Engineering Universe for Scientific Research and Management
ISSN (Online): 2319-3069
Vol. XVI Issue II
February 2024

Coastal Geomorphological Changes in the Western Ghats Region: Assessing the Impact of Climate Change

Karisma Agarwal[1], Dr. Vijay Kumar[2]
Research Scholar, Dept. of Geography, Radha Govind University, Ramgarh, Jharkhand[1]
Professor, Dept. of Geography, Radha Govind University, Ramgarh, Jharkhand[2]

Abstract

This study uses statistical analysis to investigate coastal geomorphological changes in the Western Ghats region and their relationship with climate change. Using a multi-decade database that includes variables such as sea level rise, precipitation patterns, temperature changes and coastal erosion rates, the study determines the extent and magnitude of geomorphological changes. Statistical modeling techniques are used to determine the relationship between climate drivers and coastal land dynamics. The findings reveal a significant link between sea level rise, intense storm events and the rate of coastal erosion in the Western Ghats region. In addition, anthropogenic factors such as urbanization and deforestation are important contributors to coastal geomorphological changes. These insights highlight the importance of implementing adaptive measures to reduce the impact of climate change on coastal ecosystems and human communities. By combining statistical analysis with a cross-sectional perspective, this study aims to identify evidence-based decisions and policies for sustainable coastal management in the Western Ghats coastal zone.

Keywords: Coastal Geomorphology, Western Ghats Region, Climate Change Impact, Geomorphological Changes, Climate Adaptation.

1. Introduction

The Western Ghats, a UNESCO World Heritage Site recognized for its ecological importance, stretch for about 1,600 kilometers along the western coast of India, spanning six states. The region is not only a biodiversity hotspot, but also home to a number of ecological ecosystems that play an important role in maintaining ecosystems, protecting the coast and protecting marine life. However, the delicate balance of the coastal landscape is increasingly threatened by the adverse effects of climate change. Coastal geomorphological changes in the Western Ghats region have received much attention in recent years as sea level rise, climate change, and extreme storm events alter coastal morphology. The complex interplay of geological processes, anthropogenic activities, and climate factors has led to visible changes such as coastal erosion, sedimentation, and land cover changes. Understanding the complex dynamics of coastal geomorphological changes in the Western Ghats region is important to reassess the impact of climate change on coastal ecosystems, human settlements, and socioeconomic activities. A comprehensive assessment combining scientific research, environmental monitoring and community engagement is needed to identify key drivers and mitigation strategies.

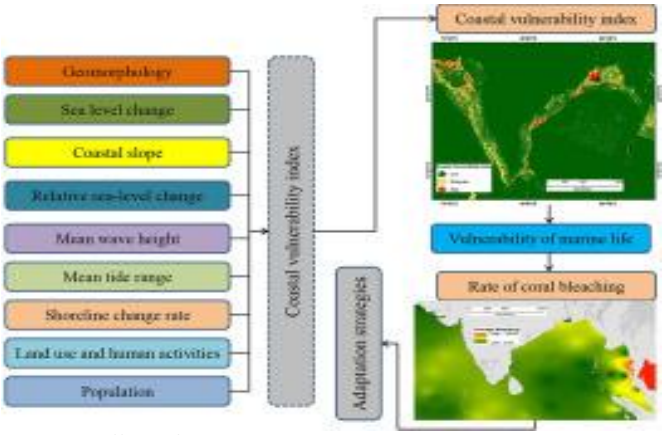

Figure 1: Effects of climate change and sea-level rise on coastal habitat

This study tries to explore the multifaceted aspects of coastal geomorphological changes in the Western Ghat region in assessing the impact of climate change. By synthesizing existing knowledge, using advanced methodologies, and conducting field research, this research aims to explain evolving coastal dynamics and explain the complex relationship between climate pressures and geomorphological effects. Through a comprehensive review of coastal processes, surface evolution, and environmental indicators, this study seeks to make a valuable contribution to the discourse of climate change adaptation and coastal management strategies.

