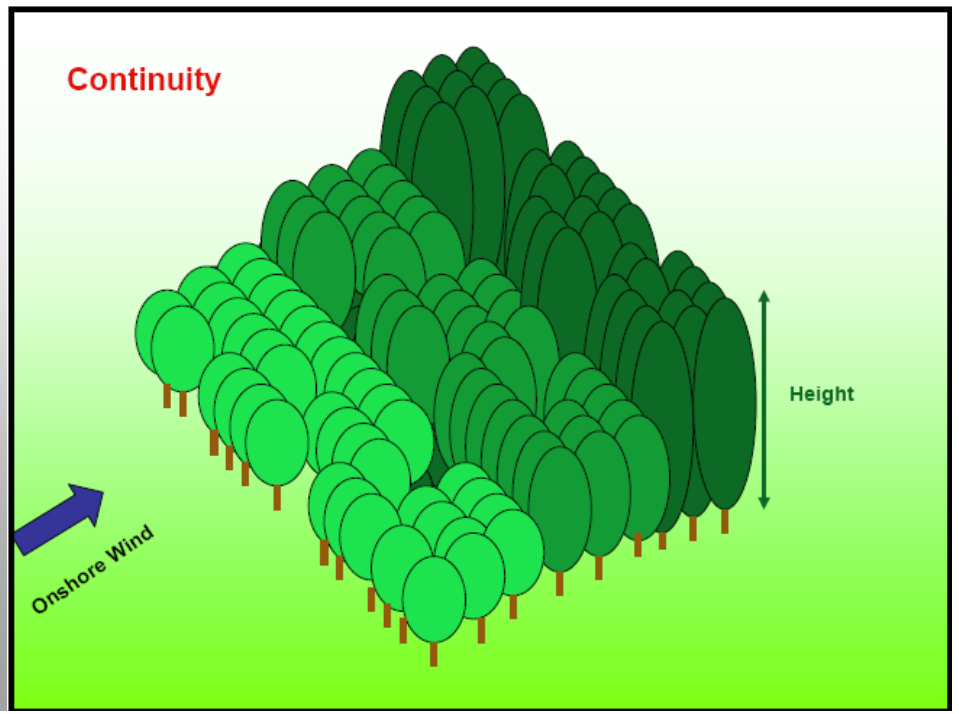


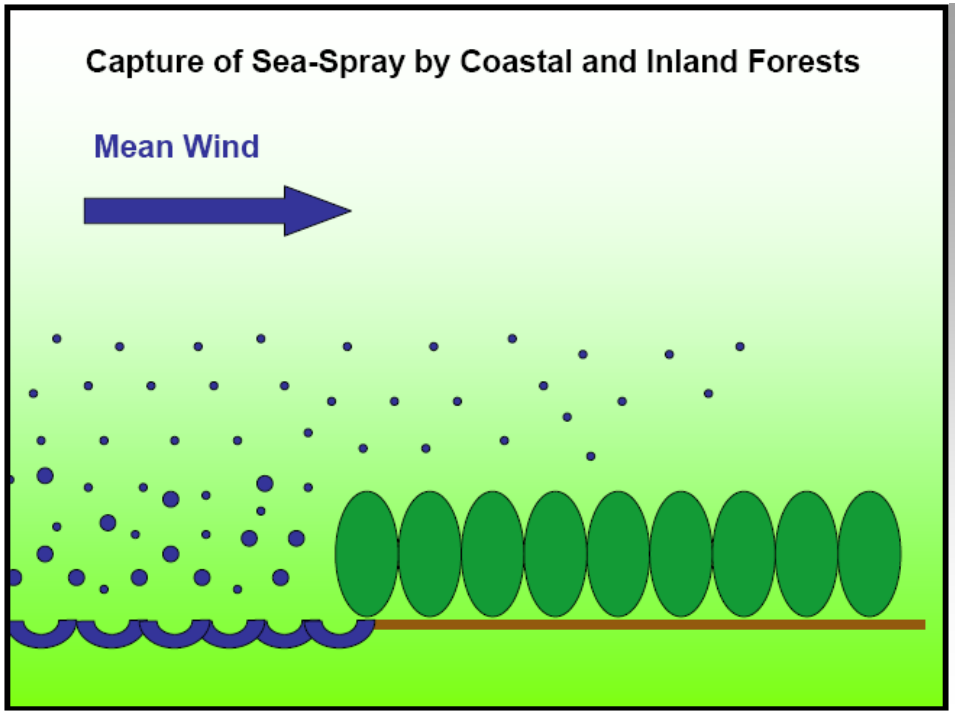
Creation of small-scale turbulence in the wake of a shelter and recovery of the undisturbed flow downwind

