CHAPTER 5:
Risk and Vulnerability Assessment

5.0 Introduction to the Risk and Vulnerability Assessment

The local mitigation plan requires an overview and analysis of vulnerability, including identification of potential damage and loss. The purpose of conducting a risk and vulnerability assessment is to understand how potential hazards of various degrees and magnitudes might result in disaster. The process evaluates risk based on the probability and frequency of occurrence of the hazard event. It further considers the exposure of people and property to the hazard and consequences of the exposure. By factoring in sensitivity to the hazard determined by socioeconomic factors, it is possible to target mitigation actions that will reduce likelihood of disasters and their associated costs.

There are numerous methods that have emerged to evaluate risks, and these range from highly technical, statistical, quantitative assessments to simple, qualitative assessments. The best assessments would combine these methods, treating each hazard separately, as well as incorporating considerations for multiple and cumulative hazards occurrences into the overall assessment framework and methodology. Unfortunately, there are uneven methods for different hazards in determining economic losses and for the valuation of critical resources, such as water.

The County GIS technician updated the hazard layers that the county has, and then developed maps showing the assets at risk. A series of hazard models were also evaluated, and the information that could be used was incorporated into the geographic information system. The digital flood maps were updated in 2010 (FEMA Map Modernization Program/NFIP) and the tsunami evacuation maps were updated in 2014 (Kwok Fai Cheung et al with County). In addition, erosion maps were updated in 2010 (Fletcher et al. 2010), and then used in analyses of sea level rise published in 2014 (Sea Grant). The fire risk assessment was updated in 2015 (Hawaii Wildfire. The wind risk maps are used for assessing building design standards, and have not been released for integration with potential loss data, although we have improved understanding of wind risk. The project team gathered the best available data for each hazard. Spatial data was not available for every hazard. For those hazards with spatial data, the GIS technician linked the real property tax database and developed an aggregated listing of loss for the hazard.

The risk and vulnerability assessment 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. Primarily the method for assessment is GIS data for the County, however, this information is supplemented with economic forecasts and asset projections. 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, where there is still an emphasis on identifying adequate shelter space for the population, including visitors.

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 plan; 2) tables listing facilities for each sector cross-referenced by hazard in Chapter 5 Appendix C; and, 3) facilities from these tables in maps for each geographic area of Kaua`i, divided by sectors in Chapter 5 Appendix A, B, D, and E.

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 ($40 million), followed by flood ($3 million), erosion ($3 million), earthquakes ($0.2 million), tsunami ($0.3 million), and landslide/debris flow/rockfall ($0.5 million) (State of Hawaii Multi-Hazard Mitigation Plan, 2010).

Following the development of the Multi-Hazard Mitigation Strategy for Kaua‘i County (first plan, 2003), the NOAA Pacific Services Center worked with the county government to develop a web-based application of their GIS hazard layers and assets. County planners and managers use the system for permit evaluation to assess the risks of developing in particular locations. As the layers are updated through the Map Modernization program and Tsunami modeling, the data has been improved in the decision-making tool.

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. The results of wind risk analyses and HAZUS-MH models inform the vulnerability and loss data.

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.

In 2010, with the development of the State of Hawaii Multi-Hazard Mitigation Plan update, the planning team worked with Martin & Chock to conduct a structural risk and vulnerability assessment of state facilities that had value greater than $250,000. These data were gathered from the property values in the State of Hawaii Department of General Accounting Services (DAGS), and then included in a HAZUS model to assess loss from single event scenarios and from average annualized loss from all hazards, in order to aid the State in prioritizing facilities for retrofit, hardening, relocation, and other hazard mitigation measures.

For Kaua`i, there were only six of 275 state facilities included in the analysis. There were not significant findings for other hazards, but for hurricanes, which Kaua`i has experienced, the losses should be considered. The Lihue Airport was ranked 21 in the State, but this facility provides the gateway for visitors, and tourism is the primary economy for the County of Kaua`i. In addition, the airport has the highest runway in the Hawaiian Islands that would allow major aircraft to land during response and post-disaster scenarios where other islands may not be operational. For State redundancy in disaster and for the protection of livelihoods in Kaua`i, it may be important to invest in retrofits to the airport. Other retrofits will need to be weighed with the cost-benefit analysis and significance of the facility to the county functions, such as the Kaua`i Veterans' Memorial Hospital.

Table 5-1. Hurricane Probabilistic Scenario

Building Name	Estimated $ Loss	Est. % Loss	$ Loss Rank in the State	% Loss Rank in the State
Lihue Airport	$6,286,140	21.0%	21	165
Kaua`i Veterans' Memorial Hospital - Original	$2,279,633	14.7%	57	217
Port Allen Pier Shed - Warehouse	$1,502,135	34.3%	79	33
Lihue Public Library	$934,539	21.0%	114	165
Lihue Courthouse	$923,644	21.0%	118	165
Kaua`i Veterans' Memorial Hospital - Obstetrics	$231,513	14.7%	226	217

Source: State of Hawaii Hazard Mitigation Plan, 2010. State Structural Risk and Vulnerability Assessment.

As part of the building code update, the County worked with Martin & Chock to develop wind speed-up maps with contours of high wind risk, funded in 2009. This has been integrated into the current building codes, currently IBC 2006, and this will likely reduce further impacts of hurricanes for future building. An additional study was approved by FEMA, but had not been finalized when this 2015 Plan Update.

Although the Hurricane Iniki loss study was conducted for wind hazards, it gives some perspective on severe losses from extreme hazards and the event has been used as the basis for wind modeling in islands to project potential risks. If a Category 1 storm as strong as

Hurricane ʻIwa, 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 storm losses and damages in Hawaiʻi.

Table 5-2. Estimated Cost of Storms in Hawaiʻi ($ billion in 1992 when study was conducted).

	Oʻahu	**Maui**	**Hawaiʻi**	**Kaua`i**
ʻIwa-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 5-3. Estimated Cost of Storms in Hawaiʻi ($ billion inflated to 2015).

	Oʻahu	**Maui**	**Hawaiʻi**	**Kaua`i**
ʻIwa-Strength Storm	$ 7.2-11.99	$ 1.3-2.3	$ 1.3-2.3	$ 0.44-0.98
Iniki-Strength Storm	$22.24-37.28	$ 4.36-7.19	$ 4.14-6.976	$1.74-3.05

Source: Hawaii Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study with calculations updated by the University of Hawaiʻi, April 2015, based on a 9% inflation rate between 2008 and 2015.

