Coastal Vulnerability of South Asia Seas

Mr. Zammath Khaleel
Senior Programme Officer (Regional)
South Asian Seas Programme-SACEP





13-17 December 2021

IOCINDIO Training Workshop on Methodologies and Approaches of Coastal Vulnerability, Sea Level Rise and Advances in Operational Oceanography Science -Technology in the Indian Ocean

South Asian Seas Programme (SASP)

- The **South Asian Seas (SAS)** Programme is under the umbrella of South Asia Co-operative Environment (SACEP) and is designated for implementation of the implementation of the SASP.

- The South Asian Seas Action Plan was adopted at Meeting of Plenipotentiaries by the five maritime countries of South Asia, on March 24th 1995,New Delhi, India.

- **SASP** is one of the 18 Regional Seas Programmes of the United Nations Environment Programme (UNEP).

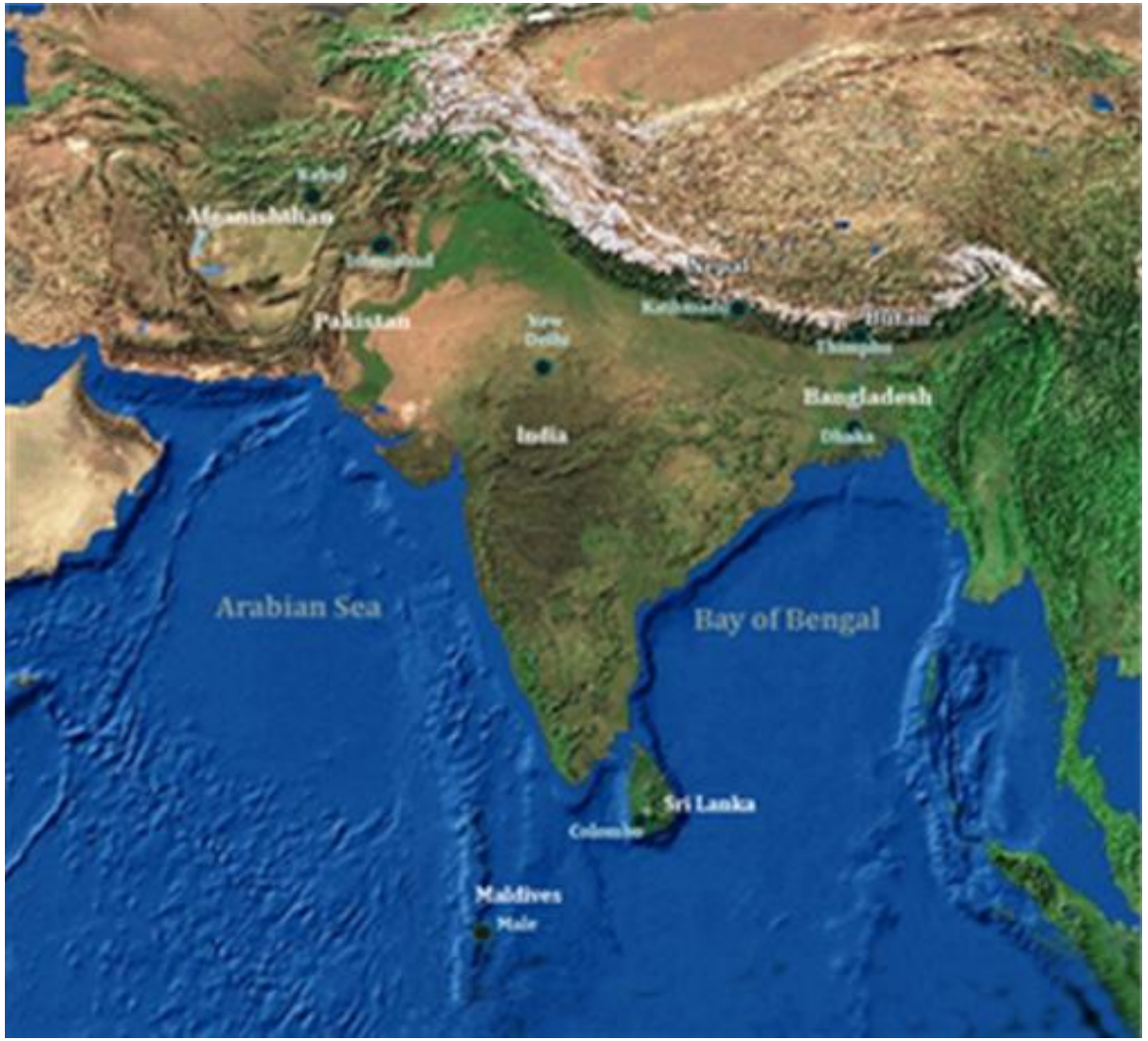
South Asian Seas Action Plan

- South Asia Seas Action Plan Objectives
  - establishing and enhancing consultations and technical co-operation among States of the region
  - emphasising the economic and social importance of the resources of the marine and coastal environment
  - Establishing a regional co-operative network of activities concerning concrete subjects/projects of mutual interest for the whole region

- The priority activities are in four specific areas:
  - Integrated Coastal Zone Management (ICZM)
  - Development of national and regional oil and chemical spill contingency plan
  - Human Resources Development through Regional Centers of Excellences
  - Protection of Marine Environment from Land based activities:

South Asia Seas Region

- Hosts an extensive system of river deltas and diverse marine and coastal habitats
  - Mangroves, seagrass, coral reefs etc
- economically valuable non-living resources like petroleum, natural gases and minerals are found within the EEZs
- An estimated 27% of the 1.6 billion population lives within 100 km of the coast.
  - Including densely populated cities like Karachi, Mumbai, Chennai, Kolkata, Dhaka)



South Asia Seas Region

The South Asian Seas Region in numbers (adopted from Marine and Coastal Biodiversity Strategy for the South Asian Seas Region)

Sources : [1] CIA, 2014 ; [2]Burke et al, 2001 ; [3] CBD National Reports ; [4]UNDP, 2014;

