

SEYCHELLES

Seychelles (28 December 2004). This bridge linking the Seychelles international airport with the capital, Victoria was destroyed by the tsunami. The sea water surges flooded low lying areas of Mahé, Praslin and La Digue, and caused widespread damage to beaches, coastal vegetation, roads, bridges, houses and other infrastructure.
© George Thande/Reuters





6. NATIONAL RAPID ENVIRONMENTAL ASSESSMENT - SEYCHELLES

6.1 Introduction

The tsunami that hit the Seychelles on 26 December had travelled about 5,000 kilometres from the earthquake zone from offshore Sumatra in less than seven hours. By midday an extreme low tide occurred throughout the granitic islands. At 1 p.m. waves ranging from 2.5 to 4 metres in height hit the east coast of Praslin and Mahé islands. The effects were felt all along the east coast of Mahé over a 30-minute period. Refracted waves hit the west coast of Praslin and Mahé between 30 minutes and one hour after the respective east coasts were hit. Another wave occurred at 5 p.m., followed by two smaller waves at 10 p.m. and at 5 a.m. on 27 December. The second wave had more or less the same effect as the first because, although smaller, it occurred at high tide. The two smaller waves caused damage only on the west coast of Praslin.

The sea water surges caused by the waves flooded the low lying areas of Mahé, Praslin and La Digue and caused widespread damage to beaches, coastal vegetation, roads, bridges, other infrastructure and houses. The flooding lasted for about six hours. Two people lost their lives.

The tsunami was followed on 27 December by extreme weather, with rainfall reaching 250 millimetres in the northern and central areas of Mahé. Torrential rains continued for several days. Runoff from the hills formed virtual rivers that swept across the country, causing widespread landslides and tree and rock falls in the northern and central part of Mahé and in other areas, with associated further damage to infrastructure, dwellings and vegetation on slopes.

Rapid assessments of impacts from the tsunami were conducted by the Government of the Seychelles (GOS). Efforts were hampered due to the heavy rainfall immediately following the tsunami, and by the limited number of staff in agencies with responsibilities in multiple areas.

Despite these challenges, initial assessments of economic damage were made rapidly incorporating damage to roads, fishing infrastructure, agriculture, public utilities, schools, reclamation land, houses, sports facilities and tourism establishments. Total estimates of damage amounted to SR 165 million (\$30 million).



Mahé Island, Seychelles (27 December 2004). President James Michel of the Seychelles inspects damage to infrastructure in the Seychelles. Initial assessments of damage to roads, fishing infrastructure, agriculture, public utilities, schools, land, houses, sports facilities and tourism establishments indicated damage amounting to \$30 million. © George Thande/Reuters

6.2 Overview of the Environmental Response

A few days after the tsunami hit the shores of the Seychelles, a preliminary estimate of damage to the environment was provided by the Department of Environment of the Ministry of Environment and Natural Resources. This preliminary assessment of environmental impacts covering damage to shorelines, vegetation, 'environmental infrastructure' such as pavement walkways and municipal parks, amounted to a total restoration estimate of SR 7.25 million (\$1.3 million). However, this figure is now considered too low.

On 21 January 2005, following a meeting at the Mauritius meeting of Small Island Developing States, UNEP Executive Director Klaus Toepfer received a request from President Michel of the Republic of Seychelles for technical and financial assistance in conducting a rapid assessment of the environmental impacts of the tsunami. This assessment was to focus on understanding the long-term consequences of the tsunami on marine and coastal ecosystems, and to assess the stability of the coastline. In addition, the work was to address rehabilitation needs of services for the Marine Parks Authority and study current levels of disaster preparedness and early warning capacities.

Requests for support were also received from the Seychelles Ministry of Foreign Affairs as well as from the National Disaster Secretariat.

As the first stage in responding to this request, UNEP organized a fact-finding mission to the Seychelles during the period 3–10 February 2005. The mission involved UNEP experts on environmental assessment and disaster management, as well as IUCN experts on coral reefs, and experts on coastal zone management. Based on the findings of the fact-finding mission, a more detailed technical assessment is planned for March 2005 to collect additional information as well as detailed impact and risk analyses.

Key stakeholders in the Seychelles natural resources sector are spread across governmental, non-governmental and private sectors. In addition to the great interest shown by the President's Office, the Ministry of Environment and Natural Resources shoulders key responsibilities. These include forestry, crop development, national parks, conservation of biodiversity, pollution control and waste management, environmental impact assessment (EIA), coastal management and hydrology, meteorology, and botanical gardens.

Fisheries are managed by a parastatal corporation, the Seychelles Fishing Authority. Of great importance for assessing the impacts of the tsunami is the Seychelles Centre for Marine Research and Technology-Marine Parks Authority (SCMRT-MPA), a parastatal responsible for many aspects of research and conservation in the coastal zone.

