

Annex II: ENVIRONMENT

A. Introduction

1. The tsunami caused extensive damage to the coastal areas of Tamil Nadu and Pondicherry, and more localized damage to the coasts of Kerala and Andhra Pradesh, affecting in total about 2,260 km of coastline. The tidal waves on the mainland reportedly reached heights of 3 to 10 meters and penetrated 300 meters to 3 km inland.

2. A number of factors make it difficult to assess the specific environmental impacts of the tsunami in the short-term, including the lack of comprehensive baseline information on most coastal and marine ecosystems in the region and the absence of on-going systematic monitoring of such systems. Additionally, and understandably, the priority in the short-term has been immediate relief to the affected populations. Nevertheless, several governmental and non-governmental agencies initiated rapid assessments, with many proposing more comprehensive studies in the medium and long-term.¹⁶

3. This rapid review of environmental issues is based on a series of very short field visits to the most seriously impacted sites in Tamil Nadu, Pondicherry and Kerala. It was not possible to conduct a direct assessment of environmental impacts, and even direct observations are clearly biased towards large-scale visible, terrestrial impacts. Moreover, many environmental effects will only manifest themselves over the medium to long-term. Apart from the site visits, discussions were held with state and local government officials and some key research institutions and agencies.

4. Given these limitations, the following provides a preliminary assessment of the known and possible primary and secondary environmental impacts of the tsunami in the short-term, and key environmental considerations for the short to medium-term reconstruction and recovery phase. No attempt is made to quantify environmental damage in monetary terms at this stage because of inadequate reliable and quantitative information on most aspects of the impacts. Some of the costs of the damage to the environment are captured in other chapters, notably agriculture and fisheries.

B. Overview of the Damage to Biological and Physical Environment

5. **Pre-tsunami Situation.** The coasts of the Indian subcontinent have high human population densities, which in Kerala exceeds 2,000 people/km². Thus, there had been considerable degradation of typical coastal ecosystems such as coral reefs, sea grass beds, mangroves, beaches, sand dunes, mud flats, lagoons and the rare and endangered tropical dry evergreen forests of the east Coromandel coast. Mangrove forests have declined by 40% in the past 120 years, while the indigenous tropical dry evergreen forests have been reduced to 1% of their earlier distribution along the east coast as a result of land conversion for different purposes including, human settlement, economic activities and infrastructure development. There is also significant pollution of near shore marine habitats due to sewage and industrial emissions. Coastal geomorphology has been altered through the development of large infrastructure such as highways, industries, ports and harbors. Other disturbances include sea-defenses such as breakwaters and groynes as well as defenses to

¹⁶ These include: the Centre for Earth Science Studies (CESS), Thiruvananthapuram, Suganthi Devadasan Marine Research Institute (SDMRI), Tutticorin, among others.

protect coastal settlements. In Kerala, for example, there has been extensive use of rubble mound seawalls to protect against coastal erosion.

6. In some places, both human settlements and major infrastructure are located extremely close to the high tide line, up to within 20 meters, partly as a result of coastal erosion. The effectiveness of such defenses has varied, while some have had clear adverse environmental impacts as they alter natural patterns of coastal erosion and accretion, which can increase the vulnerability of human settlements elsewhere along the coast. 'Shelter belt' plantations established on the beach itself have been documented to adversely affect biodiversity, for example by reducing nesting sites for endangered marine turtles.

7. **Coastal Regulation Zone Notification.** Another key feature of the pre-tsunami situation was the incomplete and inconsistent implementation of the Coastal Regulation Zone (CRZ) notification of 1991 and the associated state Coastal Zone Management Plans. The CRZ notification is the principle legislation governing development activities and land use along India's coasts in the area falling within 500 meters of the high tide line and in the inter-tidal zone. Under the notification, all areas within this zone are to be classified as CRZ I (i), I (ii), II, III or IV based on geomorphology and various other criteria, including ecological significance, existing developments and other features.¹⁷ The nature and kinds of land uses permitted vary according to the specific zone within which an area falls, with greater restrictions on CRZ-I areas, fewer on CRZ-II areas and variable restrictions in CRZ-III areas, where there is considerable scope for varied interpretation as well.