	Bangladesh	India	Maldives	Pakistan	Sri Lanka	Total
[1]Surface Land Area (000 km^2)	143.998	3,287.3	0.30	796.1	65.61	4,293.3
[2]Claimed Exclusive Economic Zone Area (000 km^2)	39.9	2,020	870.6	201.5	500.7	3,716.2
[3]Length of Coastline (km)	714	8,118	644	1,046	1,620	11,541
[4]Total population 2013(millions) Total population 2030 (millions)	156.6 185.1	1,252.1 1,476.1	0.3 0.4	182.1 231.7	21.3 23.3	1,612.4 1.916.6
[2]Percentage of Population within 100 km from the coast	54.8	26.3	100	9.1	100	27

Coastal Vulnerability

- Vulnerability is function of
  - Risk/Hazard
  - Exposure (physical, socio-economic and environmental)
  - Adaptability / Resilience ((physical, socio-economic and environmental)

Coastal Risk – Sea Level Rise

Regional Sea Level Rise Projection results for South Asia Seas region as per CMIP6 and reported under IPCC WG1

Period	Median SLR in meters (90 percentile range)			
	SSP1 – 2.6	SSP2 – 4.5	SSP3 – 7.0	SSP5 – 8.5
Near Term (2021-2040)	0.1 (0 – 0.2)	0.1 (0 – 0.2)	0.1 (0 – 0.2)	0.1 (0 – 0.2)
Medium Term (2041-2060)	0.2 (0 – 0.4)	0.2 (0 – 0.4)	0.2 (0 – 0.4)	0.2 (0.1 – 0.4)
Long Term (2081-2100)	0.4 (0 – 0.8)	0.5 (0.1 – 0.9)	0.6 (0.2 – 1)	0.7 (0.3 – 1.1)

- Averaged for entire stretch of SAS but given the local variances the local sea level rise could vary significantly

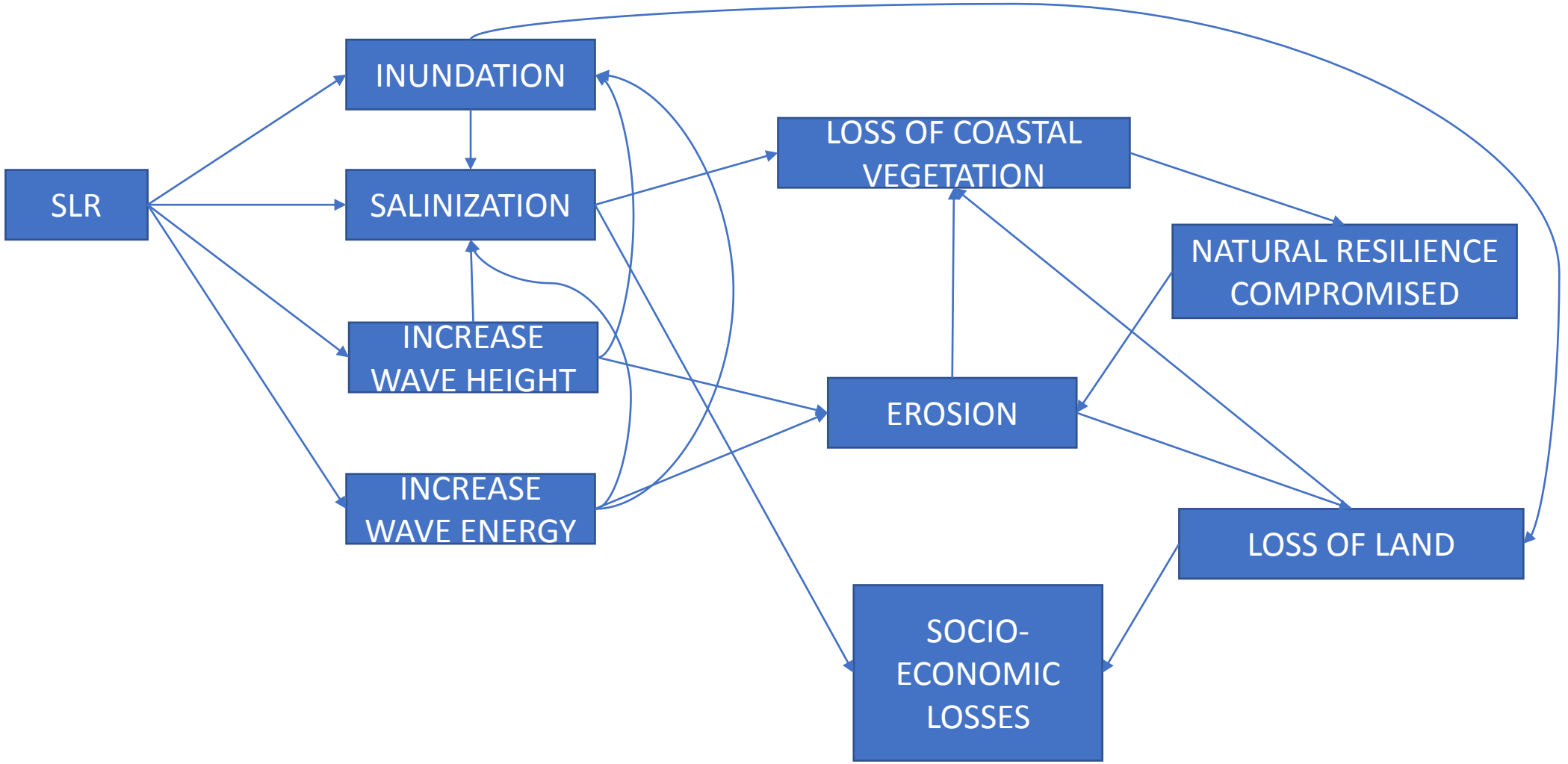
Coastal Risk – Sea Level Rise

- Variances are mostly likely attributable to
  - Local geomorphological differences (land subsidence or upliftment)
  - The differences in the records (duration and period)

