Chapter 2

Why Are Communities at Risk from Coastal Hazards?

The Indian Ocean Tsunami of December 2004 raised awareness worldwide of the potentially devastating impacts of tsunamis. Coastal communities around the world, big and small, are increasingly at risk from tsunamis and many other coastal hazards including severe storms, floods, and shoreline erosion. Risk is a function of the hazard and vulnerability of a population to that hazard. Risks from coastal hazards are defined by the type and severity of the hazard and its frequency of occurrence. Vulnerability to coastal hazards is expressed as the degree of exposure of the population and its capacity to prepare for and respond to the hazard (UN International Strategy for Disaster Reduction [ISDR] 2004). An important outcome of increasing the resilience of coastal communities is to reduce or avoid disasters by reducing hazard risk and vulnerability. Understanding and assessing risk is fundamental to enhancing the resilience of coastal communities.

Risk = Hazard (frequency and severity) **x Vulnerability** (Exposure/Capacity)

Source: UN ISDR 2004

Global climate change is predicted to cause an increase in sea level and the frequency and power of storms and storm surge. This will cause increased shoreline erosion; flood and storm damage; inundation of land; saltwater intrusion into the freshwater lens aquifer; increased levels of land-based pollutants to coastal waters, including sediments, nutrients, and contaminants; and more frequent, longer, and more powerful El Niño and La Niña events. In addition, ocean acidification and increased sea surface temperature resulting from global climate change are expected to significantly alter the function and structure of marine ecosystems (Lewin and Pershing 2006).

Risks from Coastal Hazards

Coastal communities are increasingly at risk from tsunamis and many other coastal hazards. Coastal hazards are those natural and manmade hazards that occur at the interface between the ocean and the shoreline. These chronic and episodic hazards include human-caused actions and natural events that threaten the health and stability of coastal ecosystems and communities.

NOAA LIBRARY

Shoreline erosion can be caused by a combination of hazards including sea level rise, storm surge, coastal resource degradation, and coastal development

The risk from coastal hazards is characterized by the frequency of occurrence and severity of the hazard (Figure 2-1). Tsunamis are typically infrequent events with moderate to severe consequences. Mild flooding may occur frequently, while severe flooding may be an infrequent event. Coastal erosion may be a chronic event with mild consequences or, coupled with other hazards, may result in severe impacts on the shoreline. Infrequent events with limited predictability pose the greatest risk of disaster and the longest time needed for disaster recovery. Frequent or ongoing hazards such as resource or environmental degradation processes can be monitored to reduce risk.

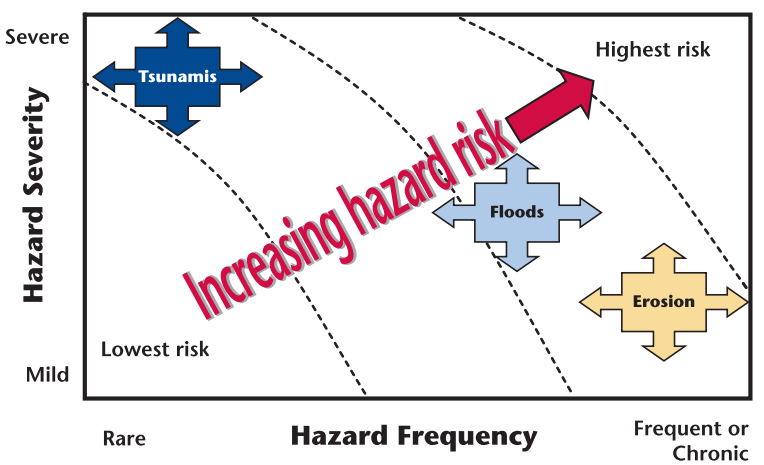

Figure 2-1. Risks from Coastal Hazards as a Function of Hazard Frequency and Severity

Tsunamis. A tsunami is a series of ocean waves typically generated by an underwater earthquake. Landslides, volcanic activity, and meteor strikes may also generate a tsunami. A tsunami wave may be very small in the deep ocean, but as it approaches land can increase to more than 10 meters in height and reach shore as a fast-moving wall of turbulent water. Tsunamis can inundate low-lying coastal areas with multiple waves that can penetrate and cause destruction far inland. There are two types of tsunamis: distant and local. A distant tsunami travels long distances from the event that triggers it to impact the coast hours later. A local tsunami can impact the coast within minutes after the triggering event, allowing little to no time for warning and evacuation. The frequency of damaging tsunamis throughout the Indian Ocean region has been low compared with other natural hazards such as tropical cyclones, earthquakes, and floods.

