Subarea concept:

Activities and land uses on Keaukaha coast were grouped into eight overlapping, but identifiable, character areas that were used as the basis for the integrated park and trail system, interspersed with residential uses — interrupted by the port. Division of the coast into subareas was one planning tool used to identify and address specific needs or conflicts between uses.

In order to implement the coastal green belt concept it was important to retain the unique ecosystems that characterized the coast. Most important were a large lagoon and major stands of trees. The lagoon was heavily used by local fisherfolk and was therefore considered by the community to be an important resource. During the Keaukaha plan preparation phase, the county was simultaneously developing plans to expand the coastal road within the existing right of way, which would have destroyed the lagoon and trees. Transportation planners were persuaded to re-align the route inland outside of the tsunami experience zone. This decision retained the lagoons while maintaining water detention and reducing vulnerability to recurring disruption from winter storms — which reduced maintenance costs. The coast route was partially funded with federal funds because it was considered to be a component of the interstate highway system (Figure 5.5).

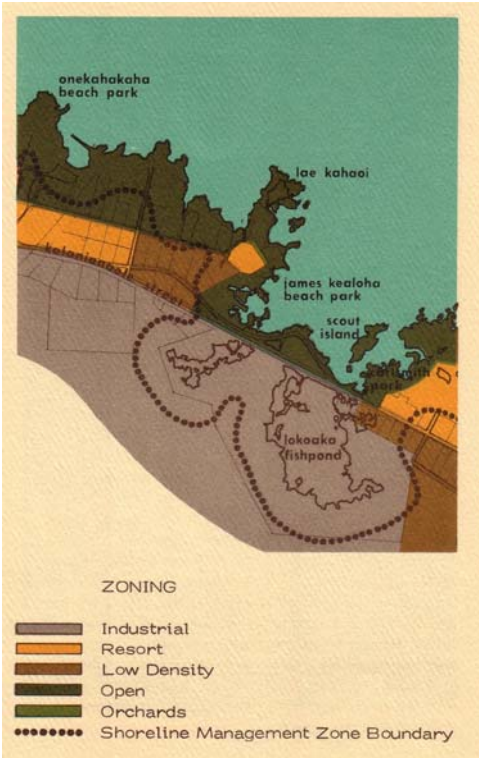

Figure 5.5 The Keukaha subarea concept with the lagoon saved by roadway re-alignment to provide additional depth for planting and safety from disruption caused by storms or tsunami (Hawaii County, 1978)

Project site:

Public and private development is required to comply with set-back and landscape requirements — irrespective of the owner. Plantings on the hotel/resort site (Figure 5.6, right) are in required set-backs and are the responsibility of private landowners. These dense plantings are intended to provide protection from storms and from tsunami. Buildings in both graphics below existed prior to adoption of the plan.

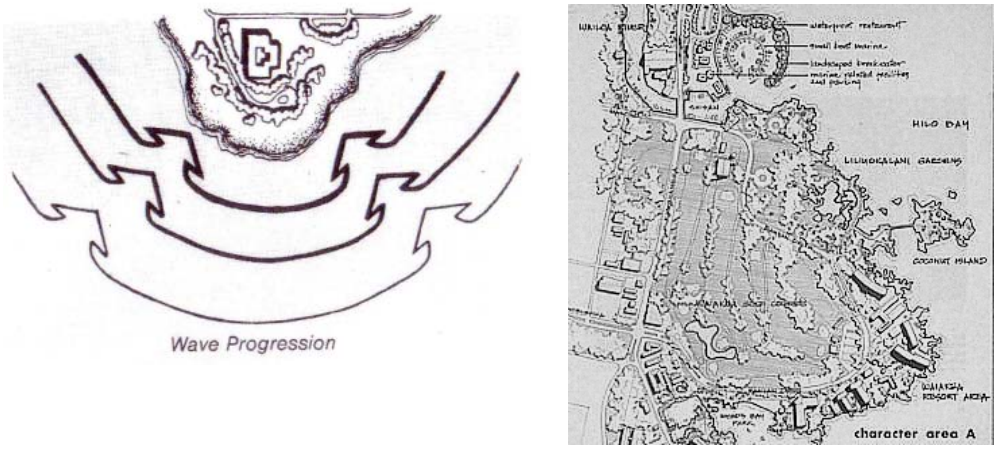

Figure 5.6 Left: Coastal land form (Urban Regional Research 1982); right, project area site plan — set-backs with protective buffers (Hawaii County, 1978)

Outcome: All components of the Keaukaha plan implemented. The county acquired the parklands, which are maintained as part of the overall county park budget.