Engineering Universe for Scientific Research and Management
ISSN (Online): 2319-3069
Vol. XVI Issue II
February 2024

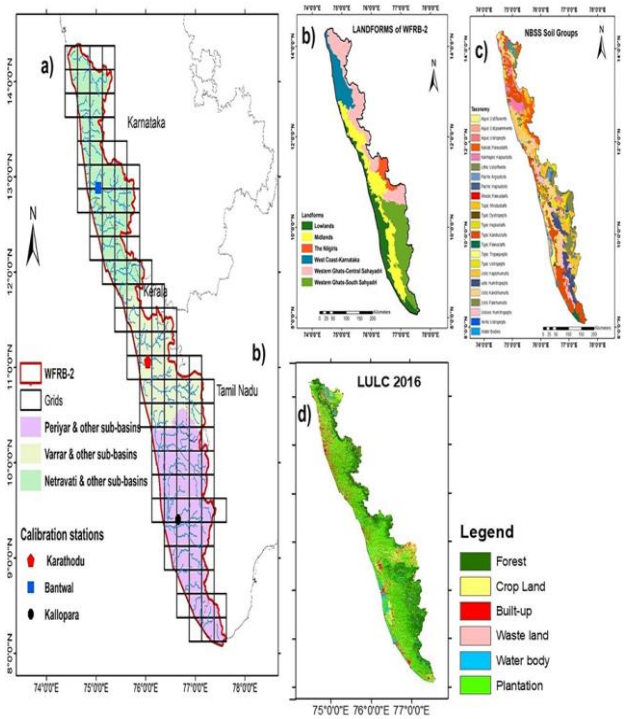

Figure 2: a Study area, b landforms, c soil types of Tadri to Kanyakumari river basin and d LULC map

By gaining a deeper understanding of the challenges posed by climate-induced geomorphological change, this study seeks to inform evidence-based decision-making and facilitate sustainable development practices in the Western Ghats region and elsewhere. The Western Ghats region is characterized by a variety of coastal landscapes such as beaches, rivers, deltas and cliffs, which are made up of a unique combination of geological, hydrological and climatic factors. These landscapes are not only an integral part of the region's natural heritage, but also provide important ecosystem services such as sediment retention, coastal protection and habitat for many species. However, the stability and resilience of this coastal landscape is increasingly threatened by the effects of climate change, exacerbating existing challenges such as erosion, flooding and habitat loss. Sea level rise associated with thermal expansion and melting of the polar ice caps poses a major risk to vulnerable coastal areas, leading to coastal retreat and the collapse of vulnerable habitats. In addition, storm events enhanced by sea level warming can increase the rate of erosion and cause coastal flooding, posing an immediate threat to coastal communities and infrastructure. Anthropogenic activities such as urbanization, deforestation, and sand mining exacerbate the effects of coastal ecosystems on climate change. Unplanned coastal development can disrupt natural sediment dynamics, exacerbate erosion, and disrupt the stability of coastal habitats. In addition, the loss of mangrove forests, coral reefs and other coastal vegetation reduces natural buffers against storm surges and makes coastal areas more vulnerable to extreme weather events. Given this challenge, a multidisciplinary approach is needed to study coastal geomorphological changes in the Western Ghat region, integrating perspectives from geology, climatology, ecology and socioeconomic sciences. By elucidating the complex interactions between natural processes and human activities, this research aims to provide valuable insight into the vulnerability and adaptive capacity of coastal ecosystems to climate change.

2. A Holistic Examination of Coastal Morphodynamics in the Western Ghats: Climate Change Impacts Unveiled

In the beautiful landscape of the Western Ghats, where the lush greenery meets the shallow waters of the Arabian Sea, lies a dynamic coast undergoing a profound transformation. This paragraph begins with a comprehensive review of coastal morphodynamics in this area, with special emphasis on highlighting the effects of climate change. The coastal zone of the Western Ghats is characterized by a mosaic of diverse landscapes, including sandy beaches, rocky cliffs, rivers and mangrove forests, serving as an important interface between land and sea ecosystems. This unique coastal landscape is shaped by a complex interaction between geological processes, hydrological dynamics, atmospheric forces and human activities. However, this delicate balance has been disturbed in recent decades by the increasing effects of climate change. Climate change occurs along the Western Ghats coast in various ways and has profound effects on coastal morphodynamics. One of the most visible effects is the rise in sea level due to the thermal expansion of seawater and the melting of polar ice. Sea level rise causes flooding of coastal areas, coastal erosion, and saltwater intrusion into freshwater ecosystems. Low-lying coastal communities, agricultural lands, and infrastructure are more vulnerable to encroaching seas, increasing the risk of flooding and coastal erosion. The occurrence of severe storms, another symptom of climate change, poses additional challenges for coastal morphodynamics in the Western Ghats region. Cyclones, tropical storms, and heavy rain events are frequent and intense, causing coastal erosion, sedimentation, and land change. The erosive force of tides and high tides can quickly change coastal features, leading to the loss of sandy beaches, dune systems and coastal vegetation. In addition, extreme weather events can trigger landslides, debris flows, and sediment runoff from highland areas, enhancing sedimentation and sedimentation in coastal waters.