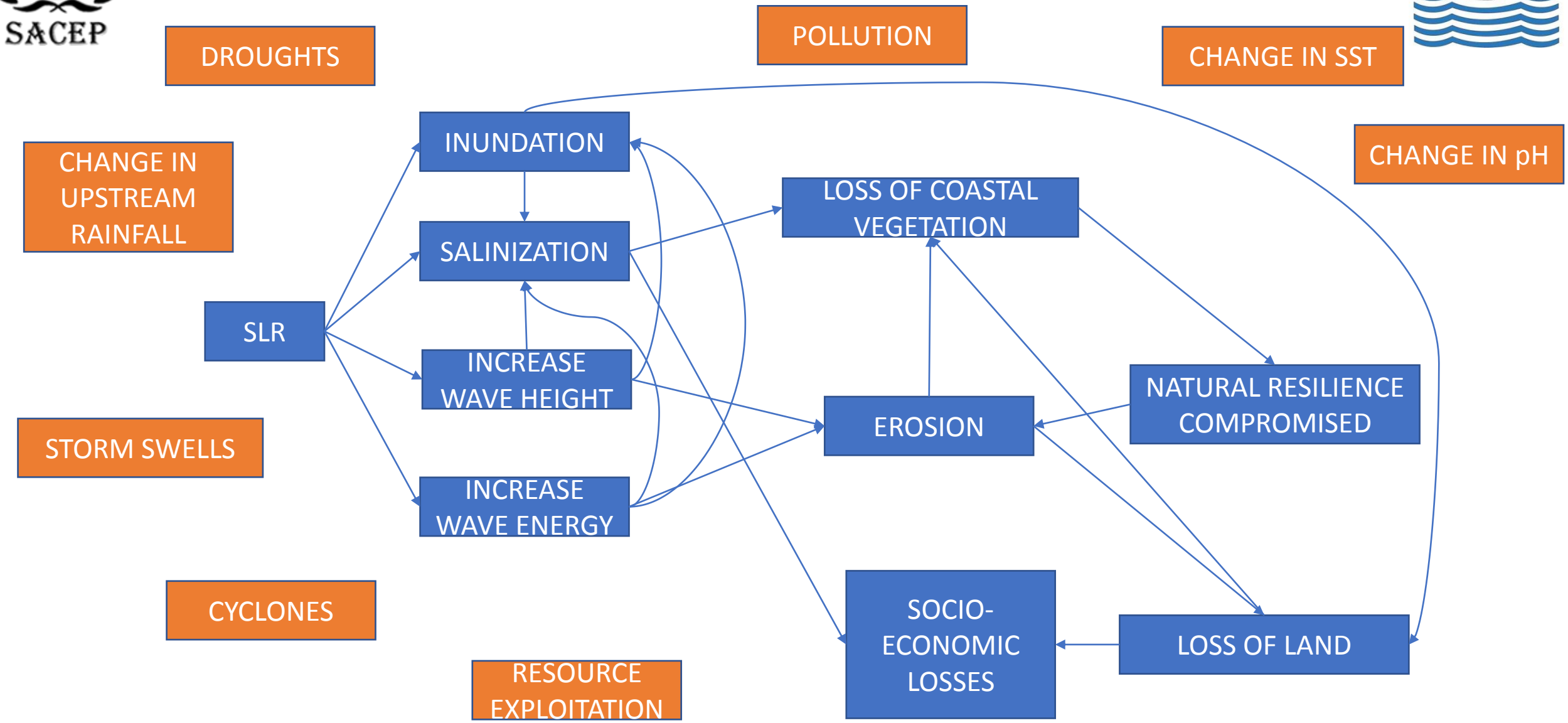
Country	Observed SLR rate	Observed Period
Bangladesh	5-7mm/year (south-west)	1981-2012
	~10 mm/year (central)	1981-2012
	14-23 mm/year (south-east)	1983-2012
India	1.7 mm / year (National Average)	
	0.33 mm/year (Chennai)	1916-2005
	5.16 mm/year (Diamond Harbour)	1948-2005
	2.89 mm/year (Haldia)	1972-2005
	3.18 mm/year (Kandla)	1950-2005
	1.30 mm/year (Kochi)	1939-2005
	0.74 mm/year (Mumbai)	1878-2005
	1.03 mm/year (Paradeep)	1966-2005
	2.20 mm/year (Port Blair)	1916-1964
	0.97 mm/year (Vizag)	1937-2005
	1.50 mm/year (Okha)	1964-1991
Maldives	3.75 mm/year (Male')	1989-2012
	2.93 mm/year (south)	1992-2012
Pakistan	1.1 mm/year	
Sri Lanka	3.1 mm/year	1993-2003

[1] Bangladesh Third National Communication 2018 (https://unfccc.int/documents/192278)
[2] India Third BUR to UNFCCC 2021 (https://unfccc.int/documents/268470)
[3] Maldives Second National Communication 2016 (https://unfccc.int/documents/181759)
[4] Pakistan Second National Communication 2018 (https://unfccc.int/documents/199292)
[5] Hazard Profiles of Sri Lanka 2012 (http://www.dmc.gov.lk/images/hazard/hazard/Report/)

Cascading Coastal Risk – Sea Level Rise



Compounding Coastal Risk – Sea Level Rise



Exposure to risks

- Exposure to SLR risk would require quantification of socio-economic and environmental parameters. As a region whole some of these parameters have been quantified below
  - *11541 km of coastline*
  - *27% of total population living is coast*
  - *Key industrial activities situated in coastal areas including fisheries and agriculture*
  - *Many densely populated cities and industrial zones are in coastal areas*
  - *6.8% of the global mangrove forests, 6% of global coral reefs, 7 major deltas and numerous estuaries and coastal lagoons, which is home to environmentally significant biodiversity*
- The above are indicative of the exposure and sensitivity of the SAS coastal region to SLR, however national and local context of the coastal community is paramount to understand the coastal vulnerabilities better.

