CHAPTER 5:
Risk and Vulnerability Assessment

5.0 Introduction to the Risk and Vulnerability Assessment

The risk of hazards, a description of assets, and potential losses by hazard has been described in previous sections of this chapter. The risk and vulnerability assessment takes all of this information into account and tries to identify areas where the county may experience loss from different types of hazards. The methods that were used for this analysis involved preparing the information within a geographic information system to collect databases and maps. The process involved taking maps and models of hazards and overlaying these layers on the assets presented in section three. A series of hazard models were also evaluated, and the information that could be used was incorporated into the geographic information system. The flood maps and tsunami evacuation maps were the best hazard layers. A wind-risk assessment was conducted based on data obtained from Hurricane Iniki, but the models show that most buildings lie in high wind risk areas in Kaua'i.

The risk and vulnerability has been prepared using the best available data. As the databases and models are updated, the tables and information contributing to the assessment will be modified in the future. The maps located in Chapter 3 Appendices have been updated with recent hazard analysis and study results, including updated wind risk maps, shoreline erosion study, flood mapping, and tsunami evacuation maps. These hazard layers are integrated with the assets identified in Chapter 4 to develop the risk and vulnerability assessment. By understanding the degrees of exposure and sensitivity of assets and resources, it is possible to develop mitigation actions to protect them. These mitigation actions appear in Chapter 7.

5.1 Vulnerable Critical Facilities and Lifelines

The lists of facilities and lifelines identified in the risk and vulnerability assessment are presented in several formats: 1) descriptions in previous sections of this chapter; 2) tables listing facilities for each sector cross-referenced by hazard in Chapter 5 Appendix 3; and, 3) facilities from these tables in maps for each geographic area of Kaua'i, divided by sectors in Chapter 3 Appendix 4.

The best available loss information has been included at the end of each hazard in section two of this chapter. Most of this information is based on modeling and estimates that occurred after Hurricane Iniki. For hurricanes, the County of Kaua'i has the best available data. For the other islands, the information was extrapolated based on the various strengths of Hurricanes Iniki and Dot. Except for flooding losses, Kaua'i needs to improve loss estimates and data for most of the other hazards.

As part of the development of information and loss estimations for the Hawai'i State Hazard Mitigation Plan, Gary Chock, of Martin & Chock, Inc., conducted a study of the average annualized loss of hazards (AAL = ∑ Li x Pi) in Hawai'i. According to this study, which only used property loss values, the biggest loss and relatively most severe hazards for the County of Kaua'i are hurricanes, followed by flood, erosion, earthquakes, and tsunami.

5.2 Risk and Vulnerability by Hazard Type

5.2.1 Potential Losses from Future Hurricanes

The best estimates of losses and vulnerability to facilities came from extrapolations of hurricanes that affected the County of Kaua‘i. The average annualized loss is the best method developed, especially to look at multi-hazard risks. The results of the study provide some of the best estimated values of property and estimations of loss that currently exist statewide to look at all of the potentially vulnerable assets.

Currently, the GIS databases are formulated separately in each county with varying licenses to parcel data and protocols for sharing of these layers. Different attributes and characteristics are attached to the parcel layers, which complicates the ability for the State to develop a value listing for all property, as prepared for the County of Kaua'i. One of the mitigation proposals recommends developing established protocols and improving the compatibility for listing of property values and therefore potential loss data. The updates and sharing protocols are important components that will allow for better use of the GIS tools with decision support tools, such as HAZUS software.

Examples of the use of improved building inventories and GIS information with HAZUS have been included in the Chapter 5 appendix. Improvements in GIS will allow improved loss information and vulnerability estimations. For this plan, however, these scenarios and estimates have not been included, but as the data and information sharing protocols improve, the State plans to include better loss estimate calculations in the next year.

Until this additional work is undertaken, some of the information prepared for hurricanes in Chapter 3 will be included in this chapter for consideration. Although this study was conducted for wind hazards, it gives some perspective on severe losses from extreme hazards. If a Category 1 storm as strong as Hurricane ‘Iwa, with winds gusting at 74 mph, strikes any of the islands in the state, we can guess from past experience that about 12% of the houses and apartments could be destroyed or heavily damaged and about 18% would probably experience minor damages. If a Category 3 storm strikes any island with the same force as Iniki, with winds raging at 130 mph, we can guess that about 38% of the homes will be heavily damaged or destroyed. An additional 40% will probably have minor damages. The following information was extrapolated from Kaua‘i Damage in 1982 and 1992 and remains the best available study and data for storms in Hawai‘i.