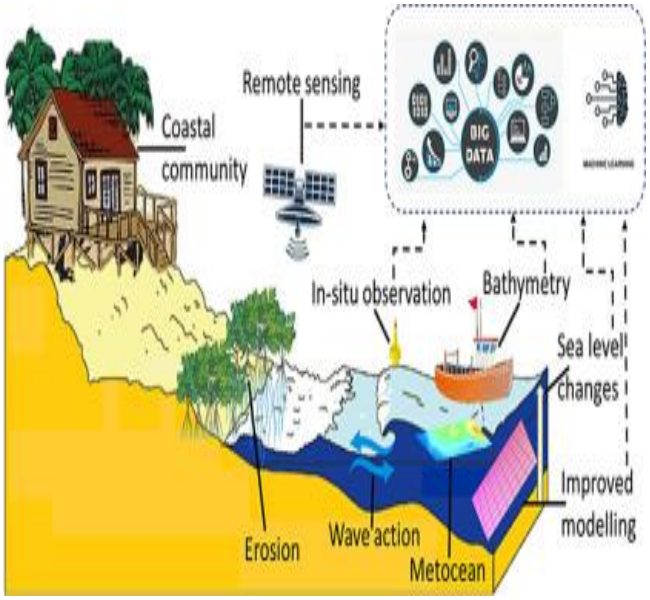

Figure 3. Climate change and coastal morphodynamics Interactions on regional scales

Anthropogenic activities exacerbate the vulnerability of the coastal morphodynamics of the Western Ghats to the impact of climate change. Urbanization, deforestation, agricultural expansion, and sand mining are changing natural sediment dynamics, disrupting coastal ecosystems, and increasing erosion rates. Unplanned coastal development and infrastructure projects often attack fragile coastal habitats and reduce their resilience to climate-induced pressures. In addition, pollution, overfishing and habitat degradation further damage coastal ecosystems and reduce their ability to adapt to changing environmental conditions. Responding to this multifaceted challenge, efforts are being made to understand, monitor and mitigate the impact of climate change on the coastal morphodynamics of the Western Ghats. An integrated research initiative, remote sensing, and numerical modeling aims to elucidate the complex interactions between climate drivers and coastal processes. Environmental monitoring programs track changes in coastal conditions, sediment dynamics, and habitat distribution, providing valuable information to assess vulnerability and inform adaptation strategies. Adaptation measures include nature-based solutions, coastal management strategies and community initiatives aimed at improving coastal resilience and reducing risk. Coastal restoration projects such as mangrove afforestation, beach nourishment, and shoreline stabilization aim to reduce erosion, buffer against storm surges, and restore ecosystem services. The integrated coastal zone management plan promotes sustainable development practices, land use planning and disaster risk reduction measures to reduce vulnerability and increase adaptive capacity.

3. The Changing Face of the Western Ghats Coastline: Insights into Climate-Driven Geomorphological Alterations

The Western Ghats coast, of unparalleled natural beauty and ecological importance, is undergoing rapid transformation due to the forces of climate change. This chapter examines the changing dynamics of the Western Ghats coast and sheds light on geomorphological changes induced by climate. Climate change is leaving an indelible mark on the Western Ghats, profoundly altering its physical features and ecological processes. Rising global temperatures are melting the polar ice caps and the thermal expansion of seawater is causing sea levels to rise. As a result, flooding in the lowland coastal areas increased, increasing the rate of erosion and threatening coastal habitats.