Earthquakes. Earthquakes are geologic events that involve movement or shaking of the earth's crust. Earthquakes are usually caused by the release of stresses accumulated as a result of the rupture of rocks along opposing fault planes in the earth's outer crust. Fault planes are typically found along borders of the earth's ten tectonic plates; these plate borders generally follow the outlines of the continents. The areas of greatest tectonic instability occur at the perimeters of the slowly moving plates, as these locations are subjected to the greatest strains from plates traveling in opposite directions and at different speeds. Deformation along plate boundaries causes strain in the rock and the consequent buildup of stored energy. When the built-up stress exceeds the rocks' strength, a rupture occurs. The rock on both sides of the fracture is snapped, releasing the stored energy and producing seismic waves, thereby generating an earthquake. Earthquakes can cause significant damage due to intense ground shaking and liquefaction. In addition, the secondary impacts of earthquakes, such as tsunamis and fires, can also cause significant damage.

Storms. Numerous meteorological events can impact the coast, including, very commonly, storms. Various types of storms impact coastal communities, such as severe thunderstorms, tropical cyclones, and extra tropical cyclones.

Storm Surge. Storm surge is simply water that is pushed toward the shore by the force of the winds swirling around a storm. This advancing surge combines with the normal tides to create the storm

NOAA LIBRARY

Storm frequency and severity is increasing as result of global climate change

tide. Tropical cyclone-induced storm tides can increase the mean water level 5 meters or more. In addition, wind waves are superimposed on the storm tide. This rise in water level can cause severe flooding in coastal areas, particularly when the storm surge coincides with the normal high tides. The greatest potential for loss of life related to a tropical cyclone is from the storm surge, which historically has claimed nine out of ten victims of these events.

Flooding. Flooding is a localized hazard that is generally the result of excessive precipitation. The primary types of flooding are riverine flooding, coastal flooding, and urban flooding. Floods can be generally classified as flash floods—the product of heavy localized precipitation in a short time period over a given location—or general floods, caused by precipitation over a longer time period and over a given river basin. Historically, flooding is the most common environmental hazard, due to the widespread geographical distribution of river valleys and coastal areas and the attraction of human settlements to these areas. The severity of a flooding event is determined by a number of local factors, including river basin physiography, precipitation patterns, and recent soil moisture conditions and vegetative state. While flash floods occur within hours of a rain event, general flooding is a longer-term event, and may last for several days.

A. WHITE

Sea level rise causes chronic flooding in coastal areas

Landslides. Landslides occur when masses of rock, earth, or debris move down a slope. Landslides may be very small or very large, and can move at slow to very high speeds. They are activated by storms and fires and by human modification of the land. Landslides pose serious threats to highways and structures that support fisheries, tourism, timber harvesting, mining, and energy production as well as general transportation. Landslides are especially troubling because they often occur with other natural hazards, such as earthquakes and floods. Landslides can also trigger other hazards, such as tsunamis. Areas that are generally prone to landslide hazards include existing old landslides; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used. Areas that are typically considered safe from landslides include areas that have not moved in the past; relatively flat-lying areas away from sudden changes in slope; and areas at the top or along ridges, set back from the tops of slopes.

NOAA LIBRARY

Oil spills are infrequent but often severe events

A. WHITE

Water quality degradation is a chronic hazard that affects ecosystem health and resilience

Spills and Chronic Pollution. There are various ways in which pollution can impact coastal areas. Spills can be in the form of oil spills from ships, toxic materials released from storage tanks, petroleum releases from severed pipelines, etc. These events can have devastating effects on coastal environments. In some cases these episodic pollution events are caused by other coastal hazards such as tsunamis, tropical cyclones, and storm surge.

Chronic pollution can be caused by numerous sources. Improper disposal of garbage in coastal communities can be a cause of pollution. Improper treatment of human waste prior to discharge in rivers and coastal waters can also be a cause of pollution. Polluted surface water runoff from land-based sources can be a significant source of pollution to coastal areas. Regardless of the source of pollution, the impacts on coastal resources can be devastating. Many coastal communities rely on coastal resources for their survival.