Table 5-4. Damage Percentage to Residential Units by Storm and Classification

	Iniki	**ʻIwa**
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 5-5. Estimated Value of Damage per Unit (updated to 2015)

Destroyed	$333,254.86 (2013 average estimated value based on destruction of single family home)
Major damage	$61,217.64 (estimated amount used on American Red Cross street sheets)
Minor damage	$1,748.67 (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 Hawaiʻi:

Table 5-6. Count of Housing Units by County (based on 2013 statistics)

County	# Housing Units 2000 to 2013	% Change from 2000 to 2013
Honolulu	340,392	1.0
Maui	71,231	1.0
Hawai'i	84,445	2.6
Kaua`i	30,189	1.3
State	526,257	1.3

Source: 2013 Hawai'i State Data Book, Section 21, Table 21.20,

Table 5-7. Residential Asset Damage, By County and By Storm (in $ millions inflated to 2015)

	Iniki		'Iwa	
County	**Structures**	**Personal**	**Structures**	**Personal**
Honolulu	22.13	6.21	4.80	2.07
Maui	2.62	1.20	0.87	0.44
Hawaii	3.05	1.42	1.09	0.44
Kaua`i	1.20	0.05	0.44	0.11
TOTAL	28.99	9.37	7.19	3.27

Source: 2013 Hawai'i State Data Book, analysis from Hawai'i Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study, with calculations updated by the University of Hawai'i, April 2015.based on a 9% inflation rate between 2008 and 2015.

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 2015. These were applied to the count of visitor accommodations to estimate damage. The data has been updated with information from the 2013 State of Hawai'i Data Book.

Table 5-8. Visitor Accommodation Damage after an Iniki-Type Storm in 2015.

County	**Total**	**Units**	**Damaged**	**Units**	**Cost**
Honolulu	34,008	18,364	$2,217.06	859	$815.32
Maui	19,259	10,400	$1,255.68	392	$872.00
Hawai'i	11,247	6,074	$733.57	041	$782.62
Kaua`i	8,692	4,321	$521.02	797	$51.23
TOTAL	72,516	39,159	$4,729.51	091	$341.17

Source: Extrapolated from data in 2013 Visitor Plant Inventory, State of Hawaii Department of Business, Economic Development, and Tourism, 2013, http://hawaii.gov/dbedt/info/visitor-stats/visitor-plant/vpi2008.pdf, with analysis from Hawaii Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study, with calculations updated by the University of Hawai'i, April 2015.based on a 9% inflation rate between 2008 and 2015.

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 $23,784.97 in 2015. 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, then adjusted with the current inflation factor (159.6%) yields the estimated cost per customer of $120,910.06 (2015). These adjustments with an Iniki-strength storm would result in estimated public utility damage to the County of Kaua‘i of over $4 billion.

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 Kaua`i wind mapping was completed by Martin & Chock, Inc. in October 2008. As of 2015, these wind assessments have not been updated, although there is a project that is being implemented that will enable the County to adopt the IBC 2012 building codes. 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.

5.2.2 Potential Losses from Flooding

The State of Hawai'i had 144 properties on the Severe Repetitive Loss (SRL) 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 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 in 2009: City and County of Honolulu-21, County of Hawai'i-17, County of Maui-4, and **County of Kaua`i-1**. With the efforts of the State NFIP Coordinator working with FEMA and the county floodplain coordinators, the SRL properties in 2010 include: City and County of Honolulu-3; County of Hawai'i-4, with one pending; County of Maui-1; and, **County of Kaua'i-0**. Until 2015, there were no SRL properties in Kauai, and the county has been dealing with repetitive loss (RL) properties in order to secure a Community Assistance Visit (CAV), and as of communication with FEMA in January, the Department of Public Works reports one remaining RL property.

Kaua'i County participated 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 NFIP program has estimated that 10% of the amount of developed (urbanized) land is located in the 100 year floodplain in Kaua'i County.

In 2009, the Federal Emergency Management Agency conducted a flood insurance study for the County of Kaua`i.[1] The final documents appear in two volumes, approved November 26, 2010, but the Flood Insurance Rate Maps (FIRMs) been approved as a digital file--dFIRMs. 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.

The digital FlRMs were revised and reviewed in 2010 but awaited repairs on the levees before final approval. With assistance from the US Army Corps of Engineers, the levee repairs allowed Kaua`i to come into compliance with the NFIP program.

The County of Kaua`i has been submitting documentation to resolve the violations affecting properties violating permit rules that are listed in the CAV and the North shore field visit on an ongoing basis since the 2003 CAV was initiated, latest in 2014. DPW last responded to FEMA in a letter dated January 16, 2015 and listed four properties where the County of Kaua`i action is still required. DPW anticipates that by the end of 2015 only one property where County action is required will remain and that the CAV can be closed at that time. The best available

data on losses indicates that there was $2 million loss from damages, but the recent resolution of these issues results in a decrease in the estimate of potential survey losses.

Table 5-9. Potential Losses from Flooding.

Kauai 500 Year Flood Zone spatial analysis of intersected parcels	Totals
Number of Parcels	2601
Number Buildings	1849
Land Value	$584,847,200
Building Value	$679,089,400
Total value of parcels and buildings	$1,263,936,600

Kauai 100 Year Flood Zone spatial analysis of intersected parcels	Totals
Number of Parcels	4419
Number Buildings	4344
Land Value	$1,905,170,800
Building Value	$1,450,651,800
Total value of parcels and buildings	$3,355,822,600

Source: NFIP Program, digital Flood Insurance Rate Maps; Kaua'i County GIS program.[2]

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://state.hi.us/dlnr/drought/):

> Drought Information Statement National Weather Service Honolulu Hi 815 Am HST Thu May 8 2014 ...Severe Drought Finally Eliminated In The State Of Hawaii... Synopsis... The Last Area Of Severe Drought...Or The D2 Category In The U.S. Drought Monitor Map...Was Finally Eased To Moderate Drought...Or The D1 Category...For The Kualapuu Reservoir Service Area In West Molokai. This Downgrade Ended D2 Conditions That Had Been Present Continuously In Various Locations In The State Of Hawaii Since June 2008. There Are No Other Drought Areas In The State. Summary Of Impacts... Kaua`i...Oahu...Lanai...Maui And The Big Island. There Are No Drought Impacts To Report. However...Drier Than Average Conditions Mainly Along The Leeward Slopes In Recent Weeks Are Setting The Stage For A Quick Return Of Significant Drought Conditions (http://w1.weather.gov/data/HFO/DGTHFO)

[2] **Disclaimer:** The following data is based on the best available Kauai GIS data. This data is a continual work in progress and is not official for land boundary, ownership, or spatial information. If more precise boundary or spatial location is required an official land survey should be conducted. The County of Kauai Real Property Department should be contacted if precise ownership data is required. Every effort has been made to ensure that the information is as accurate as possible, although no warranty is specified or guaranteed, as to the completeness, accuracy or reliability of the map data. This map should not be used for official boundary interpretations or other spatial analysis beyond the limitations of the data and is intended to be used for planning or presentation purposes. Information is the sole responsibility of the user and data shall be used and relied upon only at the risk of user. Analysis based on the TMK Parcel GIS layer did not include CPRs. The current GIS TMK Parcel layer was created from over 600 disparate paper plat maps over a period of 5 years. These plat maps were originally created by many different entities and had a wide variance of accuracy. The resulting GIS layer that was created after joining these plat maps into a digital GIS "puzzle" consequentially created additional spatial accuracy variance.