8. Generally, the notification is complex (this is compounded by 17 amendments since 1991) and has been interpreted and applied in different ways by both Centre and states. The lack of systematic application of the notification or any effective integrated coastal zone management has reduced the resilience of natural systems and increased the vulnerability of populations and infrastructure to natural disasters.

9. **Impacts on Settlements, Natural Resources and Human Production Systems.** The tsunami has had a number of impacts on settlements and human production systems, as follows:

- Salination of Ground Water and other Freshwater Resources. Seepage of sea water into shallow aquifers, wells and other freshwater sources has been reported from Pondicherry, Kerala and Tamil Nadu which have implications for immediate human health and agriculture. The permanence of such contamination must be assessed and remedial action taken in cases where salinity will not be flushed out rapidly through rainfall and other natural processes. This could be especially problematic in drought-prone areas.
- Debris and Rubble. There is a significant amount of debris and rubble requiring disposal, possibly as much as 500,000 metric tons (initial estimate). There is also the potential for more rubble and debris once the disposal of damaged housing (estimated at about 140,000 units), fishing vessels (over 50,000 boats destroyed or damaged), and other damaged

¹⁷ CRZ I (i) comprises 'ecologically sensitive or important' areas such as wildlife sanctuaries, national parks, government forests, mangroves, coral reefs, breeding and spawning grounds of fish and sites of historical importance. CRZ I (ii) comprises areas between the low tide line and the high tide line. CRZ II consists of areas that are already quite developed up to or close to the shoreline, such as major coastal settlements, ports and other large infrastructure. CRZ III consists of areas that are less developed than CRZ II areas or undeveloped but which do not merit being classed as CRZ I. CRZ IV covers the coastal stretches of the Andaman and Nicobar Islands, Lakshwadeep Islands and some other islands except where these have already been classified as CRZ I, II or III.

infrastructure is accounted for. The debris, including plastics and other toxic and non-biodegradable wastes, requires proper handling and disposal to prevent long term impacts to land and water resources. The cost for proper disposal is estimated at \$5 million.

- Erosion and Sedimentation. There has been extensive erosion of the beach/coastline in some areas, including the complete disappearance of large sand banks and changes in the shape of estuaries. Given the dynamic nature of coastal systems and natural patterns of coastal erosion and accretion, the permanence of such changes and their associated social, economic and ecological implications are unclear at present.
 - Impacts on Production Systems. Certain environmental impacts have implications for production systems such as fisheries and agriculture. The most visible is the salination of agricultural land and ground and surface freshwater sources, including ponds, tanks, irrigation canals, lakes, streams and rivers. Total affected crop land has been estimated at about 8,000 ha, with much of the damage occurring in Tamil Nadu, although both Pondicherry and Kerala reported damages in the order of 500-1,000 ha. Livestock losses were severe in Kerala while damage to salt pans amounting to over 1,400 ha was reported in Andhra Pradesh¹⁸.
 - The tidal waves left significant amounts of what appears to be sea-bed organic deposits of a sodic nature. This material settled after the tidal waves lost their forward momentum from about 200 meters inland. In some places these deposits are close to 30 cm in thickness. The affected land is unusable in its current state. Salinization of agricultural land as well yellowing of leaves and premature nut fall in coconut trees was reported on the Kerala coast.
 - Impact on Fishery Resources. The precise impacts of the tsunami on fishery resources will only become clear in the medium to long-term. Scientists at the Centre for Advanced Marine Studies (Peringapettai) mentioned that the few fishermen who had been out fishing reported catches of non-local species. There is therefore a need to monitor whether these species persist and cause displacement of indigenous species. Damage to coastal aquaculture was also reported, with initial estimates of some 400 ha of shrimp ponds having been affected across the impacted area. Over 100 small-scale oyster farms established by self-help groups were destroyed in Kerala.
 - Damage to Plantations. Additionally, some amount of damage to plantations has been reported by individual states. The Tamil Nadu forest department has reported damage to 2,581 ha of shelterbelt, mangrove and teak plantations and associated nurseries. The estimated cost to replace these is Rs. 6.50 crore (about \$1.5 million). Figures for damage to government plantations have not been reported by the other states.
10. The most significant secondary environmental impacts are likely to be as follows:
- Impacts and damages caused by relief camps, temporary shelters and other temporary structures. The construction of numerous relief camps and temporary shelter sites (about 500 in all) may have impacts on the long-term productive capacity of the land, including the possibility of permanent land use change. Initial estimates suggest that more than 1,500 ha would be required for reconstruction of damaged housing. Emergency measures taken after the tsunami have led to hastily constructed structures that will require removal and disposal, such as the temporary land bridge at Nagapattinam port.

