Climate Change and the Changing Water Cycle: Perspectives for Kerala

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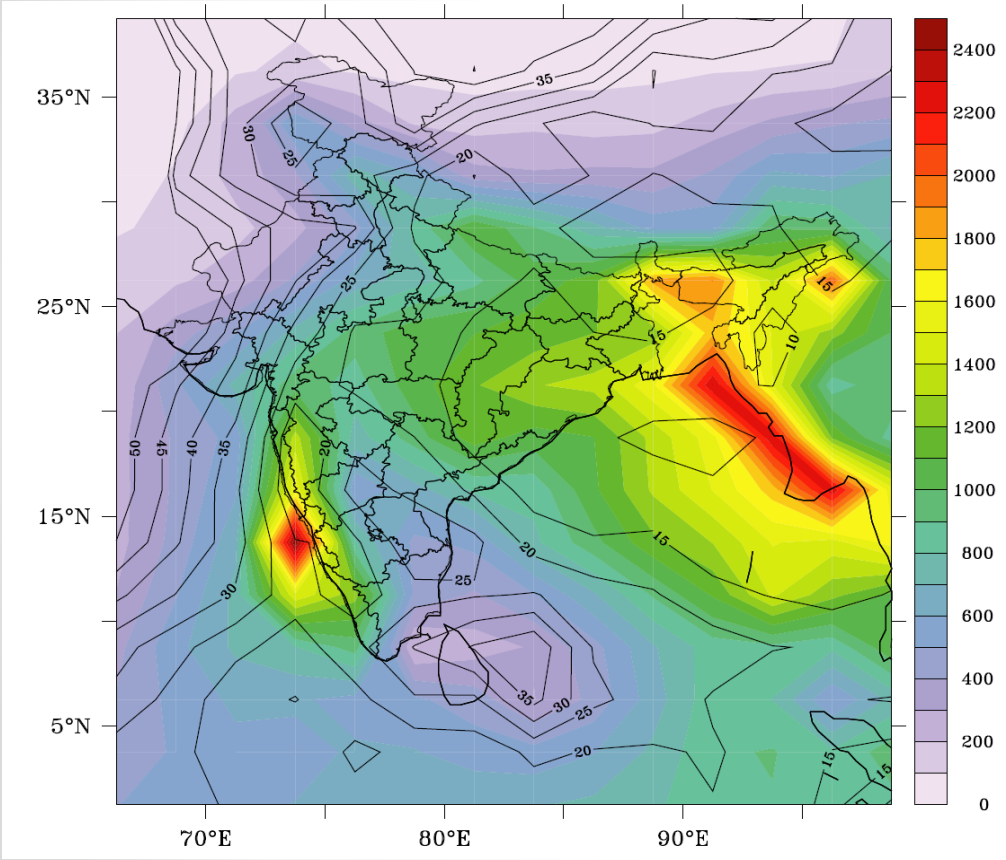
Unique Features

- Arabian to the west and the Western Ghats to the east.
- Long coastline of about 580 km as compared to 35–120 km width
- Annual mean annual rainfall is 2909 mm
- Receives 1986 mm rainfall during south-west monsoon season and contributes to 64% of the annual precipitation
- Northeast Monsoon rainfall contributing 18% of the annual on a state

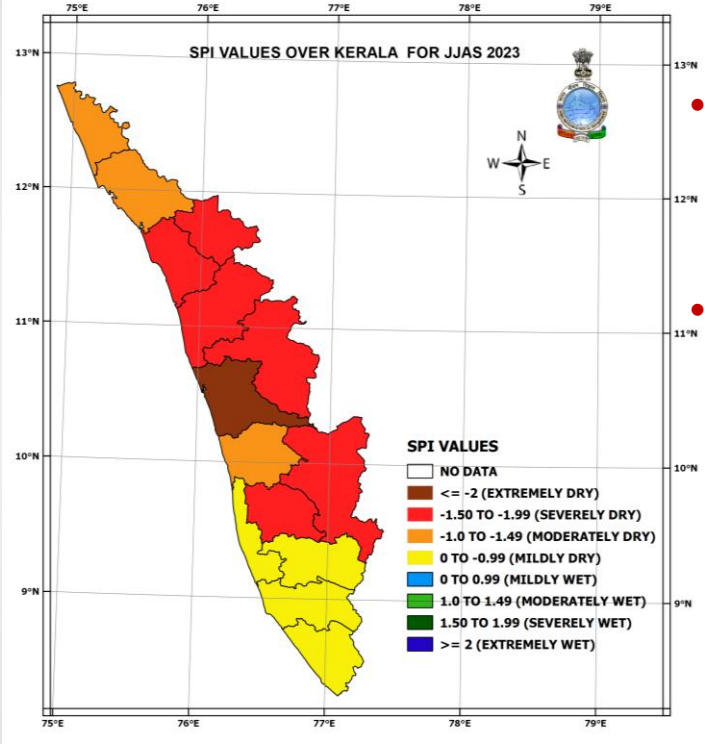
Summer monsoon rainfall (June-September)



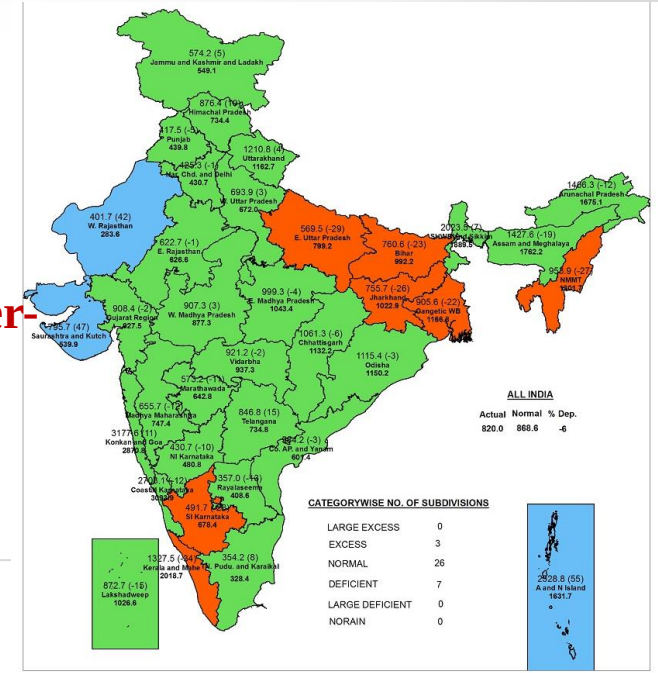
- Two rainfall maxima, centered over the Bay of Bengal and the second maximum is located along the west coast of India along Kerala
- Maximum rainfall received during the SW monsoon season is about 1200 mm
- Kerala receives higher SW monsoon rainfall as compared to other regions

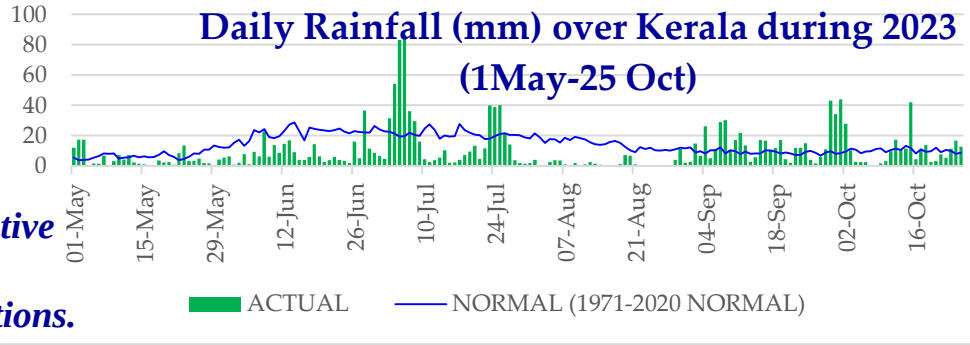
Southwest monsoon 2023

Standardized Precipitation Index (SPI)