In assessing the pre-2014 drought impacts in Hawai'i, resource managers considered better assessment methods to record losses as part of the drought impact evaluation. The best available data currently can be taken from records of the US Department of Agriculture Farm Service Agency (FSA http://www.fsa.usda.gov/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 loss data indicates drought assistance in place over time that can be used as the best available data for understanding risk and vulnerability to drought; however, the State Drought Manager did not get any reportable data for Kaua'i after 2005, likely due to shifts in plantation agriculture. FSA can only provide assistance on owned property, or properties that have leases more than 10 years. Most agriculture leases have a caveat that farmers can be evicted in 30 days, to allow for greater economic use of the property.

Table 5-10. Farm Service Agency Disaster Benefits Paid for Drought

Year	Kaua`i	Kaua`i	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

CDP = Crop Disaster Program

ECP = Emergency Conservation Program

LAP = Livestock Assistance Program

LCP = Livestock Compensation Program

NAP = Noninsured Crop Disaster Assistance Program

Table 5-11: Water Supply Sector Drought Risk Areas by County

Water Supply Sector			
County	**Drought Stage**		
	Moderate	**Severe**	**Extreme**
Hawai'i County	Kona, South Point	Kona, Kau	Kona, windslopes of Hamakua
Maui County	Kula, Kahului, Wailuku, Hana, Lahaina	Kula, Hana	Kula
Honolulu County	Central O'ahu (Mililani/Waipio)	Central O'ahu	Ewa, Haleiwa
Kaua'i County		Koloa, Anahola, Kapaa, Lihue, Poipu	Lihue, Poipu, Koloa region

Source: Drought Risk and Vulnerability Assessment and GIS Mapping Project, University of Hawaii prepared for DLNR Commission on Water Resources Management 2003. Updated 2010.

5.2.4 Potential Losses from Wildland Fires

Calculating actual costs from wildfires is difficult unless there are damages to property and structures in the agriculture and urban interfaces. The costs of impacts to water systems, wildlife, and ecosystem functions and services can be extraordinary and difficult to place monetary value on the long-term effects and impacts.

The ramifications of wildfire contribute to additional disaster threats. The wildfires erode topsoil. During periods of heavy rainfall, the burned areas erode, becoming mud flows, debris flows, and sedimentation in rivers and the ocean. Further impacts include stream bank destabilization, which could worsen impacts of heavy rainfall and lead to riparian flooding.

The Western State Fire Managers and other organizations are working on methods to address risk and vulnerability assessment and loss reduction. Even though they collect data for annual reporting, it still remains difficult to account for the losses from each fire, and to quantify the longer term costs and impacts.

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.

The Hawai‘i Wildfire Management Organization completed an analysis in 2013 and released the updated GIS layers in 2015 for the wildfire risk. This analysis has been appended to Chapter 5 Appendix E. The greatest risk occurs at the urban-wildland interface, with areas such as Kapa‘a with higher concentrations of homes and businesses at high risk.

Based on the recent analysis, the GIS manager was able to integrate data with the Real Property Tax data. The GIS maps for wildfire are located in Chapter 5 Appendix E. The following table shows the risk and potential losses for wildfires from three different scales of risk.

Table 5-12. Kaua'i Extreme, High, and Moderate Fire Risk.

Kaua'i Extreme Fire Risk 2013 spatial analysis of intersected parcels	Totals
Number of Parcels	737
Number Buildings	757
Land Value	$123,793,400
Building Value	$140,177,000
Total value of parcels and buildings	$263,970,400

Kaua'i High Fire Risk 2013 spatial analysis of intersected parcels	Totals
Number of Parcels	10624
Number Buildings	10625
Land Value	$2,282,318,000
Building Value	$2,875,625,200
Total value of parcels and buildings	$5,157,943,200

Kauai Moderate Fire Risk 2013 spatial analysis of intersected parcels	Totals
Number of Parcels	6078
Number Buildings	5950
Land Value	$1,288,746,200
Building Value	$1,706,797,400
Total value of parcels and buildings	$2,995,543,600

Source: Hawaii Wildfire Management Organization 2013, prepared by Kauai County GIS.[3]

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 Hurricanes '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, although the levels of decline in Kaua'i are far less concerning that in other parts of the state.

[3] **Disclaimer:** The following data is based on the best available Kauai GIS data. This data is a continual work in progress and is not official for land boundary, ownership, or spatial information. If more precise boundary or spatial location is required an official land survey should be conducted. The County of Kauai Real Property Department should be contacted if precise ownership data is required. Every effort has been made to ensure that the information is as accurate as possible, although no warranty is specified or guaranteed, as to the completeness, accuracy or reliability of the map data. This map should not be used for official boundary interpretations or other spatial analysis beyond the limitations of the data and is intended to be used for planning or presentation purposes. Information is the sole responsibility of the user and data shall be used and relied upon only at the risk of user. Analysis based on the TMK Parcel GIS layer did not include CPRs. The current GIS TMK Parcel layer was created from over 600 disparate paper plat maps over a period of 5 years. These plat maps were originally created by many different entities and had a wide variance of accuracy. The resulting GIS layer that was created after joining these plat maps into a digital GIS "puzzle" consequentially created additional spatial accuracy variance. Fire data was derived from Hawaii Wildfire Management Organization HWMO from their June 2013 update. Page 28 of their 38 page PDF was used to create 4 Fire Hazard layers for analysis.

Structural risk and vulnerability assessments for state critical facilities highlighted the high risk of the airports and harbor infrastructure. In the 2010 structural risk and vulnerability assessment (Martin & Chock in State of Hawai‘i Multi-Hazard Mitigation Plan 2010), damage from hurricanes (even 16% damage) to the Honolulu International Airport results in the greatest total damage costs ($320 million). The loss of Honolulu infrastructure will dramatically impact the neighboring islands---affecting food security and financial systems. Most of the airports have been located near the ocean and will be impacted by sea level rise, although the Līhu‘e Airport is the highest airport, and may provide a resource for the State, if, for example, operational support for response and recovery can be diverted to Kaua‘i. This would require further consideration of hardening the Līhu‘e Airport (potentially greater than $6 million loss from hurricanes). In addition, energy and fuel resources would need to be enhanced (proposed mitigation for an automatic switch for energy in Ch. 7) and jet fuel storage capacity needs to increase. Unfortunately, the port for fuel resources, Nawiliwili Harbor, is low-lying and subject to climate-related impacts. Relocating airports in places that have little land for developing is not necessarily an option. The cost of protection for these critical facilities will be millions of dollars.

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, Sea Grant developed a technical study for the County General Plan Update 2015 to consider the impact of long-term changes in sea levels on potential development in the County. The maps affecting communities under a range of scenarios has been included in Chapter 3 Appendix C.