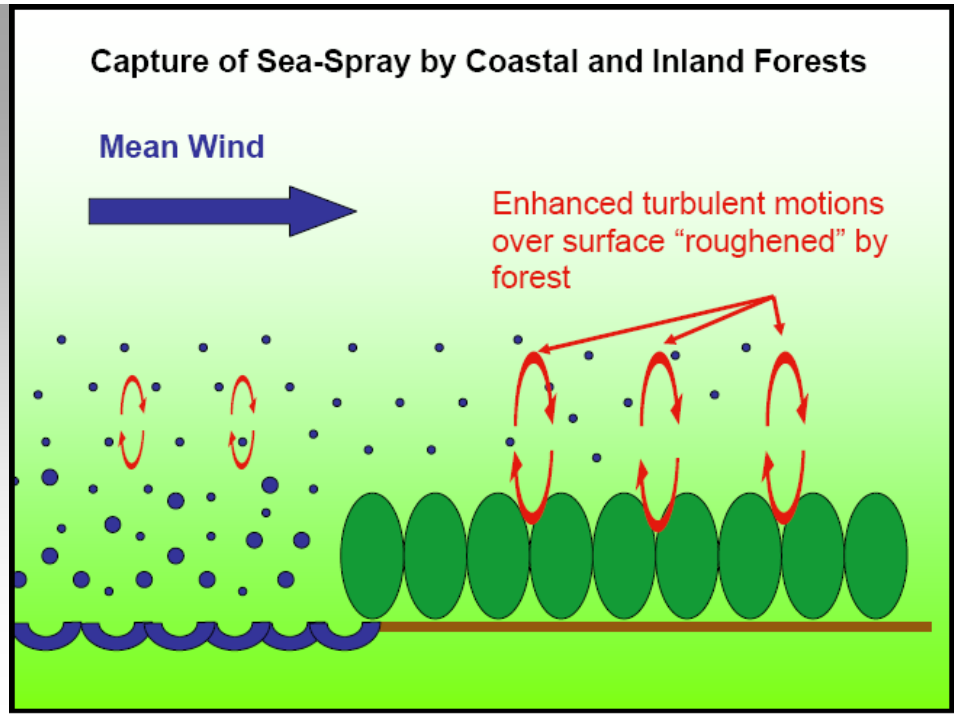

H3
H2
H1
Height
Length
Width
Onshore Wind

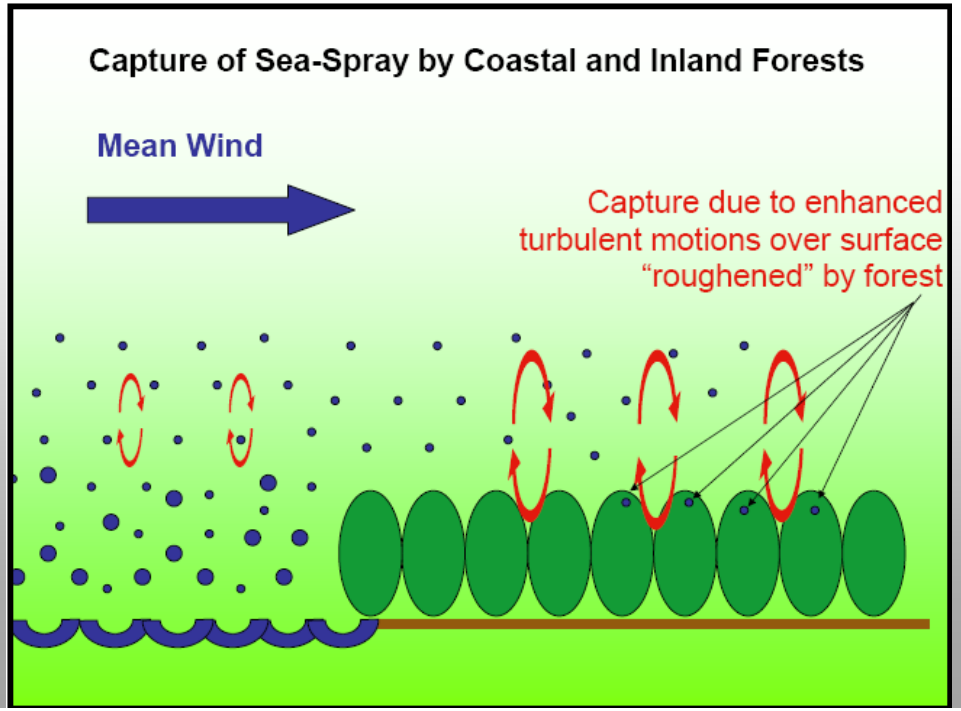

Orientation to the prevailing wind
Shelter Density
Dense
Medium
Loose
H3
H2
H1
Height
Length
Width
Onshore Wind
Angle of attack