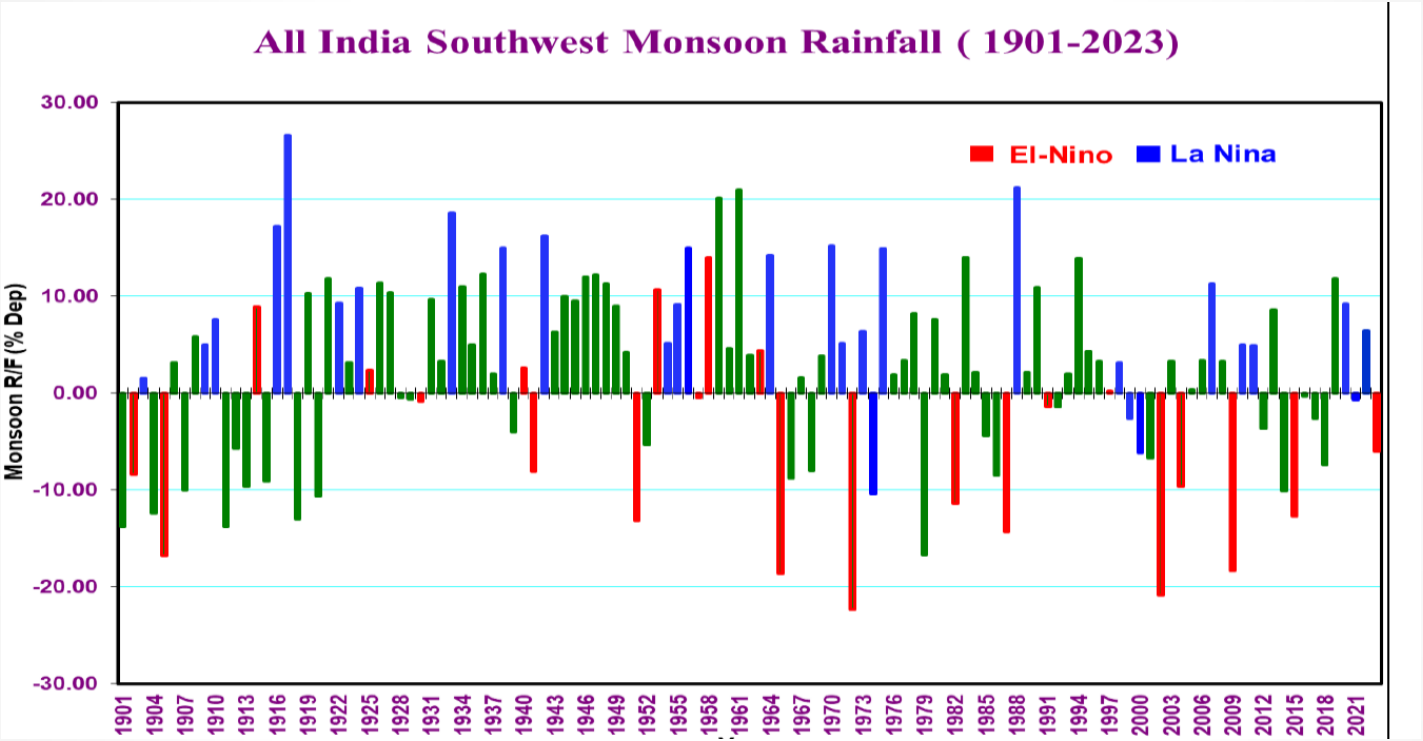
- **Summer monsoon undergoes large inter-annual variability**
- **Large deficiency in summer monsoon rainfall over Kerala during 2023**



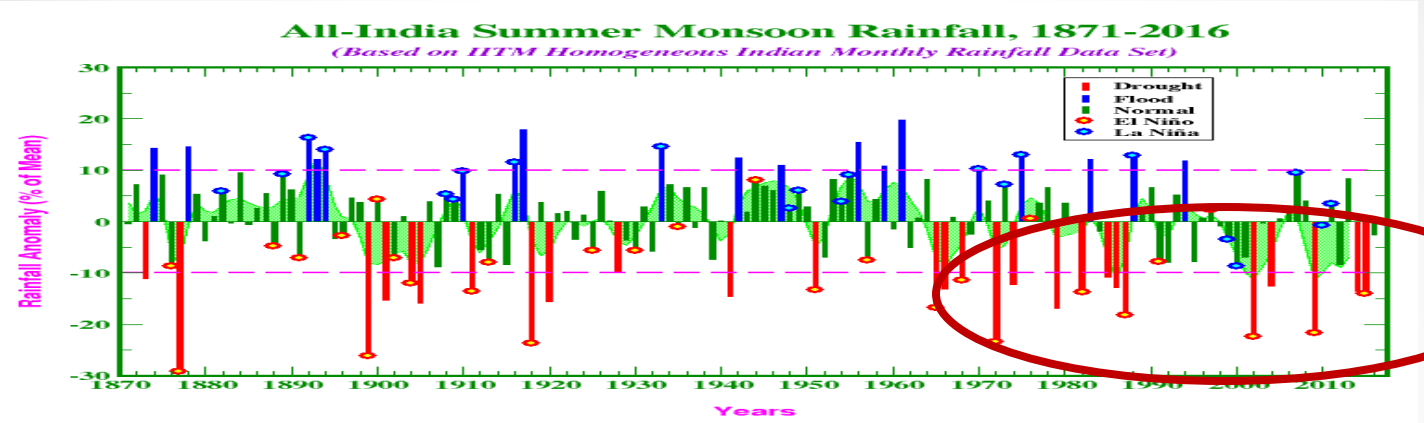


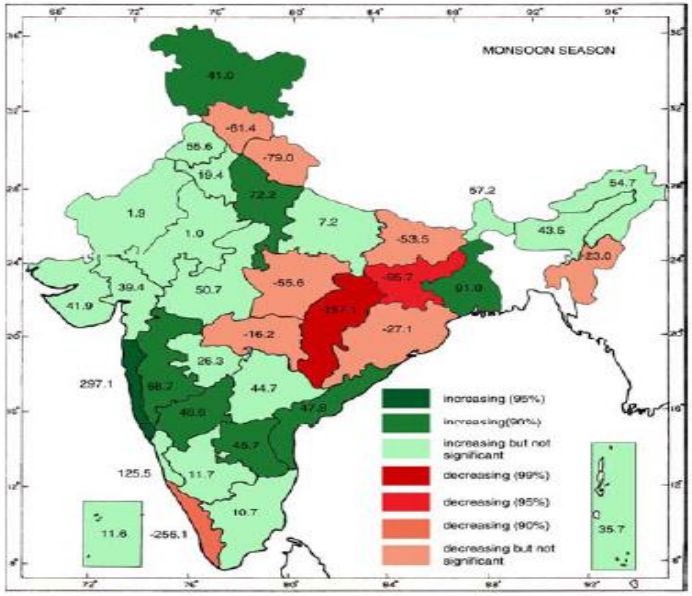
The SPI is used for defining and monitoring drought. Negative (positive) SPI values indicate shortage(surplus) of water availability at a given location relative to the normal conditions.

Inter-annual variability in All Indian Summer Monsoon Rainfall



- Inter-annual variability is caused by external drivers
- Red bars are deficient monsoon years associated with ENSO
- Indian Ocean Dipole also has a significant role on the inter-annual rainfall variability





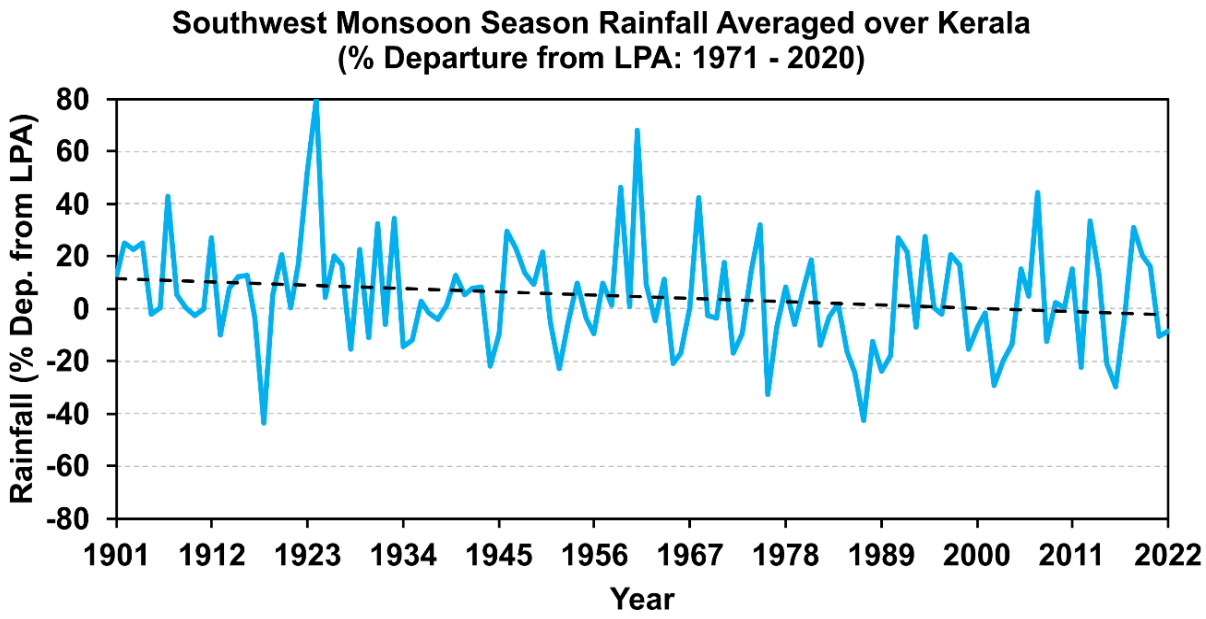
The frequency of monsoon-droughts are increasing