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.

Based on the technical study prepared by UH Sea Grant for the Kaua‘i County General Plan Update, which is currently underway, they mapped scenarios for sea level rise to look at potential impacts on shoreline development. The GIS manager has integrated the scenarios of SLR with the Real Property Tax data to reveal the following potential losses in the following table.

Table 5-13. Potential Losses from SLR.

Kaua‘i Sea Level Rise 5 to 6 Feet spatial analysis of intersected parcels	Totals
Number of Parcels	2648
Number Buildings	2948
Land Value	$1,260,061,600
Building Value	$1,036,294,900
Total value of parcels and buildings	$2,296,356,500

Kaua'i Sea Level Rise 3 to 4 Feet spatial analysis of intersected parcels	Totals
Number of Parcels	1531
Number Buildings	1844
Land Value	$896,035,800
Building Value	$753,616,700
Total value of parcels and buildings	$1,649,652,500

Kaua'i Sea Level Rise 1 to 2 Feet spatial analysis of intersected parcels	Totals
Number of Parcels	931
Number Buildings	1406
Land Value	$700,818,900
Building Value	$618,274,700
Total value of parcels and buildings	$1,319,093,600

Source: UH Sea Grant 2014; Kauai County GIS program 2015.[4]

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 2005 Hawai'i 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 Hawai'i, $11.4 million on Maui, and $11.6 million on O'ahu (http://www.nehrp.gov/pdf/earthquake_hazards_hawaii.pdf). Statewide earthquake annualized loss ratios (ALR's) have been estimated at $1300/million of asset value---$4,400/million for Hawai'i, $1,500/million for Maui, and $263/million for O'ahu. The predominant contributor to loss is single-family residential construction (Hazard State Earthquake Advisory Committee from the Hawai'i Multihazard Science Advisory Council (MSAC) to the State Hazard Mitigation Forum, 2002). Kaua`i lies

[4] **Disclaimer:** The following data is based on the best available Kauai GIS data. This data is a continual work in progress and is not official for land boundary, ownership, or spatial information. If more precise boundary or spatial location is required an official land survey should be conducted. The County of Kauai Real Property Department should be contacted if precise ownership data is required. Every effort has been made to ensure that the information is as accurate as possible, although no warranty is specified or guaranteed, as to the completeness, accuracy or reliability of the map data. This map should not be used for official boundary interpretations or other spatial analysis beyond the limitations of the data and is intended to be used for planning or presentation purposes. Information is the sole responsibility of the user and data shall be used and relied upon only at the risk of user. Analysis based on the TMK Parcel GIS layer did not include CPRs. The current GIS TMK Parcel layer was created from over 600 disparate paper plat maps over a period of 5 years. These plat maps were originally created by many different entities and had a wide variance of accuracy. The resulting GIS layer that was created after joining these plat maps into a digital GIS "puzzle" consequentially created additional spatial accuracy variance.

in an area of reduced risk and was not considered in this study; however, should a severe earthquake threaten O'ahu, the County of Kaua'i 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. In addition, a local earthquake that generates a tsunami would greatly impact Kaua'i.

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.

Using the most recently adopted tsunami evacuation GIS layers, the Kaua'i County GIS manager integrated this data with the Real Property Tax database (proprietary to the County). The data is aggregated for the island, which is the best available analysis that he could conduct.

Table 5-14. Potential Losses from Tsunami.

Kauai Tsunami Zone spatial analysis of intersected parcels	Totals
Number of Parcels	5077
Number Buildings	5066
Land Value	$2,211,307,600
Building Value	$1,780,965,700
Total value of parcel and buildings	$3,992,273,300

GIS-Based Analysis of Community Exposure and Sensitivity

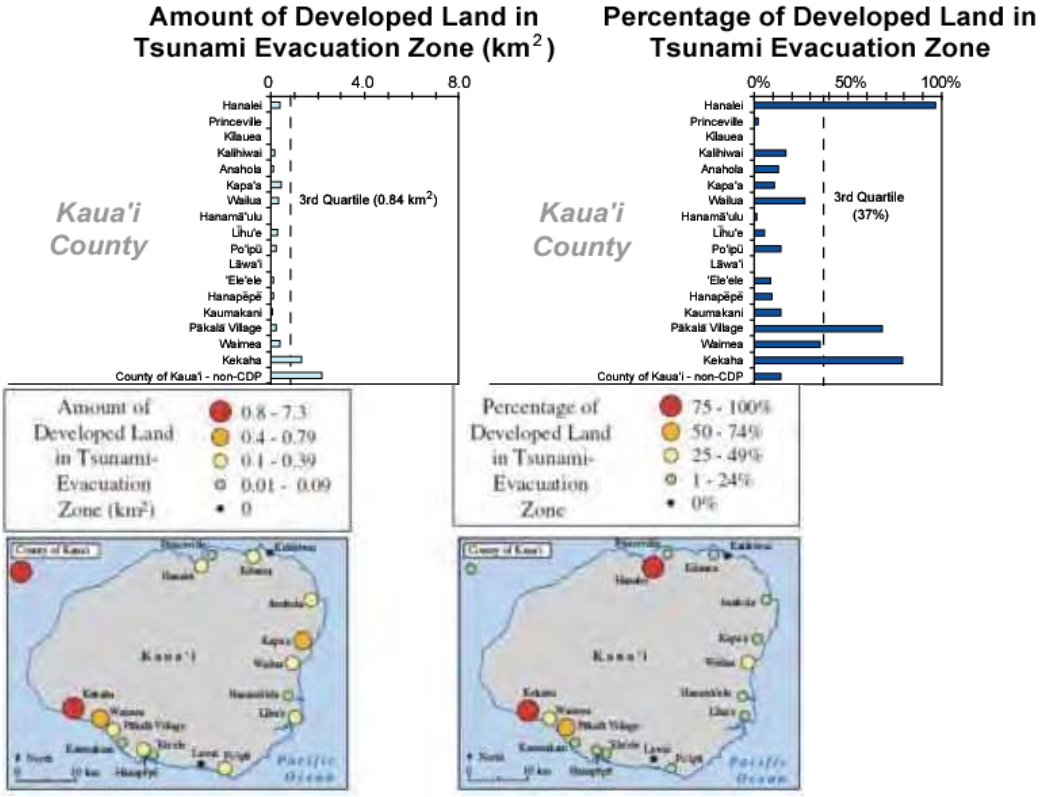
Research is needed that integrates tsunami hazard information with land cover, land use, population, and economic patterns to identify at-risk communities, regions and trade corridors. Risk of future tsunami disasters should be assessed based on projected local and regional changes in land use and population 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 blunt for more-detailed hazard and vulnerability assessments.