Table 5-1. Estimated Cost of Storms in Hawai'i ($ billion in 1992 when study was conducted).

	O'ahu	Maui	Hawai'i	Kaua'i
'Iwa-Strength Storm	$4.5-7.5	$0.8-1.4	$0.8-1.4	$0.3-0.6
Iniki-Strength Storm	$13.9-23.3	$2.7-4.5	$2.6-4.4	$1.1-1.9

Source: Hawaii Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993.

Table 5-2. Estimated Cost of Storms in Hawai'i ($ billion inflated to 2008).

	O'ahu	Maui	Hawai'i	Kaua'i
'Iwa-Strength Storm	$ 6.6-11.0	$ 1.2-2.1	$ 1.2-2.1	$ 0.4-0.9
Iniki-Strength Storm	$20.4-34.2	$ 4.0-6.6	$ 3.8-6.4	$1.6-2.8

Source: Hawaii Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study with calculations updated by the University of Hawai'i, October, 2009.

Table 5-3. Damage Percentage to Residential Units by Storm and Classification

	Iniki	'Iwa
Destroyed	8%	3%
Major damage	30%	9%
Minor damage	41%	18%
Total	**79%**	**30%**

In both storms about 10% of residential units suffering damage were destroyed. In Iniki a higher proportion suffered major damage (37% to 30%), while a smaller proportion suffered minor damage (51% to 60%).

Table 5-4. Estimated Value of Damage per Unit (updated to 2006)

Destroyed	283,958 (2006 average estimated value based on destruction of single family home)
Major damage	52,162 (estimated amount used on American Red Cross street sheets)
Minor damage	1,490 (extrapolated from data presented in the *Imua* report)

The damage ratios and values were updated and applied to the housing stock in each county as of 2005, to construct the Residential structure damage estimates in each county for both storms. The *Imua* study reported the estimated damage to personal property to be approximately 45% of the estimated structural damage. The following calculations form the best estimates of potential residential asset damage based on the most current data book statistics for the State of Hawai'i:

Table 5-5. Count of Housing Units by County (based on 2007 statistics)

County	Number of Units 2007	% Change from 2000 to 2007
Honolulu	334,792	6.0
Maui	65,102	15.1
Hawai'i	77,650	23.9
Kaua'i	29,193	15.2

Source: 2008 Hawai'i State Data Book, Section 21, Table 21.19, http://hawaii.gov/dbedt/info/economic/databook/2008-individual/

Table 5-6. Residential Asset Damage, By County and By Storm (in $ millions inflated to 2008)

	Iniki		‘Iwa	
County	**Structures**	**Personal**	**Structures**	**Personal**
Honolulu	20.3	5.7	4.4	1.9
Maui	2.4	1.1	0.8	00.4
Hawaii	2.8	1.3	1.0	0.4
Kauai	1.1	0.05	0.4	0.1
TOTAL	26.6	8.6	6.6	3.0

Source: 2008 Hawai‘i State Data Book, http://hawaii.gov/dbedt/info/economic/databook/2008-individual/with analysis from Hawaii Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study.

The estimated damage to visitor accommodations from Iniki was based on a survey of Kaua‘i's visitor rooms for the Hawai‘i Hotel Association by PKF-Hawaii which found 54% of the 7,616 surveyed to be damaged at an average value of $75,600 per room in 1991 dollars, which is adjusted to $110,807 in 2009. These were applied to the count of visitor accommodations to estimate damage. The data has been updated with information from the 2008 State of Hawai‘i Data Book.

Table 5-7. Visitor Accommodation Damage after an Iniki-Type Storm in 2008.

County	Total	Units	Damaged	Units	Cost
Honolulu	34,008	18,364	$ 2,034	859	748.00
Maui	19,259	10,400	$ 1,152	392	800.00
Hawai‘i	11,247	6,074	$ 673	041	718.00
Kaua‘i	8,692	4,321	$ 478	797	047.00
TOTAL	72,516	39,159	$ 4,339	091	313.00

Source: Extrapolated from data in 2008 Visitor Plant Inventory, State of Hawaii Department of Business, Economic Development, and Tourism, 2008, http://hawaii.gov/dbedt/info/visitor-stats/visitor-plant/vpi2008.pdf, access October 5, 2009, with analysis from Hawaii Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study.

