Chapter 3: Natural Hazards

A wildfire burns across the pali, Mā`alaea.

Maui's pristine waters, lush mountainsides, dry brushland, and dormant volcano offer an awe-inspiring variety of landscapes to explore. The different extremes in climate and terrain can come with a price: the potential for numerous natural hazards that could affect any part of the island. Chronic hazards, such as coastal erosion, flooding, and vog (volcanic smog), may persist or recur over long periods of time. Tsunamis, hurricanes, wildfires, and earthquakes vary in frequency and intensity and are difficult to predict. With the impacts of climate change superimposed on Hawai`i's existing risk from these hazards, communities may be exposed to more severe and frequent hazards, increasing risk; and potentially affecting our economy and eroding the quality of life.

Background Information

Natural hazards must be considered when planning for the future. Maui's shorelines, beaches, and near shore coastal waters are highly susceptible to damage from coastal hazards such as tsunamis, storm surge, and erosion. Inland areas can sustain wind damage, flooding, fires, and drought. These dangers pose a significant threat to life and property.

The University of Hawai`i, the National Oceanic and Atmospheric Administration, and others are working to model the likely impact of a typical tsunami event on the island of Maui. There are several densely populated areas near the coastline and/or in low-lying areas that are vulnerable to tsunami damage.

These same areas are also in danger of periodic hazards such as high surf and storm surge. During the time horizon of the MIP, it will be important to understand how sea-level rise and shoreline changes may affect low-lying areas.

Mitigation, risk, and vulnerability should be addressed for the hazards listed in Table 3-1 when planning for the long term.

Table 3 – 1: Maui's potential natural hazards

Hazards	Overview
Tsunami	Locally generated or Pacific-wide seismic waves (tsunamis) threaten Pacific island coastal communities. Due to increased coastline development, thousands of residents and tourists can be affected by a tsunami. In Hawai`i, tsunamis have accounted for more lost lives than the total of all other local disasters. In the 20th century, an estimated 221 people have been killed by tsunamis. Historically, Maui has experienced tsunami wave heights as high as 33 feet.
Earthquake/ Seismic Hazards	Landslides, ground cracks, rockfalls, and tsunamis are all hazards resulting from earthquakes. Engineers, seismologists, architects, and planners have carefully evaluated seismic hazards related to building construction. They have devised a system of classifying seismic hazards based on the expected strength of ground shaking and the probability of the shaking actually occurring within a specified time. The results are included in the Uniform Building Code (UBC) under the seismic provisions.
Volcanic Activity	The East Maui volcano (Haleakalā) has witnessed at least ten eruptions in the past 1,000 years; numerous eruptions have occurred in the past 10,000 years. Thus, East Maui's long eruptive history and recent activity indicate that the volcano will erupt in the future. Although Haleakalā is in the last stage of Hawaiian volcanic cycle, the eruption recurrence rate is estimated to be about 200-600 years. Lava flow, tephra (airborne lava fragments), volcanic gases, and ground cracks may follow another eruption.
Tropical Cyclones	"Tropical Cyclone" is a general term that can describe tropical depressions, tropical storms, and hurricanes. The systems are classified according to maximum sustained wind speeds. These storms generally affect Maui from June through November. In addition to high wind damage, tropical cyclones impart riverine (non-coastal) flooding, freshwater coastal flooding, high surf damage, highly destructive storm surge, and severe flooding in low-elevation areas with insufficient drainage. Maui's unique topography concentrates torrential rains on mountain slopes, resulting in destructive flash floods and landslides. Even a relatively weak tropical system can have the potential to result in considerable property damage and loss of life. Major tropical cyclones on average occur once every 10 years.