Shoreline Erosion. Shoreline erosion is the wearing away of the land surface by detachment and movement of soil and rock fragments, during a flood or storm or over a period of years, through the action of wind, water, or other geologic processes. Wind, waves, and long shore currents are the driving forces behind coastal erosion. This removal and deposition of sand permanently changes beach shape and structure. Additional factors involved in coastal erosion include human activity, sea-level rise, seasonal fluctuations, and climate change. Shoreline erosion is typically a chronic hazard, but severe shoreline erosion may be induced by a single storm event.

A. WHITE

Shorelines and beaches are vulnerable to erosion as sea level rises and during storm events

A.WHITE

Island nations are at increasing risk from sea level rise and shoreline erosion

Sea Level Rise. Sea level rise can be defined as an increase in the mean sea level. Throughout history, the earth has gone through periods of sea level rise and decline, which are directly tied to climate change and global warming and cooling trends over geologic and recent time. Sea level fluctuations are a part of the natural processes on earth that are determined by many factors, but largely are influenced by climate and global warming. In comparison to other disasters that affect the coastal zone, such as tropical cyclones, tsunamis, floods, and earthquakes, sea level rise is on a much more gradual time scale. The impacts of a tsunami can be seen immediately, whereas the effects of sea level rise take a longer period of time to realize. A major potential impact of sea level rise on the natural environment in the coastal zone is that of habitat loss due to wetland inundation, coastal erosion, salt water intrusion, or shift in climate limits on vegetation.

Climate Variability and Change. Short- and long-term climate variability can significantly impact coastal environments. Climate variability refers to temporal variations of the atmosphere and ocean system around a mean state. Climate variability can cause abrupt disruptions, such as floods, droughts, or tropical storms (IRG 2007). Over the past decade, scientists have improved prediction capabilities for some climate variability events such as El Niño and La Niña. Climate variability can have huge impacts on coastal environments by causing an increase or decrease in storm activity, which in turn could lead to water supply issues, drought, or increased flooding and erosion.

A.WHITE

Coral reef ecosystems are threatened by increasing sea surface temperatures resulting from global climate change and other hazards

Climate change resulting from increased anthropogenic inputs of greenhouse gases is a key development issue of our time (World Bank 2007). The direct impacts of climate change, higher

temperatures, followed by changes in the patterns of precipitation, increased intensity and frequency of extreme weather events, rising sea level, and ocean acidification are expected to result in cascading environmental, economic, and social impacts.

Coastal Resource Degradation. Many of the Earth's most complex, diverse, and productive ecological systems are located in coastal zones. Coastal resources are very productive in both a biological and economic sense. Reefs, mangroves, wetlands, and tidelands provide nursery and feeding areas for many marine species. In addition, these coastal resources also provide important buffer areas for storm protection and to control erosion. Frequently, human activities within coastal areas can contribute to the degradation of these crucial resources.

Community Vulnerability to Coastal Hazards

The increased vulnerability of coastal communities to potential hazards is partly due to the constantly increasing coastal population (Adger et al., 2005). Currently, an estimated 23 percent of the world's population (1.2 billion people) lives within 100 kilometers (km) of a shoreline and 100 meters (m) of sea level (Small and Nicholls 2003). By the year 2030, an estimated 50 percent of the world's population will live in the coastal zone.

A. WHITE

Coastal populations around the world are increasing in size and vulnerability to coastal hazards

Human activities are degrading the quality of the coastal environment and integrity of coastal ecosystems on a daily basis, making coastal populations more vulnerable. Coastal habitats such as reefs, mangroves, wetlands, and tidelands provide nursery and feeding areas for many marine species and serve as buffer areas for storm

protection and to control erosion. These coastal habitats are being destroyed by a wide range of human uses, including shoreline development, land reclamation, mining, and aquaculture. Runoff, wastewater discharges, and oil spills pollute coastal waters and endanger marine life. Overfishing and the use of destructive fishing practices are causing the decline of fishery resources and changes in marine ecosystem structure and function. The degradation of the coastal environment from chronic human-induced actions threatens food security, livelihoods, and the overall economic development and well being of coastal communities.