The estimated damage to non-accommodations Commercial Property after Iniki was based on a survey of 128 visitor related businesses on Kaua‘i by Harry Spiegelberg and Associates for DBEDT. The estimated overall damage per employee was $13,692 in 1991, which is estimated at $15,699 in 2007. DBEDT used this estimate to construct the estimated damage to non-visitor facilities. The two categories are merged into “Visitor and other facilities” and the estimated damage is the damage per employee times the number of non-agriculture, non-government employees in each county.

The estimated damage to public utilities after Hurricane ‘Iwa was $11.5 million. Assuming the same Kaua‘i share as with other business damage (87%), the cost per customer was $55,000 times the inflation factor (159.6%) yields the estimated cost per customer of $88,000 then updated (2000) with the inflation factor of 46.57% to $128,982 (2007), and an estimated public utility damage to the County of Kauai: Customers – 31,158; Damage - $ 4,018,821,156.00.

With funding from a Pre-Disaster Mitigation Grant, an updated high wind risk assessment of critical facility sites based on the new wind hazard mapping on GIS data layers has been completed and submitted to County of Kaua'i Civil Defense Agency in April 2009. The County of

Kauai wind mapping was completed by Martin & Chock, Inc. in October 2008. This assessment has improved the understanding of wind risk and enabled suggestions for relevant building code amendments. To determine speedup factors for Kaua'i, terrain models of portions of the island terrain were constructed and tested in the wind tunnel. Wind speedups or reductions were measured at several hundred locations. Martin & Chock then constructed a phenomenological model to fit the measured data, and used that model to predict the wind speedup in all areas of Kaua'i. Due to the complexity of mountainous terrain and valley gorges in Hawai'i, there are topographic wind speed-up effects. In the Hawai'i Special Wind Region, there are special topographic effect adjustments to the Basic Wind Speed established by the authorities having jurisdiction.

Figure 5-1. Annual Odds of Hurricane Wind Occurrence.

Annual Odds of Hurricane Wind Occurrence on Island by Saffir Simpson Category Based on 1000 Years of Simulation for the East & Central Pacific Region

Hurricane Category	Sustained Wind	3 –sec. Peak Gust	Anywhere in Hawaii	Kauai only
1	74 to 94 mph	82 to 108 mph	1 in 25	1 in 100
2	94 to 110 mph	108 to 130 mph	1 in 50	1 in 250
3 or 4	110 to 155 mph	130 to 191 mph	1 in 75	1 in 400
Any Hurricane	Greater than 74 mph	Greater than 82 mph	1 in 15	1 in 60

This does not include any potential effects of long-term global climatic change, which may affect the overall hazard level in the future.

Martin & Chock, Inc.

Previous risks assessed with HAZUS modeling demonstrate that the average annualized loss for hurricanes in Kaua'i County are approximately $8-10 million (Martin & Chock, Inc. 2004).

5.2.2 Potential Losses from Flooding

The State of Hawai‘i has 144 properties on the repetitive loss list with over half located in the City and County of Honolulu. The criteria for repetitive loss are two or more NFIP claims of

more $1,000 within any ten-year period since 1978. The County of Hawai‘i has 46 repetitive loss properties. The State is concerned about those properties having three or more claims and will be carefully evaluating if mitigation action is warranted. There are 43 buildings currently in this high risk category: City and County of Honolulu-21, County of Hawai‘i-17, County of Maui-4, and **County of Kaua‘i-1**. The great majority of these buildings are located along shorelines.

Kaua'i County participates in the analysis of the 43 properties conducted by the State Civil Defense Division along with the Department of Land and Natural Resources and the other three County Governments. The State Hazard Mitigation Forum provides technical and scientific assistance. Mitigation measures to be considered for each property are: acquisition, relocation, elevation, or small flood control project. Due to the scarcity and high cost of land, the most likely solutions will either be elevation or implementation of a small flood control project.

The following information pertains to the percentage of developed (urbanized) areas located in the 100 year floodplain by county. Source of information is the county NFIP coordinators:
County of Hawai‘i: 5%
County of Kaua‘i: 10%
County of Maui: 10%
City and County of Honolulu: 15%

The repetitive loss table for Kaua'i County is based on the best available data:

Table 5-8. Repetitive Loss Data for Kaua‘i County (*Source:* Department of Land and Natural Resources, Flood Control Program.)