Case study # 3: Sri Lanka — reducing river bank erosion

Mitigation concept

Bank erosion caused by riverine flooding has been a recurring problem. Multiple seasonal flooding events can result in incremental bank erosion, loss of neighbouring property, and degradation of water quality. Sediment transport to the sea leads to channel migration, which can result in siltation of corals and other marine organisms. Cumulatively, these effects can be extremely damaging. Plates 5.8 and 5.9 juxtapose mitigation in two settings compared to approaches to bank stabilization when priorities differ.

Project descriptions and evaluation considerations

Project A: Mangrove forest, Hikkaduwa, Sri Lanka

A mangrove forest has been planted to reduce low bank erosion, while also protecting adjoining wetland areas that accommodate water detention and drainage. Costs are generated in the planting, because maintenance is minimal. Some continued erosion occurs during maturation of the buffer forest.

Plate 5.8 Mangrove forest used for bank stabilization: Hikkaduwa Sri Lanka

Project B: Weligama (Mirissa) roadway stabilization:

Continuous bank erosion threatens to undermine the roadway. To reduce the threat of access disruption, a retaining wall was constructed to protect the road from erosion caused by the

migrating channel. Because of the location of the erosion other solutions, such as vegetation planting, were not feasible. The benefit of this solution was the immediate protection; a "soft" solution would necessitate re-aligning the roadway.

Plate 5.9 Retaining wall to stabilize a roadway: Weligama (Mirissa), Sri Lanka

Case study # 4: Coastal erosion mitigation

Mitigation concept

To provide protection against coastal erosion, thereby reducing threats to the critical roadway. The project consists of a raised embankment and revetment with planting on the shore side of the embankment.

Project description and evaluation considerations

Project A: Coastal hardening — Sri Lanka

Critical segments of Sri Lanka's coastal roadway are at or below sea level. Restoration and maintenance of safe access was the prime consideration; a "hard solution" was selected as an economic imperative. Some trees have been planted between the embankment and the road; however, there is insufficient area for a deep tsunami forest. Seasonal fluctuation in beach sand has been reported; during periods of low sand there is reduced access to the water by fisherfolk and others and it becomes impossible for fisherfolk to pull their boats onto land.

Plate 5.10 Left: Bank revetment, Sri Lanka. Right: Tree planting on the inland side of the revetment

Project B: Hybrid protection, Hawaii

Required set-backs from the high water, together with retaining walls and low dune planting, permit buffering from winter storms while encouraging continued beach nourishment. The project continues the use of private property with government enforcement of standards and regulations.

Plate 5.11 Vegetation protection — low retaining walls and set-backs for residential development

Case study #5: Multiple uses with forest buffers

Mitigation concept

Forest buffers are combined with other uses to: (a) provide protection against tsunamis and coastal storms; and (b) accommodate private property-based uses.

Project A: Forest buffer and wetland agriculture (rice paddies) —– Sanriku coast, Japan

This is a combination of tsunami forests with wetland and other land use that facilitate water detention to absorb storm water runoff and tsunami inundation. This scheme also deters people from moving into the hazard zone.

Plate 5.12 Combination of protective planting with agriculture to provide detention for storm water and coastal flooding water (Japan)

Projects B & C: Residential projects rearward and tsunami forest

Dense tsunami forests have been planted to protect homes from tsunamis and from the more frequent storm waves. In the case of Hawaii, the forests have been planted along the shoreline in the area mandated by state law as set-back buffers from the coast.


Plate 5.13 Left: Sanriku coast, Japan
Right: Kauai Island, Hawaii

In both cases, homes are located behind tsunami forests planted along the shore. Houses are located inland of the forest. In the Kauai example (Plate 5.13, right), houses are elevated above the projected tsunami elevation.

Case study # 6: Dune preservation and restoration programme

Mitigation concept

A first step towards improving the environment for forests is to stabilize soil conditions through dune enhancement. Such dune management programmes are multifaceted because they include restrictions on levelling and on access, as well as planting programmes and maintenance.