Hazards	Overview
Severe Storms and Flooding	Major floods from severe storms typically occur during the winter season (October through April) and account for 84 percent of the floods in the islands.[1] Kona storms are typically the most destructive storms in Hawai`i, based on frequency. Storm intensities may include wind speeds up to 60 miles per hour with flooding rains and snow storms on Haleakalā. Kona low pressure systems are relatively long-lived storms, often affecting Hawai`i for a week or more, and have been historically responsible for a great deal of damage.
Drought	Long periods without rain are not uncommon in parts of the Pacific. The implications of a drought are varied and can be dramatic. Reduced crop yields, livestock losses, reservoir depletion, and impacts to long-term watershed and aquifer health can have cumulative impacts on agricultural activity. Disputes may arise over water rights; water quality itself may decline due to higher chloride concentrations, pH, and higher temperatures.
Fires	Put simply, "wildfire" is the term applied to any unwanted and unplanned fire burning in forest, shrub, or grass. According to the U.S. Department of Forestry and Wildlife, in Maui County there were 1,291 brush fires between 1972-1999, which burned 64,248 acres and impacted 43 structures. Unlike the mainland United States, Hawai`i's ecosystems are not adaptive to wildfire. Past wildfires in Hawai`i have destroyed the last known species of certain native plants. According to local biologists, many other native plants are only a wildfire away from extinction. Wildfires also cause soil erosion, which then leads to soil runoff into the ocean, killing marine life that local populations rely on for food and cultural practices. Soil erosion and soil damage from wildfire also impact the health of Hawai`i's watersheds. When the watersheds are impacted by wildfire, soil runoff can contaminate these water sources, making them unfit for drinking.
Sea Level Rise	The University of Hawai`i Coastal Geology Center has predicted that the sea level will rise in the coming decades. This would impact all coastlines, and would most severely affect Maui's developed, low-lying communities: Mā`alaea, North Kīhei, Lahaina, Kā`anapali, and Kahului. Prudent land use planning will consider possible sea-level rise as a variable in the future.
High Wind	High winds can cause heavy damage to public buildings and homes. Construction standards, building materials, and building location determine whether a structure will endure. These winds can be the result of tropical systems, frontal systems, or Kona low pressure systems. Depending on the wind direction and speed, a Venturi effect may take place in mountainous terrain on Maui, oftentimes amplifying localized wind speeds.
Landslides	This general term covers debris flows, rockfalls, and a variety of other slope failures. Landslides are commonly related to tropical cyclone events, heavy rain on saturated ground, or earthquakes. Debris flows, sometimes referred to as mudslides, mudflows, or debris avalanches, are common types of fast-moving landslides and occur in a variety of environments. According to the City and County of Honolulu's Civil Defense Agency, the most hazardous areas are canyon bottoms, stream channels, areas near the outlets of canyons, and slopes excavated for buildings and roads.

[1] State of Hawai`i (2007). *Hazard Mitigation Plan*.

Aerial view of the destruction caused by a Kona storm, Kula.

Property damage resulting from natural hazards has become exceedingly costly for both the disaster victims and the American taxpayer. According to the Maui County Multi-Hazard Mitigation Plan (HMP), from 1989 to 1993, the average annual loss from natural disasters was $3.3 billion nationally. Over 6,000 people have been killed and 50,000 injured from natural disasters in the past 25 years (FEMA, 1998). Nationally, extreme weather caused approximately $23.9 billion in combined property and crop damages in 2011, more than double the $9.9 billion in 2010. Property damages were estimated at $20.9 billion, almost triple the 2010 total of $7 billion and 2009 total of $6.8 billion. As in 2010, flooding was a major culprit, accounting for more than $9 billion in losses. Weather-related deaths also more than doubled in 2011, reaching 1,091 victims, up from 490 in 2010. According to the National Weather Service, this number is well above the 10-year average (2002-2011) of 641.

The HMP identifies hazards and risks posed by natural disasters, and provides an action plan to reduce loss if such disasters occur. FEMA requires that this plan be updated every five years. The MIP advocates for the implementation and updating of the HMP.

CHALLENGES AND OPPORTUNITIES

Fragmented Agency Coordination

Although the Maui County Civil Defense Agency is responsible for HMP implementation, the agency cannot be successful in its mission without the cooperative efforts of many County, State, and Federal agencies. To be prepared for any hazard event, all relevant agencies have to be communicative and coordinated; this will help to ensure community resilience before, during, and after a hazard event.

In the context of social and physical systems, resilience can be described as a way to cope with uncertainty or risk. Natural hazards, such as earthquakes, severe storms, or shoreline erosion, pose a variety of risks to communities that cannot be fully described or predicted. Communities manage these risks by building the capacity to avoid or minimize the impacts of hazards, and rebound quickly from disasters.

Guiding Principles for Resilient Communities

Various communities in Hawai`i have defined six principles to plan for resilience. These principles, adapted from the Hawai`i Coastal Zone Management Program (2007), include:

- **Community-based:** engage communities in planning and implementation.
- **Place-based:** consider unique characteristics (natural resources, weather, and demographics) of each place.
- **Ecosystem-based:** recognize connections between land and sea and other components of the ecosystem.
- **Culture-based:** honor the host culture and values.
- **Risk-based:** incorporate hazard risk knowledge in all elements of planning.
- **Collaborative:** promote collaboration between stakeholders at all stages of the planning process.