Building	Area	Zone	Total Costs
Single Family	Hanalei	AE	$ 13,046.10
Other Residence	Koloa	A	$ 981,904.93
Single Family	Koloa	C	$ 263,371.16
Single Family	Hanalei	VE	$ 4,033.88
Single Family	Kapaa	A03	$ 44,542.66
Non Residential	Lihue	A	$ 15,903.70
Single Family	Koloa	C	$ 448,181.80
Non Residential	Hanalei	AE	$ 11,889.12
Single Family	Haena	VE	$ 9,462.06
Assumed Condo	Koloa	C	$ 438,207.51
Non Residential	Lawai	X	$ 34,982.91
GRAND TOTAL			$ 2,265,525.83

In September 2005, the Federal Emergency Management Agency conducted a flood insurance study for the County of Kaua'i.[1] The documents appear in two volumes. This study updates the Flood Insurance Rate Maps for the County of Kaua'i and establishes the criteria for determining flood insurance rates. As part of the NFIP, the State Department of Land and Natural Resources has launched a “Flood Hazard Assessment Tool” (http://gis.hawaiinfip.org/fhat/) that enables the general public to access information on their flood risks based on updated digital FIRM maps.

[1] Federal Emergency Management Agency. September 16, 2005. Flood Insurance Study: Kauai County, Hawaii. Community Number–150002V001B, 2 volumes.

5.2.3 Potential Losses from Drought

The State of Hawai‘i Commission on Water Resources Management has convened a Drought Council and developed a Drought Mitigation Plan. The Commission has developed a website called the “Hawaii Drought Monitor” that informs the public about the status of drought and encourages mitigation actions. The site posts drought notices, such as the following (http://www.hawaii.gov/dlnr/cwrm/drought/):

- County of Kauai County of Kauai Department of Water, June 5, 2007 - Water conservation urged in Kilauea area (pdf)

In assessing the 2007 drought impacts in Hawai‘i, resource managers are trying to determine a way to assess and record losses as part of the drought impact evaluation. The State Drought Coordinator is exploring methods for loss estimation and has referenced a recent master’s thesis that identifies methods for determining losses (Melvin 2006).

The best available data currently can be taken from records of the US Department of Agriculture Farm Service Agency (FSA). One of the mandates of FSA is to provide relief assistance to the agricultural sector for drought. A problem identified in the past with the relief assistance is that it is tied to congressional allocations for drought relief, which means that the amount of assistance is not tied to a strict formula that accounts for acreage by crop loss. This makes it difficult to account for losses tied to rates of exposure and sensitivity of location and crop or livestock. The following data does indicate drought assistance in place over time that can be used as the best available data for understanding risk and vulnerability to drought.

Table 5-9. October 2007
Farm Service Agency Disaster Benefits Paid for Drought

Year	Kauai	Kauai	Oahu	Oahu	Maui	Maui	Maui	Hawaii	Hawaii	TOTAL
Program	LAP	LCP	LAP	LCP	LAP	LCP	NAP/ CDP/ ECP	LAP	LCP	
2000	$71,837				$217,044		$16,014		$493,083	$797,978
2001							$16,710			$16,710
2002		$192,020		$55,171	$161,473		$219,407		$483,084	$1,111,155
2003			$62,466				$118,653			$181,119
2004	$223,582				$331,147		$1,313	$470,356		$1,026,398
2005	$262,842		$96,824				$10,688	$1,181,433		$1,551,787

* Programs for this year are still in progress

CDP = Crop Disaster Program
ECP = Emergency Conservation Program
LAP = Livestock Assistance Program
LCP = Livestock Compensation Program
NAP = Noninsured Crop Disaster Assistance Program

5.2.4 Potential Losses from Wildland Fires

The costs associated with fire management include personnel, equipment, and indirect impacts associated with lost use of the area, threats to ecosystems, and increased potential for future

landslides and sedimentation. Wildfires throughout the State of Hawai'i have resulted in the loss of the last of several native species of plants and animals. The damaged land often becomes more suitable for invasive species, which become established in imbalanced ecosystems, and prevent native species from returning. At the urban and forest interface, wildfires threaten homes, ranches, and farmland. Damage to the topsoil increases risk of sedimentation that threaten nearshore marine habitat.

In September 2009, the County of Kaua'i experienced a major wildland fire that burned nearly 200 acres on the south shore of the island. A few days after this fire, another blaze threatened Līhu'e Airport. Previous storms in Kaua'i have built fuel-load, which means that fires can be much tougher to fight because they can burn hotter and longer. Even though Kaua'i has had relatively fewer fires than other counties, the fires still threaten critical infrastructure and prove costly.