Cross-sectional profile
Vertical wind deflection


Continuity
Height
Onshore Wind


Capture of Sea-Spray by Coastal and Inland Forests
Mean Wind


Capture of Sea-Spray by Coastal and Inland Forests
Mean Wind
Enhanced turbulent motions over surface "roughened" by forest


Capture of Sea-Spray by Coastal and Inland Forests
Mean Wind
Capture due to enhanced turbulent motions over surface "roughened" by forest

OTHER ADVANTAGES

- **Shelterbelts can also mitigate the tsunami effects**
- **The dense growth of mangroves in thousands of kilometers of Sundarbans saved West Bengal (India) and Bangladesh from the killer impact of tsunami**
- **A six-year-old mangrove forest of 1.5 km width can reduce 1 m high waves at the open sea and 0.05 m at the coast**

Design Factors for Multi-Species Shelterbelts

- Height
- Width
- Length
- Density
- Orientation to the prevailing wind
- Cross-sectional profile
- Continuity
- “Edge” effects

ESTABLISHMENT OF COASTAL SHELTERBELT AND FOREST

- **Orient the shelter or forest perpendicular to the prevailing winds**
- **Consider the coastal curvature**
- **Plant as far into the ocean as possible**
- **Species selection**
  - **Plant shorter species on sea-ward edge**
  - **Create highest porosity (lowest density) at the sea-ward edge**
  - **Plant successively taller species in the landward direction**

COMMON SPECIES FOR COASTAL SHELTERBELTS

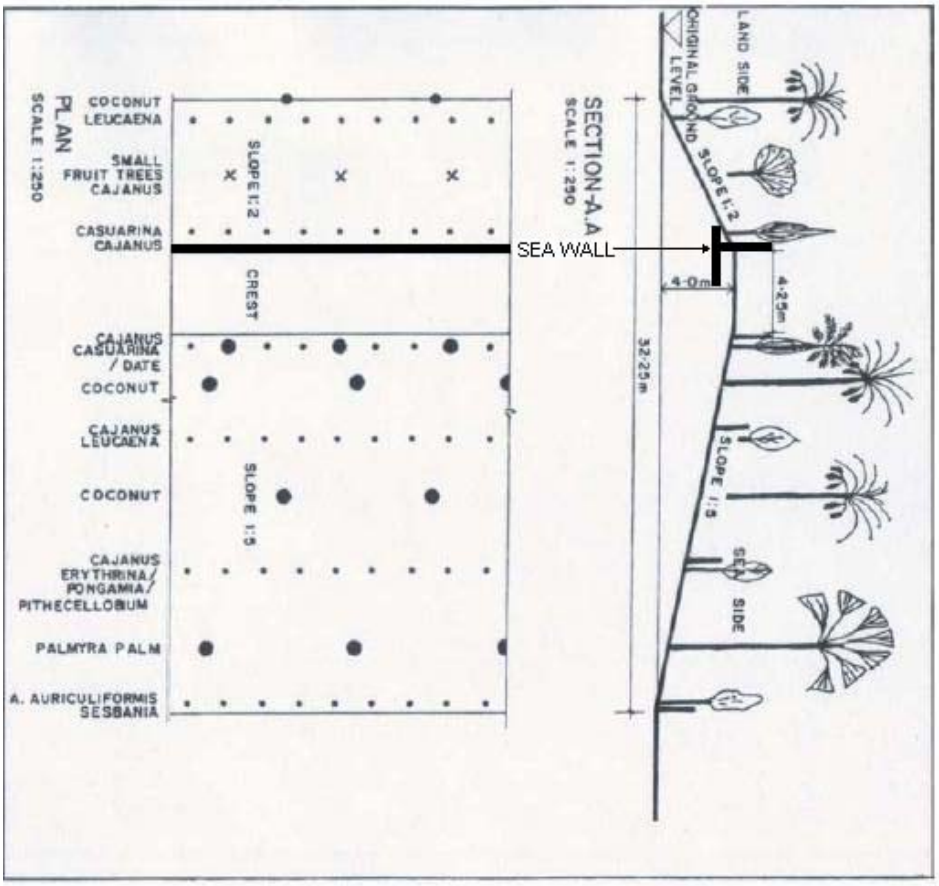
- **Mangroves (over 50 species grow throughout SE Asia)**
  - **– *Avicennia marina***
  - **– *Rhizophora apiculata***
  - **– *Rhizophora mucronata***
  - **– *Bruguiera***
  - **– *Ceriops***
- **Casuarina**
- **Palm**
- **Coconut**