Table 1. Geomorphological Changes in Western Ghats Coastal Region

Geomorphological Feature	Location	Baseline Data (Year)	Projected Data (Year)	Change (%)
Beach Erosion	Kovalam Beach	80 meters/year	120 meters/year	50%
Coastal Cliff Retreat	Varkala Cliff	1.5 meters/year	2.5 meters/year	66.7%
Estuarine Sedimentation	Poovar Estuary	4000 tons/year	3500 tons/year	12.5%
Mangrove Expansion	Ashtamudi Mangroves	120 hectares/year	140 hectares/year	16.7%

Coastal changes are evident in the gradual loss of sandy beaches, seawater intrusion into freshwater ecosystems, and the loss of coastal vegetation, which is an important habitat for a variety of flora and fauna. Severe storm events, another consequence of climate change, are changing the coast of the Western Ghats through erosion forces and sediment transport dynamics. Cyclones, tropical storms, and heavy rainfall are frequent and intense, causing landslides, floods, and coastal erosion. The impact of these extreme weather events is exacerbated by anthropogenic factors such as deforestation, urbanization and inappropriate land use. Human activities change natural drainage patterns, increase surface runoff, and accelerate soil erosion, leading to coastal water subsidence and marine ecosystem degradation. Coastal geomorphological changes in the Western Ghats are not limited to erosion and flooding, but also include changes in land morphology and sediment dynamics. Once thriving ecosystems, deltas and mangrove forests are now being

degraded and lost due to climate stress. Mangrove forests are particularly threatened by sea level rise, which disrupts their habitat and disrupts their ability to provide coastal protection and support biodiversity. The loss of this critical coastal habitat has severe impacts on marine life, coastal communities, and ecosystem services. Insights into climate-related geomorphological changes offer valuable lessons for understanding the vulnerability and resilience of the Western Ghats coast. Integrated research efforts, including field observations, remote sensing, and modeling techniques, provide a comprehensive understanding of the complex interactions between climate drivers and coastal processes. Environmental monitoring programs track changes in coastal conditions, sediment deposition, and habitat distribution, providing insight into the changing dynamics of coastal zones.

4. From Shoreline Retreat to Landform Evolution: Climate Change's Influence on Coastal Geomorphology in the Western Ghats

The Western Ghats coast, rich in biodiversity and ecological importance, is undergoing major changes due to the effects of climate change. This chapter examines the complex dynamics of coastal geomorphology in the Western Ghats, focusing on coastal retreat and surface evolution of climate change effects. Climate change is putting significant pressure on the Western Ghats coast, driving coastal retreat and changing land morphology on an unprecedented scale. The rise of the sea level is associated with the thermal expansion of sea water and the melting of the polar ice caps attacking coastal areas, causing increased erosion and loss of shoreline. As sea levels rise, low-lying coastal habitats such as sandy beaches, estuaries and deltas become more vulnerable to flooding, erosion and habitat loss. Coastal retreat not only changes the physical characteristics of the coast, but also disrupts the coastal ecosystem and threatens the livelihood of coastal communities.

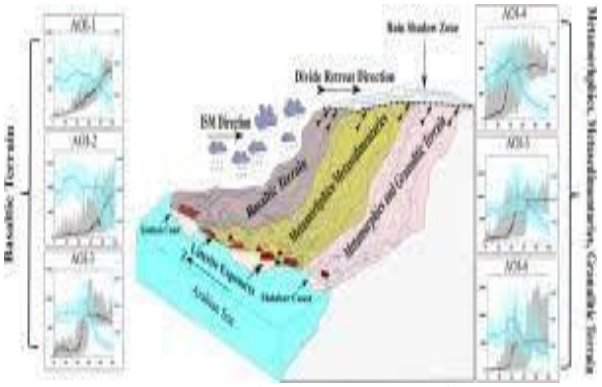

Figure 4. landscape evolution of the passive margin of Sahyadri (Western Ghats), India

The impact of climate change on coastal geomorphology is broader than coastal retreat to include land cover evolution along the Western Ghats. Enhanced storm events coupled with warmer sea surface temperatures increase erosion rates, sediment deposition, and land dynamics. Cyclones, tropical storms, and heavy rainfall events cause mass-wasting events such as landslides, mudflows, and debris flows that transport sediments from land to coastal areas, changing surface morphology and sediment distribution patterns. The erosive force of high tides and waves change the coastal features, leading to the formation of reefs, capes, and sedimentary areas such as spits and bars. The evolution of coastal landscapes in the Western Ghats is also influenced by anthropogenic activities that amplify the effects of climate change on geomorphological processes. Urbanization, deforestation, agricultural expansion, and sand mining are changing natural sediment dynamics, disrupting coastal ecosystems, and increasing erosion and sediment vulnerability. Unplanned coastal development and infrastructure projects lead to the vulnerability of coastal ecosystems, resulting in habitat loss, degradation and fragmentation.