5.2.5 Potential Losses from Climate Variability and Change

Climate variability has resulted in costs associated with strong winds, hurricanes, drought, and wildfires previously discussed in this chapter. For Kaua'i County, the losses from storms have exceeded $1.8 billion. The greatest losses from climate-related disasters have occurred during El Niño years for Kaua'i--- both Hurrican 'Iwa and Iniki, the drier than normal conditions and water conservation periods, the rainfall anomaly in 2006 that resulted in a dam breach preceded an ENSO warm event, and the 2009 wildfire. Even though it will be hard to predict, there will likely be decreases in the water resource systems.

For island ecosystems, sea level rise will have a major impact on coastal habitat and will threaten nearshore built environments. Even though the damage estimates and impacts are still not certain, there are figures ranging from 1 to 5 meters of sea level rise by 2050 should global warming continue current trends in melting of ice cap, glacier, and Greenland continue coupled with the thermal expansion of the ocean. The local, downscaled models of sea level rise have not been refined for Kauai yet, but there could arguably be consequences from increased shoreline erosion with potential storm and coastal inundation. The losses and cumulative impacts from cascading hazards could be catastrophic. Additional analyses are needed to quantify and estimate losses. Increased best practices in environmental management and disaster risk reduction will hopefully build climate adaptation and resilience in Kaua'i.

5.2.6 Potential Losses from Earthquake

In order to measure earthquake losses, researchers employ a computer program known as Hazards U.S. (HAZUS). The Federal Emergency Agency (FEMA) developed the software in partnership with the National Institute of Building Sciences (NIBS). Characteristics of a hypothetical or actual earthquake are entered into HAZUS, and HAZUS then estimates the intensity of ground shaking and calculates losses based on the ground shaking results. Losses include the number and types of buildings damaged, number of casualties, damage to transportation systems, disruption to utilities and critical services, and estimated economic losses.

Based on a 2001 Hawaiʻi State Earthquake Advisory Council (HSEAC) study, statewide earthquake average annualized loss (AAL) is about $58.2 million per year---$35.2 million on the Island of Hawaiʻi, $11.4 million on Maui, and $11.6 million on Oʻahu. Statewide earthquake annualized loss ratios (ALR's) have been estimated at $1300/million of asset value---$4,400/million for Hawaiʻi, $1,500/million for Maui, and $263/million for Oʻahu. The predominant contributor to loss is single-family residential construction (Hazard State Earthquake Advisory Committee from the Hawaiʻi Multihazard Science Advisory Council (MSAC) to the State Hazard Mitigation Forum. 2002). Kauaʻi lies in an area of reduced risk and was not considered in this study; however, should a severe earthquake threaten Oʻahu, the County of Kauai would be impacted severely in the receipt of goods, services, and finances since many systems rely on the ports and harbors or institutions in Honolulu.

5.2.7 Potential Losses from Tsunami

Tsunami risk in U.S. coastal communities is a function of the extent of tsunami hazards, land use types, population, and economic patterns in threatened areas. To improve our Nation's ability to understand and manage risks associated with tsunamis, we must augment the traditional National Tsunami Hazard Mitigation Plan (NTHMP) research focus on hazard assessments with research dedicated to understanding societal vulnerability to these threats, defined as the exposure, sensitivity and resilience of communities. To address these impacts, the US Geological Survey initiated the Tsunami Risk Assessment Project with Hawaiʻi State Civil Defense, Hawaiʻi State Office of Planning GIS Program, and the Pacific Tsunami Museum.

GIS-Based Analysis of Community Exposure and Sensitivity

Research is needed that integrates tsunami hazard information with land cover, land use, population, and economic patterns to identify at-risk communities, regions and trade corridors. Risk of future tsunami disasters should be assessed based on projected local and regional changes in land use and population patterns. This analysis can begin with regional GIS-based assessments of community vulnerability factors, such as land use and land cover types, population and demographic sensitivity, and business exposure and community economic sensitivity. A consistent database of vulnerability factors for all coastal communities threatened by tsunamis would provide a baseline for comparative studies and regional risk-reduction approaches, as well as a blueprint for more-detailed hazard and vulnerability assessments. The USGS has begun to build this regional database with work in Oregon, Washington and Hawaiʻi.

The Tsunami Risk Assessment Project (TRAP) is a study that considered variations in land use, demographics, and economic assets in land prone to tsunami hazards for the State of Hawaiʻi. Results will be summarized by evacuation zone and by Census Designated Place. This TRAP study currently represents the best available data related to risk reduction related to tsunami. This information could also be used to inform risk assessments related to coastal storm inundation and coastal flooding.