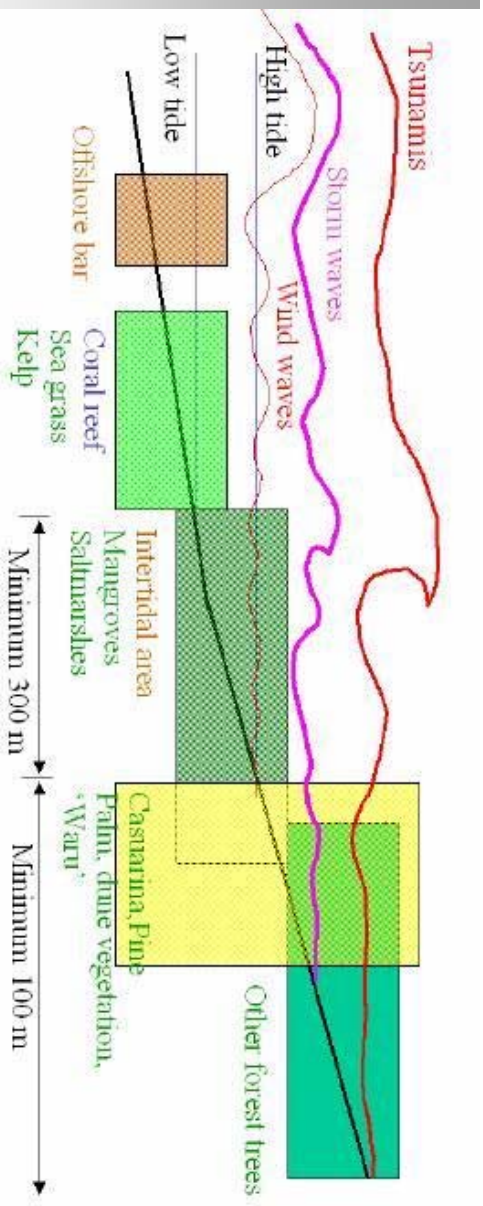
FEATURES OF COASTAL AREAS OF BANGLADESH

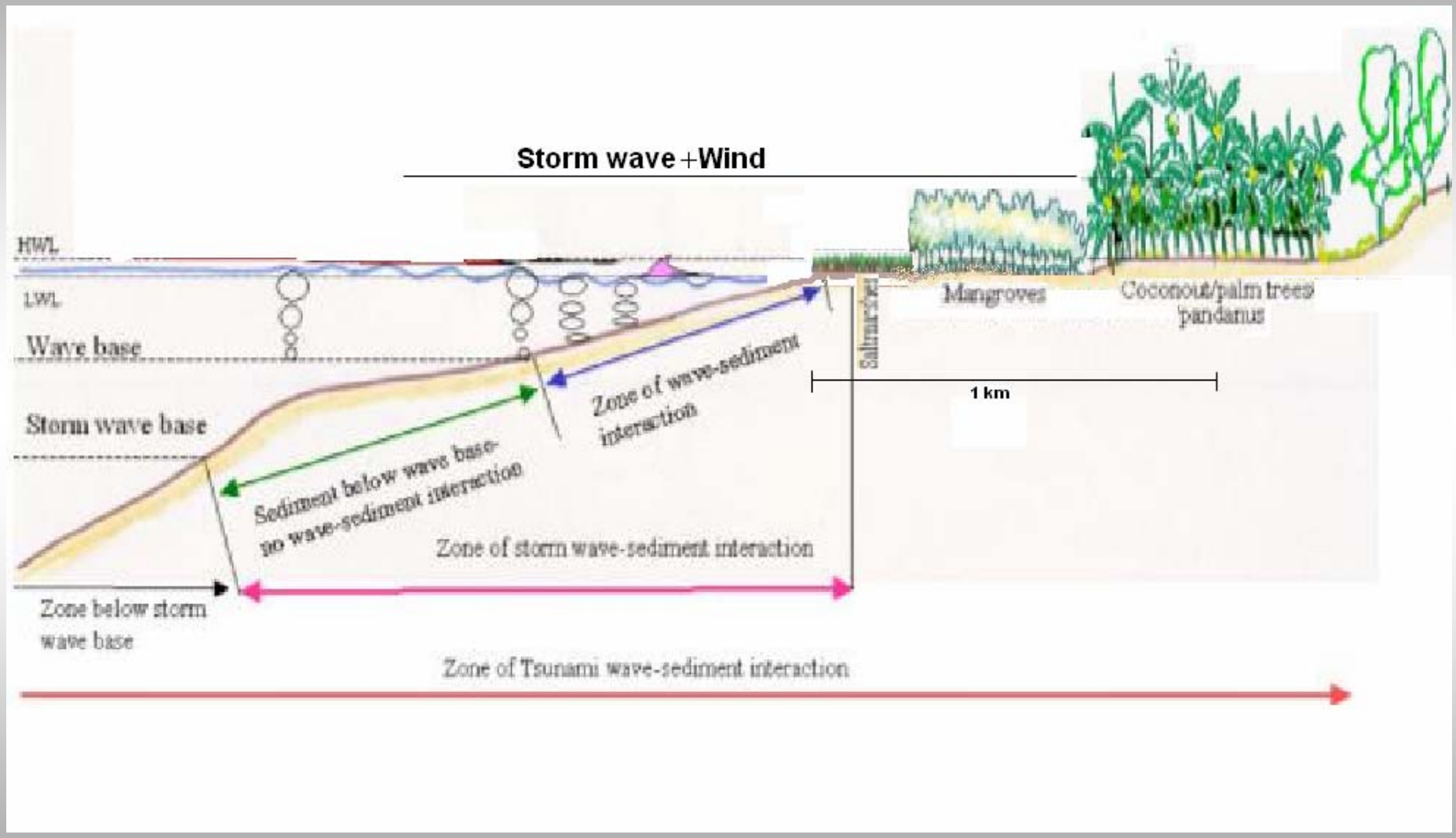
- Most of the areas (except Sunderban) are unprotected
- Islands are most vulnerable and are being affected almost every year
- Population density, agricultural activities increasing
- Risk is increasing simultaneously
- Inundation and flooding is quite common
- No considerable shelterbelts and planned development works to minimize wind speed, erosion and surge height