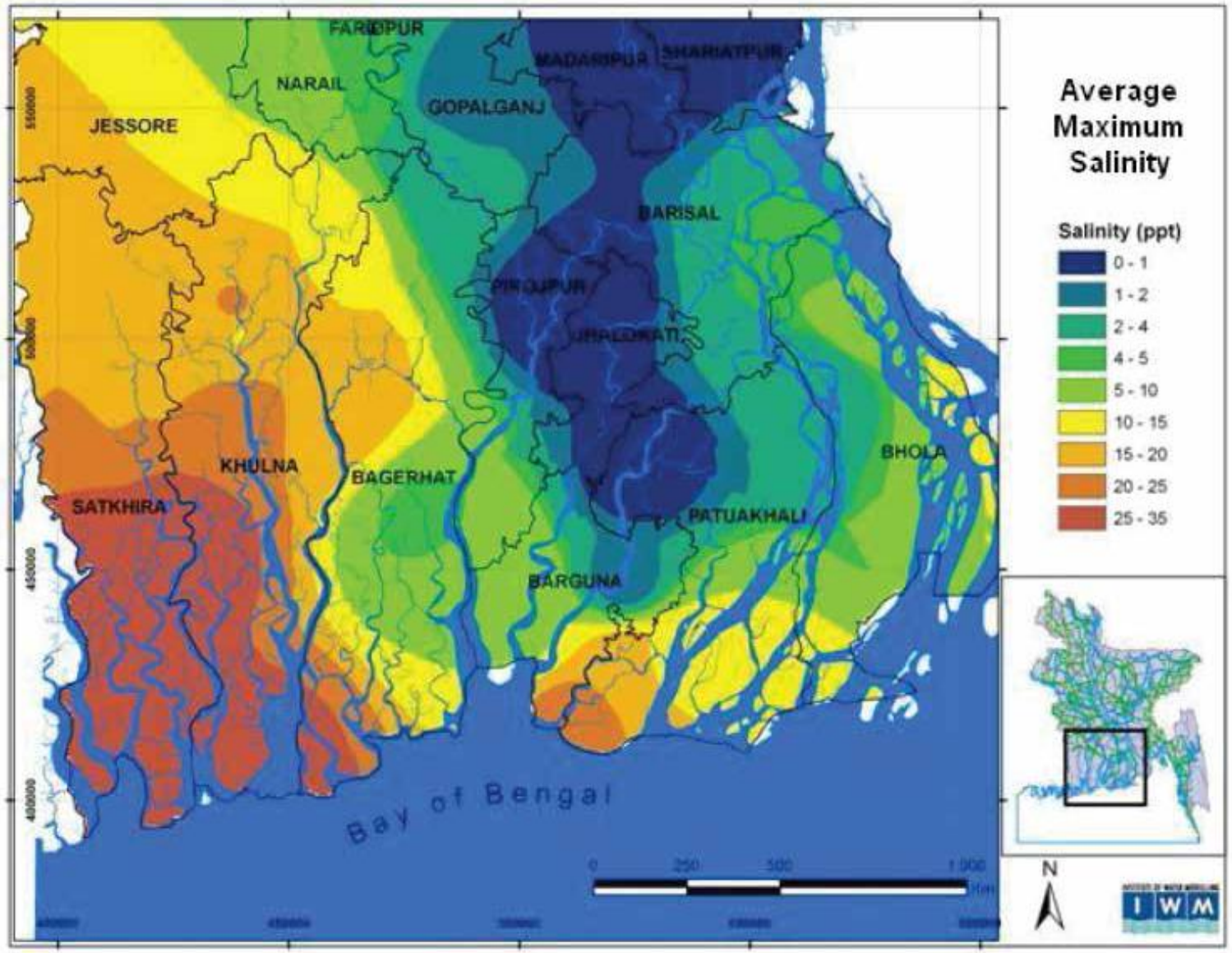
National Context - Bangladesh

- Around one third of the population lives in the coastal zone, which exceeds 50 million people
- Coastal zone is rich in natural resources and mineral and accounts for 41% of the agricultural land of the country
- Of the 63,728 sqkm of coastal area, 26.6% is below 1m, 57.8% below 2m and 79% is below 3m.
- Observes a very high SLR rate ranging between 6-23mm/year
- Land subsidence plays a role in the coastal risk assessment. Causes of land subsidence are;
  - accumulation of sediments by Ganges and Brahmaputra Rivers,
  - sediment compaction by removal of oil, gas and water from inland deltas and
  - sediment trapping from upstream reservoirs.

National Context - Bangladesh

- Salt affected area during 1973 to 2009 showed that about 0.223 million ha (26.7%) of new land has been affected . Salinity increases from 2ppt to 20ppt at Mongla.
- Increases in salinity levels in river waters have devastating effects on agriculture, water resources/ supply, sanitation, river ecosystems, biodiversity and so on.
- A World Bank (2000) study suggests that increased salinity alone from a 30cm sea level rise will cause a net reduction of 0.5 million metric tons of rice production
- Future rates of sea-level rise are expected to increase coastal flooding, erosion, and saltwater intrusion into surface and ground waters (IPCC, 2013).

National Context - Bangladesh



National Context - India

- Has the longest coastline in the region of over 8000 km and numerous islands as part of its national territory. The island includes the low lying coral island chain of Lakshadweep Atoll.
- Deltas of Mahanadi, Godaveri-Krishna, Kaveri and Tambraparani Rivers is found at the eastern coast of India. Part of Sundarbans fall on the North Eastern Coast of India.
- Indian coast is home to 5,790 sqkm of coral reefs and associated biodiversity.
- The total population of the coastal districts of India is 171 million, accounting for 14.1 per cent of India's population,
- Urban settlements along the coast have considerable wealth in the form of assets and infrastructure, including the megacities of Mumbai and Chennai.

National Context - India

- Long term tidal records from different locations show local sea level rise ranging from 0.33 to 5.16 mm/year. With average being at 1.7 mm/year
- In the past three decades about 32% of the coastline is under varying degree of erosion, 27% has seen net accretion and the remaining 41% are unchanged or stable (MoES, 2020b)
- 13% of World's cyclones in the Seas around India
- The INCOIS has prepared a Coastal Vulnerability Index (CVI) for the entire coastline and the Multi-Hazard Vulnerability Maps (MHVM) for mainland of India which indicates the probable coastal flooding due to disasters like tsunami and storm surges.