The TRAP study considers population using Census data. Population statistics include data disaggregated by gender, age, race, households, employees, single mothers, dependent

populations, public venues, and hotels. The rationale is that the locations of populations during a tsunami affect their vulnerability. These assessments show that just less than half of all hotels lie in the evacuation zone. Just over half of the renter occupied households are in the tsunami evacuation zone. The data needs to be further assessed, but this preliminary information helps to target programs to reduce risks to tsunami. Chapter 5 Appendix 4 has tables that show tsunami risk for Kaua'i County, based on land use, resident and visitor populations, business community, location of venues, and critical and essential facilities.

The summary of tsunami risk are as follows for Kaua'i County:

- Areas of highest land use vulnerability are from Waimea to Barking Sands, where the military base is located, and likely increasing risk because of greater area of impervious land cover. In terms of sensitivity, Hanalei community as the greatest percentage of their developed land in the tsunami evacuation zone, at almost 98%.
- Characteristics of residential populations at risk appeared that the greatest number of Kaua'i residents are located in Kekaha, but this is only the third most vulnerable population as almost 100% of the population of Hanalei resides in the tsunami zone, with Pākalā Village trailing at 70% and Kekaha closer to 65% of its residents in the tsunami evacuation zone.
- In looking at employee populations, the number varies widely among communities, with tourism areas having much higher employment in the tsunami zone. Hanalei and Kekaha communities in Kaua'i have 100% of their employees working in the tsunami evacuation zone.
- Visitor populations to Kaua'i stay often in Kapa'a, Wailua, Līhu'e, and Waimea in areas where 81-100% of the visitors in these places reside in the evacuation zones.
- The most expensive properties in Kaua'i County are located in Hanalei, Po'ipū, and federal lands. However, in terms of sensitivity to tsunami, Anahola, Pakala village, Kekaha, and Hanalei have more than 61% of the total parcel values in the evacuation zone.
- Of all the places in Kaua'i County and in the State, Hanalei and Kekaha appear among the most sensitive areas for tsunami risks.

5.2.8 Potential Losses from Dam Failures

Dam failure in Kaua‘i during severe rainfall resulted in loss of life. The failure caused millions of dollars in damage, response, and rehabilitation efforts, although the dams in more populated areas of Kaua‘i did not fail.

Following Hurricane Katrina, there were some assessments made that discussed potential failure of dams in the State of Hawai‘i. As a result of Act 118, SLR 2006 for addressing damage from the storms, the State allocated over $20 million to address various issues. Of this amount, $6,755,000 was directed towards dam assessments to be completed by December 2006 (Section 25, Act 118, Session Laws of Hawaii). Dam failures must be incorporated into risk and vulnerability assessments. As the Department of Land and Natural Resources (DLNR) assessments are integrated with levee and dam analyses, data improves for modeling risk from

dam failure. Spatially, the areas that lie in a zone of potential dam failure could be assessed similar to methods used in the tsunami risk assessment project described previously to get a sense of the number of residences, businesses, and other critical features are located in potential dam failure pathways. This is a gap that needs to be addressed in future risk assessment models.

5.2.9 Potential Losses from Health-related Hazards

Health risks may increase with the occurrence of natural and human-induced disasters. During the stream flooding disasters, people working in cleaning the debris became exposed to leptospirosis (a bacterial disease resulting from exposure to water contaminated with urine of infected animals that could result in a range of problems, including kidney damage, meningitis, and death). Studies at the University and the East-West Center have demonstrated links between climate variability and ENSO cycles with outbreaks of dengue fever.

Efforts to address the dengue outbreak in 2001-2002 in Hawaiʻi (the end of a La Niña event), resulted in an extensive public health effort, including: active surveillance at public health facilities, increased monitoring efforts, free testing provided to the public, and increased public awareness through press (Effler et al 2002). Coordination occurred among state and county governments, the Department of Health, State Civil Defense, County Civil Defense agencies, and the Centers for Disease Control. The cost of this response effort has not been fully assessed. With increased climate extremes associated with climate change, there may be increased efforts such as this in the future.

Health-related hazards may also include mental health and post-traumatic stress disorders associated with disasters. There will be increased vulnerability from populations already at risk----those with special needs, those with mental illnesses, those with severe illnesses, and those who might be homeless. First responders to disasters require monitoring for post-traumatic stress, depending on the characteristics of the disaster. For example, responders during the 9-11 World Trade Center crisis witnessed tremendous death and injury, and months later many suffered respiratory and other illnesses from toxins released in the burning. Society has to bear the long-term costs on the physical and mental health of crises on first responders and the general population.

