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POLICY BRIEF

Climate Resilience and Sustainable Coastal Management in Car Nicobar (CORES-CAR)

Safeguarding Coasts, Sustaining Communities

R Kiruba-Sankar, E Yuvaraj, Sirisha Adamala, Abhilash, AR Adharsh, Shoaib Rassel, S Gokul and Sonia

Executive Summary

Car Nicobar Island, the northernmost island of the Nicobar group in the Bay of Bengal, represents one of India's most ecologically sensitive and climate-vulnerable inhabited islands. Scientific assessment integrating ecological surveys, shoreline change analysis, tsunami modelling, land use mapping, and CMIP6-based climate projections demonstrates that while the island retains substantial forest cover (>80%), its coastal ecosystems and human settlements face escalating risks from erosion, sea level rise, tsunamis, extreme climatic events, and warming trends. Between 1992 and 2024, the island experienced an average shoreline erosion rate of –0.81 m/year, with localized extreme erosion reaching –40 m/year. Tsunami run-up modelling indicates that up to 42.8% of the island could be inundated under high-impact scenarios. Climate projections show significant warming under all future emission pathways and sea levels projected to rise between 0.4m (low emissions) and 0.8m (high emissions) by 2100, potentially reaching 1.4m by 2150 under worst-case trajectories. Field surveys and citizen science initiatives have identified community-based turtle conservation as a viable strategy and their potential to identify new sea turtle nesting beaches beyond those currently recognised under regulatory frameworks. These findings necessitate immediate revision of Ecologically Sensitive Area (ESA) demarcations. This policy brief recommends the adoption of an ecosystem-based, climate-resilient Island Management Plan incorporating updated ESA boundaries, hazard-informed land-use zoning, nature-based coastal protection, community co-management mechanisms, and long-term sea-level-adjusted infrastructure planning. The proposed actions, grounded in field-based evidence, are expected to advance sustainable island development, reinforce disaster risk reduction strategies, enable co-management of marine resources, and safeguard biodiversity within the fragile ecosystems of Car Nicobar.

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Contributing Institutions

1) ICAR- Central Island Agricultural Research Institute, Sri Vijaya Puram, Andaman and Nicobar Islands
2) Department of Coastal Disaster Management, Pondicherry University, Sri Vijaya Puram
3) ICAR- National Bureau of Soil Survey and Land Use Planning, Nagpur, Maharashtra

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1. Policy Context and Strategic Importance

Car Nicobar Island is a small Island in the Andaman and Nicobar archipelago (Fig 1) and serves as the administrative headquarters of the Nicobar group (Roy et al., 2017; Kiruba-Sankar et al., 2023a). Unlike the Andaman Islands, Car Nicobar is mostly flat with minimal elevation above the mean sea level (Roy et al., 2017). The landscape is characterised by dense tropical forests and extensive coral reef systems. Limited but ecologically significant mangrove patches occur mainly in the southern sector (Prabakaran, 2020). Agroforestry systems are dominated by coconut plantations that form the primary agricultural landscape (Swarnam et al., 2015). These ecosystems also support marine fisheries-based livelihoods that are central to the subsistence and economy of the tribal communities (Ravikumar et al., 2015; Kiruba-Sankar et al., 2020 & 2021). Given its ecological sensitivity, strategic location, and demographic importance, Car Nicobar requires a scientifically updated and climate-responsive island governance framework.

2. Key Scientific Evidence for Policy Action

2.1 Land Use and Land Cover

Land Use and Land Cover (LULC) mapping using Sentinel-2 and Landsat imagery indicates that approximately 80% of Car Nicobar Island is covered by dense and mixed forests, reflecting a largely intact terrestrial landscape (Kiruba-Sankar et al., 2025). Mangroves are restricted to a limited patch, primarily concentrated in the Kimios-Kakana region in the southern part of the island. Coral reef ecosystems are spread all along the western, southwestern, and northeastern coasts. Human settlements are predominantly clustered along the eastern shoreline, where key infrastructure is located, while the southern sector supports agroforestry systems, largely dominated by coconut plantations. Although the island retains substantial forest cover overall, its coastal ecosystems, such as mangroves, coral reefs, and associated habitats, are spatially limited and highly vulnerable to both natural disturbances and anthropogenic pressures (Fig 2).