¹⁸ See also Annex VI on Agriculture and Livestock.

- Water and sanitation issues are an integral part of the design of temporary shelter sites, and the proper design of temporary facilities is critical in minimizing the risks of long term impacts. There are indications that waste management is rapidly becoming a concern.
- Energy sources. The inhabitants of temporary shelters will require energy, and both the forms of energy and the sources of supply are unclear. This could exert pressure on natural resources locally.
- Changes in land use. There is an increased risk of land use change if affected agricultural lands are not rehabilitated to their earlier productive capacity or if new road segments are required
- Increase in water and chemical usage. Reclamation of agricultural land will require significant amounts of water for flushing out the salinity and some chemicals to reestablish the land's buffering abilities.

11. **Primary Impacts on Coastal and Marine Ecosystems, including Changes in Coastal Geomorphology and Pollution** The direct environmental impacts of the tsunami varied according to various factors, notably the bathymetry and geomorphology of the coastline, as well as the presence of various natural and man-made features. Thus, areas adjacent to relatively steep continental shelves were generally less damaged than coasts with an extensive shallow continental shelf, such as Nagapattinam district in Tamil Nadu, which was severely impacted. There are anecdotal reports of the buffering role of mangroves, reefs, sand dunes and plantations (primarily of *Casuarina*) as well as the rubble mound sea walls in Kerala. The precise nature and extent of this buffering need to be ascertained more systematically.

12. Changes in the coastal geomorphology have been recorded by India's Department of Ocean Development and reported by fishermen, although a full picture is yet to emerge including a comprehensive assessment of the nature and implications of these changes. Many coastal wetlands will have been affected at least temporarily by the large inflow of salt water and silt load, while there may be longer-term impacts relating to changes in hydrology caused by physical changes to coastlines.

13. Damage to mangrove saplings was observed in the Pichavaram mangroves (1,400 ha) in Cuddalore district of Tamil Nadu. Such physical damage is also likely in other mangrove areas. The backwash created as each wave retreated was potentially more damaging as sediments and other land debris were deposited on coastal and shallow-water habitats, including mangroves, seagrass beds and corals. The district forest officer of Cuddalore reported heavy siltation in the Pichavaram mangrove, and the team observed considerable debris in the mangroves (plastics, nets and other household articles). Large movements of sand were also reported in Kerala, including the black sand mined for thorium.

14. An obvious environmental impact of the tsunami is the terrestrial and aquatic pollution that has resulted from the waves and backwash. The most visible of these is the physical debris, particularly more slowly degrading waste such as plastics, and to a lesser extent rubble from damaged houses, sea walls, and other materials.

15. The Tamil Nadu government has identified seven pollution hotspots along the coast: Cuddalore, Manali, Ennore, Kasimedu, Tuticorin, Nagapattinam, and the confluence of the Cooum river near Chennai. Effluents from chemical industries, petroleum refineries, power plants and

sewage are the main pollutants. The concerns in this area are largely due to the backwash of the tsunami carrying inorganic materials and other pollutants into the sea from the human settlements. Data from the other states could not be obtained in the time available.

16. **Impacts on Protected Areas in the Coastal Zone.** The general perception is that there has been no major impact on wildlife because no significant mortality has been reported so far in larger and more visible species, particularly mammals, birds and large reptiles in the tsunami-affected mainland states. However, this does not mean that there are no significant impacts on wild flora and fauna, whether immediate or longer-term, particularly due to salinity ingress in soils and water bodies.

