Sea Level Rise: Impact on Major Infrastructure, Ecosystems and Land

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Summary

Sea level rise, due to climate change, will affect the coastline in India in a variety of ways, including inundation, flood and storm damage associated with severe cyclones and surges, erosion, saltwater intrusion, and wetland loss. There are major, existing and proposed, economic and infrastructure developments, including ports, power plants, highways and even airports, which are being planned very close to the shoreline along India's coast. Thousands of crores of new investment are being considered along the coast in cities such as Mumbai, Chennai, and Kolkata in addition to the substantial existing infrastructure.

This report concentrates on the impacts of sea level rise on coastal infrastructure, ecosystem and land in the state of Tamil Nadu, India. It highlights the financial implications of sea level rise on existing and proposed infrastructure along the Tamil Nadu coast and provides thereby an "early warning" of the implications of indiscriminate development close to the shoreline. This study does not evaluate the impact on human populations along the coast from SLR, which will likely be devastating, as recent experience from cyclones and the tsunami indicate. The intent here has been to focus on the financial implications of infrastructure, ecosystem and land loss. The analysis performed here is indicative rather than comprehensive, primarily because of data constraints, but it is hoped that its findings will provide the basis for conducting more detailed studies covering larger portions of the Indian peninsula.

The Tamil Nadu coastline is about 1,076 km, with thirteen coastal districts, and it forms a fairly large contiguous and narrow coastal strip dotted with fragile ecological features and rampant development activities. *Using Tamil Nadu as a case study, the analysis in this report provides preliminary estimates of the replacement value of major infrastructure, the present value of ecosystem services associated with damage to wetlands and the market value of land at risk from 1m of sea level rise by 2050*. Since the area at risk from SLR is much larger than the area that is actually inundated, the area at risk for a 1m rise in mean sea level is also identified.

The area at risk from a 1m SLR is estimated on the basis of district-level analyses of the likely impacts from storm surges. For five coastal districts, Nagapattinam, Thiruvarur, Thanjavur, Pudukottai, and Ramanathapuram, the area along the coast that is below 10m above current mean sea level is estimated to be at risk from a 1 metre SLR, because of the very high storm surges that already affect them. For the remaining eight coastal districts, the coastal area that lies below 5m elevation relative to current mean sea level is estimated to be at risk from a 1 metre SLR. A 1m

rise in average sea level would permanently inundate about 1091 square kilometres along the Tamil Nadu coast, but the total area at risk would be nearly six times as much.

The study estimates the total replacement value of infrastructure (ports, power plants and major roads) impacted by sea level rise to be between Rs. 47,418 and Rs. 53,554 crores (in 2010 terms). The present value of wetlands (estimated in terms of foregone ecosystem services through 2050) impacted by sea level rise is estimated to be between Rs. 3,583 and Rs. 14,608 crores. By far the largest impact will be on the land at risk, whose market value is estimated to be between Rs. 3,17,661 and Rs. 61,15,471 crores. In comparison, Tamil Nadu's annual Gross Domestic Product is estimated to be around Rs. 2,50,000 crores, indicating that very significant value is at risk along the coast due to climate change impacts from sea level rise alone.

Data and Methods

The analysis carried out in this study was based on publicly available information on infrastructure location and investments. GIS baseline information was taken from sources such as LandSat 7 and OpenStreetMaps as well as government agency websites. In some cases, this information was obtained through Right To Information (RTI) requests. Market values for coastal land were estimated on the basis of interviews with real estate agents, after collecting around 80 data samples of agricultural, commercial and residential price estimates all along the Tamil Nadu coast.

Ports, power plants, the ECR (including its possible extension along the coast), wetlands and land were considered in the analysis. Other private and public investments, such as hotels and resorts, housing developments, shrimp farms and other commercial establishments were not included, in part because of the lack of available data, but also because the details needed for the analysis would have been overwhelming.

Detailed geomorphological analysis and modelling of the coastline would need to be carried out in order to provide precise estimates for the land area at risk of inundation, storm surges and erosion as a result of SLR. Such techniques were well beyond the scope of this preliminary study. Instead, an important simplification in this analysis is that district-level Probable Maximum Storm Surge heights obtained from Kalsi et al. (2007) have been used as the basis on which to estimate the land areas in each district that would be at risk from future storm surges, flooding and erosion associated with SLR.

Recommendations

1. Comprehensive vulnerability assessment of the entire coast should be conducted

This report is a first approximation of the replacement value of coastal infrastructure, market value land and present value of ecosystems at risk from SLR. Further analysis at higher levels of resolution and more detailed information for the entire coastal region of India needs to be conducted in order to estimate the total risk to land, infrastructure, ecosystems, human population and livelihoods. This must include analysis of the potential for erosion and shoreline retreat, expected flooding and storm surges at different levels of SLR, subsidence, and the impact of other human activities such as ports, commercial activity and groundwater withdrawal on the coastal zone.

2. Climate Change considerations should be integrated into coastal infrastructure development: Existing structures in the area of high risk will need to be modified to withstand SLR and its impacts. Development in areas of high risk needs to be limited and proposed structures need to consider SLR and its associated impacts in the evaluation. Except for infrastructure that is essential along the coast, including indispensable ports, new development should be planned at considerable distance from the shoreline.

3. Wetlands need to be protected: The high protection value of wetlands along the Tamil Nadu coast as well as elsewhere in the peninsula needs to be taken into consideration whenever any development threatening their survival is proposed. To the extent existing threats to wetlands can be mitigated or removed, necessary actions should be carried out.

4. Coastal protection measures should be carefully assessed and carried out if necessary: These could include the following:

- Provide assistance to at risk communities, building resilience;
- Early warning systems;
- Better understanding of the role of coastal ecosystems acting as a guardrail;
- Anticipate migration and prepare inland facilities and prepare at risk communities.
- Plan for and implement shoreline protection measures, where feasible and necessary

Coastal District	Ports		Power plants		Mangroves		Roads		Land	
In Rs. crores	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Thiruvallur	9,106	9,794	13,814	13,814	-	-	-	-	33,939	9,24,130
Chennai	7,639	9,786	-	-	-	-	6	16	2,29,976	4,59,951
Kanchipuram	500	500	-	-	-	-	63	173	7,882	14,30,749
Villupuram	400	830	-	-	-	-	24	65	5,277	63,871
Cuddalore	3,825	3,825	-	-	710	2,894	64	176	7,615	4,64,531
Nagapattinam	1,873	1,873	-	-	2,421	9,871	374	1,029	7,120	22,33,596
Thiruvarur	-	-	-	-	-	-	57	157	4,347	2,08,356
Thanjavur	-	-	-	-	-	-	122	336	1,860	94,547
Pudukottai	-	-	-	-	-	-	117	321	874	10,930
Ramanathapuram	-	-	-	-	452	1,842	301	827	17,344	1,30,021
Tuticorin	8,585	9,456	-	-	-	-	16	44	1,149	86,151
Thirunelveli	532	532	-	-	-	-	-	-	33	7,160
Kanyakumari	-	-	-	-	-	-	-	-	246	1,479
TOTAL	**32,460**	**36,595**	**13,814**	**13,814**	**3,583**	**14,608**	**1,144**	**3,145**	**3,17,661**	**61,15,471**

Summary results with replacement value for infrastructure, present value of ecosystem services for wetlands, and market value for land in different coastal districts of Tamil Nadu with a 1 metre sea level rise.

MAP SHOWS LOCATIONS OF SEZs, PORTS, POWER STATIONS, ECO-ZONES OVER POSSIBLE FLOOD RISK AREAS.