Evaluation considerations

Costs include the need for enforcement because such programmes will initially be unpopular in many sectors. Hotel developers often maintain that dunes block views or pathways to the beach; housing constructed by the informal sector is often located in dune areas — which must be prohibited and alternative locations must be found. In addition, access routes, including paths and standards, must be developed and clearly marked.

Benefits will include stabilized soils and reduced coastal erosion, including sediment deposition and siltation. These benefits, in turn, reduce degradation of corals and related environmental assets.

Plate 5.14 (left) Pedestrian trail with sign stating “Please keep off the dunes” — soil stabilization project (Oregon, USA)
Plate 5.15 (right) Structure pathway for a particularly sensitive dune (Oregon, USA)

4 Phase III: Institutional issues to encourage planting of forests and trees as part of coastal management

Objectives: Forest and tree planting, as well as management programmes, must become integrated with overall institutional processes associated with coastal management.

4.1 Part I: Institutional issues relating to forests and trees in comparison with other structures

4.1.1 Institutional overview of case studies

Using forests and trees for hazard mitigation is inherently a multidisciplinary and multisectoral field that requires commitment and cooperation among multiple agencies and donors. The first step towards integrating forests and other planting programmes into coastal management is to assess if current institutional practices positively or negatively influence vegetation management.

Case study # 1: Hilo Bayfront reconstruction plan after the 1960 tsunami

Implementing responsibility

There was no oversight body responsible for coordinating all components of the project on a long-term basis. Multiple components of the project were not developed by local planners. The planning process did not consider the feasibility of the recommendations.

- Breakwater: US Army Corps of Engineers — unpopular with locals
- Redevelopment project: County, with federal funds and oversight
- Park: County
- Tsunami forest: County

Case study # 2: Hilo–Keaukaha shoreline plan

Implementing responsibility

A single oversight body was responsible for all components of the project on a long-term basis. It was also responsible for coordinating with multiple departments and stakeholders including private parties (hotels, residents, shop owners and others).

- Acquire open space for planting: County
- Re-align roadway: County, with federal funds
- Building setbacks: County
- Tree planting within set-backs: County requirements implemented by private owners

Case study # 3: Riverine bank erosion

Implementing responsibility

Both projects have single purpose objectives — not part of a comprehensive plan.

- Project A (Sri Lanka Mangrove Forest): National-Department of Forestry
- Project B (Riverine Bank Erosion, Sri Lanka Retaining Wall): Multiple national entities, including the Road Development Authority

Case study # 4: Coastal bank erosion

Implementing responsibility

- Project A (Sri Lanka Embankment): Multiple national entities, including the Coast Conservation Department, ports and harbours and the Road Development Authority
- Project B (Honolulu Vegetation Buffer):
    - Set-back standards: Administered and enforced by local government
    - Planting by local government

Case study # 5: Multiple uses with forest buffers
Implementing responsibility for all projects (in Japan and the United States)

- Forest planting: Local and national government
- Residential development: Private owners in accordance with local laws

Case study # 6: Dune restoration and access, Oregon
Dune preservation and restoration goals part of the state land-use law; individual dune restoration projects administered locally.

Implementing responsibility

- Dune preservation goals: State of Oregon
- Dune preservation programme: Local community with funds from the state

4.1.2 Themes of successful implementation
The case studies indicate that inclusion of forests and trees as part of an integrated strategy most often occurred under the following conditions:

1. Multiple proponents: Part of an overall plan with commitment from multiple stakeholders. Successful efforts have reflected intersectoral "buy in" and have been multidisciplinary in their objectives. For example, the Keaukaha Shoreline Plan and forest/rice paddies in Japan demonstrate multiple proponents in preserving and enhancing vegetation.
2. Land availability: Land must be available for a forest project to be feasible. Where land acquisition is problematic or where immediate shore protection is necessary, hard solutions tend to be preferred. In communities where coastal set-backs are enforced, such lands have been used, for example in Hawaii and Japan.
3. Management programme: A coordinating body must exist to oversee multisectoral projects from their inception through implementation and long-term management. Environmental management must be grounded on coordinated policy implementation and institutional consistency.

4.2 Part II: Create a management programme for enforcement and oversight
Coastal areas are traditionally among the most intensively used portions of a community with many competing objectives and stakeholders for limited resources. Coastal management therefore requires a consistent framework for decision-making. Prerequisites to coordinated implementation of vegetation management programmes include the following actions.