17. Limited information was obtained for three protected areas in Tamil Nadu. The Point Calimere Sanctuary and adjoining area was flooded for two days after the tsunami. An increase in the salinity of some water bodies has been reported and this has resulted in the death of numerous fishes, but there are indications that the salinity levels are beginning to decrease. At least in the short-term many aquatic birds seem to have moved further inland, especially flamingos. Sand and silt has been extensively deposited up to 500 m inland. Authorities believe there were no significant impacts on Pulicat Bird Sanctuary which lies north of Chennai. The Gulf of Mannar Marine National Park was sheltered to an extent by the Sri Lankan land mass.

18. There seem to be no large-scale impacts on the globally significant coral reefs and associated habitat and resources, including reef-associated fishes. Preliminary assessments indicate physical damage to some 2 percent of the total available corals, comprising table corals and branching corals, and to seagrass beds. Monitoring will be required to see how well these corals regenerate.

19. The above preliminary information underscores the need for more systematic and comprehensive assessments of the impacts of the tsunami on biodiversity along the Indian coast. Wetlands International has identified a number of important sites that should be assessed and monitored for such impacts in all tsunami-affected countries, including India.

C. Reconstruction Strategy

20. This section proposes key principles to be considered in the design and implementation of an environmentally sustainable rehabilitation and reconstruction program for tsunami-affected areas. These principles propose a framework for considering issues, remedial options and opportunities to enhance environmental management and outcomes associated with man-made and natural systems.

21. Mainstreaming environmental considerations into sectoral interventions. There are environmental dimensions to practically every sector affected by the tsunami. This requires the consideration of environmental issues in all sectoral reconstruction planning and action, particularly the siting of temporary and permanent settlements. Actions related to reconstruction and recovery should seek to ensure that the sustainability of coastal and marine ecosystems is not compromised, and is ideally enhanced as the goods and services they provide underpin the livelihoods and immediate welfare of large coastal populations. Wherever possible, 'soft' options with fewer adverse environmental impacts should be favored over 'hard' options that may involve changes to coastal hydrology and other natural processes.

22. Learning lessons from the tsunami event. Tsunamis occur relatively infrequently in the Indian Ocean. The present situation offers an opportunity to assess and monitor the resilience of natural and modified ecosystems to such extreme events, which in turn will help plan mitigation of the potential impacts of a range of natural risks and hazards, which affect coastal areas periodically. Such monitoring can also help plan against the anticipated adverse impacts of climate change. In the short-term, such monitoring is key to identifying environmental damage and prioritizing environmental restoration¹⁹.

23. Need for a comprehensive coastal zone management strategy. Such a strategy would reflect the dynamic nature of the coastal and marine environment and support multiple-use objectives, without compromising the sustainable supply of environmental goods and services. These objectives would reflect livelihood needs, reduce vulnerability to natural hazards, and the conservation of biodiversity and ecological services.

24. Focus on localized site-specific solutions. The extent of the damages along the coastline and the fear of a tsunami recurring must not lead to uniform strategies being applied across the board without full consideration of the different variables such as climatic factors, bathymetry and coastal topography associated with vulnerability to natural hazards. Economic, environmental, social and cultural factors must all be taken into account when developing disaster risk mitigation strategies, and solutions must be anchored in the prevailing circumstances of local situations.

D. Reconstruction Needs

Short-term Priorities

25. With emergency relief operations largely over, attention is shifting to short and medium term recovery actions and strategies. The most pressing issues are likely to be linked to the relocation of a large number of affected people from temporary shelters to permanent housing sites, and the need to reestablish the productivity of affected areas. It is likely, however, that a significant number of people may be using temporary shelters beyond six months. Careful planning and management are required to mitigate adverse environmental impacts, particularly in relation to waste management and natural resource use for energy, water and other household needs²⁰.

26. Equally important, because of long-term implications for local livelihoods and human welfare, is the need to initiate a series of systematic rapid environmental assessments, and to develop environmental and sustainability strategies that can be integrated into the varied activities proposed under the reconstruction and recovery phase. Short-term priority actions include the following:

- Development of guidelines for rubble, debris and other waste removal and disposal: As there will be significant amounts of debris both in the water and on land, a concerted debris management strategy and management plan will be required. The plan should include guidance on the proper management of reconstruction related debris and waste materials. This should reduce the risks associated with strewn debris to people, livestock, equipment

¹⁹ Such assessments and monitoring should be linked with the comprehensive vulnerability mapping and analysis proposed in the chapter on disaster risk management.

