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**REVIEW ARTICLE** **OPEN ACCESS**

# Review on consequences of climate changes on India's LECZ

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**ABSTRACT**

*One of the most significant hazards to coastal areas is climate change, which are already overburdened by human activity and population growth. In recent years, the Indian coast has experienced urban sprawl. Mumbai, Kolkata, and Chennai are the megacities on the Indian coast, which are located at an average elevation of 2-10 meters and are frequently affected by cyclonic surges. A surge in the relative rate of sea level rise is caused by Regional change in climate. Low-lying communities will experience enduring flooding as a result of these coastal shifts. The impact will be much more noticeable in coastal areas because of the sensitivity of coastlines to rising sea levels, increasing recurrence of cyclones and related storms, increases in precipitation, and shifts in ocean temperatures. There are already concerns in the area about conflicts between considerable human activity and biologically varied marine habitats.* This article describes mitigation strategies, detrimental effects of climatic changes on countless industries. It might be used as the foundation for creating regional disaster management plans. Climate change is a major hazard to coastal areas.
***Key words:*** *Climate change, LECZ, disaster management.*

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## INTRODUCTION

The length of the Indian coastline is approximately 7517 kilometer's, and it is heavily populated. Climate change and unpredictability are putting this ecosystem at risk. Climate shift as defined by Intergovernmental Panel on Climate Change "long-term change in the mean and/or variability of the climate" (IPCC). United Nations Framework Convention on Climate Change defines it as "A change in the atmosphere on a global scale and a long-term increase in natural climate variability brought on by human activity".

In accordance with the IPCC's 6th Assessment Report, carbon dioxide (CO2) is the main contributor to global warming. Since 2011 (report AR5), concentrations have been rising, carbon dioxide (CO2) about 411 ppm, methane (CH4) 1868 ppb, nitrous oxide (N2O) 331 ppb annually in 2019. There has been significant global warming as a result. The previous four decades have been the warmest compared to any decade since 1851, and the final two decades of the twenty-first century had a global surface temperature that was approximately 1 degree Celsius higher than the period between 1850 and 1900.

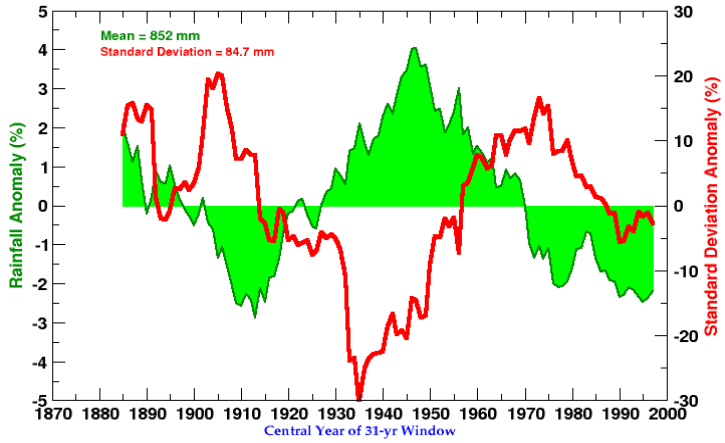


**Figure 1:** Epochal pattern of summer monsoon rainfall; source: IITM

Extreme weather and climatic events' frequency, intensity, regional extent, frequency, and timing, as well as sea level and land surface temperatures, are all impacted by this apparent climate change [10]. Climate catastrophes are already occurring frequently and violently on Earth, and they'll get worse in 20 or 30 years [11]. Coastal regions will be hardest hit by extreme weather and climate change [10].

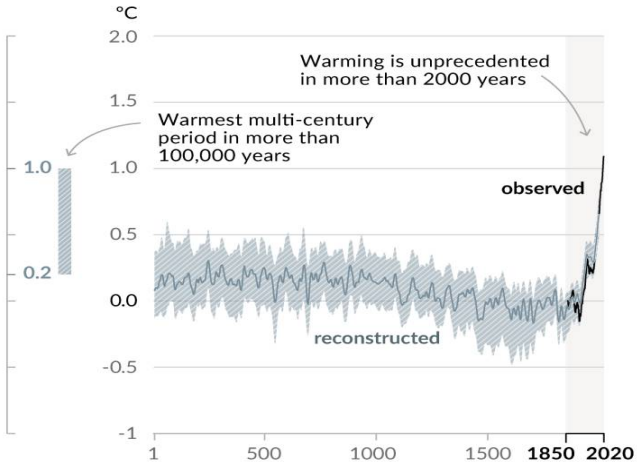


**Figure 2:** Reconstructed and fluctuations noted in the surface temperature throughout the globe (1 - 2000) (1850-2020); source: IPCC AR, 2021