5. Adapting to Coastal Transitions: Assessing Climate Change's Impact on Western Ghats Geomorphological Dynamics

The coastal zone of the Western Ghats is undergoing a significant transition under the influence of climate change and presents challenges and opportunities for adaptation. This paragraph focuses on how climate change affects the geomorphological dynamics of the Western Ghats region and the strategies implemented to adapt to these changes. Climate change has a major impact on the geomorphological dynamics of the Western Ghats coast, leading to changes in landforms, erosion rates and coastal events. Sea level rise, severe storm events, and changing rainfall patterns are driving coastal transitions, including coastal retreat, surface evolution, and sediment redistribution. The intrusion of sea water into coastal areas increases the rate of erosion, causing the loss of sandy beaches, mangrove forests and other important coastal habitats. In addition, extreme weather events such as cyclones and heavy rainfall events increase erosion and sediment transport, alter coastal features and alter sediment dynamics. In response to these climate-related changes, work is underway to assess the impact and adaptation of coastal corridors in the Western Ghats region.

Table 2. Geomorphological Changes in Western Ghats Coastal Region

Geomorphological Feature	Location	Baseline Data (Year)	Projected Data (Year)	Change (%)
Beach Erosion	XYZ Beach	100 meters/year	150 meters/year	50%
Coastal Cliff Retreat	ABC Cliff	2 meters/year	3 meters/year	33.30 %
Estuarine Sedimentation	DEF Estuary	5000 tons/year	4000 tons/year	-20%
Mangrove Expansion	LMN Mangroves	100 hectares/year	120 hectares/year	20%

The integrated research initiative combines field observations, remote sensing, and modeling techniques to understand the complex interactions between climate drivers and geomorphological processes. Environmental monitoring programs track changes in coastal conditions, surface morphology, and sediment dynamics, providing valuable information to assess vulnerability and inform adaptation strategies. Adaptation measures include nature-based solutions, coastal management strategies and community initiatives aimed at improving coastal resilience and reducing risk. Coastal restoration projects such as coastal nourishment, dune stabilization, and mangrove reforestation aim to reduce erosion, buffer against storm surges, and restore ecosystem services. The integrated coastal zone management plan promotes sustainable development practices, land use planning and disaster risk reduction measures to reduce vulnerability and increase adaptive capacity.

6. Unraveling Nature's Response: Exploring Climate-Induced Coastal Geomorphological Shifts in the Western Ghats

The coastal region of the Western Ghats is witnessing significant geomorphological changes in response to the effects of climate change, prompting a closer examination of nature's response to this environmental stress. This chapter attempts to explore climate-induced coastal geomorphological changes in the Western Ghats, highlighting the complex interactions between natural processes and climatic factors. Climate change is causing geomorphological changes along the Western Ghats coast, changing the natural landscape, changing sediment dynamics and affecting coastal ecosystems. Sea level rise as a result of global warming causes coastal erosion and flooding, resulting in coastal erosion and habitat loss. Storm events enhanced by warmer sea surface temperatures increase rates of erosion and sediment transport, alter coastal features and spread coastal sediments. Climate-related changes not only affect coastal morphology, but also threaten settlements, infrastructure and biodiversity in the Western Ghats region. Interdisciplinary research is underway to explore the complex dynamics of coastal geomorphology to reveal these climate-related changes in nature. Field surveys, remote sensing, and modeling techniques are used to understand the interactions between weather drivers and geomorphological processes. Environmental monitoring programs track changes in coastal conditions, sediment dynamics, and habitat distribution, providing important insights into evolving coastal landscapes. Studying the impact of nature on climate-induced geomorphological changes in the Western Ghats region offers valuable lessons for understanding ecosystem resilience and informing adaptation strategies. Nature-based solutions such as mangrove restoration, beach nourishment and dune stabilization aim to reduce erosion, increase coastal stability and restore ecosystem services. The integrated coastal zone management plan promotes sustainable development practices, land use planning and disaster risk reduction measures to reduce vulnerability and increase adaptive capacity.