The Public Utilities Corporation is responsible for assessing impacts to freshwater and sewage systems, while the Seychelles Fishing Authority is addressing impacts to the Fisheries sector. Agriculture and soil impacts, are covered by Crop Development and Promotion and Landscape Management.

The non-governmental sector includes several organisations such as the Marine Conservation Society of the Seychelles, Nature Seychelles, and the Seychelles Island Foundation.

To complete a rapid assessment, the team split into two groups for the purpose of field visits, two members concentrating on underwater work, while the remaining four were land-based. Coral reefs and marine habitats were assessed through existing documents and reef status assessments housed at SCMRT-MPA, together with a preliminary reef survey conducted by SCMRT staff assisted by IUCN in January-February 2005.

In geographical coverage, the main gap in the team's work was the focus on the inner granitic islands of Mahé, Praslin and Curieuse, to the exclusion of the coralline islands. Despite an overall impression that the tsunami has had only short-term impacts on the outer islands, there is clearly a greater hazard to such places from climate change, increased cyclones and sea-level rise. Many such islands, for example Aldabra, are of global significance in terms of biodiversity.

6.3 Preliminary Findings: Impacts on the Natural Environment

The Republic of the Seychelles comprises a group of 115 islands located in the western Indian Ocean between 4 and 11 degrees south of the Equator. The land area covers 455 square kilometres. A total of 41 islands are granitic, with rugged topography rising to a maximum altitude of 905 metres, including the so-called inner islands, of which Mahé (155 square kilometres), Praslin (38 square kilometres) and La Digue (10 square kilometres) are the most socio-economically advanced. All the granitic islands are situated within a distance of 50 kilometres from Mahé. The rest of the islands are coralline, rising only a few metres above sea level, and scattered throughout the western Indian Ocean. More than 95 per cent of the population of the 85,000 inhabitants is concentrated on the inner islands of Mahé (86 per cent), Praslin (8 per cent) and La Digue (2 per cent). The population density on the three islands is 468 inhabitants per square kilometre.

The Seychelles islands form part of the Indian Ocean Biodiversity Hot Spot and Centre of Plant Diversity. The biodiversity of the islands is therefore highly significant particularly in terms of plants, invertebrates, amphibians, reptiles and freshwater fish. Seychelles forests and biodiversity are under great pressure from various development sectors. The pressure is highest on the coastal plain which represents over 80 per cent of flat land or land of high value for development. This pressure is greatest on the coastal ecosystems such as lowland woodland, dunes, beaches and lowland wetlands including mangroves. The coastal plains of the three main populated islands of Mahé, Praslin and La Digue are predominantly covered by coconut plantations, trees of agro-forestry value and native coastal vegetation.

Coral Reefs, Sea Grass Beds and Sandbars

The Seychelles has a coral reef area of 1,690 square kilometres with 310 coral species and eight sea grass species. The islands form a critical stepping-stone in the biogeographic distribution of shallow marine species across the Indian Ocean.

Preliminary assessments in five islands suggest that little direct damage was caused by the tsunami on coral reef habitats and that the majority of assessed reefs experienced less than 5 per cent damage. However, damage was low partly because of the extensive reef degradation from the 1998 El Niño, estimated at 80-90 per cent, and only partial recovery since then. Many of the previously degraded reefs were particularly vulnerable to physical damage by the tsunami waves due to the weakened reef infrastructure and bio-erosion, but the general degree of prior degradation made assessment of the cause of damage unclear. Damage to the substrate was noted by the presence of scars where rocks and corals were torn off, and in back reef areas by exposed rubble that was previously covered by sand. Damage to corals was noted by broken branches of staghorn *Acropora* and branching *Pocillopora* colonies, and by damaged soft corals. In only a few cases, however, the extent of damage was between 5 per cent and 10 per cent, with a maximum of 27 per cent at one site in the marine park at St. Anne. High damage at this site was likely due to the rubble framework degraded by the El Niño coral mortality.

Damage to sea grass beds was similarly low, with only one definite case of damage recorded at Baie Ternaie Marine Park, Mahé Island. In this case, a sea grass bed adjacent to a drainage channel in the reef was smothered by sediment, probably mobilized from the extensive shallows and reef flat area, and backwash from land. Deposition occurred as sediment was being transported offshore by strong currents.