Scenarios suggested with avian flu or other disease scares, such as SARS, would have a significant impact on tourism as people decrease their travel. Following the September 11, 2001 terrorism event in New York, Hawaiʻi experienced significant declines in tourism to Hawaiʻi because of the fear of flying. The H1N1 influenza has thus far resulted in thousands of incidents globally, but only 1-5 confirmed cases in Kaua'i County, according to the Flu Tracker (http://flutracker2.rhizalabs.com/cbi/snapshot/page?concept=~fd000a02514f427d6c114918049a5efc175eb4803e9d9cf73e9f). It took almost a decade for tourism to rebound on Kauaʻi after Hurricane Iniki. Scares of infectious disease and pandemic flu could collapse the economy. Efforts to include risk and vulnerability for health-related disasters need to be incorporated into risk reduction efforts.

5.3 Hazard Risk and Vulnerability for Kauai Landowners

Kaua'i County's risk and vulnerability to natural hazards has been assessed based on the best available data and information; however, all of the data and information needed is not known. The County of Kaua'i has chosen to direct its focus on making improvements to critical facilities that will withstand many different types of disaster scenarios and varying magnitudes of disasters. Most of the buildings are at risk to high winds and topographic speed-up effects, which has been investigated by Martin & Chock, Inc with recommendations to improve building codes with respect to wind risks. The County of Kaua'i adopted the 2003 International Building Code and 2003 International Residential Codes with amendments. The 2003 IBC and 2003 IRC became effective approximately January 22, 2008.

Even with the adoption and implementation of the new codes, there are no certainties. Therefore, the priority of the disaster advisory committee has been to focus on implementation of policies and regulations that are already part of its code, and to ensure improvements of critical facilities and infrastructure, using the best knowledge and measures to date.

The following table, 5-10, provides an estimate of the aggregate value of critical facilities identified in appendix 2. As in the appendix, the following tables were organized into the geographic areas of the island. The information is taken from the real property tax database for the County of Kaua'i. These values can be used to estimate losses from disaster impacts.

Table 5-10. Critical Facilities Values for Land and Buildings.

MAJOR LAND OWNER	NUMBER OF PARCELS	SUM OF LAND VALUE	SUM OF BUILDING VALUE
Kekaha			
Līhu'e Land Company	9	$ 3,126,400.00	$ 1,881,500.00
E.A. Knudsen Trust (Koloa)	9	$ 4,256,700.00	$ 54,400.00
Gay & Robinson	43	$ 5,732,800.00	$ 9,468,800.00
Govt. County of Kauai	10	$ 1,391,300.00	$ 1,614,500.00
Govt. Federal	5	$ 3,086,500.00	$ 204,800.00
Govt. State	99	$ 157,875,900.00	$ 3,552,500.00
Govt. State Department of Hawaiian Homelands (DHHL)	70	$ 6,240,200.00	$ 3,750,500.00
Govt. State HHA	4	$ 500,200.00	$ 7,293,600.00
Hawaii Conference Foundation (United Church of Christ)	1	$ 201,100.00	$ 21,700.00
Kikiaola Land	7	$ 6,704,700.00	$ 3,268,200.00
Roman Catholic Church	5	$ 1,729,800.00	$ 433,600.00
other	886	$ 75,562,900.00	$ 57,407,200.00
subtotal		**$ 266,408,500.00**	**$ 88,951,300.00**
Hanapēpē			
Alexander & Baldwin	31	$ 7,187,700.00	$ 2,393,000.00