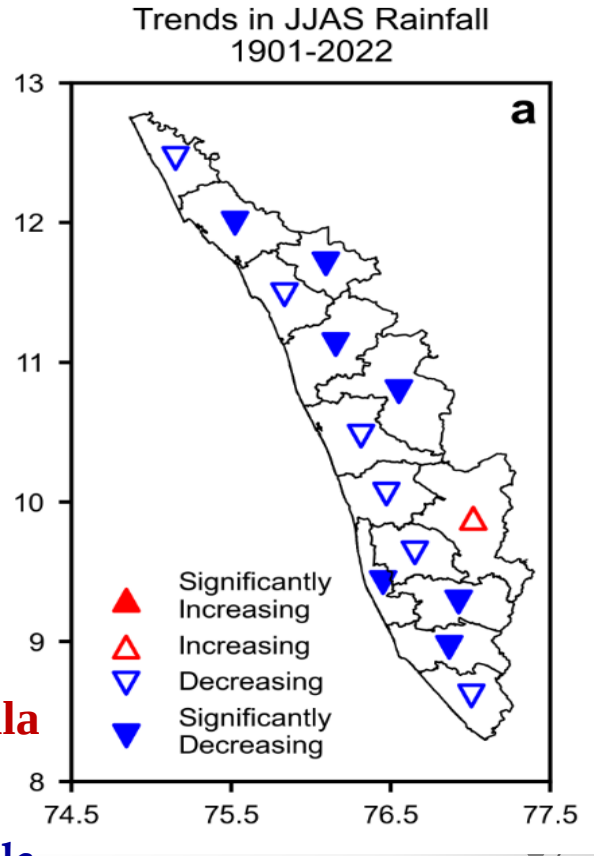
Long-term trends in the Indian monsoon rainfall

Guhathakurtha and Rajeevan, 2006: Trends in monsoon rainfall over India (1901-2003)

Significant negative trends: Kerala, Jharkhand, Chattisgarh

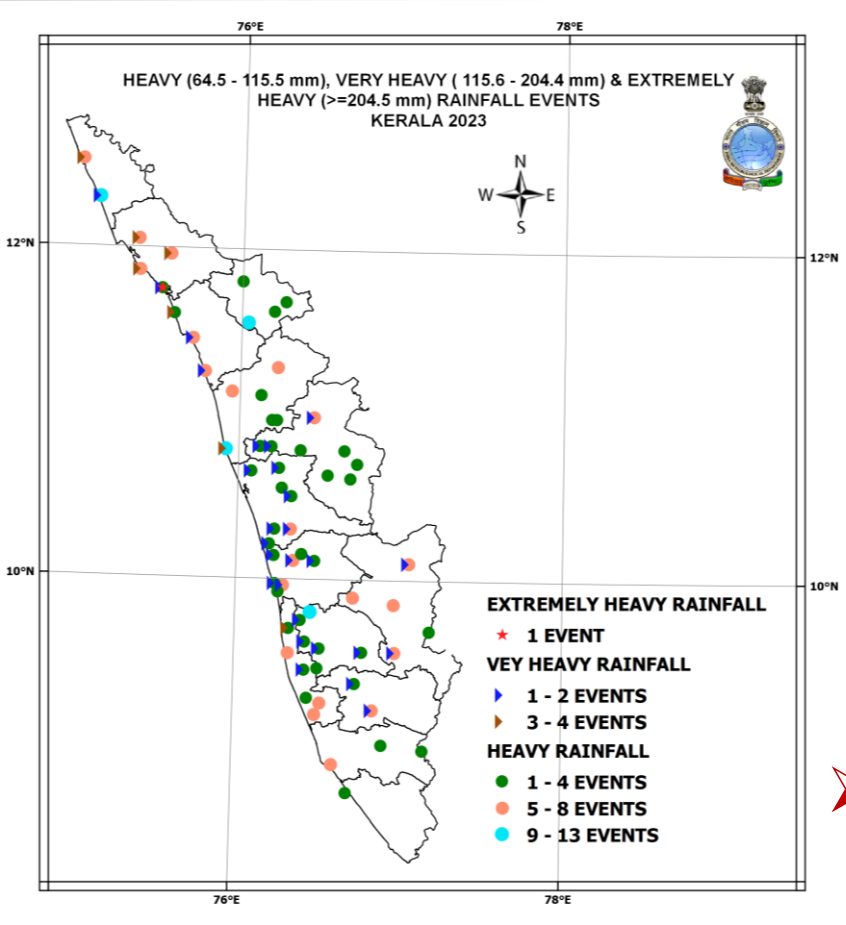
Long-term change in summer monsoon rainfall



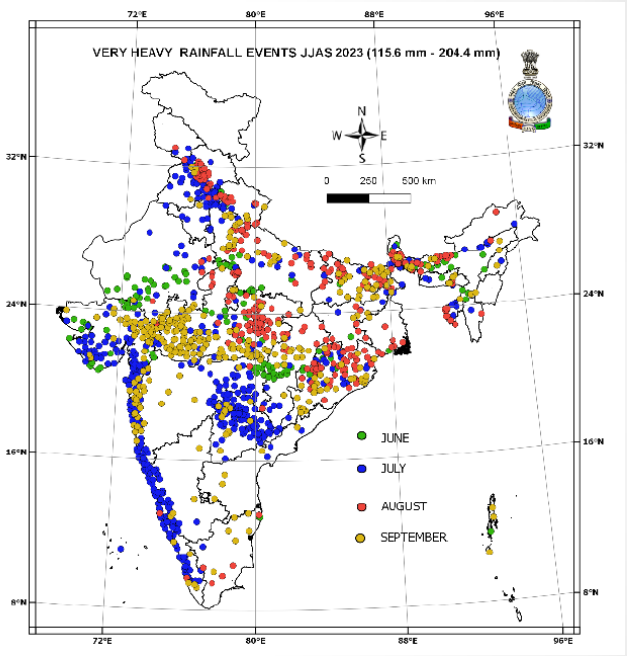


- **Summer monsoon rainfall has been decreasing over Kerala**
- **Significant decreasing trend in most of the districts**

Heavy rainfall events over Kerala

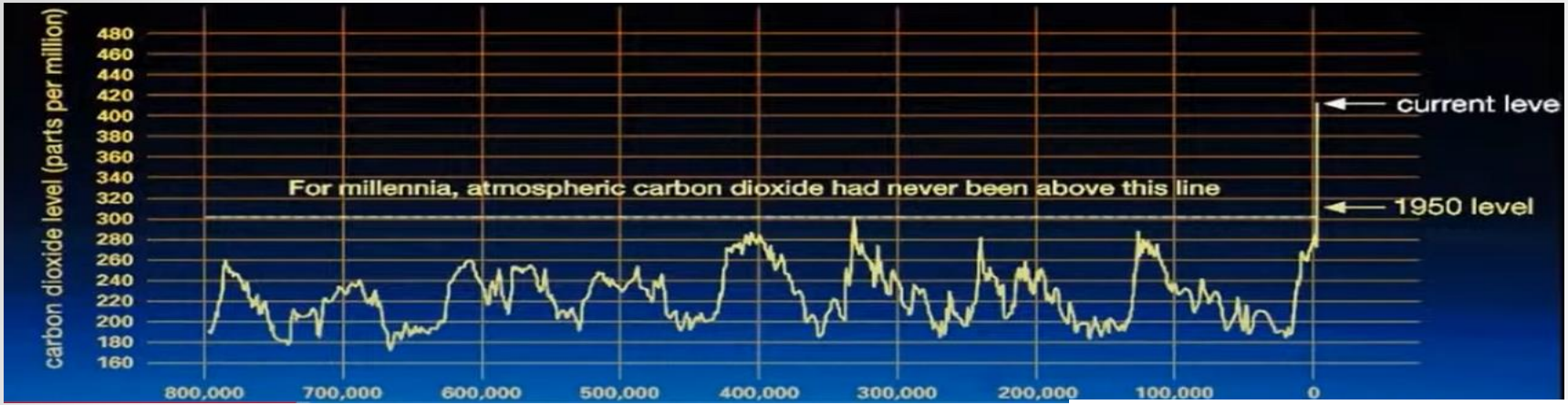


Very heavy rainfall (115.6 to 204.4 mm) events over India



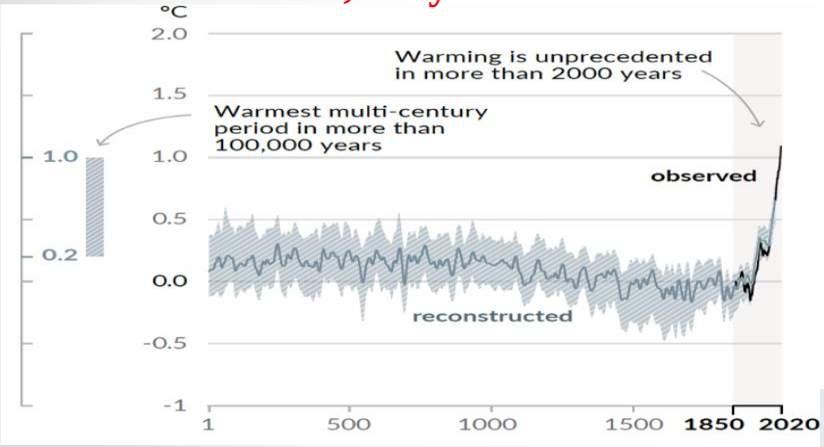
- **Heavy and extremely heavy rainfall has been increasing under warming climate**