Sea levels are rising due to global warming, harming coastal areas. The worldwide average sea level rise from 1901 to 2018, was 0.21 m; from 1901 to 1971, the sea level rose by 1.30 millimeters per year, and by 1.90 millimeters per year between 1971- 2006. The present pace of 3.71 mm/yr from 2006 - 2018 is especially alarming for the coastal regions of India [11]. Coastal locations are also prone to tropical cyclones and erosions due to increase in sea-level. According to the IPCC AR4 Report 2007, climate-induced changes will have a higher detrimental impact on developing nation beaches due to dense population pressure and lesser capacity for adaptation (IPCC, 2007). Warming of the Indian Ocean, rising sea levels, and stronger tropical cyclones may cause harm to low-lying coastal regions. Climate change's other negative effects include coastal flooding and storm surge inundation. The same analysis showed that between 1951 and 2015, summer monsoon rainfall (June to September) decreased by 6.2%, with a noticeable fall in the Indo-Gangetic plain and Western Ghats. Towards the end of 21st century, the mean and variability of monsoon rainfall were also predicted to rise (CMIP5). Less monsoon rainfall caused more frequent and widespread droughts between 1951 and 2016, mainly in the central India, south western coast, the south peninsula, and north east. In a warmer climate, India would be impacted by (RCP805) increasing monsoon rainfall variability and water vapour demand [1-12].

**CLIMATE CHANGE AND THE SITUATION**

In 2020, a study published by the Ministry of Earth Science (MoES), Government of India, entitled "Assessment of Climate Change across the Indian Region", recognising it as one of the country's most apogean and alarming issues. According to the research [16], from 1901 - 2018, average Indian temperature rose around 0.70° C, with a predicted rise of 4.40° C by the end of this century.

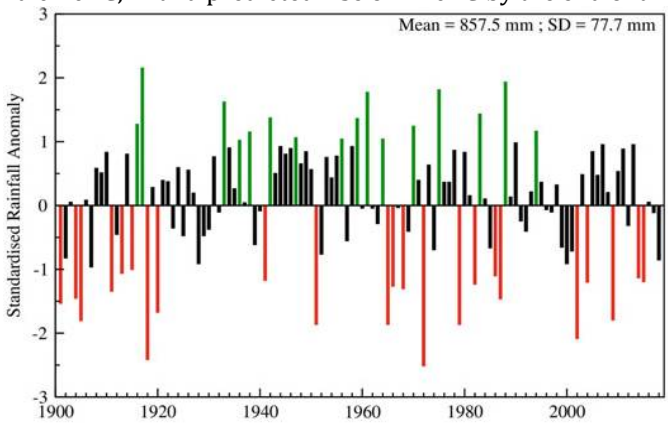


**Figure 4:** Anomaly in rainfall over India during summer monsoon; source: Krishnan et all 2020

According to the study, summer monsoon rainfall has declined by 6.2% since 1951 and is expected to rise by 4.40° C towards the end of the this century (RCP8.5). The same research also discovered that around the beginning of the century, monsoon rainfall variability and mean summer rainfall both increased. There was an overall decrease in monsoon rainfall between 1951 and 2016, which increased the prevalance and geographic area of drought, especially in central India, northeastern, southwestern coast, the south peninsula. According to a climate model, towards the end of the this century, severity of drought and geographic area are expected to increase due to increasing volatility of llmonsoon rainfall and significant need of water vapour in a warmer atmosphere. According to the paper, warming in Indian Ocean, sea level rise, and intensifying tropical cyclones, would contribute to a devastating effect on low-lying coastal regions. Additionally, the management of coastal zones will be hampered by climate change-induced shoreline alteration, storm surge inundation, and coastal flooding, which would undoubtedly upset the coastal people [12]. Hence, it is high time to investigate the pattern and impacts of climatic changes on Indian coasts and devise solutions at the earliest.