USGS published its first analyses of tsunami risk throughout the state in 2008 (Wood et al 2008). The study utilizes the State GIS layers, the evacuation zones, and it is integrated with a national employment database to get a more detailed assessment of risk. The study currently represents the best available data related to risk reduction related to tsunami, although the State has tried to find funding for reanalysis, but has not succeeded in obtaining funds to access the employment database (about $20K cost for single use). The evacuation maps have also been updated. Most of the point data has not changed significantly, and the 2008 analysis still

provides important information on risk and vulnerability. The updated Kaua'i County GIS mapping with the new hazard layers also provides information on vulnerability (see critical facilities at risk in Chapter 3 Appendix A and Chapter 5 Appendix C). This information could also be used to inform risk assessments related to coastal storm inundation and coastal flooding.

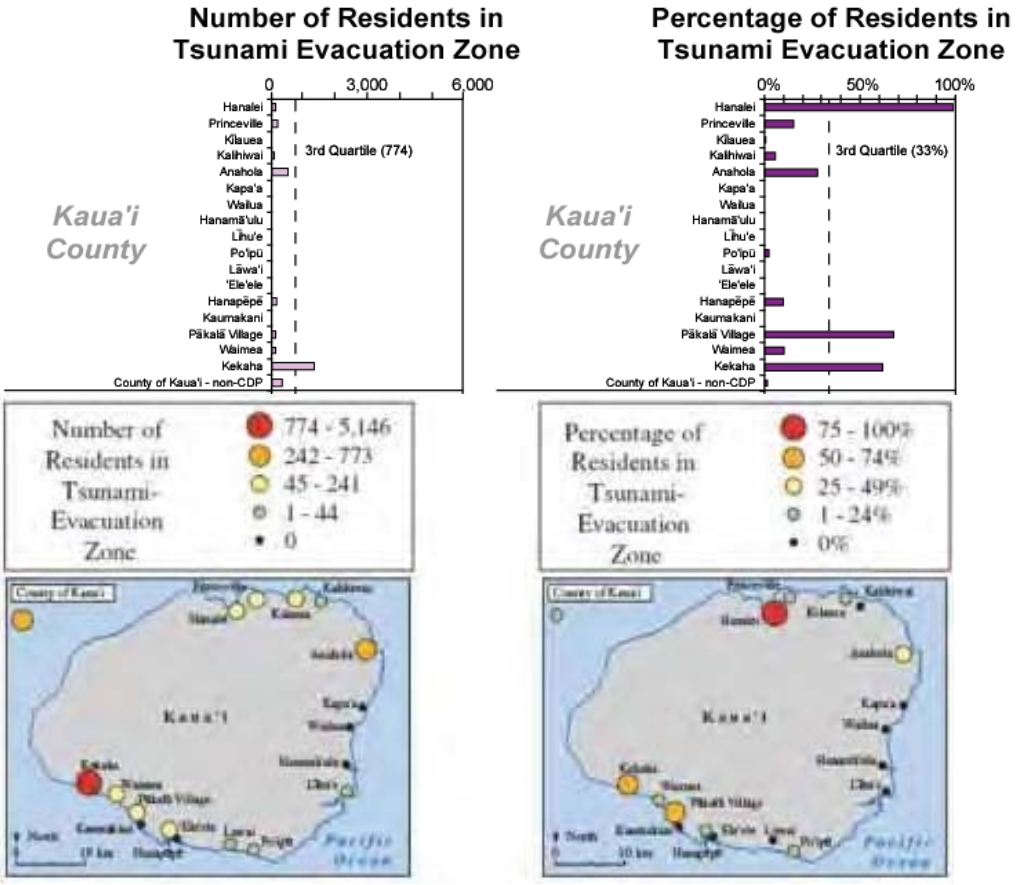
The USGS tsunami study considers population using Census data. Population statistics include data disaggregated by gender, age, race, households, employees, single mothers, dependent populations, public venues and hotels. The rationale is that the locations of populations during a tsunami affect their 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. With the revised evacuation maps implemented in 2013, the risk could be greater.

Figure 5-2. Land Vulnerability to Tsunami.



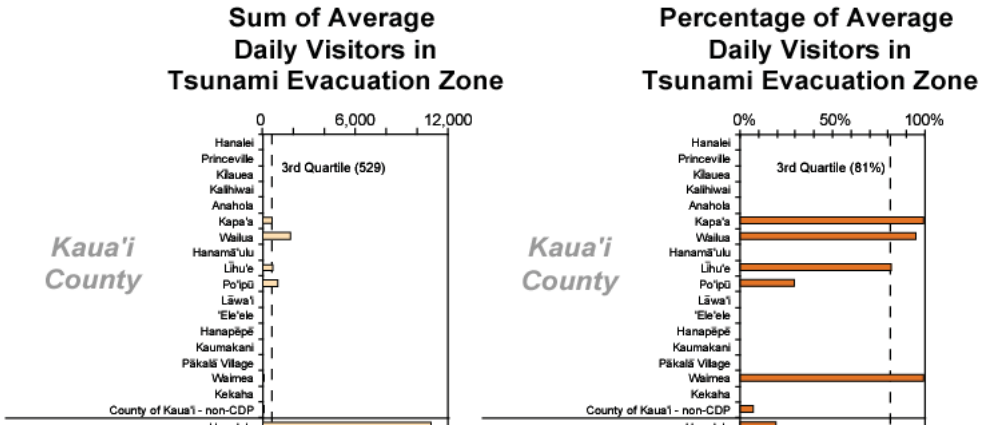
Source: Wood et al 2008.

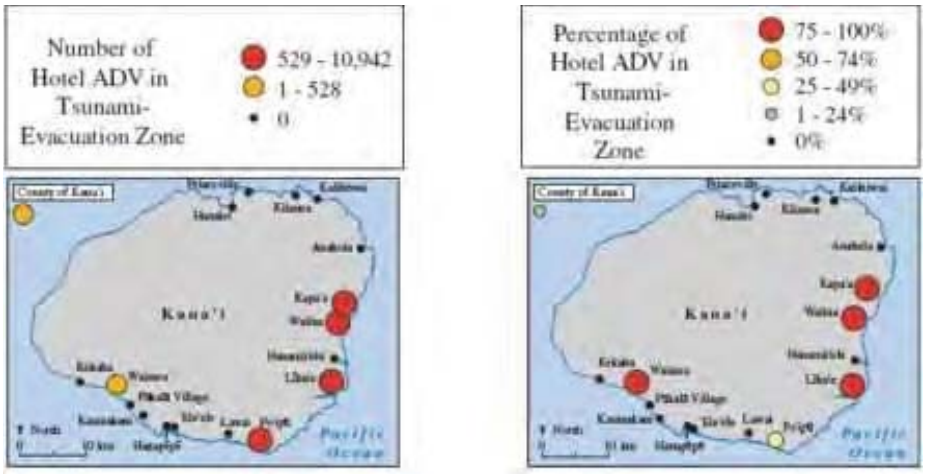
Figure 5-3. Population Vulnerability to Tsunami.



Source: Wood et al 2008.