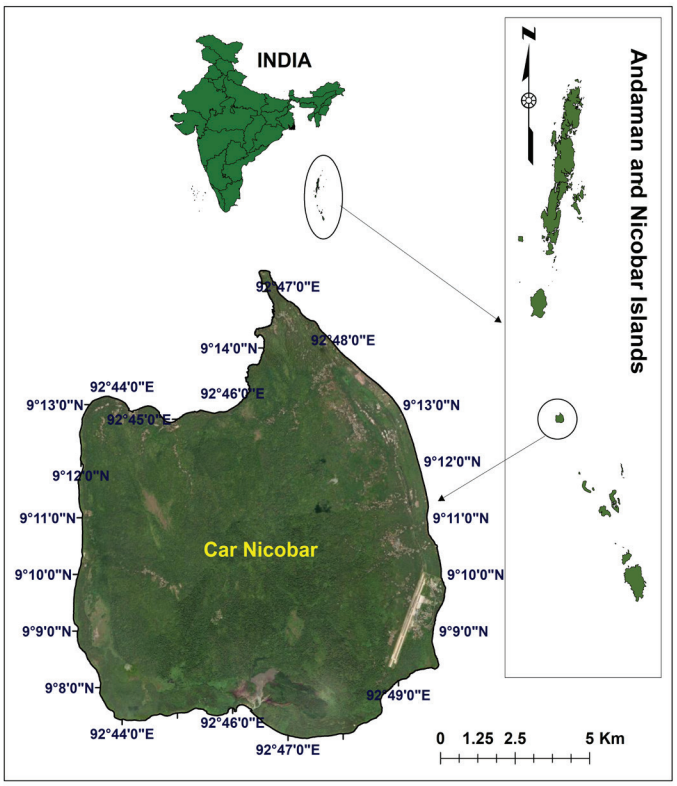

Fig. 1 Location map of Car Nicobar Island

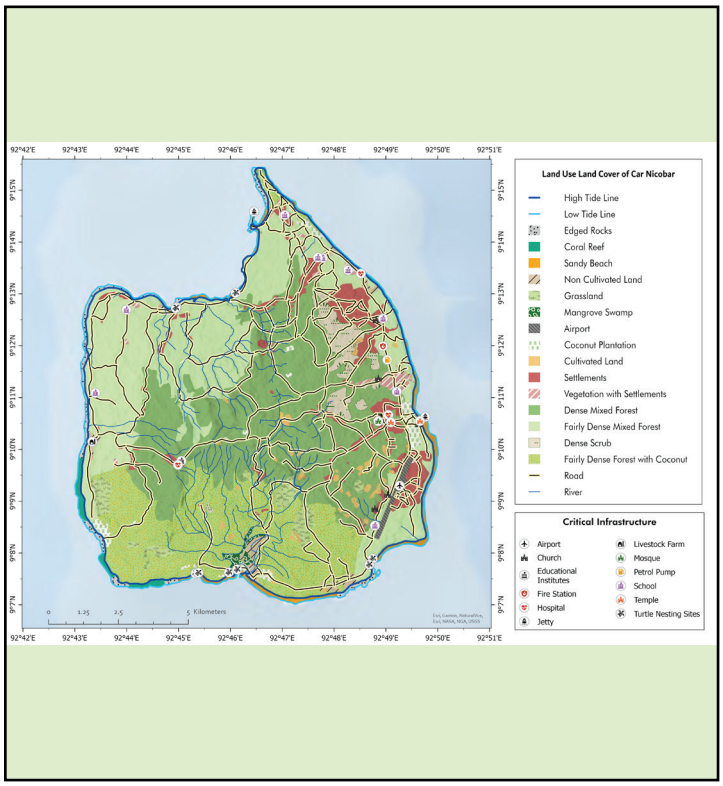

Fig. 2 Land Use Land Cover (LULC) map of Car Nicobar

2.2 Shoreline Change and Coastal Instability

The Digital Shoreline Analysis System (DSAS) method was used to analyse shoreline changes. The analysis covering the period from 1992 to 2024 reveals a pronounced phase of coastal erosion between 1992 and 2005, during which the island experienced significant shoreline retreat. The maximum erosion rate recorded during this period, following the 2004 Indian Ocean Tsunami, reached –40.09 m per year, indicating low-lying coastal stretches. Over the full assessment period, the island shows an average long-term erosion rate of –0.81 m per year, underscoring persistent coastal vulnerability. The southern and southeastern coasts emerge as the most erosion-prone sectors. In addition, post-tsunami structural interventions, particularly near Mus Jetty, have altered local accretion patterns, influencing sediment dynamics. Overall, shoreline instability on the island is shaped by a combination of tectonic subsidence following the 2004 earthquake, sea level rise, wave and current regimes, and anthropogenic modifications such as coastal infrastructure development (Fig 3).