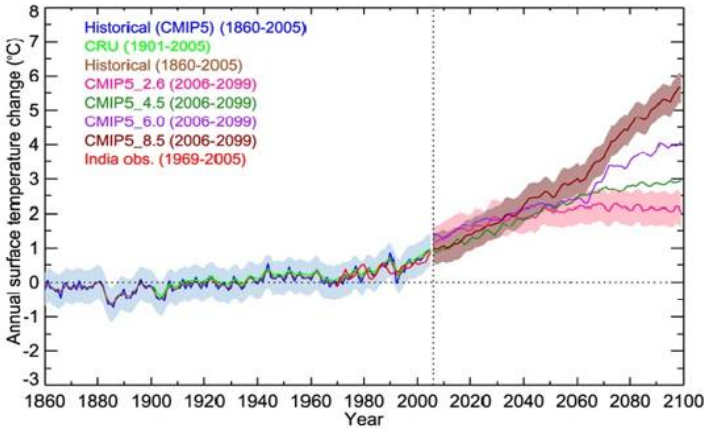


**Figure 4:** Projected CHIP5 and CRU annual temperature changes over india relative to the 1901-1960;(source: 2]

Furthermore, according to a study, the surface temperature in India increased about 0.0551 K each decade from 1861 - 2005, reflecting the pattern of global warming. In order to identify the natural and external forces (natural and anthropogenic) responsible for ST variability, seasonal variability is examined along with coupled model intercomparison phase 5 (CMIP5) models for the twentieth and twenty-first centuries. Over the 20th century, the two main causes of global warming were gases emitted by greenhouse, land overuse [2-4].

The trend of warming has been slowed by anthropogenic aerosols. The CMIP5 prediction across India reveals a significant rise in ST RCP 8.5, when it reaches a peak of 5 K towards the end of the 21st century. ST grows until 2050, then lowers, according to RCP2.6 emission projections. ST seasonal fluctuation in the twenty-first century shows a notable increase in the summer. RCP8 scrutiny of anomalous warmth and cold occurrences for 2080-2099 compared to a baseline from 1986-2006. According to these scenarios, they are expected to rise significantly. However, by colloquial the regional anthropogenic activities and land overuse, it may be able to restrict additional warming over the Indian zone [5-8].

## THE INDIAN COASTS AND CLIMATE CHANGE:

### Shifts in precipitation and temperatures:

The yearly mean temperature on the eastern coast is expected to increase from 28.7±0.60°C to 29.3±0.71°C, while the western coastal region is more likely to rise from 26±0.80°C to 27.5±0.4°C, according to Gangwar [4]. It is anticipated that both of these augmentations will happen. Precipitation on the eastcoast is predicted to be between 859±85.80mm and 1281±204.80mm in the 2030s compared to 1970. [2].During the same time period, it could vary on the western coast from 9352±85.34mm to 1794±248mm [2]. Accordingly, the east coast rise is anticipated to range from 0.2 %to 4.4 %, while the west coast rise is anticipated to range from 6% to 8%. Another study by Geethalakshmi [5] revealed that, despite the likelihood of a one to five-day drop in the amount of rainy days, the amount of precipitation that falls on the east coast is anticipated to rise by one to four millimetres per day.

**Tropical cyclone dynamics:**

Recent studies and published research indicate that, the North Indian Ocean basin, has experienced a decline in the number of tropical cyclones, between 1951 and 2018 [19, 20]. Since 1951, this trend has been present. On the other hand, over the past 20 years, the number of extremely dangerous cyclonic storms has substantially increased throughout post-monsoon season [21, 17, 33]. Two distinct studies both published their findings. The severity of tropical cyclones was also expected to worsen over the ensuing decades, according to the climate models. Additionally, it is anticipated that the amount of water caused by storm surge will increase, flooding low lying coastal regions and deltaic areas, especially along the nation's eastern coast [25, 26].

**Sea Level Rise:**

Analysis of historical data showed that the average yearly increase in sea level over the previous century was only one to two mm worldwide. Climatic changes are widely believed to be the primary causes for this rise, Even along the shores of Indian ocean, without any exception to the norm. Studies by Unnikrishnan et al. predict that in the not too distant future, Mumbai, Kochi, and Vishakhapatnam's mean sea levels will rise by about 0.70, 1.15, and 0.70 mm annually, respectively. A statistically consequential rise in sea level at 5.75mm/year being the rate, has been recorded by nne of the significant tidal gauge stations along the East Indian coast, according to Unnikrishnan and Shankar's 2007 study [31, 32].

The rapid rate of sinking of the delta's of Ganges being 4 mm/year is one of the main reasons to this enormous rise in sea level, but climatic changes pose an even larger hazard. The average rate of sea level rise along the East Indian coast (1,353 mm/ year) is significantly higher when compared to the West coast, claims Sudha Rani et al. [30]. (0.372 mm / year). However, the results of practically all of these investigations have unmistakably shown that report of the IPCC during third assessment is notably similar to the estimate of the pattern sea level of the North Indian Ocean . The coastal regions are the ones that are most at risk in this kind of scenario. Numerous observations have been made that indicate future coastal areas will unavoidably flood on both the west and east coasts. According to research by Ranger et al. [24], Mumbai will experience severe floods by the year 2080 that are more than twice as bad as the storm that hit the city in 2005. Therefore, in order to safeguard coastal areas and the inhabitants who reside there in the not-too-distant future, a robust paradigm for risk assessments in addition to mitigation techniques is vitally essential.