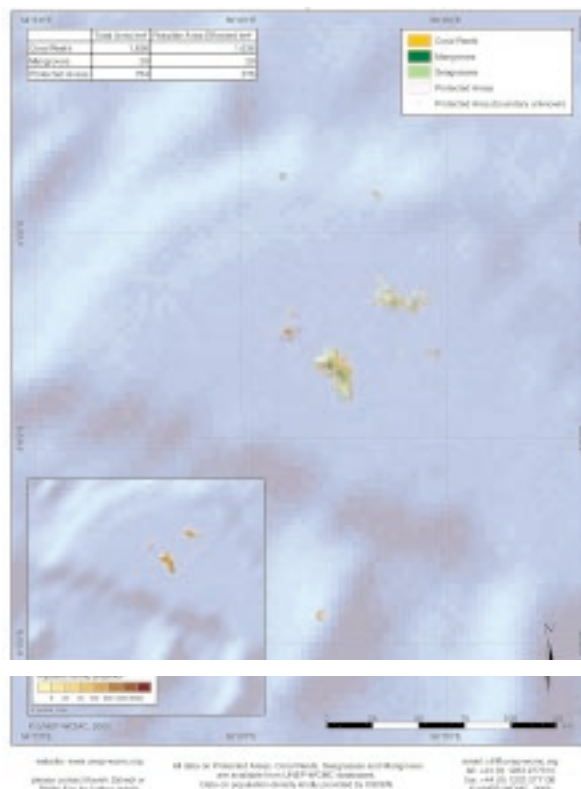
Beaches and Shorelines

There are two primary classes of natural coastline in the Seychelles: steep granitic shorelines, which are highly resilient to waves, and flatter coastal plains fringed by coral reefs, which are more vulnerable. A third class of shoreline, those protected by coastal reclamation, is artificial and increasingly important around Victoria. These basic shoreline differences had a profound effect on the impacts of the tsunami on the shoreline and terrestrial habitats: there were virtually no impacts on granitic coastlines (where the slopes exposed to ocean waves have prevented development on the shoreline itself), while coralline and highly altered shorelines around Victoria experienced significant damage.

Coastal erosion is considered a major problem and threat to human infrastructure along the coast. Chronic coastal erosion from wave impacts of tropical depressions/cyclones, has been identified at 25 major erosion hotspots. In some cases, such as Mahé and Praslin, erosion-sensitive sites are retreating an average of between one and three metres per year. Coastal sand and coral mining in the Seychelles over the past two decades has exacerbated the problem. However, these practices are now much reduced due to the enforcement of the Removal of Sand and Gravel Act (1991) and the Environment Protection Act (1994).

The effects of the tsunami on coastal erosion are clearly visible at both the exposed eastern side of the islands, but also at the western side like the Anse Kerlan beach section in the north-west of Praslin. The refracting tsunami waves caused erosion of beach cliffs of more than 2.5 metres in places. The rehabilitation costs of this single, eroding beach range between \$0.5 million to \$1.4 million depending on the type of protection option. It is believed that all erosion hotspots were impacted by the tsunami.

Priority Ecosystems and Protected Areas in the Seychelles



Mangroves and Coastal Vegetation

At present mangroves are limited to small patches within the coastal zone, covering a total of approximately 29 square kilometres. Nine mangrove species are recorded for the Seychelles. The marine national park of Port Launay on Mahé Island and the Curieuse Marine National Park, are the best protected areas. Behind the new land reclamation in front of Victoria, Mahé a new mangrove forest has developed. Beach crest and coastal vegetation is found bordering practically all-soft shores of the Seychelles. Much of it has been planted artificially and is a mix of local and non-local species.

The tsunami caused widespread impacts to mangroves and coastal vegetation. Direct impacts to the mangroves are caused by inputs of sand and silt that cover the pneumatophores (breathing roots). Furthermore, in some places the water circulation through mangroves will have changed due to direct effects such as newly created flow channels and indirect effects of blocked or altered circulation elsewhere. Significant short-term effects were not observed. Longer term monitoring of mangrove health could provide a clearer picture. Of major concern is the altered hydrodynamic environment in the Curieuse Marine Park. In this location, intensified circulation and wave exposure, caused by damage to the causeway, may threaten the future of the mangroves there. Short-term intervention may be required, but a prior cost-benefit analysis is recommended.

Other coastal vegetation has been visibly impacted at many locations. The severity of the impact is increased in situations where the bordering beach and foreshore are narrow, either naturally or by previous erosion. The impacts consist mostly of uprooted plants at the beach crest or exposed root systems. As most beach crest and coastal vegetation is salt tolerant long-term impacts are not expected. The role of beach crest and coastal vegetation was very important in reducing the impact of the tsunami wave, due to sediment stabilization, sand trapping and wave attenuation. The maintenance and extension of areas of mangroves and coastal vegetation is of importance to reduce the vulnerability of the coastal zone for erosion and impacts of calamitous events.