Guiding principles can be applied in all stages of the planning cycle. Specific steps to plan for resilience in a community:

- **Step 1**: Characterize hazard risk
- **Step 2**: Define resilience goals and status
- **Step 3**: Develop actions and partnerships

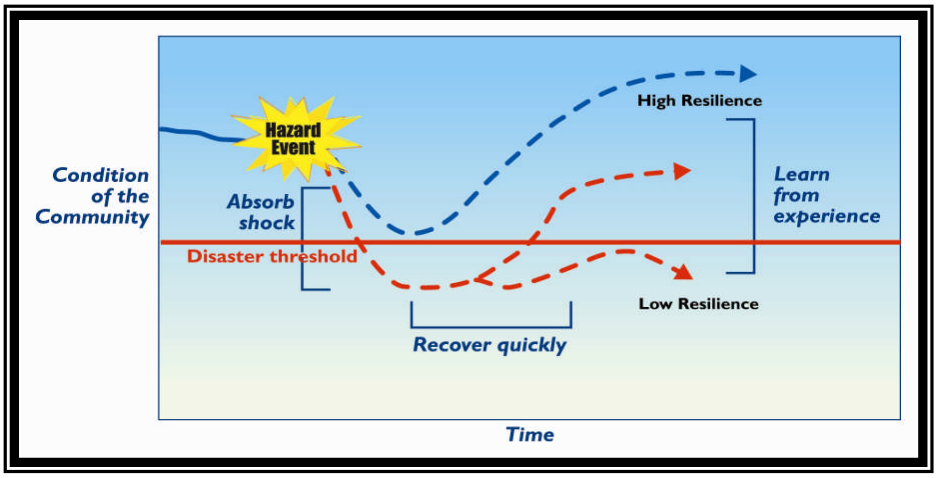

Figure 3 - 1: Goals of resilient communities (U.S. Indian Ocean Tsunami Warning System Program).

Hazard mitigation is action taken to permanently reduce or eliminate long-term risk to people and their property from the effects of natural hazards.

The purpose of multi-hazard mitigation is two-fold: 1) protect people and structures from harm and destruction; and 2) minimize the costs of disaster response and recovery. Hazard mitigation planning is the process that analyzes a community's risk from natural hazards, coordinates available resources, and implements actions to reduce risks.

In 1995, FEMA introduced a National Mitigation Strategy to ensure the national focus on mitigation. The National Strategy promotes the partnership of government and the private sector to "build" safer communities. Hazard mitigation encourages all Americans to identify hazards that may affect them or their communities to take action to reduce risks. Mitigation actions help safeguard personal and public safety. Retrofitting bridges, for example, can help keep them from being washed out, which means they will be available to fire trucks and ambulances in the event of a storm. Installing hurricane clips and fasteners can reduce personal and real property losses for individuals and reduce the need for public assistance in the event of a hurricane. Increasing coastal setbacks reduces the risk of deaths and property losses from tsunamis, storm surge, and sea-level rise.

Limited Routes For Safe Evacuation

In several areas of the island there is only one access to get into or out of a region. For years this has been a problem for Lahaina travelers when there is a wildfire or a rockslide, and this limitation could be disastrous if a tsunami impacted the south- and/or west-facing shores. Likewise, Hāna and East Maui are prone to being cut off from the rest of the island in the event of earthquakes or rockslides.

Property owners, businesses, service providers, and government have a tendency to delay the preparation for natural dangers until there is a crisis. This lack of preparation puts both life and property at risk.

Warning sign posted after 2006 earthquake, Kīpahulu.

Improved Public Outreach and Education

Increasing awareness through public forums that educate communities about natural hazards will empower the public with solutions that will enable the entire community to work together when a crisis strikes. School programs can also be implemented to teach children how they can respond to an emergency situation.

Another important benefit of hazard mitigation and education is that public investment in disaster preventative measures can significantly reduce the impact of disasters in the future, including the cost of post-disaster cleanup.