4.2.1 Create and empower an oversight body to oversee the management programme
Implementation of objectives that promote planting of trees and forests highlights the need to integrate ecosystem management with other development or economic objectives. Such integration requires a mechanism to coordinate planning and decision-making. An oversight body is essential to orderly coastal management. This body would integrate and coordinate forest management with coastal management and disaster management. This body with also have the mandate and authority to coordinate policies between different jurisdictional authorities (including local/national/or different ministries with differing priorities, e.g. forestry and transportation).

4.2.2 Institute regulatory consistency
Enforcement of standards on both public and private property development — including prohibitions on building in designated areas, is essential to the long-term implementation of vegetation management programmes.

Predictable regulatory oversight is based on three factors:

1. A designated coastal management zone: Administrative zones are defined within which mitigation strategies are applied that are sufficiently large to encompass both the direct hazard and the area influenced by the potential hazard.

   Tier 1 (coastal zone): Define the land area directly impacted by each hazard such as coastal flooding, riverine flooding, landslides, cyclone or tsunami during the hazard analysis. Where applicable, subzones should also be defined, for example, the floodway and the floodplain — the floodway is an ideal location for planting.

   Tier 2 (coastal influence zone): Define the area that includes features that are vulnerable to damage and which potentially can reduce wave and wind impact, thereby reducing susceptibility to collateral damage. The area includes offshore and nearshore environments in which ecological influences such as trees and forests are or could be located.

2. Standards and rules for allowable and preferred uses in the coastal management zone: Articulated goals must guide future development to desired locations, and building construction must comply with standards. (Note: Many of the "successful" case study examples in this paper have used mandated set-back areas to plant forest buffers.)

3. Adopt and enforce regulations: Enforcement of laws such as set-back regulations and construction laws, as well as prohibition of practices such as coral or sand mining, will significantly contribute to reduced exposure to hazards. It is essential that commitment to regulations be enforced; for example, no construction of any kind (including by the informal sector) or building in designated areas.

4.2.3 Facilitate integrated planning processes through data sharing

A fundamental aspect of coordinated coastal management is the ability to correlate baseline data collected by many stakeholders, including national ministries, local agencies and NGOs. Review of planning processes in many countries throughout Asia indicates that data sets are not readily available to departments and agencies that have not collected them. This lack of data sharing is a serious impediment to integrative management.

4.2.4 Public education on the importance of coastal management

Sustained coastal management, including implementation of planting forests, requires local commitment. It is crucial that all sectors (public and private) accept that the implementation of planting programmes is long term. Before forests reach maturity, extensive land management may be required to prevent the use of young trees for fuelwood or other purposes.

5 Economic social and environmental costs and benefits

Objectives: Institutionalize coastal hazard management policies to maximize economic, social and environment benefits while reducing costs. This evaluation process will also develop a framework within which to explicitly demonstrate the long-term benefits of forests and trees as vehicles to achieve damage reduction.

5.1 Phase 1 for cost benefit: Review hazard, vulnerability and risk assessment findings

The benefit–cost analysis is an outgrowth of the multiphase approach outlined by this paper. Hazard and vulnerability analysis identifies key items of exposure in terms that, so far as possible, are spatially and quantifiably defined. For example, the Hikkaduwa base map in Figure 5.1 indicates environmental features such as wetlands and marshes and economic parameters such as transportation linkages, built up areas, agricultural areas and coral reef mining. The vulnerability analysis explicitly correlates interactions between social, environmental and economic variables.

5.2 Establishing a structure for cost–benefit-based decision-making

Typically, a cost–benefit analysis evaluates the viability of a project in relation to the costs of construction vs. revenue generated. An integrated cost–benefit analysis such as is being discussed in this paper will evaluate disparate alternatives. Costs and benefits will be evaluated for specific courses of action in relation to considerations summarized in Table 5.5.

Table 5.5 Cost–benefit criteria[†]

	Cost–benefit evaluation		
Goals	**Low**	**Medium**	**High**
Effectiveness	Does not solve problem effectively	Is moderately effective in solving problem	Is very effective in solving problem
Time to implement	Many years	Several years	Three or fewer years
Permanence	Temporary	Short life span	Relatively permanent
Cost[‡]	Very expensive	Moderately expensive	Inexpensive
Technical feasibility	Difficult to implement	Moderately able to implement	Easily implemented
Social/political feasibility	Unpopular/affects few	Able to implement with political cost	Popular/affects many
Environmental impact	Significant impact	Medium	Low/positive impact

[†]Clallam County 2004.