Gay & Robinson	3	$ 4,300.00	$ -
Govt. County of Kauai	5	$ 208,800.00	$ -
Govt. Federal	2	$ 243,600.00	$ -
Govt. State	121	$ 32,920,700.00	$ 3,353,800.00
Hawaii Conference Foundation (United Church of Christ)	1	$ 101,700.00	$ 17,800.00
Robinson Family	9	$ 5,301,000.00	$ 10,020,200.00
subtotal		**$ 45,967,800.00**	**$ 15,784,800.00**
Po'ipū and Kōloa			
Alexander & Baldwin	41	$ 115,194,400.00	$ 3,871,200.00
E.A. Knudsen Trust	62	$ 50,140,600.00	$ 57,046,500.00
Govt. County of Kauai	25	$ 6,744,600.00	$ 88,300.00
Govt. State	35	$ 5,769,500.00	$ 6,200.00
Grove Farm	15	$ 14,851,800.00	$ 6,680,400.00
Nat'l Trop. Bot. Garden	7	$ 2,930,300.00	$ 812,900.00
Takanaka Corporation	1	$ 4,440,300.00	$ 13,138,400.00
other	572	$ 269,880,400.00	$ 405,067,665.00
subtotal		**$ 469,951,900.00**	**$ 486,711,565.00**
Līhu'e			
Līhu'e Land Company	57	$ 36,587,100.00	$ 21,330,200.00
Govt. County of Kauai	16	$ 3,450,800.00	$ 719,400.00
Govt. Federal	15	$ 7,297,100.00	$ 27,600.00
Govt. State	37	$ 285,343,400.00	$ 1,971,500.00
Grove Farm	6	$ 1,394,500.00	$ 34,100.00
J.T. Waterhouse	4	$ 3,339,200.00	$ 506,000.00
Kauai Lagoons	2	$ 15,685,600.00	$ 18,053,700.00
Roman Catholic Church	2	$ 255,400.00	$ 361,400.00
W.H. Rice	15	$ 2,720,000.00	$ 150,700.00
other	371	$ 118,595,700.00	$ 368,738,400.00
subtotal		**$ 474,668,800.00**	**$ 411,893,000.00**
Kapa'a			
Līhu'e Land Company	1	$ 74,400.00	$ -
Bette Midler	9	$ 157,500.00	$ -
Govt. County of Kauai	25	$ 3,885,500.00	$ 351,900.00
Govt. Federal	1	$ 103,600.00	$ -
Govt. State	240	$ 37,328,100.00	$ 4,602,100.00
Govt. State Department of Hawaiian Homelands (DHHL)	65	$ 14,808,900.00	$ 921,300.00
Hawaii Conference Foundation (United Church of Christ)	1	$ 184,300.00	$ 201,100.00
Kamehameha Schools	4	$ 17,000.00	$ -

Keālia Plantation	20	$ 9,038,800.00	$ 205,600.00
W.H. Rice	1	$ 2,800.00	$ -
other	1087	$ 220,409,200.00	$ 225,620,600.00
subtotal		**$ 286,010,100.00**	**$ 231,902,600.00**
Hanalei			
Lihue Land Company	7	$ 4,189,835.00	$ 216,715.00
Alexander & Baldwin power plant	1	$ 456,800.00	$ 41,100.00
Govt. County of Kauai	16	$ 19,098,600.00	$ 87,500.00
Govt. Federal	24	$ 42,499,100.00	$ 117,200.00
Govt. State	40	$ 14,111,100.00	$ 1,725,200.00
Hawaii Conf. Foundation	1	$ 400,500.00	$ 68,600.00
Kamehameha Schools	19	$ 9,111,000.00	$ -
Kikiaola Land	1	$ 3,412,400.00	$ 86,800.00
Magoon Estate	1	$ 65,000.00	$ -
Nat'l Tropical Botanical Garden	2	$ 1,413,200.00	$ -
Pflueger	8	$ 23,406,200.00	$ -
Princeville Dev.	21	$ 36,317,600.00	$ 47,653,200.00
Robinson L&H	5	$ 1,710,500.00	$ 93,500.00
Roman Catholic Church	1	$ 276,700.00	$ 21,600.00
Waioli Corporation	30	$ 5,721,400.00	$ 164,000.00
other	1142	$ 357,681,100.00	$ 135,487,300.00
subtotal		**$ 519,871,035.00**	**$ 185,762,715.00**
TOTAL VALUES		**$ 2,062,878,135.00**	**$ 1,421,005,980.00**

References

County of Kaua‘i Hazard Mitigation website. http://www.mothernature-hawaii.com/county_kauai/county_kauai.htm 2007. Accessed 6/2009.

County of Kaua'i. 2000. County of Kaua'i General Plan. http://www.kauai.gov/Government/Departments/PlanningDepartment/TheKauaiGeneralPlan/tabid/130/Default.aspx 2007. Accessed 6/2009.

Flu Tracker (http://flutracker2.rhizalabs.com/cbi/snapshot/page?concept=~fd000a02514f427d6c114918049a5efc175eb4803e9d9cf73e9f).

Hawai'i State Department of Business, Economic Development and Tourism, Tourism Research Branch, *Annual Visitor Research Report* (annual) and records. See http://www.hawaii.gov/dbedt 2009. Accessed 6/2009.

Hawai'i State Hazard Mitigation Forum website. www.mothernature-hawaii.com 2007. Accessed 6/2009.