SUMMARY OF NATURAL HAZARDS ISSUES

- Fragmented agency coordination
- Lack of plans to protect life and property
- Limited routes for safe evacuation
- Need to improve public outreach and education
- Development and/or redevelopment located in hazardous areas

GOAL, OBJECTIVES, POLICIES, AND ACTIONS

Goal:

3.1 Maui will be disaster resilient.

Objective:

3.1.1 Increased inter-agency coordination.

Policies:

3.1.1.a Reinforce the island's preparedness capacity by:
(1) Applying the latest data-gathering techniques/technology;
(2) Pursuing funding opportunities;
(3) Improving monitoring and advance warning systems;
(4) Fostering public awareness; and
(5) Working with external agencies to coordinate disaster mitigation and response.

Implementing Actions:

3.1.1-Action 1 Consolidate and update the geographic information systems (GIS) hazards data bank in the Maui County Emergency Operations Center. Allow for the use of outside data to be included in the data bank.

3.1.1-Action 2 Acquire the latest GIS technology in hazard, risk, and vulnerability assessments.

3.1.1-Action 3 Establish a standing County Hazard Mitigation Committee, comprised of representatives from all levels of government and the private sector.

Objective:

3.1.2 Greater protection of life and property.

Policies:

3.1.2.a Identify critical infrastructure, lifelines, roads, and populations that are vulnerable to coastal hazards, and encourage strategic retreat and relocation to safer areas.

3.1.2.b Consider the location of dams, reservoirs, holding ponds, and other water-containing entities that are upstream of inhabited areas to anticipate, avoid, and mitigate inundation risks, and discourage new development in areas where possible inundation hazards may exist.

3.1.2.c Strengthen current development standards to minimize destruction of land and property.

3.1.2.d Encourage the use of construction techniques that reduce the potential for damage from natural hazards.

3.1.2.e Increase the County's resilience to drought.

3.1.2.f Increase food and energy security through local production and storage.

Implementing Actions:

3.1.2-Action 1 Develop an Emergency Management Center in Central Maui.

3.1.2-Action 2 Implement the HMP, and subsequent updates, to the extent it is consistent with MIP.

3.1.2-Action 3 Develop a Post-Disaster Recovery and Reconstruction Plan that will ensure Maui's resilience to coastal hazards.

3.1.2-Action 4 Develop plans and/or incentives to do the following:
(1) Encourage rebuilding inland as an alternative to shoreline hardening;
(2) Streamline the reconstruction of structures that are moved substantially inland;
(3) Encourage the relocation of existing structures so they are away from shoreline areas; and
(4) Encourage the relocation of vulnerable coastal roads that are susceptible to destruction from natural hazards, such as a portion of North Kihei Road and the Pali to Puamana realignment.

3.1.2-Action 5 Periodically update the shoreline rules to enable the Maui Planning Commission to provide safe setbacks from the shorelines and incorporate best management practices.

3.1.2-Action 6 Use and update the Federal Emergency Management Agency-Digital Flood Insurance Rate Maps (DFIRM) in the permitting process to minimize development in flood-prone areas.

3.1.2-Action 7 Following each coastal erosion disaster, identify and document the new shoreline position to be used for reviewing future development.

3.1.2-Action 8 Following each natural disaster, gather data to plan for future disaster events.

3.1.2-Action 9 Update coastal-planning requirements to factor in incremental effects of rising sea levels.

3.1.2-Action 10 Increase water storage and development of additional capacity in Upcountry Maui and other areas susceptible to drought and encourage efficiency in conservation programs.

Objective:

3.1.3 A more coordinated emergency response system that includes clearly defined and mapped evacuation routes.

Policies:

3.1.3.a Identify and expand shelter facilities and evacuation routes away from areas susceptible to natural hazards.

Implementing Actions:

3.1.3-Action 1 Develop an island-wide evacuation routes plan.

3.1.3-Action 2 Identify and develop required shelter capacity.

3.1.3-Action 3 Plan for opening and staffing the shelters to ensure that the facilities are made available at the time of evacuation orders.

Objective:

3.1.4 A more educated and involved public that is aware of and prepared for natural hazards.

Policies:

3.1.4.a Promote public education and involvement related to natural hazards awareness and preparedness.

3.1.4.b Coordinate a multi-agency effort to establish and promote a comprehensive public education program that will focus on practical approaches to preparedness, damage prevention, and hazard mitigation.

Implementing Actions:

3.1.4-Action 1 Develop regularly scheduled mitigation training for public and private emergency responders and establish volunteer groups to elevate public awareness of emergency procedures.