**Increase of Oceanic Sea Surface Temperature (SST):**

The tropics of Indian Ocean has recently undergone a significant increase in ocean warming, with an average SST increase of roughly one degree between 1951 and 2015 at a pace of 0.15°C/decade. According to the study, between 1982 and 2018, there were 66 Marine Heat Wave (MHW) incidents in the western part of Indian Ocean as opposed to 94 in the Bay of Bengal. Marine heat wave occurrences increased by twice to three times in the Northen aspect of Bay of Bengal, but in the western Indian Ocean region by four times(i.e. 1.5 incidents per decade).There were six marine heat waves that lasted 52 days in the western Indian Ocean in 2021. There were four maritime heat waves in the northern aspect of Bay of Bengal over a period of 32 days. Despite being above average, these heat waves did not shatter all existing records. In terms of the quantity of incidents, the 2021 western Indian Ocean heat waves were among the top four [22, 23].

**EVALUATION OF INFLUENCES:**

**Influence on fisheries:**

Fishing is one of the most common ways for people to make a living in coastal areas. Fishing has been negatively impacted by the raise in sea surface temperature, which is predicted to be due to greenhouse gas emissions. Any species raised in aquaculture is poikilothermic, which means that its internal body temperature is sensitive to outside stresses. This implies that even a slight shift in SST will have an impact on the species' development and metabolism. Salim et al. [29] discovered that the unexpected monsoon rains increase the likelihood of employment losses in Kerala's coastal fishing villages. According to [26], climate change is presumed to reduce ecosystem services along the Indian East Coast by roughly 25% by 2050. A loss of 17 billion US dollars would result from this. Therefore, it's crucial to have effective risk-reduction techniques [27].

**Influence on agriculture:**

Changes in temperature, rainfall, humidity, etc., affect agriculture everywhere, but in coastal areas, seawater intrusion, cyclones, and rising soil salinity make agriculture more vulnerable to climate change. Almost everywhere along India's coast, the phenology of plants has been hurt by changes in the weather. Additionally, irregular rainfall and higher temperatures have made it more difficult to grow crops conventionally. According to Kumar et al. [14], if temperatures rise too high, cultivated paddy and maize yields in eastern coastal districts may fall dramatically. Additionally, as temperatures have risen, pest

entry into crops has become simpler, which has reduced crop productivity and yield. The cashew nut agrosystem has been significantly impacted by climate change even on the west coast, particularly in Kerala [28]. The conventional cropping calendar has been messed up as a result. Additionally, the majority of residents of India's coastal regions are small farmers who cannot afford to employ costly climate-smart practises, which places them at a disadvantage [15-18].

**Influence on Economic Sectors, Infrastructure:**

According to climate models and a NASA forecast, ten of India's largest coastal cities, including Mumbai and Chennai, will be submerged by rising sea levels by the year 2030. [27]. This floods, according to The Indian Express (2021), might cost billions of dollars and have a substantial detrimental influence on the country's economic growth. Pramanik [22] examined how various sea-level rise scenarios would alter various land use patterns in a thorough analysis. He discovered that metropolitan areas would be significantly impacted by sea level rise. Rising sea levels will have a significant influence on Mumbai's economy, as well as on public health, infrastructure, and the need to relocate, according to Pednekar and Siva Raju's report from 2019 [21].

According to a different study by Saleem Khan et al. [29] sea level rise will impel thousands of people to relocate, and many will lose their jobs. The ports of India 12 major, 206 intermediate and small are endangered by rising sea levels caused by climate change. Cities around the shore are anticipated to experience additional issues as a result of climate change. Numerous problems already exist in these cities, such as unplanned high density settlements, fast population growth, urban poverty, and wide access gaps to infrastructure and public services. The effects of climate change will exacerbate these problems and significantly affect the weak and disadvantaged.

## CONCLUSION

The existence of climate change is currently accepted as fact rather than a myth. Even the unfavorable outcomes of such a shift are obvious. In such situations, a socially inclusive policy framework is unavoidably needed to fully assess the negative impacts of climatic change on numerous sectors as well as to design easing actions. A wide range of stakeholders from all sectors and organisations should collaborate to protect those areas that are most vulnerable to these changes. Even if a number of national, international, corporate, and NGOs have already started to work in these fields, policy and research should be used to develop more all-encompassing and socially comprehensive approaches.

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