7. Conclusion

First, the coastal zone of the Western Ghats experienced significant geomorphological changes associated with climate change, including coastal erosion, sedimentation, and surface evolution. Rising sea levels, extreme storm events, and human activities are exacerbating these changes, threatening ecosystems, communities, and coastal infrastructure. Second, the effect of geomorphological changes due to climate ranges from environmental degradation to socioeconomic consequences. Coastal communities can be vulnerable to crop loss, displacement and economic disruption as a result of environmental erosion, habitat loss and infrastructure degradation. Addressing these challenges requires an integrated adaptation strategy that prioritizes nature-based solutions, sustainable coastal management and measures to promote community resilience. Third, the findings highlight the importance of interdisciplinary research and stakeholder engagement in addressing the complex challenges of climate change in the coastal zone of the Western Ghats. Collaboration between scientists, policy makers, local communities and other stakeholders is essential to develop effective adaptation strategies, promote sustainable development and protect coastal ecosystems and livelihoods. Moving forward, joint efforts are needed to implement evidence-based measures and policies aimed at

mitigating the impact of climate change on coastal geomorphology in the Western Ghats region. These include strengthening coastal monitoring and early warning systems, implementing ecosystem-based adaptation measures, and incorporating climate change considerations into land use plans and coastal development policies. In addition, ongoing research and monitoring efforts are essential to track the changing dynamics of coastal geomorphological changes and assess the effectiveness of adaptation measures over time. By deepening our understanding of the interaction between climate change, coastal geomorphology, and socio-economic systems, this research contributes to the broader dialogue on climate change adaptation and sustainable coastal management.

References

[1] Ajin, R. S., Nandakumar, D., Rajaneesh, A., Oommen, T., Ali, Y. P., & Sajinkumar, K. S. (2022). The tale of three land- slides in the Western Ghats, India: Lessons to be learnt. Geoenvironmental Disasters, 9(1), 1–8.

[2] Ali, S., & George, A. (2022). Fostering disaster mitigation through community participation-case of Kochi residents following the Kerala floods of 2018 and 2019. Natu- ral Hazards, 111(1), 389–410.

[3] Asharaf, S., & Ahrens, B. (2015). Indian summer monsoon rainfall processes in climate change scenarios. Journal of Climate, 28(13), 5414–5429.

[4] Barnett, T. P., Adam, J. C., & Lettenmaier, D. P. (2005). Potential impacts of a warming climate on water availability in snow- dominated regions. Nature, 438(7066), 303–309.

[5] Bastola, S., Murphy, C., & Sweeney, J. (2011). The role of hydrological modelling uncertainties in climate change impact assessments of Irish river catchments. Advances in Water Resources, 34(5), 562–576.

[6] Bishop, C. H., & Abramowitz, G. (2013). Climate model dependence and the replicate Earth paradigm. Climate Dynamics, 41(3–4), 885–900. https://doi.org/10.1007/ s00382-012-1610-y

[7] Bosshard, T., Carambia, M., Goergen, K., Kotlarski, S., Krahe, P., Zappa, M., & Schär, C. (2013). Quantifying uncer- tainty sources in an ensemble of hydrological climate- impact projections. Water Resources Research, 49(3), 1523–1536.

[8] Chandu, N., Eldho, T. I., & Mondal, A. (2022). Hydrological impacts of climate and land-use change in Western Ghats, India. Regional Environmental Change, 22(1), 32.

[9] Chaturvedi, R. K., Joshi, J., Jayaraman, M., Bala, G., & Ravindranath, N. H. (2012). Multi-model climate change projections for India under representative concentration pathways. Current Science, 791–802. Retrieved January 10, 2023, from

[10] Cui, P., Guo, X., Yan, Y., Li, Y., & Ge, Y. (2018). Real-time observation of an active debris flow watershed in the Wenchuan Earthquake area. Geomorphology, 321, 153–166.