Most of the coastal population lives in relatively densely populated rural areas and small to medium cities, rather than in large cities. In these relatively rural communities, basic services and disaster warning and response mechanisms are limited (Figure 2-2). Limited capacity of a community to plan for and respond to coastal hazards makes coastal populations increasingly vulnerable and increases disaster risk.

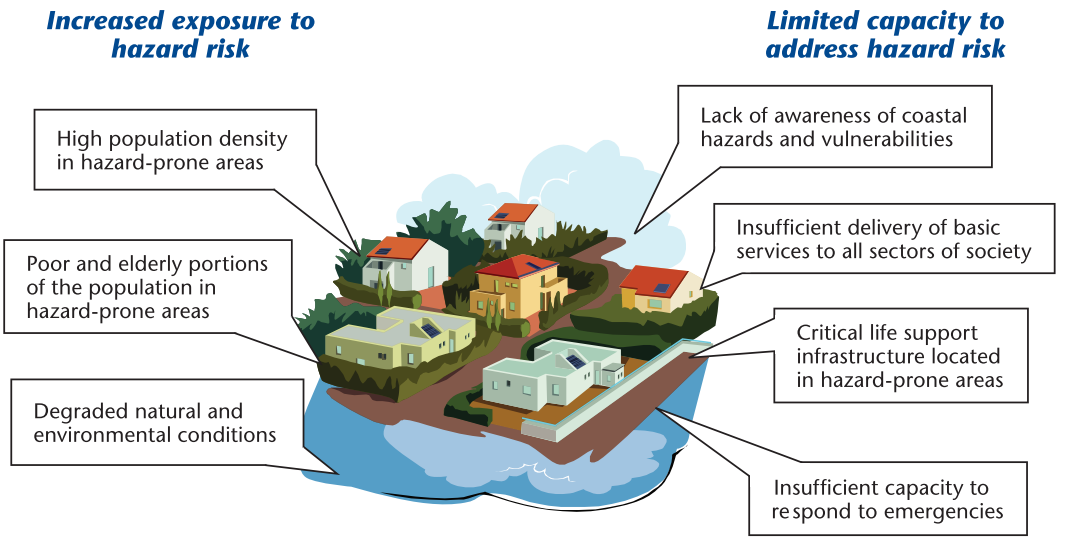

Figure 2-2. Factors that Contribute to Vulnerability in Coastal Populations

Economic development pressures along the coast, population density and distribution, and human-induced vulnerabilities, coupled with increasing frequency and duration of storms, sea level rise, and other chronic coastal hazards, increase risk. These conditions set the stage for more frequent and severe disasters and reduced time and capacity to recover. The time period between disaster event and recovery is becoming shorter, and some coastal communities find themselves in a state of perpetual response to and recovery from one disaster event after another. The assessment of risk is an important element of CCR. Communities must identify their exposure to hazard impacts to proactively address emergency planning, response, and recovery and implement hazard mitigation measures (Figures 2-2 and 2-3).

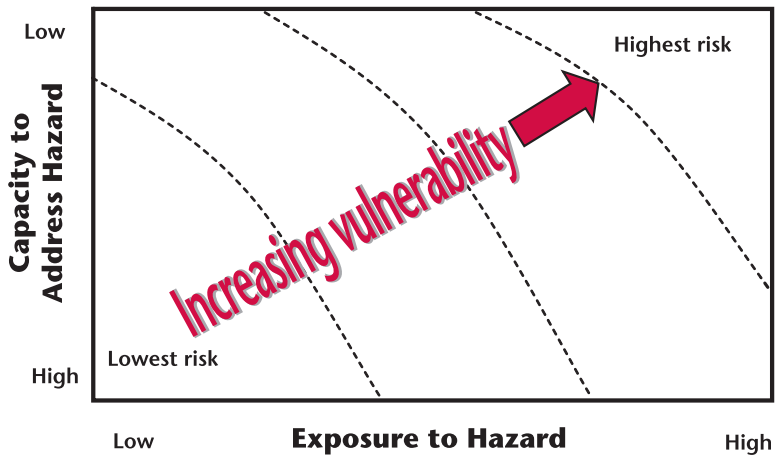

Figure 2-3. Community Vulnerability as a Function of the Degree of Exposure and the Capacity to Address Hazard Risks

A. STEIN

Coastal communities, dependent on the sea for food and livelihood, are at increasing risk from coastal hazards