Anthropogenic contributors to climate change

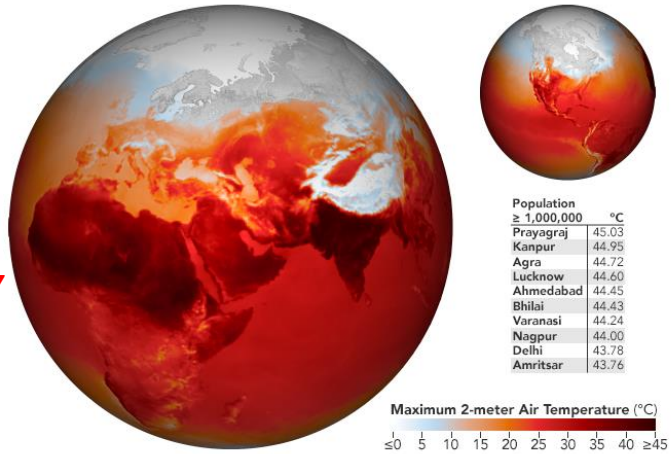


417ppm
Oct 2023

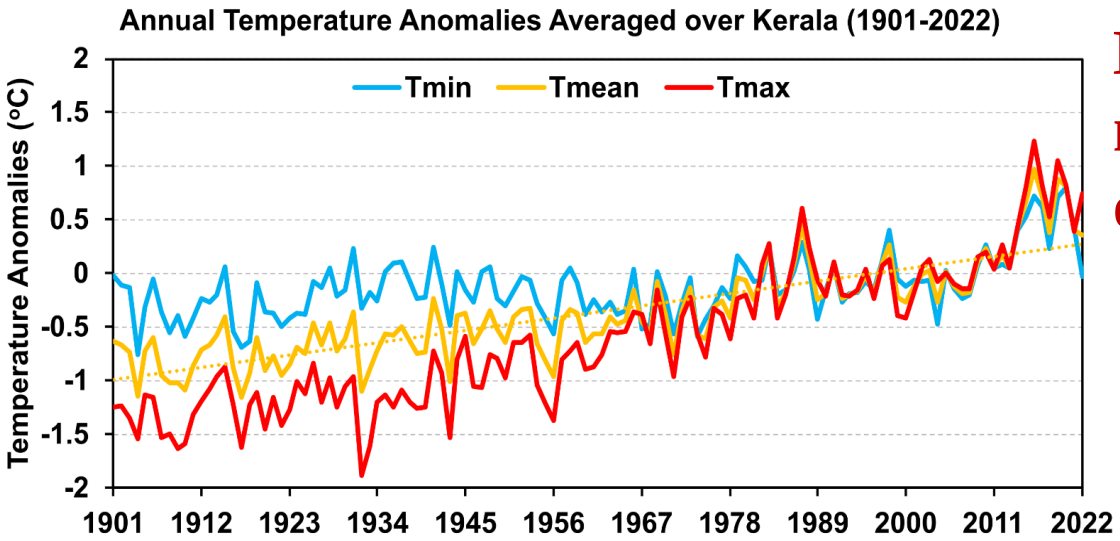
Changes in global temperature over the last 2,000 years



Kerala witnessed a significant increase in the average maximum temperature (~ 1.67 C/100 years). Ref : ICCS, Kerala.

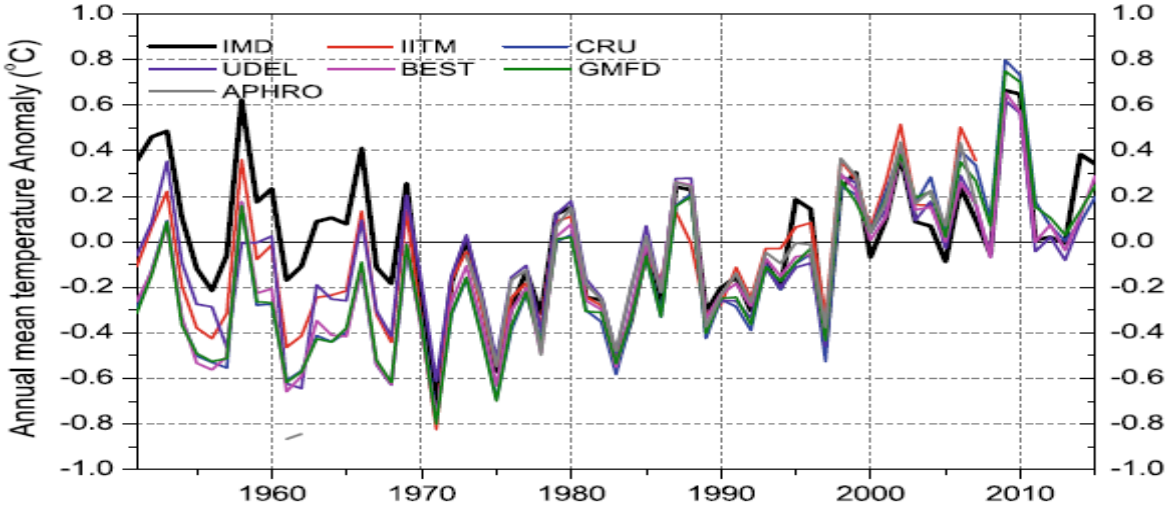


2023 summer was the hottest summer on record since 1880.



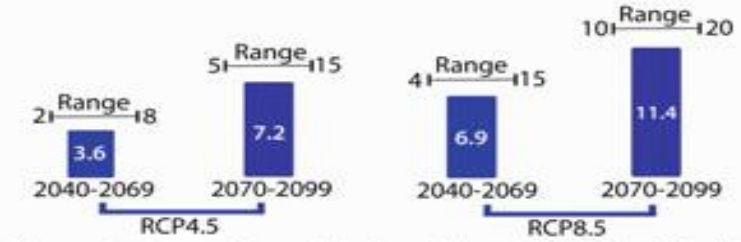
Long-term change in annual mean surface temperature over Kerala

Annual mean surface temperature over India

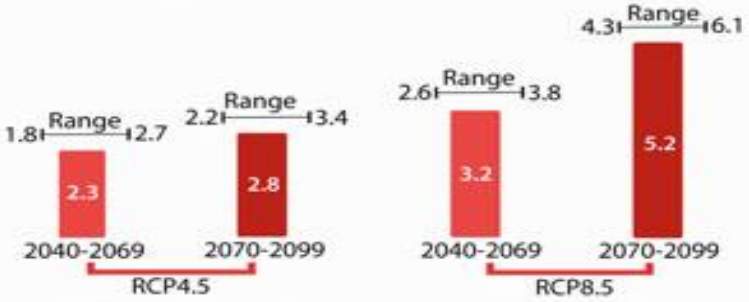


- **Surface temperature has been increasing**

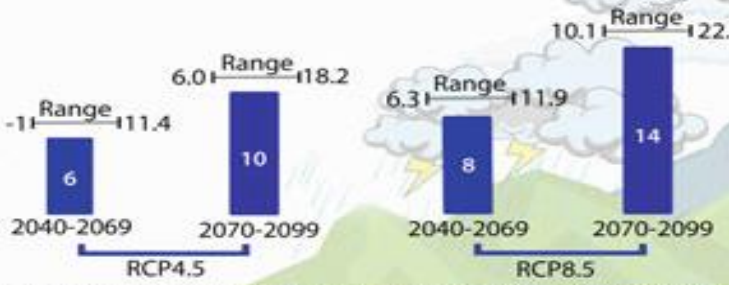
Projected Changes over the Indian Region



