

Annex XI: COASTAL PROTECTION

A. Introduction

1. The impacts of the tsunami were influenced by the differences in the topography of India's east and west coasts. The east coast is characterized by sand accretion. Most of the coast is covered by well-developed coastal dunes, sand slips and sand bars, and the slope of the beaches is gentle. Some part of the shoreline does not have any natural barriers such as mangroves or even sand dunes. The state of Tamil Nadu has a program to construct a rubble mound seawall (RMS) to protect the vulnerable coastal area from sea-related hazards, but only 40 km has been built at present.

2. In the east, 39 major rivers and drains meet the Bay of Bengal. Nagapattinam and Pondicherry, which were badly hit by the tsunami, are located in the middle of the Cauvery delta, a lowland area below sea level in parts and extending far inland, which is very vulnerable to flooding and storm surges – as well as tsunami inundation. The east coast was struck both directly by the tsunami with waves believed to have been more than 5 m in height and also through the reflection of waves by the island of Sri Lanka. Because of its vulnerable topography and limited coastal protection, the overall impacts were especially severe.

3. On the west coast, affected areas suffer from erosion problems; beach slopes are steep. Many coastal protection works have been undertaken, including groynes and seawalls. Groyne systems have been used in Kanniyakumari district, and seem to have worked well even in the face of the tsunami; they are believed to have saved the lives and property of many in coastal villages.

4. In Kerala, gentle slope-type coastal embankments that also work as buffers against beach erosion are the main protection structures. Because the beaches are steep, and this area is located behind Sri Lanka, the tsunami wave height is believed to have been relatively low and so its impact was less than on the east coast.

B. Damage Overview

5. Data for this damage assessment has been collected through field visits to each of the main affected stretches of coastline; review of state government damage assessment reports and technical reports; and consultation with relevant divisions in each district.

6. Although the overall impact of the tsunami on the east coast was severe, damage to coastal protection structures was limited. Most are designed to cope with high wind waves, and survived the tsunami with only minor damage. The Rubble Mound Seawalls (RMSs) survived and were reported to have saved many lives and properties. However, most of the small coastal embankments to protect roads and other infrastructure did not have sufficient depth to cope, and suffered severe damage. Many existing flood banks near the mouths of rivers were damaged, especially in Nagapattinam district.

C. Immediate Needs

7. The damage estimates in Table 1 are based on the cost of restoring damaged coastal protection infrastructure to sound working condition. The total estimated cost of damage is Rs. 186

crore, (\$42.8 million³⁸) comprising Rs. 104.0 crore (\$23.9 million) in Tamil Nadu, Rs. 42.0 crore (\$9.7 million) in Kerala, and Rs. 40.0 crore (\$9.2 million) in Andhra Pradesh. Estimates of losses are not included as these have been captured in the assessments for other sectors in this report.

Table 1: Immediate Restoration of Coastal Protection, Tamil Nadu and Kerala

Item^a	Description	Damage (Rs. crore)
1. Tamil Nadu		
Vedaranyam canal	Widening and strengthening of the bank	7
Buckingham canal	Widening and strengthening of the bank	3
Rivers and drains	Strengthening of 245 km banks of rivers and drains	75
Coleroon River Bank	Strengthening of river bank	6
Additional straight-cut from Vedaranyam canal to Buckingham canal	Restoration, strengthen and widening of rivers and canal banks	9
Rubble mound seawall	Restoration (Chennai and Madurai)	2
Coastal Protection Infrastructure	Equipment restoration (Chennai and Trichy)	2
Subtotal		104
2. Kerala		
Coastal Protection Infrastructure	Restoration of 28 km of RMS wall	42
Subtotal		42
3. Andhra Pradesh		
Sea wall tidal banks in Kruthivene Mandal	E.G. District and W.G. District	11
Tidal banks in Kruthivene Mandal	Krishna District	6
KET and Kona tidal banks	Krishna District	18
Study and survey etc.		5
Subtotal		40
TOTAL		186

^a Based on information available at the time of the assessment, no requirements for immediate restoration were identified for Pondicherry, although medium term reconstruction and recovery estimates were identified as discussed below.