Turtle Nesting Sites

The Seychelles is a critical habitat for sea turtles, listed as endangered on the IUCN Red List. Significant populations of the green (*Chelonia mydas*) and hawksbill (*Eretmochyles imbricata*) turtles commonly use beaches for nesting. Sea turtle nesting sites are located on many of the beaches around the inner Seychelles islands. As such, they are vulnerable to erosion of the upper beach noted above. The peak nesting season for hawksbill turtles is December to February. Fortunately the highly eroded beaches (e.g. Kerlan, Anse Royal), were not highly important as nesting sites, and direct exposure of turtle eggs was only reported for two nests from Curieuse Marine Park. Turtle monitoring programmes from other islands, including Aldabra, Farquhar, D'Arros, St. Joseph, Bird and Aride islands indicated no known damage.

At Anse Cimetiere, Curieuse, high beach erosion is normal at this time of year. In Curieuse Marine Park, at least two hawksbill turtle nests were flooded and eggs exposed. Although a number of these eggs were recovered and reburied by rangers, such incidents may have occurred on other beaches where park staff were not present. Long-term impacts on nesting activity need to be monitored. Reports from Cousin Island show that turtles stayed off the beaches from 26-27 December 2004.

Case study: Coastal erosion on Praslin Island

Few people realise that the tsunami can turn corners. Praslin, the second largest island on Seychelles, was badly affected on the west as well as the east coast. The first sign along 2km Anse Kerlan (Kerlan Bay) was a massive tidal retreat as the tsunami pulled water away from the island. When the returning waves struck they flooded over the dunes, toppling trees, damaging houses and destroying garden crops. As they retreated, the waves dragged up to 200,000 cubic metres of sand out to sea, leaving a steep erosion cliff up to 2.5m high in places.

Anse Kerlan, is not only a popular beach for tourists and local people, but also for nesting Hawksbill and Green Turtles. The erosion of the beach threatens protective vegetation, soils, housing and turtle nests. Action is essential to prevent further loss of sand in the north-west monsoon season.

Hydrodynamic studies are needed in order to recommend either building of groynes (which could affect the turtles) or replenishment of lost sand. More immediately, the authorities must restore the coastal vegetation and instigate a regular monitoring programme. Training and capacity-building are essential.



Anse Kerlan, Seychelles (5 February 2005). Eroded turtle nesting beach.
© Mark Collins/UNEP

Estuaries and Wetlands

Estuaries and wetlands found in the Seychelles are limited in area, due to the steep geography and therefore limited extent of the coastal plains. Wetlands have been gradually utilised by agriculture or reclaimed for infrastructure. Non-mangrove wetlands in the coastal plains have been directly hit by the tsunami causing salinization of surface water and groundwater. Heavy rains that followed the tsunami have probably flushed a considerable amount of salt out of these systems. Immediate impacts to vegetation can be seen in yellowing or shedding of leaves of herbs, shrubs and trees. Long-term impacts are not expected due to naturally intensive flushing of these systems with fresh water. Wetlands are rare in the Seychelles and perform important functions in water storage and safeguarding of biodiversity.

Surface and Groundwater

All the islands in the Seychelles rely on surface water. Groundwater is only used to augment water supply during the dry seasons in La Digue Island. The impact of the tsunami on groundwater has not been assessed. However, the Crop Development and Promotions Division reported an increase in groundwater levels of mostly saline water in the coastal areas, just after the tsunami and before the torrential rains.

Soils and Agriculture

The salt water that flooded the shore undoubtedly washed away nutrients and increased the salt content of the soil. The torrential rainfall would have leached salt from the soil, though parts of Victoria still had a high salt content of 1.2 per cent. This is double the amount most plants in the Seychelles can tolerate. Sodium also destroys soil structure, thereby reducing infiltration rate. This might have contributed to the flooding in coastal areas caused by the torrential rains that fell a day after the tsunami.

Many ornamental plants and food crops were affected either by force of the seawater surge or by exposure to saline water. Ornamental palms in Victoria including those previously believed to be salt tolerant died and had to be replaced. Leguminous trees and herbaceous trees also died immediately. Of the palms only *Pitchodia pacifica* was not affected.

Though the tsunami caused some damage to agriculture, the effect of the torrential rains which followed was more devastating. Damage caused by the tsunami on eight farms has been estimated at SR 375,852 (\$70,000) and that from the torrential rains was on 36 farms and estimated at SR 1,345,773 (\$250,000).

Marine and Terrestrial Protected Areas

At present marine parks occupy about 10 per cent of the area of the continental shelf, generally occupying the nearshore of the islands. The principal impacted marine areas were found within the marine protected areas of the Seychelles. Sites in the Baie Ternaie Marine Park, and Anse Cemitiere in the St. Anne Marine Park (Mahé) and Curieuse Marine Park suffered the highest damage from the wave impacts and subsequent silt deposition on the reefs and sea grass beds. Inshore and terrestrial protected areas such as the proposed Ramsar site at Port Laumay were not significantly affected.