Change in Annual Precipitation (%) over the Hindukush Himalayas



Change in Surface Air Temperature (˚C) over the Hindukush Himalayas

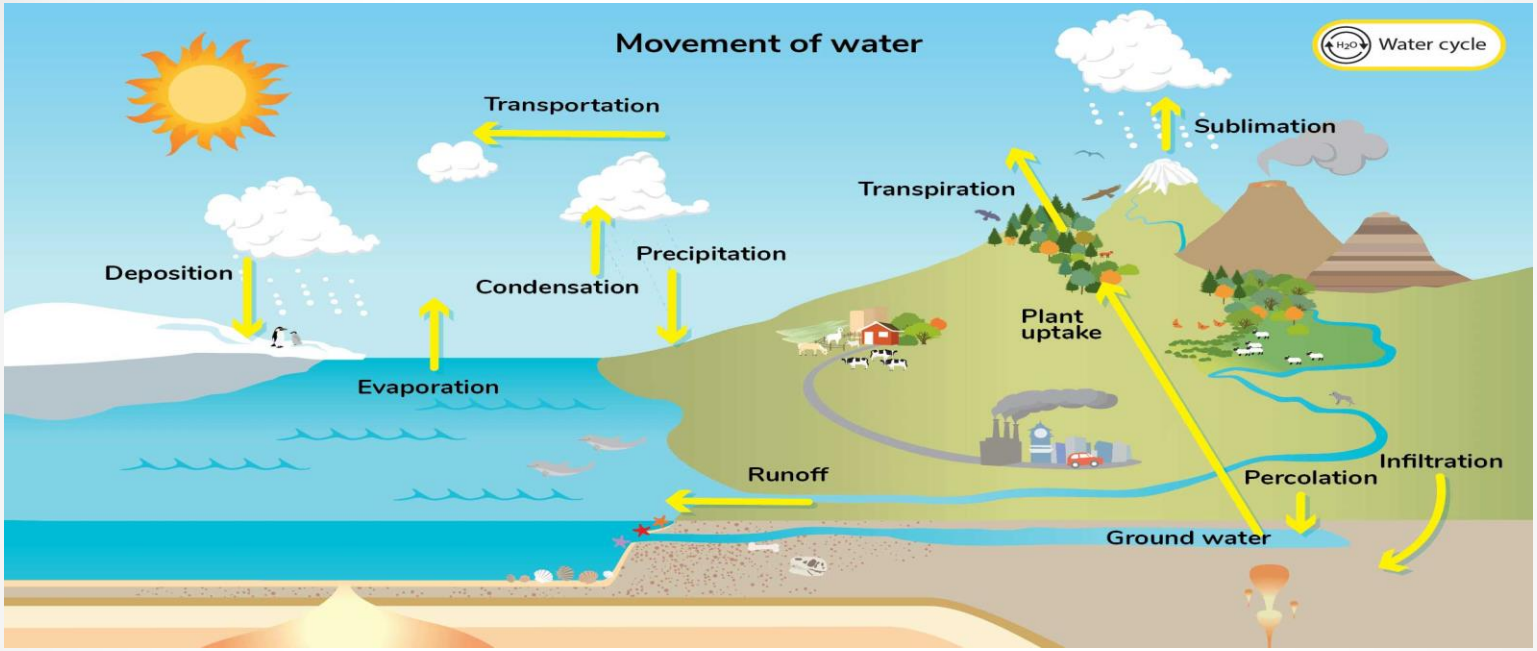


Change in Summer Monsoon Precipitation (%) over India

Change in Sea Surface Temperature (˚C) of the Tropical Indian Ocean

Change in Surface Air Temperature (˚C) over India

Water cycle changes



- Approximately 75% of the Earth's surface is covered by water
- Water is constantly moving between the atmosphere, land, and ocean, shaping our planet's climate and ecosystems.
- Global warming alters the water cycles through changes in the Earth system and changes the patterns of atmospheric circulation and contribute to the frequency and severity of droughts and floods

With every increment of global warming, changes get larger in regional mean temperature, precipitation and soil moisture

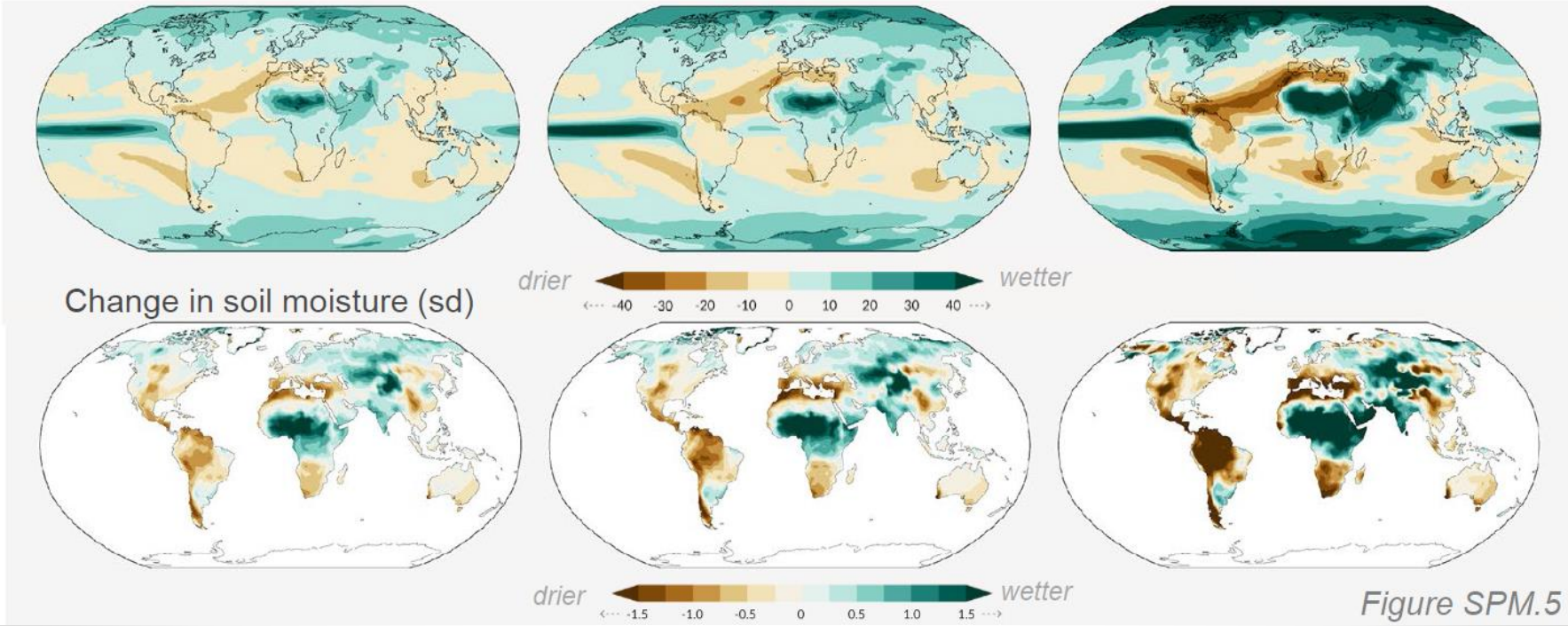
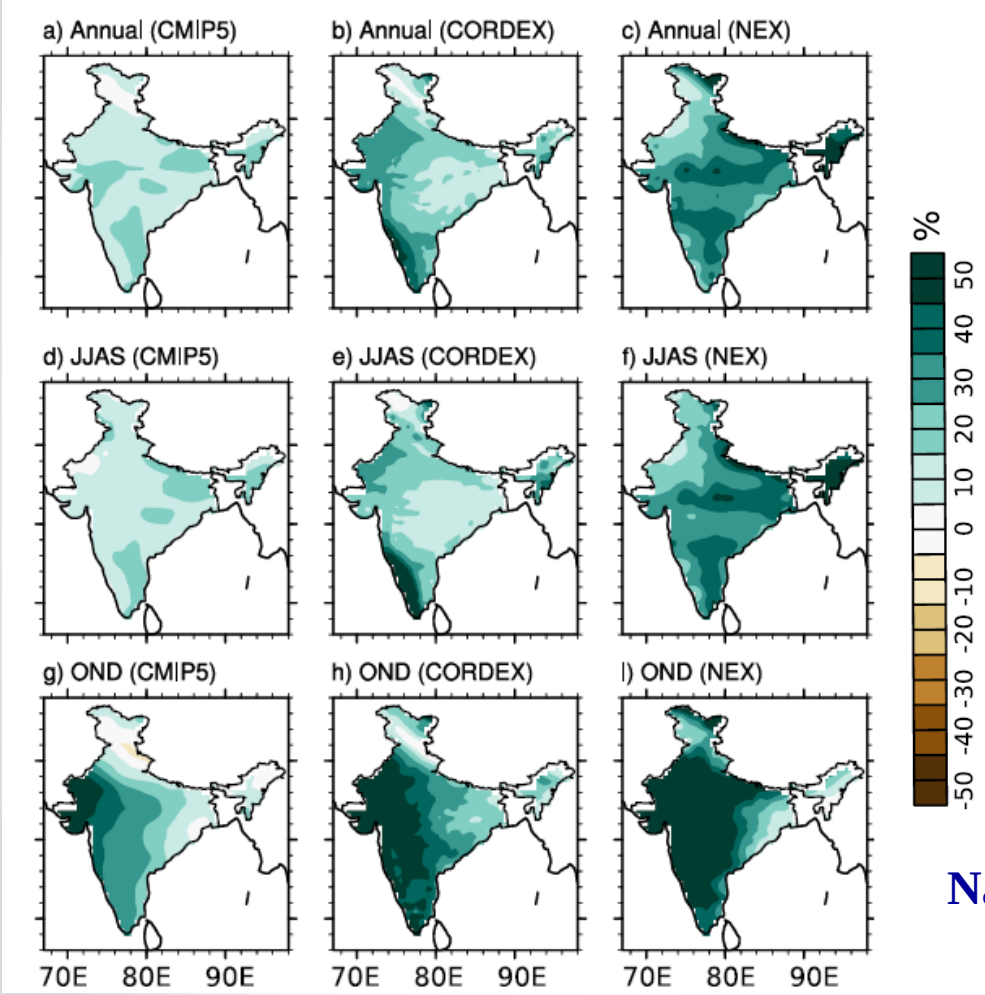
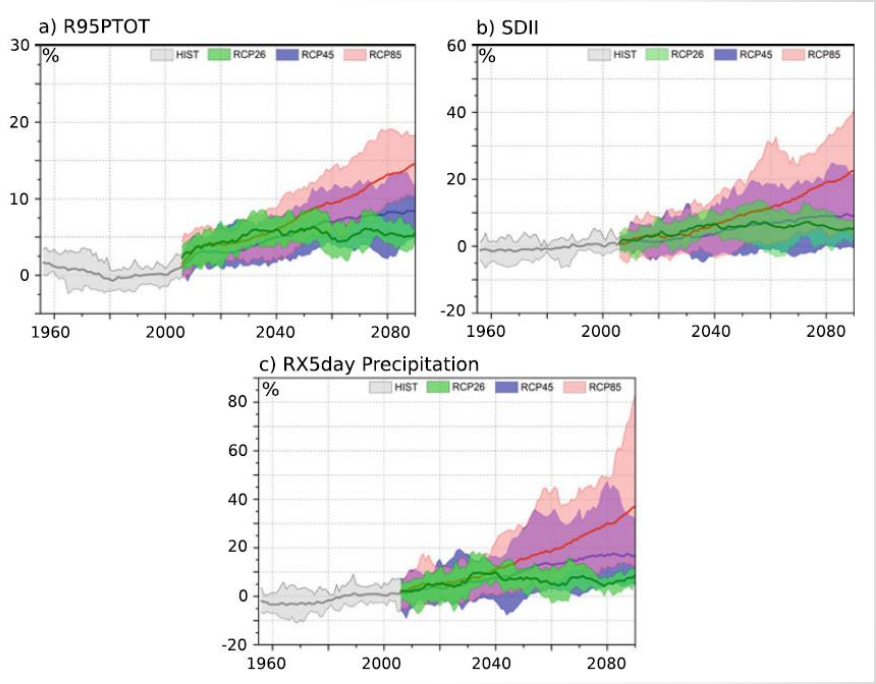