8. The immediate focus should be on restoration of damaged infrastructure for protection against coastal hazards such as cyclones and subsequent storm surges and river floods. Especially in Nagapattinam district, serious damage has been reported at river and drain banks, and these need to be restored immediately. In the event that vulnerable coastal hamlets are relocated to lowland areas, anti-flood measures such as raising the level of relocation sites and constructing embankments are required.

9. In Tamil Nadu, the strengthening of the Vedaranyam and Buckingham canals, and of 245 km of river and drain banks at the confluence point with the Bay of Bengal are immediate necessities to prevent inundation in Nagapattinam district. The proposed restoration of coastal protection infrastructure indicated in Table 1 will be distributed all along the coastline. In Kerala, most restoration work will be in Kollam and Alappuzha districts. Although direct damage to coastal protection structures such as RMSs or groynes was relatively small in both Tamil Nadu and Kerala, an immediate survey of the safety of the structures, followed by restoration work, is needed.

³⁸ For the purposes of currency conversion an exchange rate of Rs 43.5 / US\$ is used.

D. Reconstruction Strategy

10. The aim of the reconstruction and recovery strategy is to strengthen coastal protection infrastructure in order to permanently reduce future damage and loss of life from sea-based hazards. In planning coastal protection measures, it is important to consider the land use of the coastal area concerned, as well as the status of coastal erosion. The coastal zone can be divided into three categories: (i) port and city area; (ii) fishery village or fishery and agricultural usage area and (iii) little human activity (as a village relocation or environmental preservation). Each category may require different measures.

11. Coastal protection work will need to be closely coordinated with recovery and rehabilitation works for highways, ports and fish harbors. In some cases, it may be appropriate to adopt an integrated approach to design these facilities. For example, a coastal highway might be built on top of a coastal protection embankment.

12. Since a range of different technical options are available, their relevance is location-specific, and the technical and other factors involved are complex, it is essential that the selection and design of additional infrastructure is based on thorough technical studies, and taking into account the lessons learned from the recent tsunami and other recorded events. A list of technical options is provided in Appendix 1.

13. The suggested technical studies should be closely coordinated with the ongoing government-financed study of ocean disasters being undertaken by the federal Department of Ocean Development.

14. In the case of Tamil Nadu, the studies should cover the entire length of the coast since it is mostly unprotected at present. Because the length of coastline to be protected is long, construction cost and period may be important factors in selecting the type of structure. The scope of the studies should include (see also Appendix 1):

- (i) Assessment of coastal hazards including tsunami effects. This will require statistical analyses of extreme natural hazards. Because cyclones, storm surges and high tides are regular phenomena in south India, existing research may be available though not for tsunamis.
- (ii) Beach erosion control studies for the southern Indian coast. These should include assessment of the characteristics of the coast such as long term and seasonal topographical changes of beaches, and the characteristics of littoral sand drift; and evaluation of technical options for erosion control work through modeling to predict coastal topographical changes caused by deployment of the coastal structure. Environmental and social impacts will also have to be examined.

15. With respect to the civil works for reconstruction and recovery, expert assistance should be provided to state governments for construction supervision, and monitoring of effectiveness and associated refinement of coastal protection that tends to be necessary for this kind of work. The suggestions for reconstruction and recovery works here are very tentative, and are in response to requests from the state governments. They incorporate preliminary expert inputs. A two-stage approach is envisaged:

16. The medium term covers the more vulnerable areas that require improvement in coastal protection infrastructure as soon as necessary studies have been completed. These works should be completed within 1-3 years. The longer term covers additional vulnerable areas where works should be completed within 3-5 years. It is likely that there are substantial requirements for longer term measures, but at the time of this assessment only very limited information of the requirements was available.