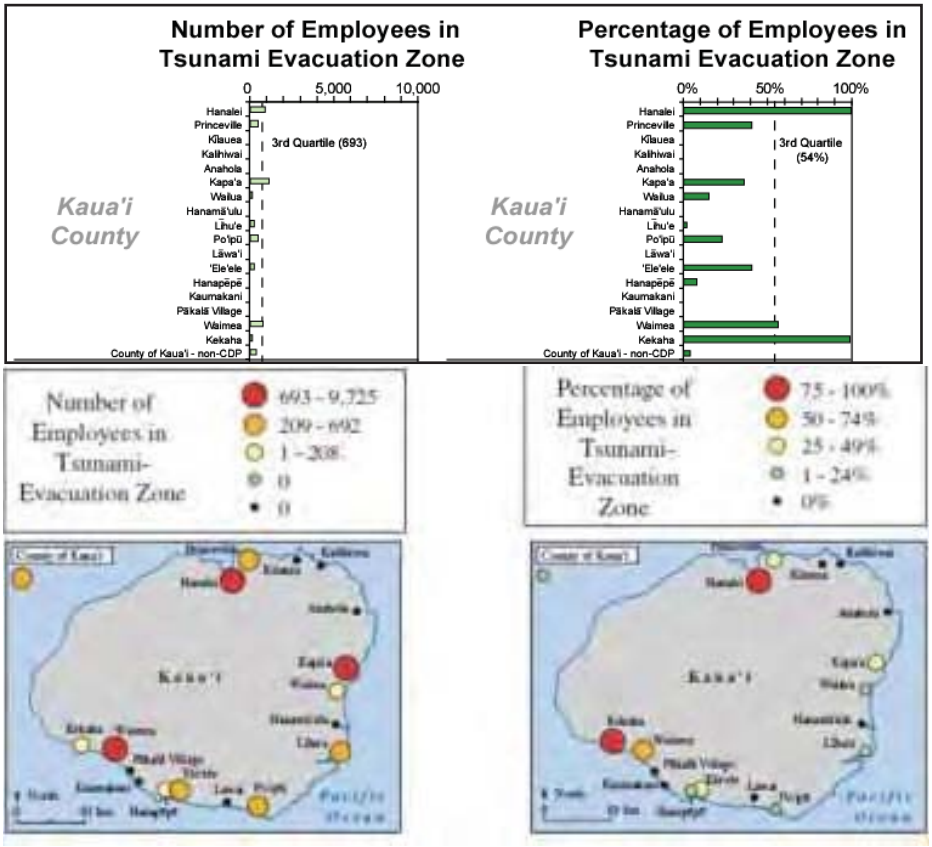
Figure 5-4. Tourism Industry and Visitors at Risk.





Source: Wood et al 2008.

Figure 5-5. Employees at Risk from Tsunami.

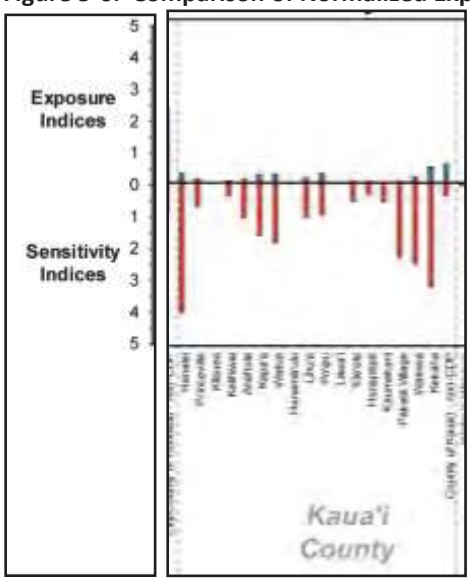


Source: Wood et al 2008.

After examining land use, visitor, population, and economic risk from employment, the analysis combines these factors to produce an analysis of exposure and sensitivity. The exposure refers to the area and extent of the potential tsunami, or the evacuation layer. The sensitivity refers to all of the assets and resources located in this area. As seen below in Figure 5-6, the exposure in Kauai County is relatively small, however the majority of the economic, critical infrastructure, residential population, visitors, and other assets lie in this small area, resulting in high levels of sensitivity, especially for Hanalei, Kekaha, Waimea, Kapa'a and other coastal areas. The North Shore

Community Resilience Plan (2014), as well as the tsunami warning and evacuation system implemented in 2014 consider these vulnerabilities in trying to address economic and other impacts to the County.

Figure 5-6. Comparison of Normalized Exposure and Sensitivity Indices.



The summary of tsunami risk identified in the USGS study (Wood et al. 2008) shows that:

- 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 has the greatest percentage of their developed land in the tsunami evacuation zone, at almost 98% (Wood et al).
- 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 often stay in Hanalei, Kōloa, Kapa'a, Wailua, Līhu'e, and Waimea in areas where 81-100% of the visitors in these places stay 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.
- 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.
- Hanalei, Hā`ena and Kekaha appear among the most sensitive areas for tsunami risk due to greater inundation runup and height, exacerbated by one-lane bridges, and coastal

highways at risk to coastal inundation and landsides which make vertical evacuation extremely problematic.

Critical to effective planning for evacuation and disaster response and recovery, is the need for improved data on housing types, updated status of the use of housing and occupancy rates, particularly in more rural communities.

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 need to 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. The loss estimation has not been calculated for dams. The State has worked on dam breach scenarios for 11 dams in the State, with seven in Kaua'i, and continues to update the assessment with levels of risk in the database provided to the public (see DLNR Dam Safety Program, updated 2014, (http://132.160.239.52/daminventory/). The risk analysis results are located in Chapter 3 Appendix F.

5.2.9 Potential Losses from Health-related Hazards

Health risks may increase with the occurrence of natural and human-induced disasters.

The State of Hawai`i Health Risk and Vulnerability Assessment (HRVA), conducted in 2014 by the Hawai`i State Department of Health Public Health Preparedness Program, provides a synopsis of core public health issues for disaster planning consideration (DOH HRVA, 2014). Direct health impacts may include "death, illness, and injury caused by physical effects of the disaster" whereas "indirect post-disaster impacts may include injury, illness or death, related to debris or unstable structures hazardous material exposure, poor sanitation, polluted water; reduced access to preventive and chronic health care; limited access to food and potable water, among others" (DOH HRVA, 2014).

Due to Hawai'i being a popular international destination, there is an ongoing threat of the introduction and spread of communicable diseases, including: avian influenza (bird flu) H5N1 viruses, which can be spread from infected wild birds to domesticated birds, and to humans, with few human-to-human transmission cases reported in the region; and, 2) swine flu H1N1

viruses, of which Hawai`i has had outbreaks in the past (DOH HRVA). Bioterrorism attacks, the intentional release of harmful agents such as viruses and bacteria to incite illness or death with various transmission methods including through air, water, food and person-to-person contact, also pose important risks to the safety and security of the State (DOH HRVA). 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, Hawai'i experienced significant declines in tourism to Hawai'i because of the fear of flying. In 2009, there was an outbreak of H1N1 at a school on O`ahu, with 16 individuals infected, none resulting in hospitalization or death (http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5851a3.htm) but there have been no oubreaks on Kaua`i to date.