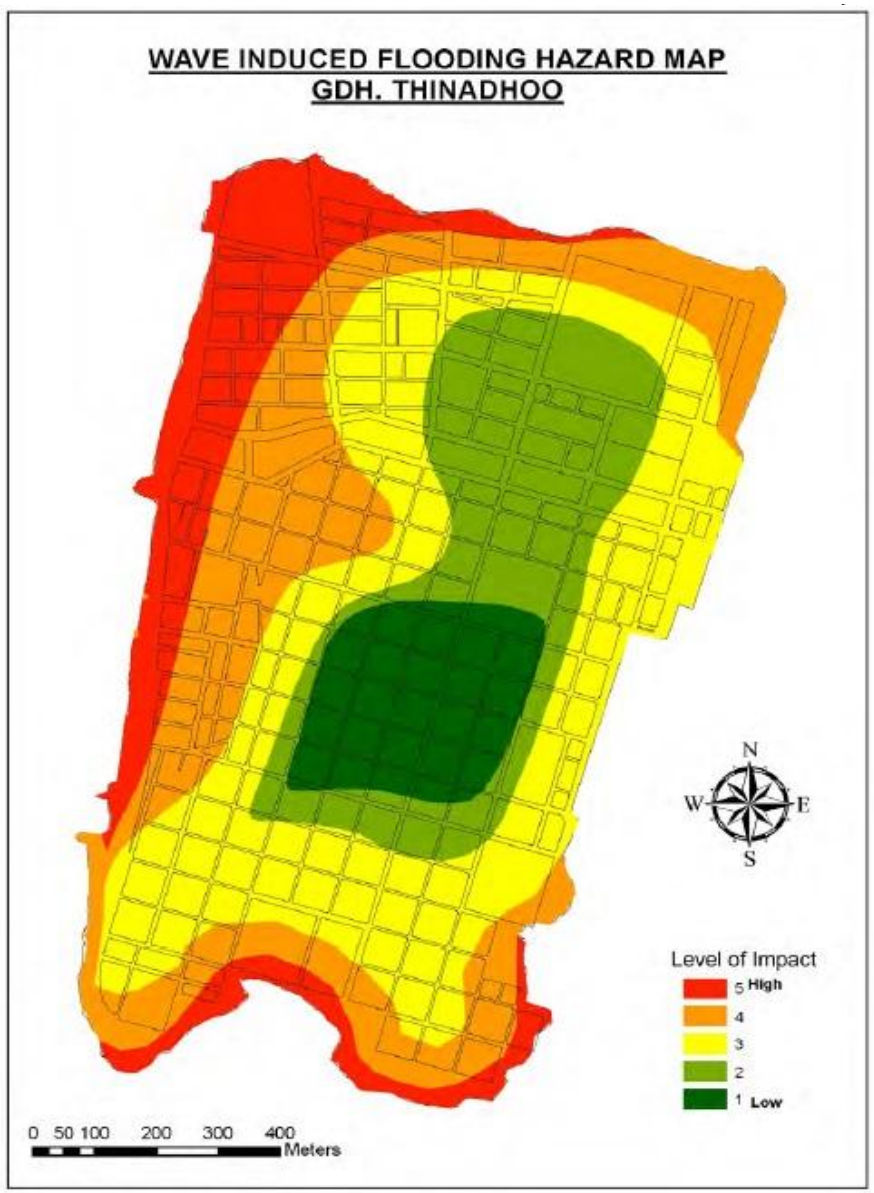
National Context - Maldives

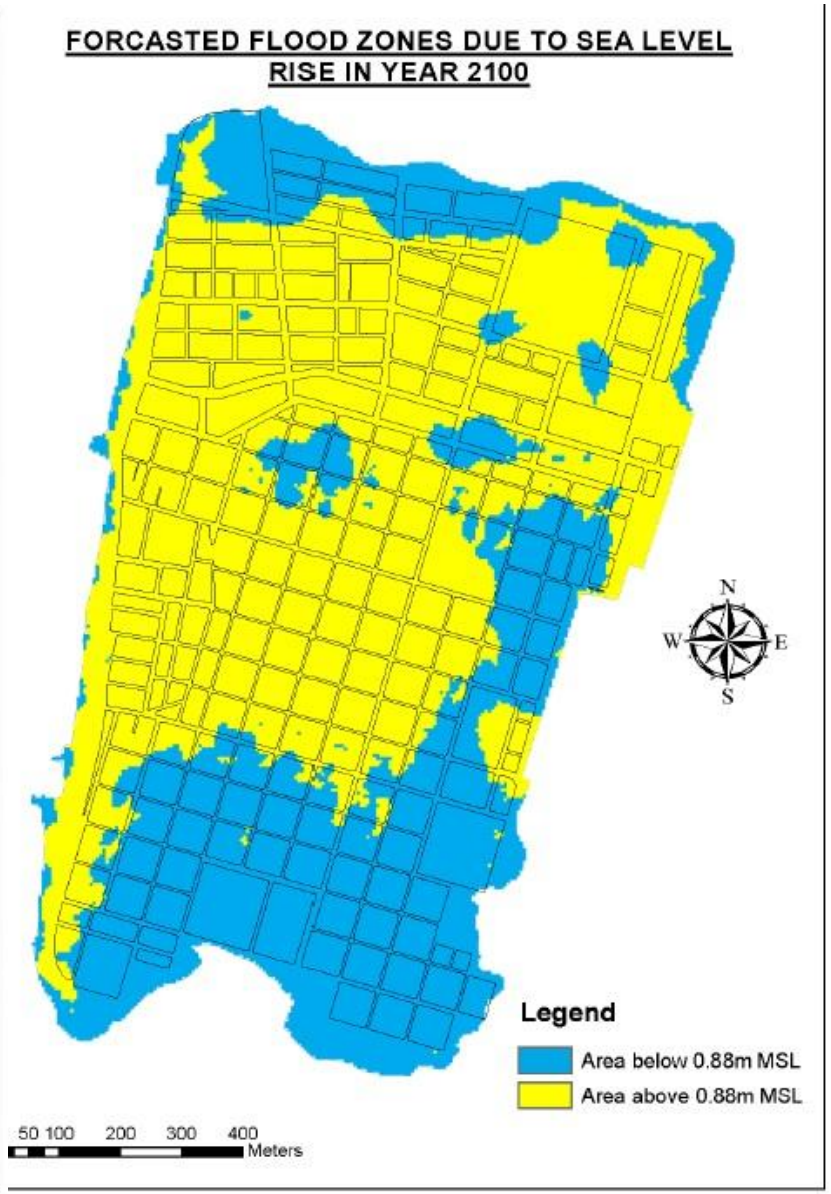
- Completely made up of chains of 1200 coral islands with the average elevation of 1.5m with 80% of dry land under 1m.
- Average size of the islands varies from less than 1sqkm up to about 8 sqkm. Thus, 100% of the population lives within 1 km of shoreline. All critical infrastructures are placed close to shoreline and are severely exposed to oceanographic disasters.
- Has no option of retreat.
- Maldives has gained land area over the past two decades mostly due to coastal modification projects (reclamation) .
- Swell waves that generate far from Maldives (in the Indian Ocean, west of Australia, off the coast of Madagascar) are known to cause flooding in the Maldives islands (NDMC, 2007), causing damages to properties, household goods, saltwater intrusion to groundwater aquifer and erosion.