STUDY AREA: Char Monica

PROPOSED DESIGN OF SHELTERBELT WITH EMBANKMENT

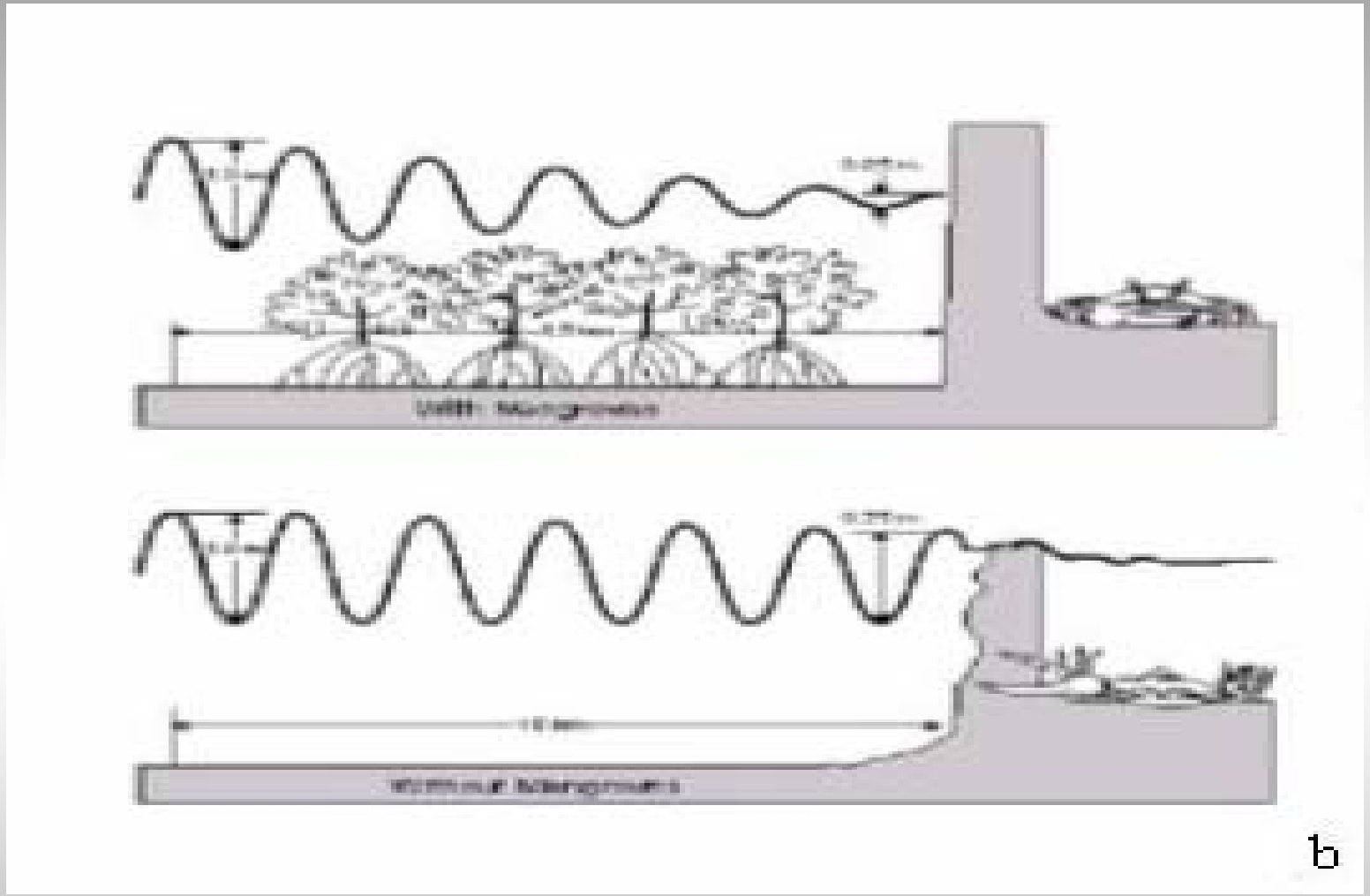




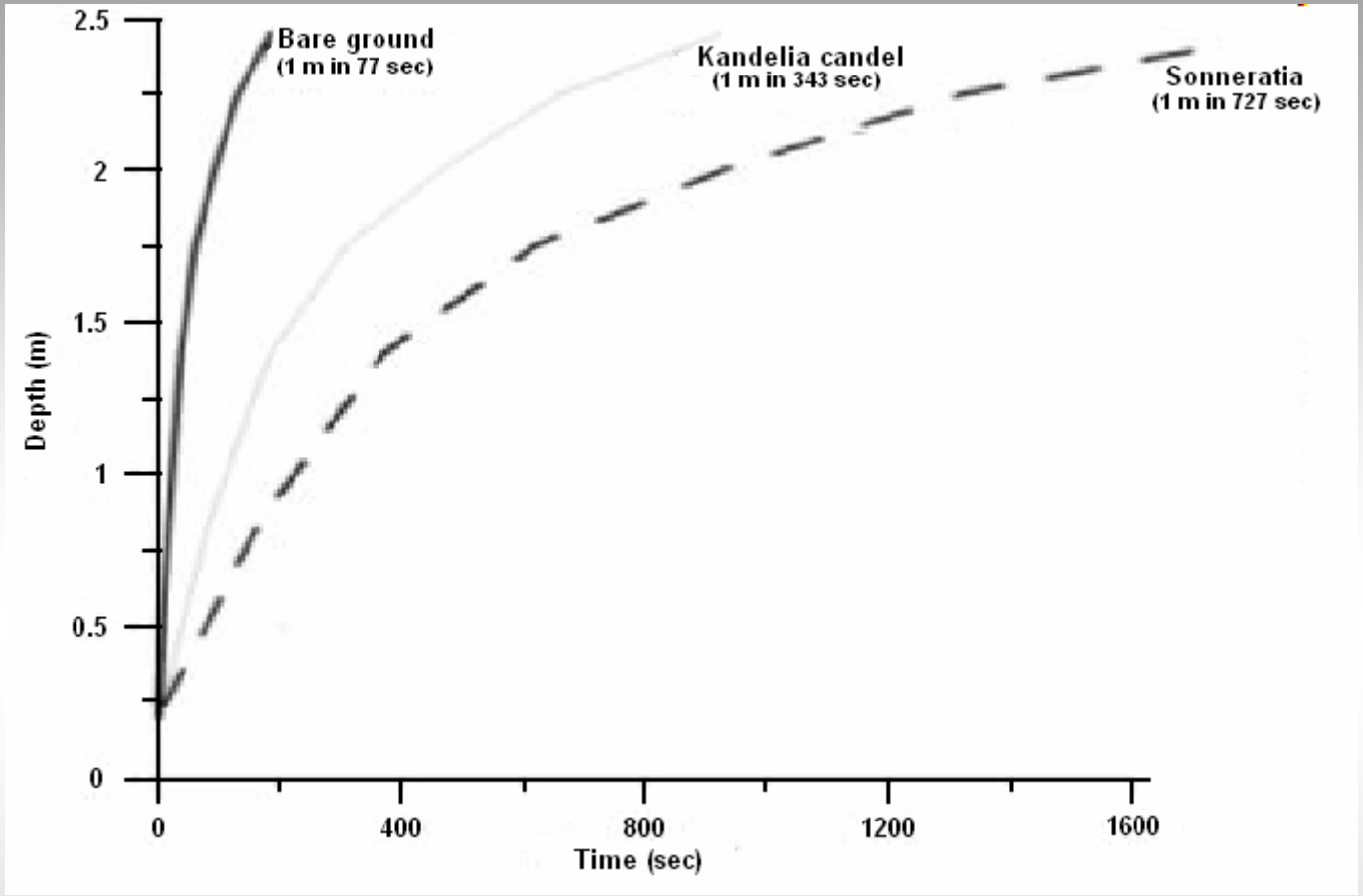

Storm wave +Wind
HWL
LWL
Wave base
Storm wave base
Sediment below wave base-
no wave-sediment interaction
Zone of wave-sediment
interaction
Zone of storm wave-sediment interaction
Zone below storm
wave base
Zone of Tsunami wave-sediment interaction
Saltmarshes
Mangroves