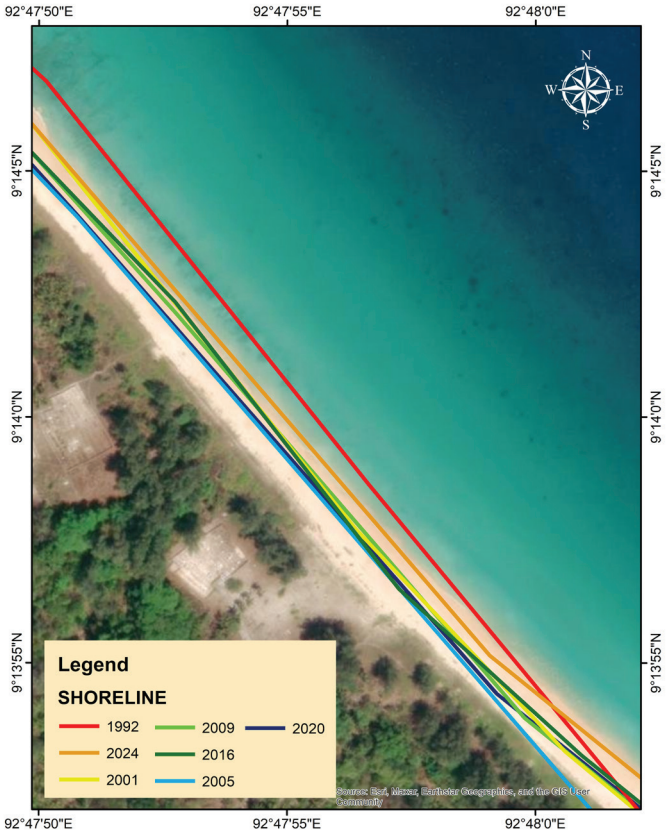

Fig. 3 Shoreline change analysis of Car Nicobar

Policy Implications:

Mandatory coastal setback regulations and erosion buffer zones are required, particularly in the southern and southeastern areas.

2.3 Tsunami and Inundation Risk

Tsunami inundation modelling based on historical run-up data assessed three potential scenarios of 5 m, 10 m, and 19 m wave run-up elevations. The analysis indicates that under the extreme 19 m run-up scenario, approximately 5,740 hectares, equivalent to 42.82% of the total island area, could be inundated. The results further reveal high exposure of coastal settlements such as Malacca, Arong, and Kakana, which fall within the projected inundation zones. The distance of wave penetration in the 2004 Tsunami from the coast ranged from 295.87 to 1202.57 m (Kumar et al., 2007). Importantly, the affected areas also overlap with agricultural lands and key sea turtle nesting beaches, highlighting not only the risks to human habitation and livelihoods but also the vulnerability of ecologically sensitive coastal habitats.

Policy Implications:

Hazard zonation must be formally integrated into land-use planning, infrastructure approval, and relocation strategies. Further, the capacity-building activities for local communities need to be enhanced through disaster mock drills and early warning systems.

2.4 Sea Turtle Nesting Based on Ecologically Sensitive Areas (ESA)

Field surveys conducted between 2023 and 2025 identified important sea turtle nesting beaches on Car Nicobar Island such as Passa, Kakana, Teetop, Kimios, Mus etc. (Fig 4). Species diversity includes Olive ridleys (*Lepidochelys olivacea*), Green turtles (*Chelonia mydas*) and Hawksbill turtles (*Eretmochelys imbricata*), underscoring the ecological significance of these coastal habitats. Notably, some of the newly confirmed nesting locations such as Teetop are identified in recent surveys (Kiruba-Sankar et al., 2026a).