National Context - Maldives

- Observed sea level rise higher than global average between 2.93 - 3.75 mm/year.
- Based on SRES scenarios sea surface height may increase up to 40 cm by the end of century.
- Coupled with tidal variation and waves this could lead to seasonal inundation in most of the islands in the archipelago.
- Tidal waves can flood the islands, particularly when the storm tide coincides with the normal high tides causing severe flooding in coastal areas.
- Detail risk and vulnerability assessment done on select few islands (Figure). Cost and resources required to do risk assessment at island level has been a major barrier.

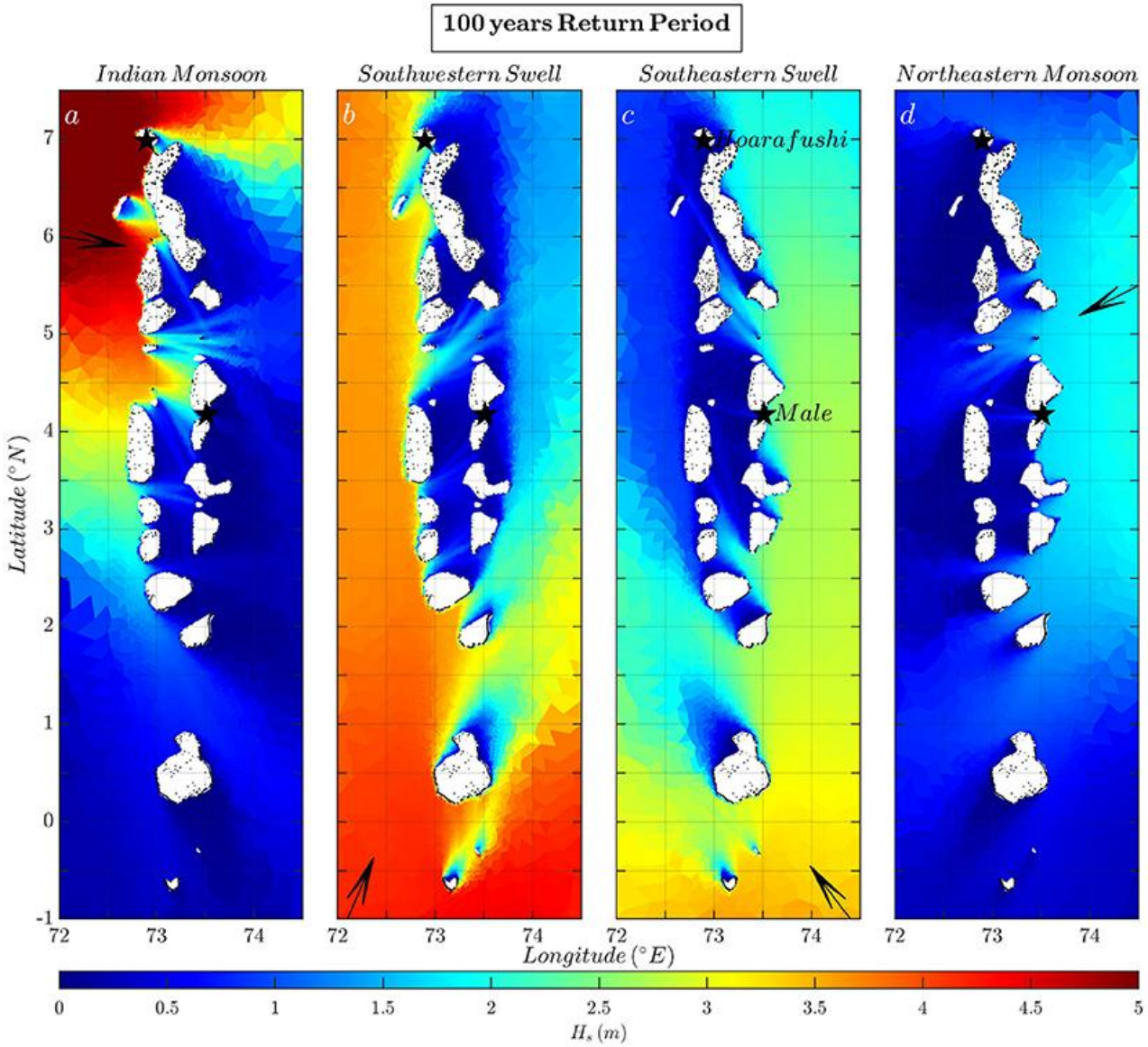
National Context - Maldives

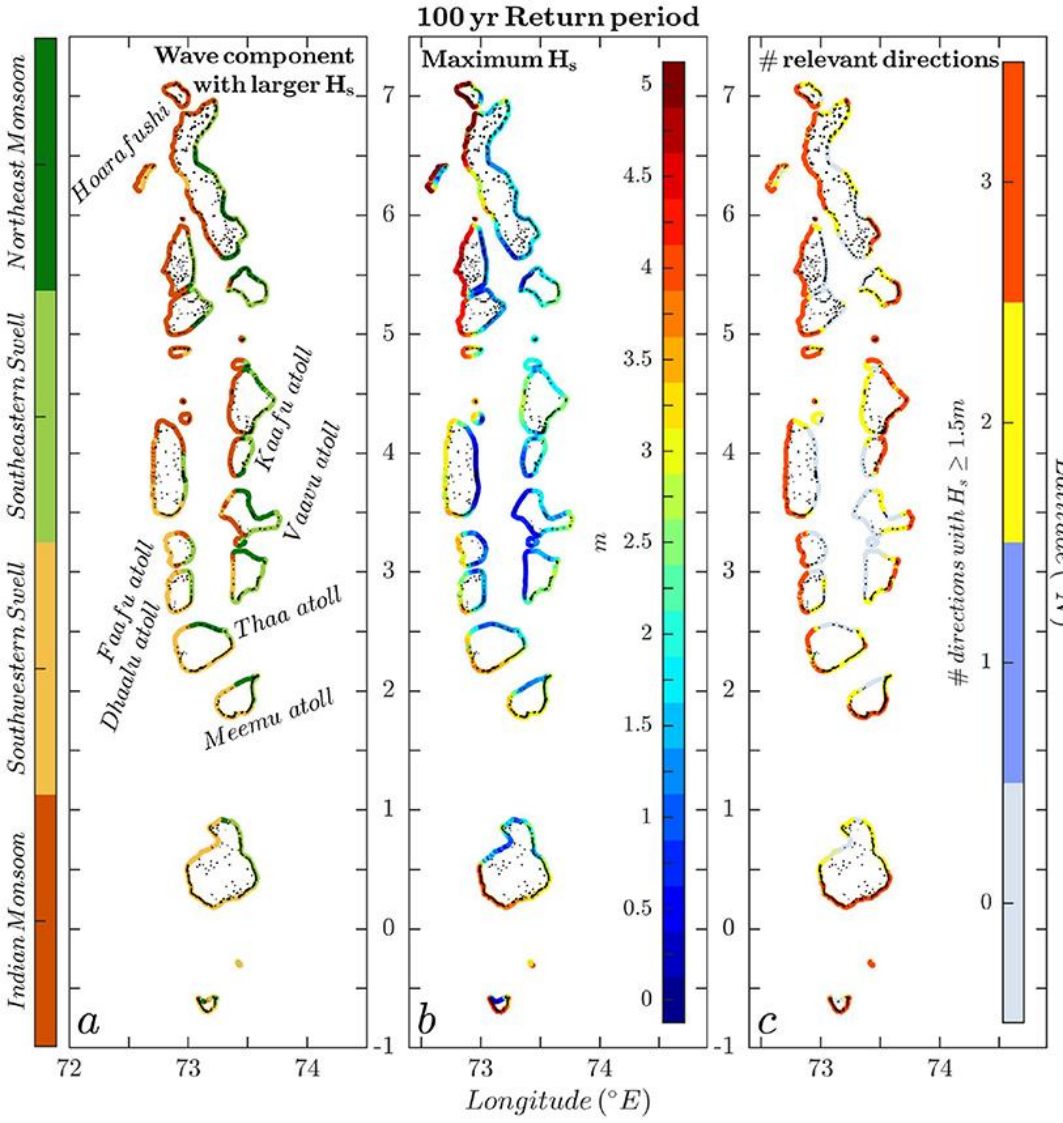




- Amores.et al 2021

National Context - Maldives





National Context - Pakistan

- 1050- km long coastline spread along the provinces of Sindh and Balochistan. Threat to coastal areas due to projected sea level rise and increased cyclonic activity due to higher sea surface temperatures
- Indus River Delta houses the largest arid climate mangroves in the world on an area of 345,000 ha
- Total mangrove area in Sindh province is about 600,000 ha and Balochistan province, has a total area is estimated to be 7,340 ha. These mangroves provide food and shelter during larval stage of the life cycle for some 80% of the commercial species caught from water.