Figure SPM.5

Precipitation (RCP8.5, 2070-2100)

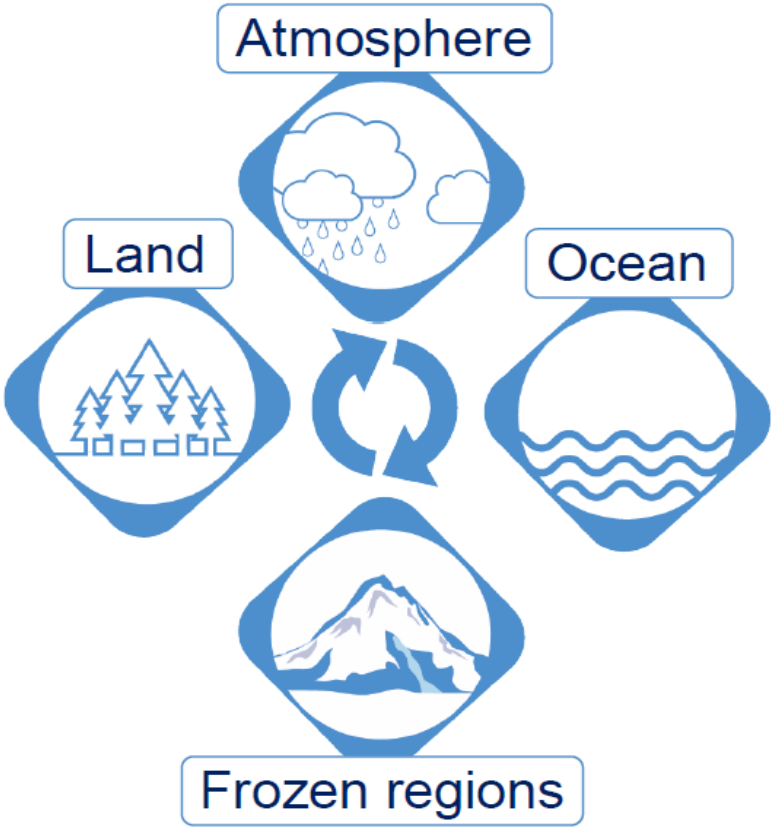


Precipitation Indices

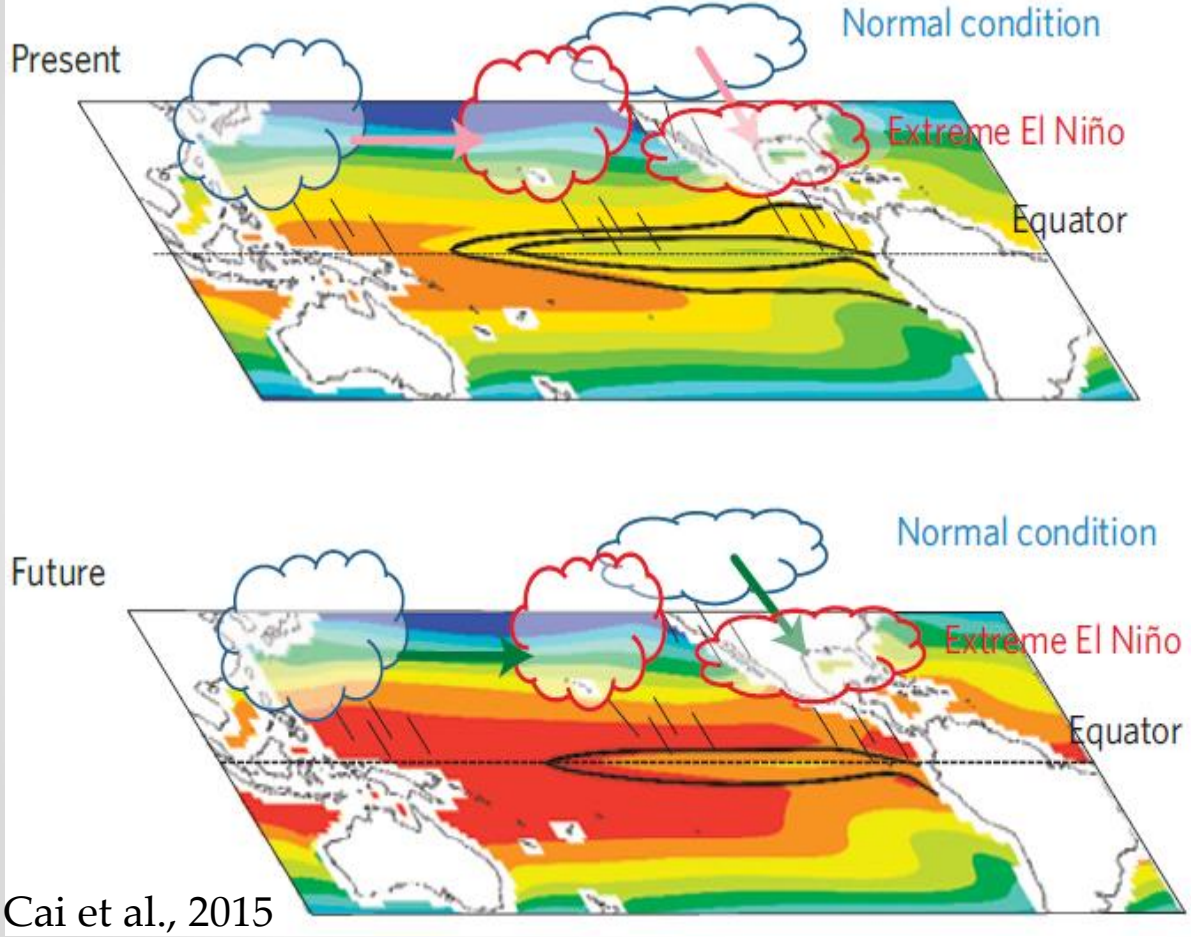


National Climate Change Assessment Report, MoES, Govt. of India

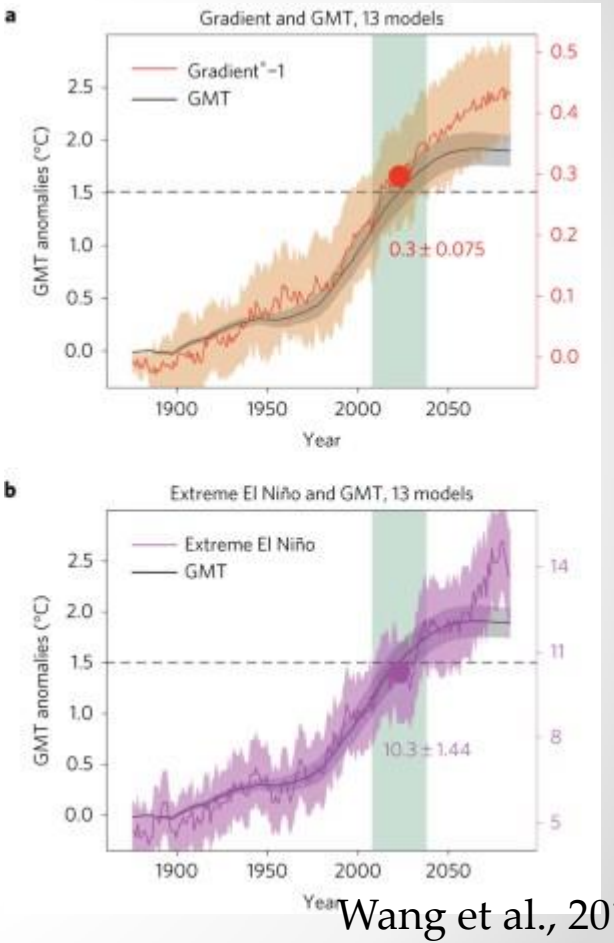
Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events