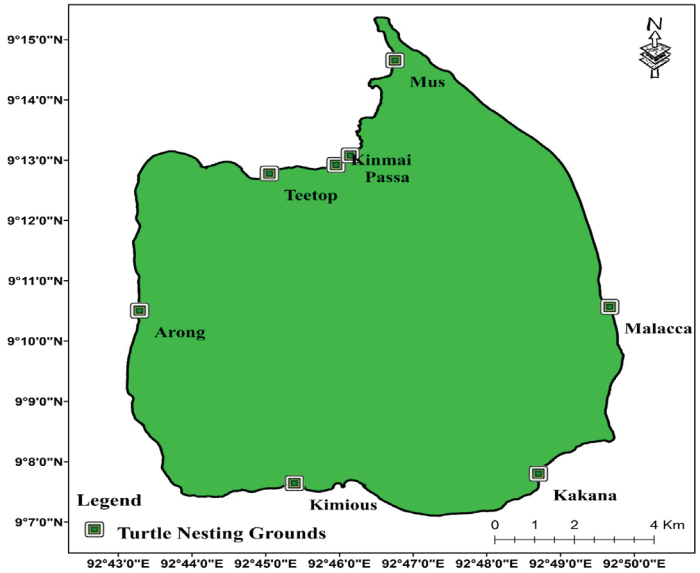

Fig. 4 Major turtle nesting beaches in Car Nicobar

The nesting of Olive ridley turtles in Teetop beach underscores the greater significance of the beach site for future conservation strategies. Recurring nesting of Olive ridley turtles in Teetop Beach warrants designation of such an important nesting beach as an ESA, thereby promoting conservation and protection of sea turtle nesting grounds in the Island (Kiruba-Sankar et al., 2026 a and b). The updated field evidence indicates the need to revise and expand ESA demarcations to ensure comprehensive protection of critical nesting and associated marine habitats in Car Nicobar Island (Fig 5 and 6).

Fig. 5 Olive ridley turtle neonates in Car Nicobar

Fig. 6 Turtle eggs relocated by Nicobarese tribes in Teetop village to prevent predation

Policy Implications:
ESA boundaries must be updated based on new field evidence and integrated with citizen science monitoring by engaging the local tribal communities.

2.5 Climate Change and Sea Level Rise

Analysis of historical climate data from 1980 to 2024 indicates a statistically significant increase in winter rainfall and a consistent rise in minimum temperatures, reflecting weak but persistent warming signals over the island. While maximum temperatures did not show strong long-term trends, the gradual increase in night-time temperatures suggests an emerging shift in baseline thermal conditions. Future projections based on CMIP6 multi-model ensembles under various SSP scenarios indicate a significant rise in both maximum (Tmax) and minimum (Tmin) temperatures across all emission pathways. Sea surface temperatures (SST) are projected to increase substantially, with the strongest warming observed under the high-emission SSP5-8.5 scenario. Rainfall projections, however, show variability across scenarios, with some indicating increases and others showing no clear long-term trend. Sea level rise projections further highlight escalating long-term risk, with levels expected to rise by approximately 0.4 m under SSP1-2.6 and around 0.8 m under SSP5-8.5 by 2100, potentially reaching about 1.4 m by 2150 under high-emission conditions (Fig 7).

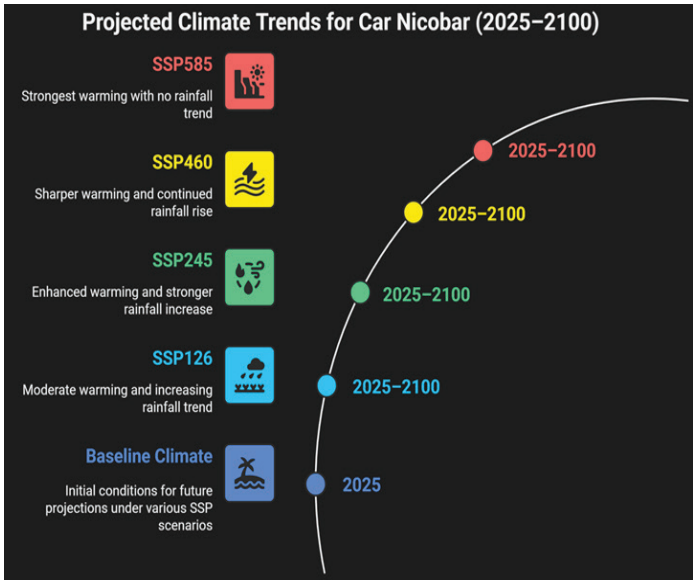

Fig. 7 Climate projections for Car Nicobar (2025-2100)

Policy Implications:
All infrastructure planning must consider long-term sea-level projections, not short-term horizons. The impacts of climate change and the adaptations of tribal communities need to be monitored to develop an inclusive climate change action plan.