- Indus Delta faces major threats due to inadequate fresh waterflows in deltaic region and sea level rise, which could significantly contribute to losses of coastal wetlands and mangroves by increasing salinity in the coastal areas.

National Context - Pakistan

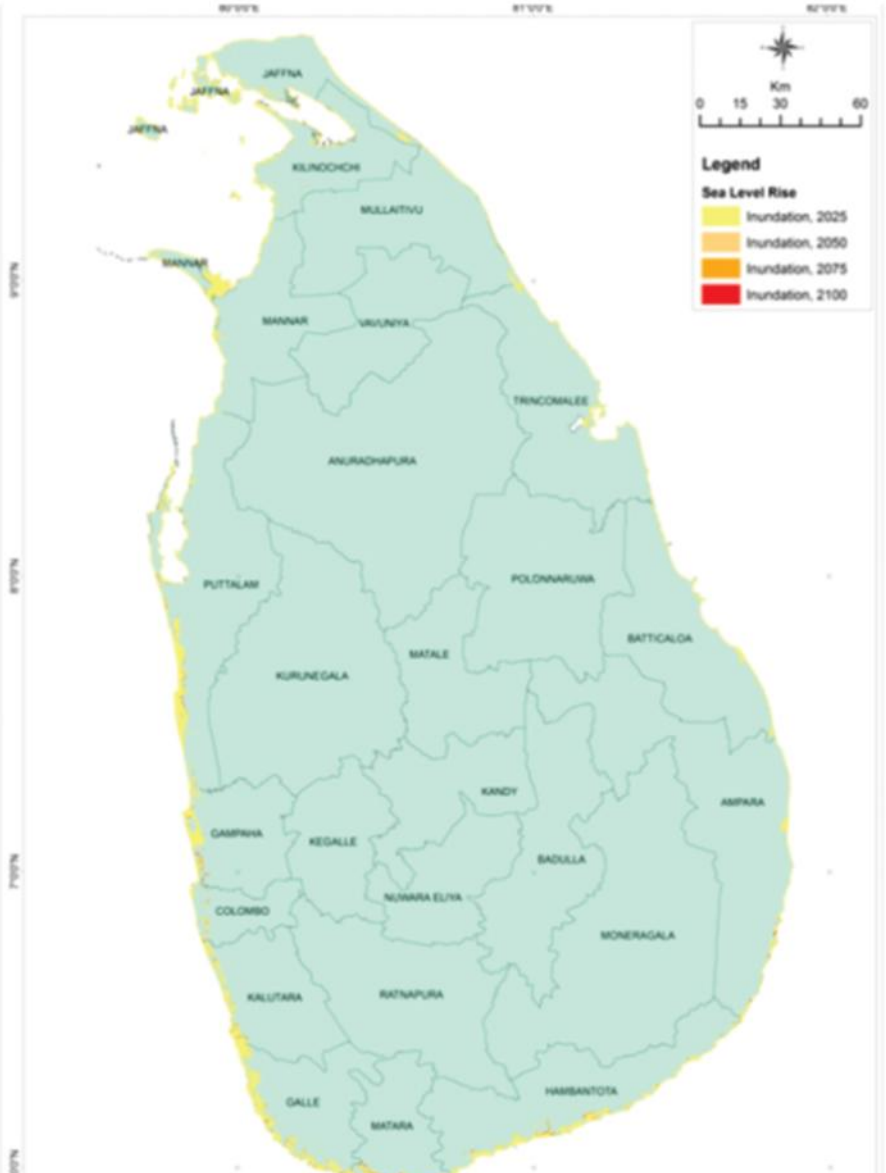
- Sea level at Pakistan's coastline shows an increasing trend of 1.1 mm/ year. But Balochistan coast is tectonically being uplifted at the rate of 1- 2 mm/ year
- Sea level impact on coastal areas and its resources via degradation of mangrove forests, inundation of low- lying areas, declining drinking water quality, and decrease in fish and shrimp productivity
- The Sindh coastal zone's vulnerability is considered higher due to flat topography, high population density industrial activities along coastal areas, such as Karachi. Furthermore, the delta region is both sinking and shrinking
- Increased level of coastal erosion due to sea level rise; (the current level is as high as 176 m per year in some places in the Indus creek system).
- By 2050, after seawater incursion into the delta, 0.79% of the Indus Delta population will be at risk while 2.73% of the delta area will potentially be lost.