[‡]Based on an approved ratio of implementation and maintenance costs to quantifiable benefits that can include damage avoidance.

6. Applying insights from previous analyses to cost–benefit decision-making

6.1 Dune and vegetation preservation

6.1.1 The formal sector

Plates 5.4 and 5.5 illustrate the potential impacts of economic uses on dune vegetation which is a prerequisite for soil stabilization (important for tree growth). An important difference between the two plates is a significant difference in the social profile of the economic sector. In Plate 5.4, social and economic impacts fall primarily on the formal sector, while in Plate 5.5 social and economic impacts fall primarily on the informal sector. These differences will lead to significant differences in mitigation strategies and in the cost–benefit analysis that will be required to implement the strategy.

In Plate 5.4, the main building complies with coastal development set-back guidelines. Intrusion onto dunes can be mitigated by the property owner using the strategies illustrated in Plates 5.11, 5.13 and 5.14. These solutions would all rate high in compliance with the goals in Table 5.5.

6.1.2 The informal sector

In Plate 5.5 dune vegetation was destroyed for home and fishing-support construction by the informal sector within the immediate littoral zone, and as such was environmentally damaging. Strategies to mitigate conditions in Plate 5.5 are complex and the cost–benefit analysis must take into consideration non-quantifiable issues. Social and political issues reflect difficult choices because the land is not owned by the party experiencing the social impacts. Strategies to mitigate social impacts require alternative sites for housing as well as for the fishing industry — which will have significant cost implications. A new fishing harbour was constructed in the vicinity, for which long-term economic impacts are intended to eventually improve housing options. Environmental issues for this site were also weighed against economic requirements. Instead of preserving vegetation and creating a site for forests and trees, the coast was hardened to protect the road.

6.2 Bank stabilization (choosing between forests and retainage)

6.2.1 Mangrove forest

Plate 5.8 (mangrove forest used for bank stabilization) and Plate 5.9 (retaining wall to stabilize roadway) are both located in Sri Lanka on rivers that are prone to channel migration.

For the mangrove forest site in Plate 5.8, the effectiveness of mangrove planting was rated very high, while the time to implement was not a factor. The adjacent uses were agricultural; thus, some continued erosion and bank overflow were not considered to be critical issues during the implementation period. Cost was not an issue because land for planting was available. All of the other ratings were high.

6.2.2 Retaining wall to stabilize roadway

The top community priority was to maintain access. It was therefore necessary to choose an effective means to retard bank erosion caused by the migrating river channel. The retaining wall had a high rating with respect to effectiveness and time to implement, as the river will continue to migrate; thus, its permanence depends on continued maintenance. Hybrid solutions (not represented in the plates) could be considered to reduce erosive velocity, such as giving the river additional overflow area further upstream (see forest/rice paddies in Plate 5.12). The cost of such a solution would depend on land availability and current uses along the channel.

7 Conclusions

Coastal regions will always be focal points for societal use, *inter alia* commerce, tourism, recreation, housing and fishing. Integrated coastal zone management balances ecosystem preservation and restoration against the short- and long-term needs of society. Such balancing of disparate and seemingly conflicting requirements necessitates establishing priorities to which participating stakeholders can ascribe. Strong leadership that is sensitive to integrative management will be required to "champion" the long-term effectiveness of forests and trees over the more expedient effectiveness of short-term "fixes" such as hard solutions. Integrative multisectoral planning has the merit of institutionalizing societal needs with the needs of healthy ecosystems. Unfortunately, the needs of society are multifaceted, with differing values held by differing constituencies. The value of forests and other vegetation buffers has been clearly demonstrated by recent disasters.

Multisectoral integrative planning establishes a framework within which to structure such a systematic programme. Clear identification of risk factors is only the first step in establishing locations for forests and vegetation buffers to maximize protection. The next step is to develop the management plan with an institutionalized administrative structure that will achieve the following:

- The need for collaboration/coordination between various government ministries and local populations.
- Implementation of planting based on a thorough assessment of such variables as: (a) location characteristics; (b) species; and (c) other and related mitigation strategies addressing social environmental and economic impacts as identified during the cost–benefit analysis.

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Field study presentation: Mangrove planting for coastline protection — to plant or not to plant?