²⁰ See related Annexes on Housing, Livelihoods, and Rural and Urban Infrastructure amongst others.

and the environment. Debris management should be supported by a concerted effort to clean up affected areas.

- Temporary-shelter Community Environmental Management Plans (CEMPs): A generic CEMP should be developed and then adapted to each relief shelter site to provide basic guidance on the proper management and maintenance of sanitary infrastructure, including the management of household waste and regular monitoring of drinking water quality.
- Assessment of impacts on drainage and increased risk of flooding: There is an immediate need to assess whether the risk of flooding, or severity of usual floods, may increase as a result of changes in coastal geomorphology and heavy sedimentation in estuaries, canals and other waterways along the coast²¹.
- Relocation site selection criteria: In case of relocation of affected or at-risk villages to alternate permanent resettlement sites, the populations should be supported by site selection criteria that incorporate appropriate environmental and social provisions.
- Development of environmental and social criteria for reconstruction efforts: Work should begin immediately on the development of environmental and social criteria for reconstruction work.
- Rapid environmental assessments: A number of assessments are required to better guide the reconstruction strategy and ensure long-term sustainability. These should include the following:
 - *Non-field based assessments of the damage and impacts*: An assessment of the physical damage caused by the earthquakes and tsunami to the coastline by comparing satellite imagery before and after the event. Ecologically significant sites need to be given particular attention.
 - *Field-based assessments*. Based on the results of the initial non-field-based techniques, an intensive field-based rapid assessment should be conducted. In addition to assessing the direct environmental impacts on ecosystems and habitats, impacts on ecological goods and services that underpin local livelihoods and human welfare should be assessed. These would include natural resource related direct production changes, such as impacts on fishing grounds and fish catch as well as losses relating to decline in tourism.

Medium-term Priorities

27. Community Environmental Management Plans (CEMPs): A generic CEMP should be developed and then adapted to each new permanent relocation site. CEMPs should provide basic guidance on the proper management and maintenance of sanitary infrastructure, including the proper management of household waste.

28. More effective integration of environmental considerations in coastal zone planning and development: There is urgent need to upgrade coastal zone management practices in general, and to factor in much more proactively the environmental dimensions associated with development, natural resource use, protection of environmental services, and conservation of biodiversity.

²¹ This was mentioned as a particular concern in Kerala in relation to the coming south-west monsoon by the Centre for Earth Science Studies (CESS) in Thiruvananthapuram.

29. On-going monitoring and studies: The rapid assessment phase will help identify locations and communities that require the most attention, and determine key issues that require addressing during the recovery phase. A range of experts from various sectors should be consulted at this stage. During the second phase, ecologically sensitive areas and other severely impacted regions need to be revisited to establish the full extent of the damage with more comprehensive studies. Where required, baselines will have to be established for sustained monitoring of ecological recovery, and mitigation measures should be devised for ecosystems that may not recover to their former state without management intervention. The results of these more detailed assessments and systematic monitoring will provide invaluable inputs for an adaptive approach to integrated coastal zone planning and management.

30. Opportunities for ecosystem restoration and management for better coastal zone protection and biodiversity conservation: The rapid and longer term environmental assessments proposed here should lead to the identification of priorities and opportunities for environmental restoration and improved management of coastal and marine ecosystems to generate multiple benefits for different natural resource user groups. Two clear opportunities for ecosystem restoration were identified during this damage assessment:

- The first relates to the opportunities for mangrove restoration along both the east and west coast. Kerala, for example, has over 40 major estuaries and numerous coastal lagoons. Improved management of its existing mangroves which cover some 1,700 ha, and the establishment of new mangroves over 200 ha can be considered. The establishment of new mangroves is already taking place in Pichavaram and other parts of Tamil Nadu.
- The second opportunity is the possibility of restoring the tropical dry evergreen forest, which is indigenous to the eastern coast from south of Andhra Pradesh to just north of the Gulf of Mannar. From a biodiversity perspective, this forest type has been identified as both globally significant and highly endangered. Restoration of this forest is already being undertaken in one area of Tamil Nadu. There is need to assess the potential for restoring this forest in other areas along the coast and to evaluate its potential for reducing vulnerability to cyclones, flooding and other natural hazards.