National Context – Sri Lanka

- The country has a coastline of around 1600 km of the main island with additional 100+ smaller islands within the territorial waters with only few exceeding 1000ha of area.
- The coast consists of 45 estuaries, around 40 lagoons, 680 sqkm of coral reef, 11,800 ha of beaches and 7606 ha of sand dunes.
- The coastal area makes up 19% of the land area, 22% of the population, 65% of the urbanized land, 17% of agricultural lands and 20% of the home gardens .
- Principal roads and railway network connecting the cities are located along the coastline. Some of the other principal industries including 80% of the all tourism infrastructure are located in coastal areas.

National Context – Sri Lanka

- Has an observed SLR rate of 3.1 mm/year. In addition, country is vulnerable to rain induced flooding and cyclonic storms.
- Coastal salinity is expanding, triggered by change in evo-transpiration, use of inorganic chemicals in agriculture and sea level rise.
- Hazard profile of Sri Lanka uses SRES scenarios and predicts nearly 25 thousand ha of land being permanently inundated by 2100
- Sri Lanka Hazard Profile covers SLR, Erosion, Flooding and Cyclones (http://www.dmc.gov.lk/images/hazard/hazard/Report/)



Regional Mitigation Efforts

- South Asia Nitrogen Hub
- Plastic Free Rivers and Seas Project (PLEASE)
- Marine and Coastal Biodiversity Strategy for the South Asian Seas Region
- Regional Seas Indicators
- regional oil and chemical spill contingency plan

Thank you for Listening

Topic	Pressure Indicators	State Indicators	Response Indicators
Global/Climate Change		CI-4 Annual mean sea surface temperature (25m below the surface) Category of Indicator: Ocean warming CI-11.1 Aragonite saturation CI-11.2 pH CI-11.3 Alkalinity Category of Indicator: Ocean acidification	**CI-19.1 % national adaptation plans in place** **CI-19.2 Sector based national adaptation plans** **CI-19.3 Number of existing national and local coastal and marine plans incorporating climate change adaptation** **Category of Indicator:** **Climate change adaptation**
Fisheries and aquaculture	CI-5 Fish catches within EEZs (tonnes) – total capture production Category of Indicator: Fish landings	CI-7 Destruction of habitat due to aquaculture Category of Indicator: Aquaculture CI-12 FAO stock status: % stocks overfished compared to MSY Category of Indicator: Level of exploitation of commercial fisheries CI-13 Marine trophic index Category of Indicator: Species replacement as a consequence of capture fisheries	**CI-20 Fisheries measures in place (by-catch limits, area-based closures, recovery plans, capacity reduction measures) and multilateral/bilateral fisheries management arrangements** **Category of Indicator:** **Fish harvested within safe ecological limits** **CI-6 Application of risk assessment to account for pollution and biodiversity impacts** **Category of Indicator:** **Aquaculture**
Coastal zone management		**CI-8 Length of coastal modification and km2 of coastal reclamation** **Category of Indicator:** **Population pressure / urbanization**	**CI-22 National ICZM guidelines and enabling legislation adopted** **Category of Indicator:** **National ICZM in place**

Topic	Pressure Indicators	State Indicators	Response Indicators
Pollution	CI-1 Chlorophyll a concentration as an indicator of phytoplankton biomass Category of Indicator: Total inputs of nitrogen and phosphorus from agriculture, sewage and atmospheric nitrogen CI-2 Trends for selected priority chemicals including POPs and heavy metals Category of Indicator: Inputs of marine chemical pollution Trends for selected priority chemicals CI-3 Quantification and classification of beach litter items Category of Indicator: Overall levels of marine litter Quantification of beach litter Items CI-17.3 % of untreated wastewater Category of Indicator: Wastewater treatment facilities	CI-9 Locations and frequency of algal blooms reported Category of Indicator: Eutrophication status CI-10.1 Status of selected pollutant contamination in biota and sediments and temporal trends Category of Indicator: Pollution hot spots CI-10.2 Number of hotspots Category of Indicator: Pollution hot spots CI-10.3 Trends in the ambient noise level measured by observation stations and/or with the use of models if appropriate	**CI-16 % National action plans ratified / operational** **Category of Indicator:** **National Action Plans to reduce input from LBS** **CI-17.1 % coastal urban population connected to swage facilities** **Category of Indicator:** **Wastewater treatment facilities** **CI-17.2 % of wastewater facilities complying with adequate standards** **Category of Indicator:** **Wastewater treatment facilities** **CI-18.1 % port waste reception facilities available** **Category of Indicator:** **Incentive to reduce marine litter at source** **CI-18.2 Incentives to reduce land-based sources** **Category of Indicator:** **Incentive to reduce marine litter at source** **CI-18.3 Amount of recycled waste on land (%)** **Category of Indicator:** **Incentive to reduce marine litter at source**
Species and Habitats		**CI-14. Distribution of Red List Index species** **Category of Indicator:** **Endangered species** **CI-15 Trends in critical habitat extent and condition** **Category of Indicator:** **Loss of critical habitat**	**CI-21 % Marine protected areas designated** **Category of Indicator:** **Critical marine habitat under Protection** **CI-15bis National guidelines and enabling legislation adopted to manage, and where possible control, pathways for the introduction of invasive alien species**