Coconut/palm trees
pandanus
1 km

FEATURES OF DESIGN

- 500-800m zone of wave sediment interaction
- 1km long marsh and mangrove from sea shore
- Forest should be continuous and dense.
- Priority is given for taller and trees of high adaptability
- Stabilized elevated land or bank with sea wall as per design
- Mixed cropping system
- Preservation of low land and flood plain
- Reforestation as long as possible from bank.



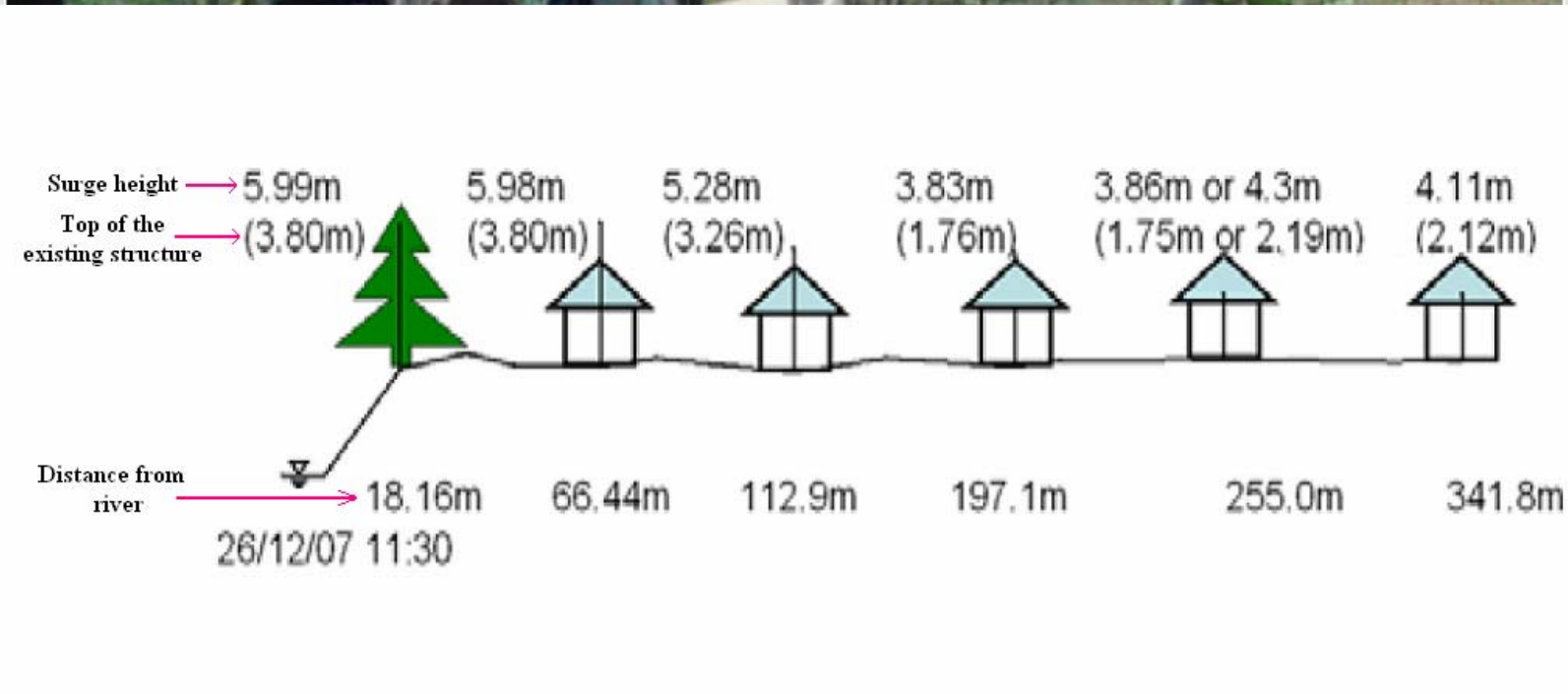
The wave field with (top) and without (bottom) mangroves.
(Mazda *et al.*, 1997)



Model predictions of the rise of water level at a point 500 m from the shore for flat terrain following a 5-m tsunami at the shore. Three scenarios: Bare ground, mature *Kandelia candel* forest and mature *Sonneratia* forest. The trees are assumed not to be destroyed by the wave. Time starts when the tsunami arrives at that point.