By June 2009, there was a statewide outbreak of H1N1 swine flu, with two cases on Kaua'i (http://archives.starbulletin.com/content/20090611_state_swine_flu_tally_adds_first_Kaua`i_cases), and one case on Oahu resulting in an individual's death. The H1N1 influenza has thus far resulted in thousands of incidents globally, but less than 10 confirmed cases in Kaua`i County, according to the Flu Tracker (http://www.cdc.gov/flu/weekly/fluactivitysurv.htm).

Identification, containment and treatment of pandemic outbreaks and cases of bioterrorism are further complicated by the highly transient nature of the tens of thousands of daily visitors, the State's isolation, and the associated delay in importing the necessary medical supplies, medicines and resources.

In addition, because Hawai'i has a tropical climate, and is at risk to impacts from climate change like warming temperatures, the State could experience bacterial disease proliferation, such as leptospirosis caused by the genus Leptospira, which is present in freshwater streams and bodies of water throughout the islands (DOH HRVA). There is also the potential increase in the incidence of vector-borne diseases, such as dengue fever, which is transmitted locally through the mosquito Aedes albopictus. Efforts to address the dengue outbreak in 2001-2002 in Hawai'i (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). With 4 individuals infected on Kaua`i and 199 statewide (http://www.nytimes.com/2002/05/12/us/outbreak-of-dengue-fever-is-declared-over-in-hawaii.html), 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.

Special populations have additional needs that must be understood in relation to hazard and climate change-related impacts. Post-disaster health-related impacts may include: limited access to chronic care and mental health services; mental health and post-traumatic stress disorders associated with disasters amongst residents and first responders (5); access to

housing for homeless persons, and; access to transportation services for persons with functional and access needs.

There will be increased vulnerability from populations already at risk, including 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, and thus hazard mitigation planning must integrate such measures into the scope.

The HRVA also provides an analysis of residual health risks under three disaster scenarios: hurricane, tsunami and flood. Residual risk indices were calculated for human impacts, community impacts, and impacts to various core public health functions and infrastructure. The HRVA results showed that risk and subsequent gaps in preparedness and response capacity were highest for hurricane and tsunami (equal score), followed by flood. It took almost a decade for tourism to rebound on Kaua`i after Hurricane Iniki. Scares of infectious disease and pandemic flu could collapse the economy. Thus, efforts to include risk and vulnerability for health-related disasters need to be incorporated into risk reduction efforts.

5.3 Potential Loss and Impacts for Kaua‘i Landowners for Non-Spatial Risk

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. While many of the buildings are at risk to high winds and topographic speed-up effects, Kauai County does not have a good loss layer of the damages to property and buildings. The analyses conducted by Martin & Chock showed increased wind speed factors for topographic effects, as discussed. Even with the adoption and implementation of the new codes, there are no certainties. Therefore, the priority of the DMC 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, 5-15, provides an estimate of the aggregate value for land and buildings in Kaua‘i. As in the appendix, the following tables were organized into the geographic areas of the island using data from the real property tax database for the County of Kaua`i. These values can be used to estimate losses from disaster impacts on land and facilities that are not included previously in the analysis for wind, drought, erosion (although this is part of the sea level rise analysis), climate variability and change (multiple impacts), earthquake, and dam failure. Po'ipū and Kōloa have the highest values for buildings, and many of these are part of the tourism industry, which is the primary economic driver for the County. The property values for the land in Līhu‘e are greatest, and this is likely because of the land use for government and critical infrastructure, such as the main hospital, port, and airport.

Table 5-15. 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	$27,137,152.00	$16,274,975.00
E.A. Knudsen Trust (Koloa)	9	$36,948,156.00	$470,560.00
Gay & Robinson	43	$49,760,704.00	$81,905,120.00
Govt. County of Kaua`i	10	$12,076,484.00	$13,965,425.00
Govt. Federal	5	$26,790,820.00	$1,771,520.00
Govt. State	99	$1,370,362,812.00	$30,729,125.00
Govt. State Department of Hawaiian Homelands (DHHL)	70	$54,164,936.00	$32,441,825.00
Govt. State HHA	4	$4,341,736.00	$63,089,640.00
Hawaii Conference Foundation (United Church of Christ)	1	$1,745,548.00	$187,705.00
Kikiaola Land	7	$58,196,796.00	$28,269,930.00
Roman Catholic Church	5	$15,014,664.00	$3,750,640.00

other	886	$655,885,972.00	$496,572,280.00
subtotal		**$2,312,425,780.00**	**$769,428,745.00**
Hanapēpē			
Alexander & Baldwin	31	$62,389,236.00	$20,699,450.00
Gay & Robinson	3	$37,324.00	$ -
Govt. County of Kaua`i	5	$1,812,384.00	$ -
Govt. Federal	2	$2,114,448.00	$ -
Govt. State	121	$285,751,676.00	$29,010,370.00
Hawaii Conference Foundation (United Church of Christ)	1	$882,756.00	$153,970.00
Robinson Family	9	$46,012,680.00	$86,674,730.00
subtotal		**$399,000,504.00**	**$136,538,520.00**
Po'ipū and Kōloa			
Alexander & Baldwin	41	$999,887,392.00	$33,485,880.00
E.A. Knudsen Trust	62	$435,220,408.00	$493,452,225.00
Govt. County of Kaua`i	25	$58,543,128.00	$763,795.00
Govt. State	35	$50,079,260.00	$53,630.00
Grove Farm	15	$128,913,624.00	$57,785,460.00
Nat'l Trop. Bot. Garden	7	$25,435,004.00	$7,031,585.00
Takanaka Corporation	1	$38,541,804.00	$113,647,160.00
other	572	$2,342,561,872.00	$3,503,835,302.25
subtotal		**$4,079,182,492.00**	**$4,210,055,037.25**
Līhu'e			
Līhu'e Land Company	57	$317,576,028.00	$184,506,230.00
Govt. County of Kaua`i	16	$29,952,944.00	$6,222,810.00
Govt. Federal	15	$63,338,828.00	$238,740.00
Govt. State	37	$2,476,780,712.00	$17,053,475.00
Grove Farm	6	$12,104,260.00	$294,965.00
J.T. Waterhouse	4	$28,984,256.00	$4,376,900.00
Kaua`i Lagoons	2	$136,151,008.00	$156,164,505.00
Roman Catholic Church	2	$2,216,872.00	$3,126,110.00
W.H. Rice	15	$23,609,600.00	$1,303,555.00
other	371	$1,145,634,462.00	$3,189,587,160.00
subtotal		**$4,120,125,184.00**	**$3,562,874,450.00**
Kapa'a			
Līhu'e Land Company	1	$645,792.00	$ -
Bette Midler	9	$1,367,100.00	$ -
Govt. County of Kaua`i	25	$33,726,140.00	$3,043,935.00
Govt. Federal	1	$899,248.00	$ -
Govt. State	240	$324,007,908.00	$39,808,165.00
Govt. State Department of Hawaiian Homelands (DHHL)	65	$128,541,252.00	$7,969,245.00