6.4 Preliminary Findings: Impacts on the Human Environment

Over 90 per cent of the Seychelles population lives on the granitic islands of Mahé and Praslin. There are two distinct zones on these islands: the hillsides and the coastal plain. Most development, such as industries, hotels, schools and houses, is on the coastal plains. The government policy of discouraging development on the hillside because of erosion and resulting landslides, will increase the infrastructure in the coastal zone which is also very vulnerable to tsunamis and other tidal waves.

Industrial Sites, Power Plants and Ports

The damage sustained by the ports infrastructure was mostly at Victoria Port. Two sea walls collapsed, five quays had wide cracks along their structure and the internal fittings of some fish processing factories were damaged as a result of the massive waves. Besides the rubble, there were no reports of any contaminants released into the environment even from flooding of factory premises. Any waste generated was disposed of within the normal waste disposal stream. For example, the 24 tons of contaminated fish at Oceana Fisheries was used to prepare stock feed, in line with the waste management practice of the country.

Sewage, Debris and Solid Waste

The discharge of raw sewage into some marshes and the lagoon for 10 days was the biggest water pollution incident. The violent and sudden reversal of the waves and backwash caused the failure of the Roche Caiman Bridge. This bridge provides support to a 500 millimetre-diameter sewer conveying sewage from Victoria to the treatment works at Provident. As a result, the sewer line broke and spilt raw sewage into the lagoon. Another 150 millimetre-sewer rising main from Roche Camain Stage II was also affected.



Mahé, Seychelles (26 December 2004). People assess the damage after the tsunami hit the Seychelles capital Mahé. Seawater surges flooded the low lying areas of Mahé, Praslin and La Digue and caused widespread damage to beaches, coastal vegetation, roads, bridges, houses and other infrastructure. The tsunami was followed on 27 December by extreme weather, with rainfall reaching 250 millimetres in the northern and central areas of Mahé. Torrential rains continued for several days, causing further damage to infrastructure, dwellings and vegetation. © Terence Fortune/Reuters

Because sewage could no longer be pumped to the treatment works, raw sewage also overflowed at the pump stations. The effect of the discharge was not assessed as the high dilution factor in the lagoons is believed to have lessened the adverse impact on the environment. Because the sewer requires the support from the bridge, it could only be repaired after the bridge had been rebuilt. This took 10 days during which residents were informed of the threat and advised to take basic hygiene precautions.

The solid wastes generated as a result of the tsunami were mostly debris from broken structures. Most of the damage came from Mahé and Praslin islands and to a lesser extent La Digue. In residential areas along the coast, the tsunami caused extensive structural damage to five schools, about 100 houses, sports facilities, rock armouring, sea walls and five bridges. This generated 296 tons of debris which cost SR 82,500 (\$15,500) to dispose of.

Apart from the damage to two bin sites and ten bins there were no reports of pollution from litter. Assessments carried out after the tsunami in coral reefs, did not show any litter in the water. However, there are reports of increased litter observed in Aldabra after the tsunami.

Water Supply

The incoming waves swept debris, dead trees and sand into drains. This blocked the system which drains water from inland. Seychelles has a chronic erosion problem which causes landslides in the hillsides. As the tsunami was closely followed by torrential rainfall, the blocked drains and the high silt load from the hillside, resulted in big floods on the coastal plains. A total of 8,947 metres of drains costing SR 800,000 (\$150,000) needed desilting.

The collapse of another bridge, at Anse La Mouche and that of the Roche Caiman broke water supply pipes which convey water from the Desalination Works to Hermitage reservoir and to the East Coast Reclamation area. The outer islands (Cerf, Round, Long, Moyenne and St Anne) are all provided with water from the east coast of Mahé through a submarine pipe. The tsunami caused the submarine pipe to move laterally causing abrasion, rupturing the pipe. The Public Utility Corporation provided temporary connection for the water supply.

Impact on Fisheries

In the weeks following the tsunami, fish supply in the markets was low. However, this was due to damage to the fishing fleet, and no reports of reduced fishery productivity have been received.

6.5 Preliminary Results: Environmental Management Capacity

Environmental Monitoring

The Seychelles covers a large oceanic area of some 1.3 million square kilometres, with a central core of granitic islands and dispersed outer islands. The increasing severity and variety of extreme events (cyclones, heavy rains, El Niño events and now the tsunami) puts these small island systems at increasing risk and necessitates the expansion and strengthening of environmental monitoring capacity at the national level. With climate change, three specific risks are increasing in the Seychelles. First, the cyclone belt is widening and is approaching the equator and the Seychelles (5 – 10° S). Second, sea level rise is accelerating and finally, increased sea surface temperatures have already caused a first round of catastrophic coral bleaching in the country. None of these risk factors are sufficiently recorded by the present monitoring capacity in the Seychelles, which was degraded by the tsunami. Improved monitoring capacity in the Seychelles will play not only a national, but an international role, as the country straddles a broad swathe of the central Indian Ocean.