Increasing Extreme El Nino under global warming

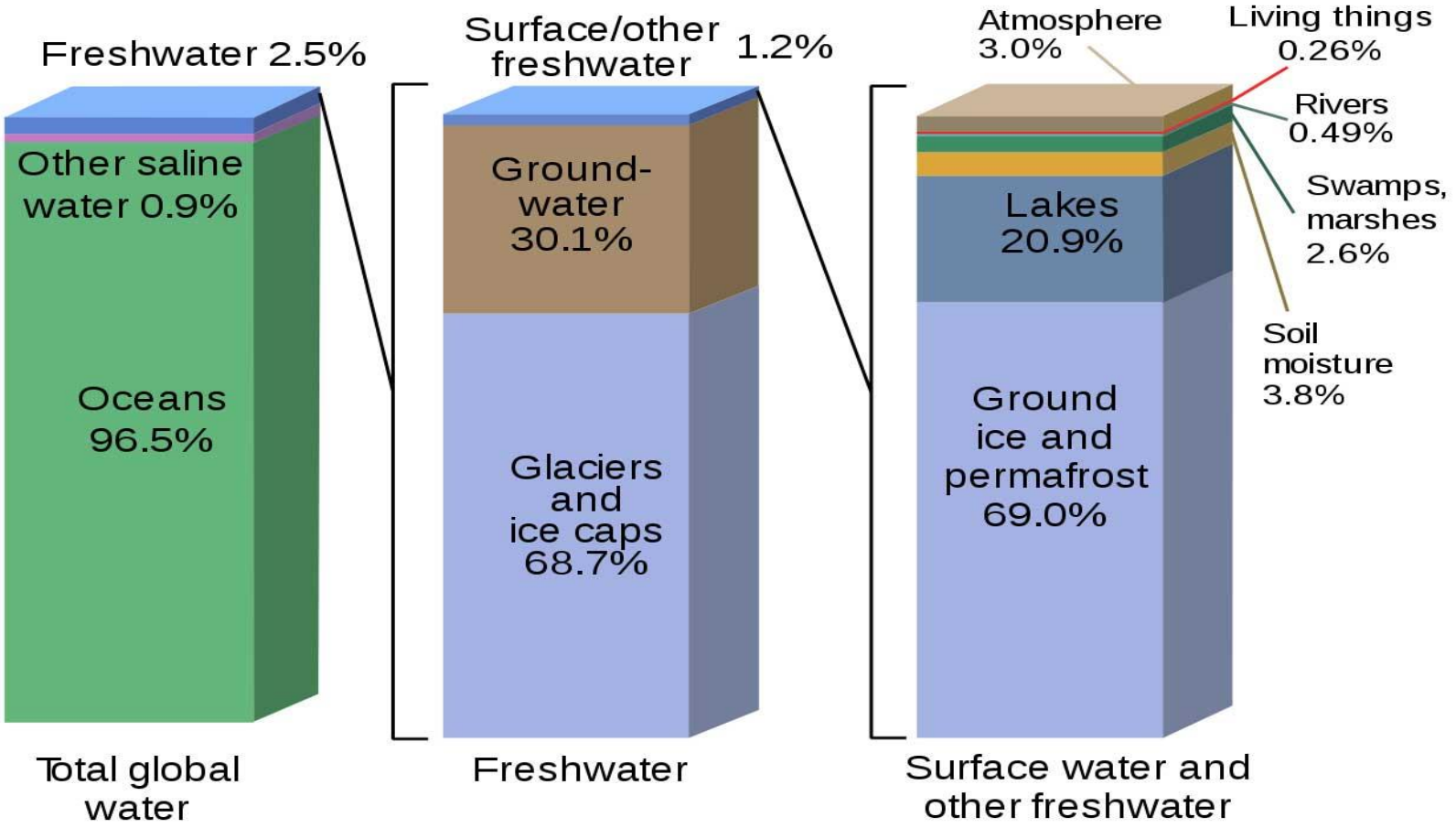


Cai et al., 2015

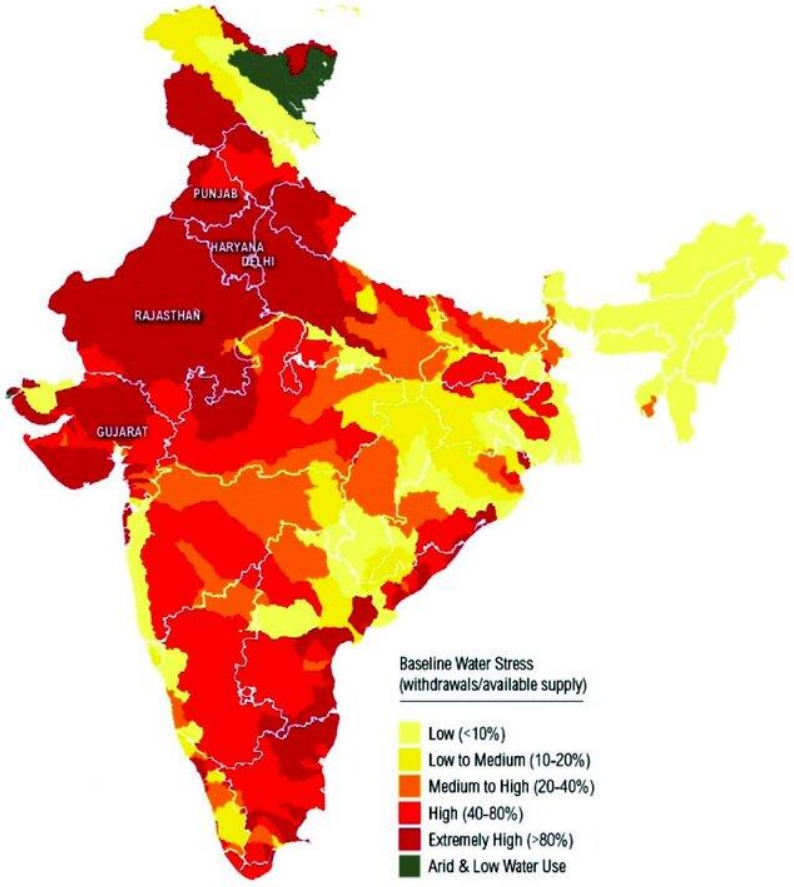


Wang et al., 2017

Where is Earth's Water?



Water stress in India - about 54 percent of geographical area faces high to extremely high water stress by 2030 (WRI, 2015)