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The 2004 Indian Ocean tsunami was generated by a massive 9.3 Richter scale earthquake. The destruction wreaked by this tsunami was colossal in terms of loss of human life and coastal property. A number of anecdotal reports indicated that mangrove forest played a role in saving lives and property; destruction and degradation of mangroves were blamed for exacerbating the damage incurred. As a result, governments and NGOs are embarking on plans to plant mangrove belts along coastlines to provide protection from future tsunamis. This paper provides basic information on the natural distribution and regeneration of mangroves, examines the need for mangrove planting along coastlines in tsunami-affected areas based on field observations, repositions policy priorities for mangrove protection and rehabilitation, and offers options for coastal protection where mangrove planting is not possible.

Key points and observations emphasized in the discussions

An integrated approach is necessary in coastal area/disaster management planning to accommodate seemingly conflicting objectives such as ecosystem management, housing and economic development. This could lead to a reduction of exposure to disasters. Planning for coastal areas must often consider multiple hazards, as they tend to appear in the same places (with some exceptions).

An integrated sectoral approach comprises three stages:

1. Hazard vulnerability and risk assessment
    - Define area boundaries and map land use.
    - Identify hazard(s), frequency and severity.
    - Assess the vulnerability of different features within areas to different hazards taking geography, coastal on- and offshore topography and vegetation into account.
    - Risk assessment (hazard + vulnerability). Identification of hot spots, classification of probability and consequence of occurrence (high, medium, low).
2. Mitigation strategy planning
    - Identify mitigation tools — engineered (seawalls, dykes, revetments), ecosystem (coral reefs, sand bars, forests, wetlands) and hybrid approaches.
    - Selecting and evaluating integrative mitigation strategies — develop evaluation criteria and assess the effectiveness of different strategies.
3. Institutional issues to encourage planting of forests and trees as part of coastal management
    - Institutional issues supporting inclusion of forests and trees in disaster management — multiple proponents, land available, effective coordination and management.
    - Create a management programme — establish and empower an oversight body, institute regulatory consistency, facilitate integrated planning and data sharing, educate the public.

Coordinated, integrated and participatory planning is an effective way to enhance coastal area management and the role trees and forests play in coastal protection. The use of bioshields should be considered within the framework of disaster management strategies, which also include effective early warning systems and evacuation plans.

Malaysian case study: Controversy existed over the protective capacity of mangroves following the tsunami, but decisions had to be made about protecting and rehabilitating mangroves, in the

additional context of sea-level rise. Adequate protection of existing mangroves should be given priority.

Casualties from the tsunami occurred in estuaries and on open beaches, but rebuilding took place directly on the coast nonetheless.

Mangroves are not useful for protection near the epicentre of a tsunami/earthquake, or were degraded and mostly absent in tsunami-hit areas.

Mangroves may be rehabilitated and can self-repair if the hydrology is correct and natural seed recruitment is possible. Many efforts failed owing to a lack of technical information on how to establish mangroves. The correct species should be used in the right place; abandoned shrimp ponds should be rehabilitated, but this does not apply to mudflats or rocky coasts. Non-mangrove species may be used for beaches and sand dunes.

Additional points made in subsequent discussions: That there was less difficulty with reconstruction and rehabilitation after Hurricane Katrina in the state of Florida (where disaster management issues are taken very seriously) in comparison with the state of Lousiana (where there is no disaster management plan and no building codes), was reported as a recent example of the importance of coastal planning for the mitigation of natural hazards.

Apropos possible coastal planning approaches in localities where ownership is often unknown (for example, Aceh, Indonesia), and whether hard or soft structures should be used, it was stressed that each community is different and blanket recommendations are not possible; therefore, every site should be studied on a case-by-case basis.

It should also be taken into account that the planning process takes approximately five years due to the need for a consultative, participatory process, which is critical for beneficial outcomes.

Early warning systems, training and awareness-raising should be included in disaster management approaches and may be more appropriate than “tsunami shelters” (i.e. shelters similar to those used for protection against cyclones).

It was suggested that discount rates should be considered in determining the types of structure to be used in coastal protection.

In addressing rehabilitation and reconstruction needs after the 2004 Indian Ocean tsunami, several countries have called for the urgent restoration of mangroves. In some cases the high demand for mangrove seeds and propagules has led to overcollection, which has damaged the ability of natural mangroves to regenerate.