Case study: Environmental Risk to the People of Victoria, Seychelles



Victoria, on the east coast of Mahé, the largest island in the Seychelles, took the full force of the tsunami. In addition to major impacts on bridges, roads, port facilities and boats in the harbour, the seawater was driven hundred of meters up into the city drainage system, blocking pipes with silt and flooding roads, shops and houses. Blocked pipes, drains and culverts slowed the return of the water to the sea, causing severe losses to business and expensive destruction of public amenities, landscaping, parks and gardens.

The risk of pollution with sewage consequent spread of disease across the city centre met with an immediate response from the city authorities, but there is now a need for planning and reconstruction to meet the challenge of the increasing number of ecological disasters.

In addition to immediate repairs, maintenance and improvements to sewerage systems, the government is developing a master drainage scheme, creating a national database on hydrology, and evaluating the importance of marshlands and rainwater harvesting in water and drainage management. In total, repairs and improvements to drainage in Mahé will cost more than US\$2 million.

Building and restoring monitoring capacity should incorporate multiple levels, including physical (sea level and tides, air and sea temperature, winds, etc), biological (coral reefs, plankton, pelagic and fishery resources, coastal vegetation, mangroves and terrestrial flora and fauna) and socio-economic (vulnerability indices, water supply, resource use, etc) levels. Additionally, strategic alliances combining government and non-government (private sector) monitoring initiatives need to be strengthened, especially with the challenge of maintaining information flow from the dispersed outer islands and extensive oceanic areas. Developing sustainable capacity for monitoring that is largely self-sufficient is critical to the long-term integrity of the system. Of critical importance is the role of the Marine Parks Authority in monitoring the health of marine ecosystems as indicators of the general status of the islands and to maintain their health as important protective barriers and economic resources.

The tsunami damaged the tidal gauge station of the Meteorological Service, located near the International Airport. Also damaged was key infrastructure of the MPA such as moorings. Some monitoring equipment was lost. Monitoring capacity was also damaged in other areas immediately following the tsunami; the heavy rains damaged the four main meteorological stations in Mahé and the station in Praslin and the 35 rainfall stations. They were, however, repaired within a month, underlining the importance of building self-sufficiency in monitoring and disaster response capability in the country.

Environmental Framework Laws

Long-term government plans for an integrated coastal zone management strategy (ICZM) will include a comprehensive legal framework, but this is not yet in place. Coastal zones are currently covered by various regulations, including the Beach Control Act, covering the use of resources and different activities between high and low water mark, and the Town & Country Planning Act. The commonly used 25 metre set-back regulation has no legislative backing. It is too rigid and should apply as a minimum applicable to coastal areas of low sensitivity. More sensitive areas should adopt larger set back widths in light of recent experience. Moreover the set back regulation should be upgraded to a law, in order to protect the coastal zone more effectively.

Bearing in mind the impact of actions inland on coastal ecosystems, forest management laws, now 60 or more years old, may need reform to embrace the environmental impacts of forestry and deforestation on the coastal zone.

In urban areas, the 1994 Environmental Protection Act, covering waste management, pollution and sewage, appears to have served Seychelles well during the recent tsunami. EIA is required for all developments, at various levels of detail.

At the international level, the Seychelles is party to the Conventions on Biological Diversity, World Heritage, Migratory Species, International Trade in Endangered Species and the Ramsar Convention on Wetlands of International Importance. A Biodiversity Act, currently under development, is foreseen as providing the enabling legislation for these conventions and additional technical support might be desirable.

Coastal Zone Management

Solving complex, interrelated problems in the coastal zone requires an holistic vision on coastal processes, both natural as well as socio-economic. The vertical and horizontal integration of effort is facilitated by institutional strengthening of the national, district and local authorities, applied scientists and stakeholders. To date there is no high level, coordinating National Committee for ICZM. Its establishment should be considered in order to improve coordination and integrated decision-making. This National Committee could also play an important coordinating role in tying together the challenges and solutions of the interrelated zones: the mountains, rivers, coasts and reefs. Such coordination could also strengthen

the linkage between the implementation of international conventions such as Convention on Biological Diversity and the UN Framework Convention on Climate Change.

A legal framework for ICZM including a national ICZM plan is not available. At present coastal legislation and activities by the various stakeholders is fragmented and has perverse effects on the sustainable development of coastal resources.