2.6 Degradation of the Coastal Ecosystems

The beaches in the Nicobar Islands are increasingly exposed to plastic debris (Dharani et al., 2003), and Car Nicobar Island is no exception (Kiruba-Sankar et al., 2023b). Due to anthropogenic activities, a considerable share of locally generated plastic waste remains within the island system and gradually accumulates along coastal areas (Fig 8).

Fig. 8 Discarded fishing nets in Car Nicobar

This problem is particularly pronounced on beaches that also serve as important nesting grounds. Therefore, systematic and sustained initiatives are required to remove accumulated debris and strengthen waste management practices across the island. In addition to pollution, elevated SST can trigger coral bleaching events, leading to degradation of reef structures and the loss of associated marine biodiversity (Krishnan et al., 2011; Marimuthu et al., 2012). Such impacts not only threaten ecological stability but also undermine the ecosystem services that coral reefs provide to coastal protection and fisheries productivity.

Policy Implications:

Strengthening island-level waste management systems is essential to prevent the accumulation of plastic debris along coastal habitats. Regular beach clean-up programmes and community-based waste monitoring should be institutionalized to reduce ecological impacts. In addition, conservation measures must prioritize the protection and monitoring of coral reef ecosystems, including the establishment of long-term reef health surveillance and climate stress monitoring programmes.

3. Strategic Policy Options

3.1 Ecosystem-Based Integrated Island Management

Key pillars:

1. Updated ESA demarcation
2. Nature-based coastal buffers (mangroves, shelterbelts)
3. Hazard-informed spatial zoning
4. Climate-screened infrastructure
5. Community co-management and citizen science
6. Marine spatial planning
7. Coral reef monitoring
8. Marine debris management plans
9. A Coastal Information Hub for evidence-based policy

4. Recommended Policy Actions

•Notify newly identified sea turtle nesting beaches as Ecologically Sensitive Areas (ESAs) and strengthen regulatory protection for critical coastal habitats.

•Integrate updated shoreline erosion and tsunami hazard maps into district planning and strictly enforce coastal setback lines in high-erosion zones, especially along the southern and southeastern coasts of Car Nicobar.

•Initiate mangrove restoration to enhance natural coastal buffering and shoreline stabilization.

•Establish a permanent turtle and shoreline monitoring cell to support continuous ecological monitoring and coastal surveillance.

•Mandate climate-risk screening for all new infrastructure proposals and retrofit critical infrastructure using projected sea-level-rise scenarios.

•Develop a Marine Spatial Plan (MSP) for Car Nicobar waters to regulate marine resource use and strengthen biodiversity conservation.

•Institutionalize community co-management frameworks to ensure sustained participation of tribal and local stakeholders in coastal and marine resource governance.

•Strengthen collaboration between scientific institutions and local communities to support biodiversity conservation and climate-adaptive management in Car Nicobar (Nicobar Times, 2024).

5. Conclusion

Scientific assessments clearly indicate persistent shoreline instability, significant exposure to tsunami hazards, rising air temperatures, warming seas, and projected sea level rise that threatens already limited coastal ecosystems. The island's critical habitats, including mangroves, coral reefs, seagrass beds, and turtle nesting sites, occupy relatively limited spatial extents and are highly vulnerable to both climatic and anthropogenic pressures. In this context, an updated, ecosystem-based Integrated Island Management Plan is essential to safeguard livelihoods, biodiversity, infrastructure, and the island's long-term habitability. The way forward requires citizen science initiatives, science-based zoning, strategic ecosystem restoration, climate-resilient infrastructure planning, and governance frameworks that meaningfully integrate community participation and traditional knowledge systems.

For further information, please contact:
The Director
ICAR–Central Island Agricultural Research Institute (ICAR–CIARI)
Sri Vijaya Puram–744105

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