Source : http://www.fao.org/docrep/010/ag127e/AG127E11.htm

IMPACTS OF SUPER CYCLONE SIDR



Overall Summary of Damage and Losses

Sector	Sub-Sector	Disaster Effects (BDT Million)			Disaster Effects (US$ Million)		
		Damage	Losses	Total	Damage	Losses	Total
Infrastructure		**71,064**	**2,130**	**73,194**	**1,029.9**	**30.9**	**1,060.8**
	Housing	57,915	—	57,915	839.3	—	839.3
	Transport	8,006	1,725	9,731	116.0	25.0	141.0
	Electricity	576	359	935	8.3	5.2	13.6
	Water and Sanitation	157	46	203	2.3	0.7	2.9
	Urban and Municipal	1,696	—	1,696	24.6	—	24.6
	Water Resource Control	4,918	—	4,918	71.3	—	71.3
Social Sectors		**4,482**	**1,453**	**5,934**	**65.0**	**21.1**	**86.0**
	Health and Nutrition	169	1,038	1,206	2.4	15.0	17.5
	Education	4,313	415	4,728	62.5	6.0	68.5
Productive Sectors		**1,734**	**32,083**	**33,817**	**25.1**	**465.0**	**490.1**
	Agriculture	1,472	28,725	30,197	21.3	416.3	437.6
	Industry	262	2,035	2,297	3.8	29.5	33.3
	Commerce	—	1,258	1,258	—	18.2	18.2
	Tourism	—	65	65	—	0.9	0.9
Cross-Cutting Issues		**420**	**0**	**420**	**6.1**	**0.0**	**6.1**
	Environment	420	—	420	6.1	—	6.1
Total		**79,904**	**35,665**	**115,569**	**1,158.0**	**516.9**	**1,674.9**

DISCUSSIONS

- The designed landscape will provide an effective coastal barrier
- Reduction of surge height and wind speed will protect inland crops and structures from sudden shock
- Death toll will be decreased at a large margin
- Vast land area can be saved from saline water and sediment
- Increase of approach time will help to shift people and livestock to the shelter. People will get time to save their wealth.
- Coastal islands can be used for agriculture effectively due to minimum land erosion
- Inland potable water sources can be preserved from contamination.

DISCUSSIONS

- Lifetime of existing structures will increase
- Extension of tourism industry
- People will find alternate source of income when fishing is not possible
- It will lessen tension providing barrier against tsunami
- National income from forest and wetland
- Large finance which might be needed for relief, maintenance and other purposes will be used for development works throughout the country
  - For example if the Sidr effect could be minimized 20%, around 335 million dollar would be saved from instant losing and a great amount of money from redevelopment and maintenance.

Next Priority

- **Rainwater Harvesting**
- **Ecological Sanitation System**
- **Desalination by Solar Energy**
- **Solar energy for Power Generation**
- **Generation of Salt**

Prospects of Eco-san from Pilot Project

- Eco-san toilet: few damaged (water infiltration) compare to other reconstruction at cyclone
- Cyclone Ayla: good indicator for Eco-san toilet
- Benefit of safety and comfort
- does not contradict Muslim practices

- Strengthening awareness campaign on positive aspects
- Comfort and privacy important drivers for behavior change

Expertise Involvement

- Disaster Management Specialist
- Remote sensing and GIS Specialist
- Environmental Engineer and specialist
- Geotechnical Engineer
- Agricultural Specialist
- Structural Engineer
- Eco-san Specialist
- Renewable resource analyst
- Transportation Specialist

Our Ideas with GoB Issues and Strategy

T1 : Food Security, Social Protection and Health

T2P2 : Improvement of cyclone and storm surge warning

T2P4 : Risk management against loss on income and property

T3P3 : Repair and maintenance of existing coastal polders

T3P6 : Adaptation against tropical cyclones and storm surges

T4P3 : Preparatory studies for adaptation against sea level rise

T4P4 : Monitoring of ecosystem and biodiversity changes and their impacts

T5P7 : Afforestation and reforestation programme

T6P1 : Revision of sectoral policies for climate resilience

T6P3 : Strengthening human resource capacity

T6P4 : Strengthening institutional capacity for climate change management

THANK YOU

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