The CZM-Unit within MOE is at present coordinating a limited number of activities, solely related to coastal erosion and adaptive measures. The tasks of the CZM-Unit should be enlarged to a wider scope in order to prepare for functioning as a technical secretariat for a future National Committee for ICZM. The CZM-Unit should be enlarged through increases of human resources and of technical capabilities.

Early Warning and Awareness Raising

The Meteorological Service is responsible for early warning. However, their monitoring capacity is extremely limited. Fundamental needs include equipment for monitoring water levels, waves and sea surface temperature, training of personnel and linkages to international meteorological organisations for coordination. At the same time, an increase in the public awareness of hazards is needed, specifically geared to schoolchildren.

Disaster Management

For about twenty years after independence, the Seychelles islands were fortunate in escaping major environmental and natural hazards. That situation changed when the 1997 El Nino floods struck the Seychelles, raising public and government awareness about the necessity of strategic disaster management. The President's Office revitalised the National Disaster Management Committee, which was asked to prepare a National Disaster Response Plan (NDRP). The Ministry of Environment and Natural Resources was given the lead. In September 2002, a strong tropical storm caused major damage to the environment and tourism, prompting the Ministry to request additional capacity from UNEP and the UN Office for Coordination of Humanitarian Affairs (OCHA). The results of the joint UNEP/OCHA Seychelles assessment (March 2003) highlighted the need to finalise and implement the NDRP drafted a few years before. In 2004, a second UNEP mission to Seychelles was asked by the Office of the President to focus on preparation of a National Strategy for Risk and Disaster Management. A draft document was prepared in 2004 and is in final stages of completion and printing.

Turning to the question of capacity for disaster management, in October 2004 Seychelles created a National Disaster Secretariat under the management of Michel Vieille, Director for Risk and Disaster Management. The Secretariat acts as the operational arm of the National Disaster Committee, but as yet has no additional staff, nor basic equipment for operations. There is a serious need for capacity-building estimated to cost \$250,000 over five years.

Utilizing Local Knowledge

The limited field assessments carried out revealed little evidence of local techniques for coastal zone management, but this aspect is worthy of closer investigation. In certain areas, such as Anse Royale, coconut-leaf walls are constructed to protect the coast. In other areas of the western Indian Ocean coconut fibre, mangrove stakes, stone walls and sandbags have also been used locally and to good effect.

In the outer islands of the Seychelles, local people and organisations should be more involved in the monitoring and early warning programmes using improved means of communication. Estimated costs for mobilising local knowledge are \$25,000 annually.

6.6 Recommendations

The following conclusions were based on site visits and discussions with Seychelles organizations.

The tsunami damage in the Seychelles is extensive on a national level. The response of authorities has been speedy and thorough, thereby limiting knock-on impact. It is especially relevant to mention the inherent limitations of the small scale of island resources. Government disaster management programmes have shown resilience during the tsunami but were stretched to the limit of local operational capabilities. Good waste management has limited the load of waste and pollution to the sea.

Team members have observed that management of the coastal vegetation has been effective in reducing the impacts of the tsunami. Maintaining the health and extent of coastal vegetation is therefore important for mitigation of future hazards.

The tsunami impact is recognized as only one part of a sequence of human and natural induced hazards, and in particular coral reef damage was minimal in relation to the large, catastrophic impacts of coral bleaching in 1997/8. Reports of other natural hazards occurring in the Seychelles indicate significant additional threats to humans and to the island ecosystems.

Activities for the Short Term

In the short term (starting 2005) the following actions are proposed in support of early warning, assessment and monitoring, together with urgent repairs to protect coastlines:

- Undertake a detailed environmental assessment of the impacts in order to establish the current environmental baseline, as well as to provide inputs to land use planning and reconstruction.
- Assess and repair as appropriate the damage to Curieuse Island causeway. If this is to be done it will be essential to do it before the next South-East monsoon in April 2005, when wave damage to the mangrove communities will intensify.
- Restoration of marine parks infrastructure (mooring buoys, patrolling and monitoring equipment) to maintain the ecological and tourist infrastructure.
- Mitigate beach erosion and repair damage to protective infrastructure in the coastal zone as much as possible using soft solutions such as beach nourishment.
- Intensify monitoring beach profiles in selected erosion prone locations.
- Strengthen nearshore marine habitat mapping to establish impacted areas and rates of recovery. Integrate onshore damage and marine habitat information to assess the spatial relationship between shoreline damage and location of protective ecosystems.
- Reiterate and strictly apply existing rules on setback lines for coastal zone development, in order not to further degrade the resilience of the coast.
- Identify areas vulnerable to soil erosion. Undertake efforts to stabilize hillsides and to maintain forest cover in order to reduce loss of topsoil and impact of silt on coastal ecosystems.
- Develop and start implementing Integrated Coastal Zone Management Plans for each island taking into account dynamic coastal processes, coastal ecosystems and location of uses in the coastal zone, linking of marine and terrestrial ecosystems (including steep hill areas), through integrating ICZM and MPA management plans.
- Development of a national policy for early warning and disaster management that incorporates cross-cutting roles of government agencies, collaboration with the private sector and reductions in vulnerability of the national economy and coastal communities to ocean risks.