17. Pending the technical studies described above, the suggested coastal protection work in Tamil Nadu consists of construction of: (i) gentle slope-type RMS; (ii) retaining wall for parts of the RMS; and (iii) groynes for protection against beach erosion. These coastal works will also provide protection against cyclones, storms and depressions besides the rarity of a tsunami. In the medium term, this will involve construction of 40 km of RMS, 20 km of concrete retaining walls for parts of the existing RMS in urbanized areas, and 50 additional groynes. The longer term will cover construction of the remaining requirement of 415 km of RMS, 35 km of concrete retaining walls for parts of the RMS, and 426 additional groynes.

18. In Kerala, the medium term reconstruction and recovery work will address essential requirements for protection against tsunamis and sea erosion. This can consist of construction of: (i) 73 km of new RMS wall; and (ii) 97.45 km of RMS wall reformation work. The longer term will focus on completion of the remaining coastal protection that is needed. This can cover: (i) construction of a new RMS wall along 74 km of uncovered coast; and (ii) restoration of about 37 km of the existing RMS wall due to settlement of the structure.

19. The restoration of coastal protection works is proposed to be done within a period of 3 years – the immediate works of restoration (estimated to cost Rs. 85 crore) to be completed in the first year and the balance (estimated cost Rs. 81 crore) in year 2-3.

20. An important factor that will need to be considered, when comparing the RMS wall proposed by the state governments with other alternatives, is the impact on the surrounding coastal environment and on erosion.

21. Groynes are often not a very satisfactory countermeasure for beach erosion. Their purpose is to interrupt the littoral drift to try and maintain the beach. However, on their leeward side, the supply of sand is interrupted and erosion occurs. In an extreme case, in Kanniyakumari district, groynes were used as a kind of breakwater for fishing by extending the length seaward. The greater length has considerably accelerated the problem of leeward side erosion there.

22. Both Kerala and Tamil Nadu use the gentle-slope type RMS. These types of structures were developed to reduce the effect of wave reflection. However, if beach erosion should reach the RMS (if the RMS faces directly the sea), scouring will occur at the foot of the RMS and this may lead to its collapse. In such cases immediate reformation work is needed. In Kerala, where there is considerable seasonal topographical change, there are serious risks of erosion reaching the RMS, and costs of maintenance are high. It is in this context that Kerala has proposed 69 km of reformation work in the medium term, representing 11 percent of its existing RMS. In considering technical options, another issue is physical and visual access to the beach. Structures like RMS are an obstacle. An option is offshore submerged breakwaters with beach sand nourishment. This is especially appropriate where beach erosion is already serious. Although this method is more costly than RMS, its maintenance costs are generally less and the beach is maintained effectively.

Appendix 1: Options for Coastal Protection

Option	Description	Advantages	Disadvantages
1. Groyne	Construction of structure from the shoreline to the sea	Easy to implement Reliable trapping of sand on one side Less costly than offshore structures	Erosion to leeside Negative impact on the scenery
2. Seawall (Gentle Slope RMS)	Rubble mound made of rocks	Easy to implement Less costly than offshore structures	Less capacity to retain the shore line Regular maintenance cost Disruption of access to beach Negative impact on scenery and environment
3. Headland Defense Work	Comprehensive system of shorter groynes	Stable shore line balancing inflow and outflow of littoral sand drift	Longer time for studies and designs Negative impact on scenery
4. Beach Nourishment	Provision of sand to the beach	Instant effect on beach Easy to maintain	Regular maintenance cost
5. Offshore Breakwater	Detached Breakwater parallel to shoreline	Reliable trapping of sand Less maintenance cost	Most costly Risk of erosion at other beaches Negative impact on scenery Impact on water flows
6. Artificial Reef	Submerged detached break water parallel to shoreline	No impact on scenery Less maintenance cost	Costly Less capacity of trapping sand
7. Combination of Options 2-6			

The south Indian coast is prone to several water-related natural hazards such as cyclones, storm surges, depressions and flooding. In order to select a feasible coastal protection option, the following studies are required:

Analysis of water-related natural hazard

Statistical analysis of extreme wave and tide values for long period for more than 30 years, or simulated wave and tide data.

Assessment of littoral sand drift

Present and past topographical changes, and characteristics of littoral sand drift
Depth survey records including the topographical change, wave and climate data, deposited material properties, and sand and/or silt material supply from rivers etc