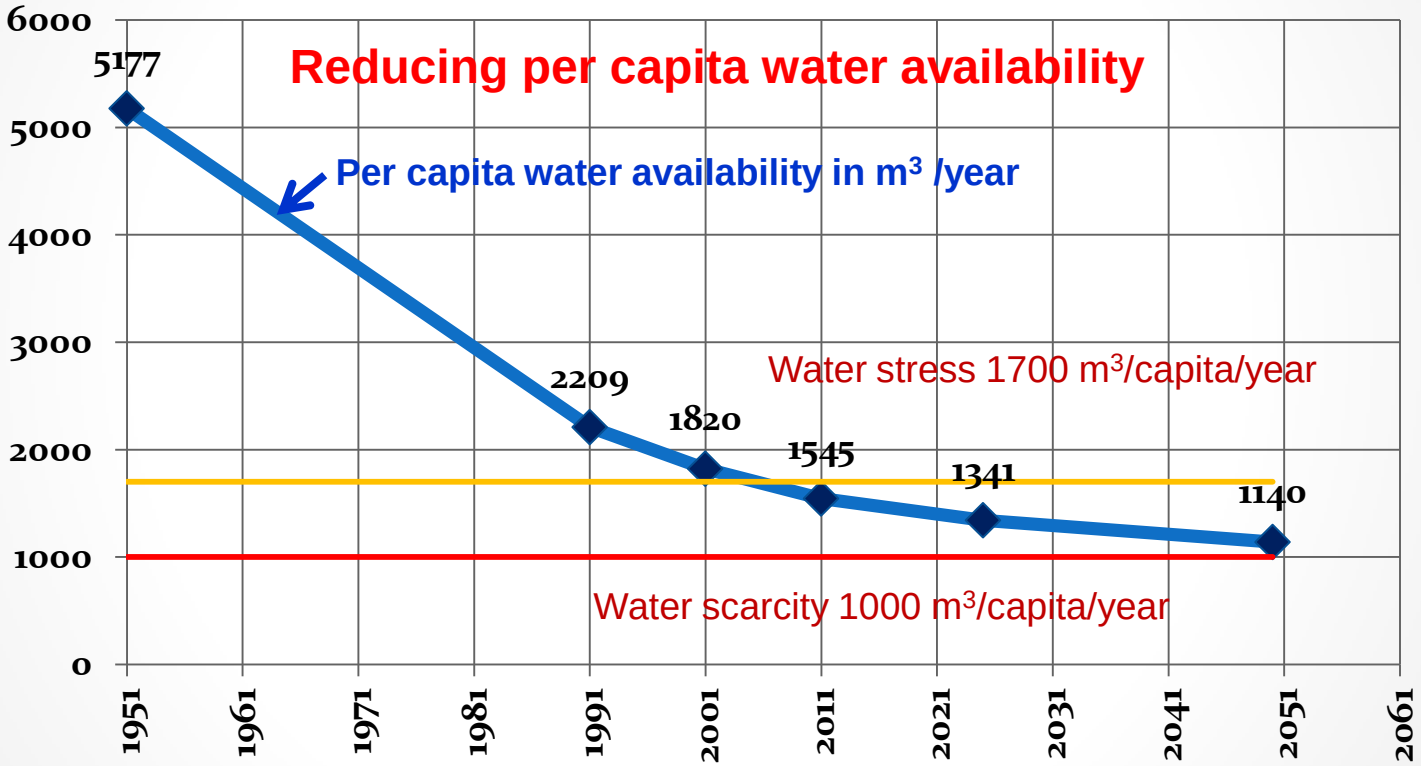


Water Stress

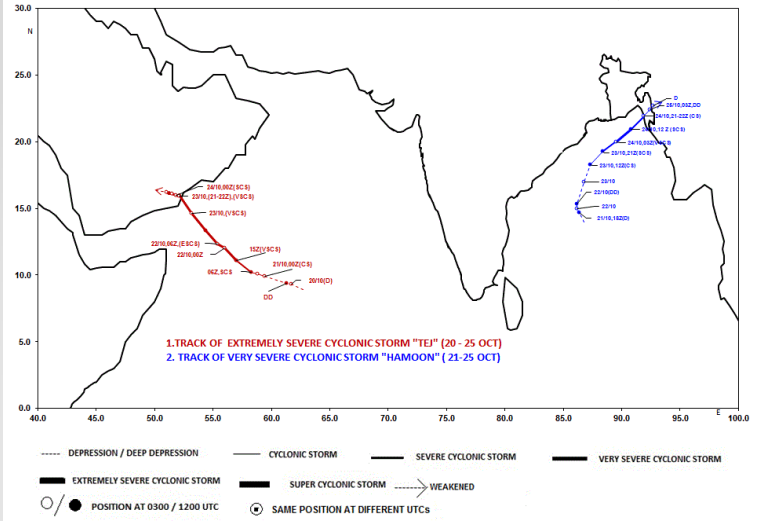
S.No.	States / Union Territories	Total No. of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
	States											
1	Andhra Pradesh	670	501	75	60	9	24	4	45	7	40	6
2	Arunachal Pradesh	11	11	100	0	0	0	0	0	0	0	0
3	Assam	28	28	100	0	0	0	0	0	0	0	0
4	Bihar	534	432	81	72	13	18	3	12	2	0	0
5	Chattisgarh	146	122	84	22	15	2	1	0	0	0	0
6	Delhi	34	3	9	7	21	2	6	22	65	0	0
7	Goa	12	12	100	0	0	0	0	0	0	0	0
8	Gujarat	248	194	78	11	4	5	2	25	10	13	5
9	Haryana	128	26	20	21	16	3	2	78	61	0	0
10	Himachal Pradesh	8	3	38	1	13	0	0	4	50	0	0
11	Jammu & Kashmir	22	22	100	0	0	0	0	0	0	0	0
12	Jharkhand	260	245	94	10	4	2	1	3	1	0	0
13	Karnataka	176	97	55	26	15	8	5	45	26	0	0
14	Kerala	152	119	78	30	20	2	1	1	1	0	0

Central Ground Water Board (CGWB)

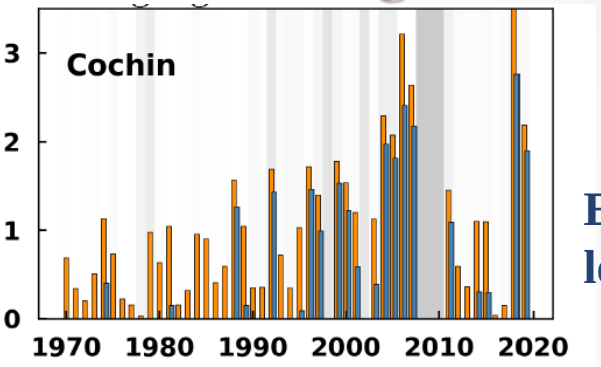
Water Scenario in India



TEJ 2023 (AS) and Hamoon 2023 (BoB

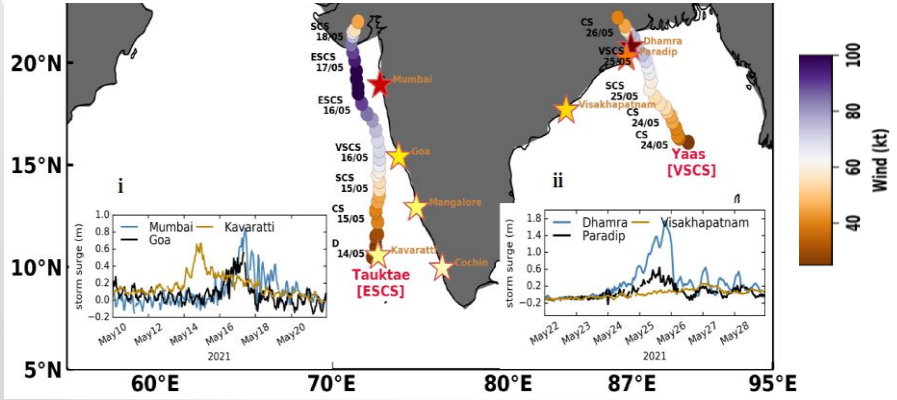


Increasing ocean warming, intensifying cyclones and increasing ESL

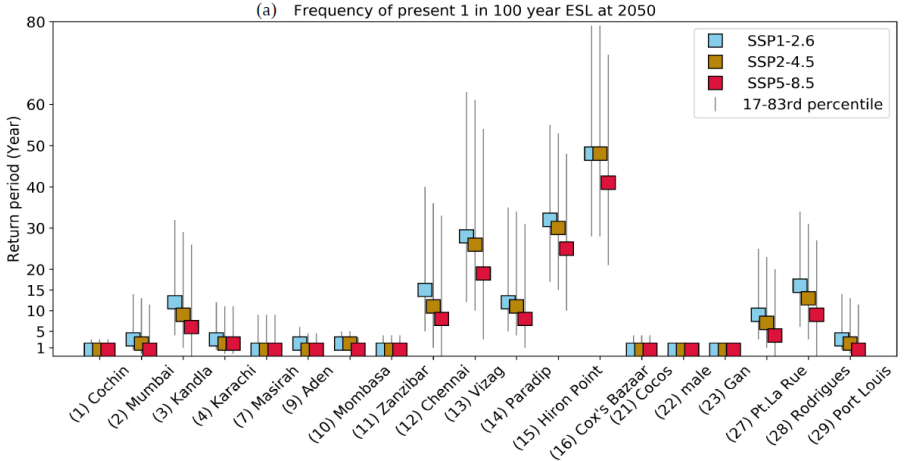


Extreme sea level

Very severe cyclonic storm Tauktae – 16 May 2021

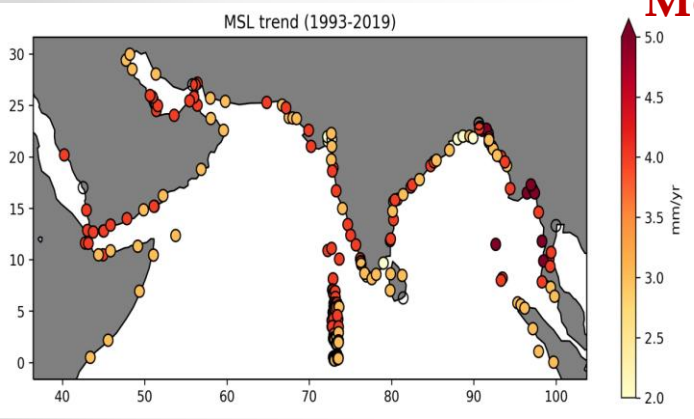


Projected change in ESL



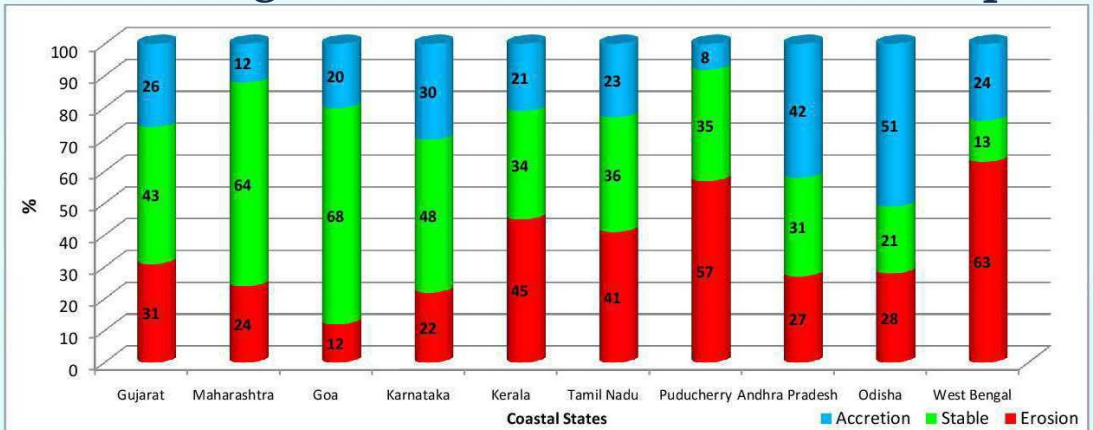
Sea level rise along Indian coast

Mean sea level rise



Station	Median projections of MSL rise (m) relative to 1995-2014 baseline period (IPCC AR6, SSP2-4.5 Scenario)	
	2050	2100
Mumbai	0.17	0.46
Cochin	0.22	0.58
Trivandrum	0.21	0.57

Shoreline change status of Indian coastal states (percentage)



Source : NCCR, Govt. of India

What can we do?

Climate Change Mitigation: ***Action taken to stop climate change by reducing the amount of greenhouse gasses in the atmosphere***

Climate Change Adaptation: ***Action taken to deal with climate change impacts and reduce the effects on lives, livelihoods and ecosystems***

Action : ***Climate change is likely to pose new challenges to water resource management and agriculture. Develop efficient methods for storing west-flowing river for addressing irrigated needs as well as addressing drinking water requirements***
Develop coastal protection measures for reducing impact of rising sea level


THANK
YOU!