Activities for the Medium to Long Term

- Implement capacity building programmes in order to reach self sufficiency in coping with hazards and managing the natural ecosystems of the islands.

- Strengthening exchange of knowledge and management experience between SIDS and states bordering the Indian Ocean.
- Develop improved drainage schemes. Implement management of wetlands to cope with water storage and reduction of flooding in combination with forest and hillside land-use management in order to reduce loss of topsoil. Analysis of water drainage, slopes, forest management and the role of infrastructure on hillside erosion and flooding of the coastal plains.
- Development and implementation of long term monitoring programmes (physical processes, ecosystem state, land-use state).
- Address stability issues of the coastline.
- Development of a national policy for Marine Protected Areas and ICZM that recognizes the protective function of coral reefs and maximizes protection and conservation in the long term.

References

1. BEAVER, K., 1995. *Common Wild Plants of the Seychelles Coastal Lowlands*.
2. DEPARTMENT OF THE ENVIRONMENT, 2005. *Preliminary assessment and evaluation of damages cause by the sea level rise of the Sumatra Earthquakes on the Environment Sector*.
3. GOVERNMENT OF SEYCHELLES, 2005. *Preliminary Report on the Effects of the Tsunami of the 26 December 2004 on the Inner Granitic Islands of Seychelles*.
4. GOVERNMENT OF SEYCHELLES, 2004. *Seychelles Assessment of the Barbados Programme of Action +10*.
5. GOVERNMENT OF SEYCHELLES, *Report on Water and Sewerage Infrastructure Resulting from the Tidal Wave, on 26 December 2004*.
6. GOVERNMENT OF SEYCHELLES, Environmental Management Plan of Seychelles 2000 – 2010.
7. GOVERNMENT OF SEYCHELLES, 2005. Project for Ecosystem Rehabilitation After Tsunami and Torrential Rainfall.
8. GOVERNMENT OF SEYCHELLES, MINISTRY OF ENVIRONMENT & TRANSPORT/ SEYCHELLES FISHING AUTHORITY PROGRAMME Pre COIUE Programme de la Commission Oceanographique Intergouvernementale IOC, *Etude Pilote de La Cartographie, des Zones Peu Profondes De Mahe* (Seychelles) Atlas.
9. INTER-GOVERNMENTAL PANEL ON CLIMATE CHANGE, 1991. *Seven Steps to the Vulnerability of Coastal Areas to Sea Level Rise: Guidelines for Case Studies*.
10. MCNUS J. ZWOL C., GARCES L. AND SADACHARAN D., 1998. *A framework for Future Training in Marine and Coastal Protected Area Management*. ICLARM Conf Proc57, 54p.
11. SEACAM, 2001. *The Voyage from Seychelles to Maputo*, Vol. II Success and Failures of Integrated Coastal Zone Management in Eastern Africa and Island States, 1996 – 2001.
12. SEYCHELLES FISHING AUTHORITY, 2003. *Technical Report*, Seychelles Artisanal Fisheries statistics for 2003.
13. ROBINSON J. MARLENE I., MICHEL M, OHMAN M, AND PAYET R., 2004. *Spatial and Temporal Distribution of Reef Fish Spawning Aggregations in the Seychelles – An Interview based Survey of Artisanal Fishers*, Western Indian Ocean J. Mar Sci Vol 3 No. 1. Pp 6369.
14. UNEP GPA, *Key Principles to Guide the Reconstruction of Coastlines Affected by the Tsunami*.
15. UNEP GPA, 2004. *Shoreline Change in the Western Indian Ocean Region: An Overview*.
16. UNEP/OCHA, 2004. *Assessment Report, Tropical Depression Storm Over Praslin and Satellite Islands in Seychelles*.
17. UNITED NATIONS FOOD AND AGRICULTURAL ORGANIZATION, 2005. *Rehabilitation of agricultural production and fisheries, food security, Seychelles*.
18. UNITED NATIONS FOOD AND AGRICULTURAL ORGANIZATION, 2005. *Situation reports on Seychelles*.
19. UNIVERSITE DE LA REUNION, CazesDuvat V., Robert, R. *Atlas De l'environnement Cotier des Iles Granatiques de L'archipel des Seychelles*.