Hawaii Conference Foundation (United Church of Christ)	1	$1,599,724.00	$1,739,515.00
Kamehameha Schools	4	$147,560.00	$ -
Keālia Plantation	20	$78,456,784.00	$1,778,440.00
W.H. Rice	1	$24,304.00	$ -
other	1087	$1,913,151,856.00	$1,951,618,190.00
subtotal		**$2,482,567,668.00**	**$2,005,957,490.00**
Hanalei			
Lihue Land Company	7	$36,367,768.00	$1,874,584.75
Alexander & Baldwin power plant	1	$3,965,024.00	$355,515.00
Govt. County of Kaua`i	16	$165,775,848.00	$756,875.00
Govt. Federal	24	$368,892,188.00	$1,013,780.00
Govt. State	40	$122,484,348.00	$14,922,980.00
Hawaii Conf. Foundation	1	$3,476,340.00	$593,390.00
Kamehameha Schools	19	$79,083,480.00	$ -
Kikiaola Land	1	$29,619,632.00	$750,820.00
Magoon Estate	1	$564,200.00	$ -
Nat'l Tropical Botanical Garden	2	$12,266,576.00	$ -
Pflueger	8	$203,165,816.00	$ -
Princeville Dev.	21	$315,236,768.00	$412,200,180.00
Robinson L&H	5	$14,847,140.00	$808,775.00
Roman Catholic Church	1	$2,401,756.00	$186,840.00
Waioli Corporation	30	$49,661,752.00	$1,418,600.00
other	1142	$3,104,671,948.00	$1,171,965,145.00
subtotal		**$4,512,480,584.00**	**$ 185,762,715.00**
TOTAL VALUES		**$17,905,782,212.00**	**$12,291,701,727.00**

Source: Data from the Kaua`i County Real Property Tax Database Kaua`i County GIS Program, and State of Hawaii Databook 2013.

The University of Hawai‘i Multi-Hazard Mitigation Plan (2010 data) analyzed the structural risk and vulnerability of the Kaua‘i Community College (KCC) campus, detailed in Table 5-X. The study provided average annualized loss ($125,627) and potential loss data from high winds. KCC is an important resource for the County. It not only provides an educational resource, but it has participated in disaster risk reduction activities with the County, providing sheltering for the community during Hurricane Iniki, and ensuring the safety of students on the campus.

Table 5-16. List of most vulnerable/highest risk buildings at Kaua'i CC

Kauai CC - Building Vulnerability List		Total Number of Campus Buildings =		49
		1000-year Hurricane Event Vulnerability		
	Building	Modeled Building $ Loss	$ Loss Risk Percentile	Loss of Functionality (Num. of Days)
High Dollar Losses	KAUAI CC-LRC/ADMIN	$ 3,180,076	**>95%**	158
	KAUAI CC-CAMPUS CENTER BLDG	$ 2,460,428	**>95%**	130
	KAUAI CC-THEATER	$ 2,343,360	**90-95%**	105
	KAUAI CC-ELECTRONIC TECH	$ 1,849,763	**90-95%**	105
	KAUAI CC-NURSING/BUS EDUCATION	$ 1,262,318	85-90%	158
	KAUAI CC-NATURAL SCIENCE BLDG	$ 1,095,069	85-90%	130
High Loss of Functionality	KAUAI CC-SOCIAL SCIENCE	$ 558,699	70-75%	239
	KAUAI CC-FACULTY BLDG#1	$ 243,949	60-70%	239
	KAUAI CC-WELDING SHOP#2	$ 198,675	60-70%	239
	KAUAI CC-MACHINE SHOP	$ 847,647	75-80%	198
	KAUAI CC-CARPENTRY SHOP	$ 1,201,316	85-90%	173

References

DBEDT. 2013. Hawaii State Data Book 2013. Department of Business, Economic Development & Tourism; Research & Economic Analysis. http://dbedt.hawaii.gov/economic/databook/db2013/ Accessed February 2015.

DOH. 2014. State of Hawai`i Health Risk and Vulnerability Assessment (HRVA). Hawai`i State Department of Health Public Health Preparedness Program. July 2014.

Fletcher III, Charles H., E. Grossman, B. Richmond, A.E. Gibbs. 2002. Atlas of Natural Hazards in the Hawaiian Coastal Zone. US Department of the Interior US Geological Survey. CD-ROM. http://geopubs.wr.usgs.gov/I-map/i2761/

Fletcher, C.H., Romine, B.M., Genz, A.S., Barbee, M.M., Dyer, Matthew, Anderson, T.R., Lim, S.C., Vitousek, Sean, Bochicchio, Christopher, and Richmond, B.M. 2012. National assessment of shoreline change: Historical shoreline change in the Hawaiian Islands: U.S. Geological Survey Open-File Report 2011–1051, 55 p. (Also available at http://pubs.usgs.gov/of/2011/1051.)

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte, 2013: Online Rainfall Atlas of Hawai'i. *Bull. Amer. Meteor. Soc.* 94, 313-316, doi: 10.1175/BAMS-D-11-00228.1.

Hawaii Wildfire Management Organization. 2013. Kauai Wildfire Hazard: An Assessment of 36 Factors that Contribute to Wildfire Hazard. Honolulu: Kauai Fire Department and the Department of Land & Natural Resources Division of Forestry and Wildlife (DOFAW).

IPCC. 2014. Summary for Policymakers. From: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1–30, doi:10.1017/CBO9781107415324.004.

Kaua`i Drought Committee, DLNR. 2004. County of Kaua`i Drought Mitigation Strategies. Kaua`i Drought Committee and State of Hawai`i Department of Land and Natural Resources Commission on Water Resource Management. *Prepared by:* Wilson Okamoto Corporation. October 2004.

Kaua'i General Plan Update Technical Study. 2014, June. Kaua`i Climate Change Assessment. University of Hawai'i Sea Grant College Program. http://seagrant.soest.Hawai`i.edu/sites/default/files/publications/web-8-18-14-kc3ha-final.pdf.

State of Hawaii, 2010. "State Structural Risk and Vulnerability Assessment" conducted by Martin & Chock in State of Hawaii Hazard Mitigation Plan, 2010 Update.

University of Hawaii Social Science Research Institute and Martin & Chock. 2010. Structural Risk and Vulnerability Assessment for Kauai Community College. In UH Multi-Hazard Mitigation Plan.

Wood, N., Church, A., Frazier, T., and Yarnal, B. 2008. Variations in community exposure and sensitivity to tsunami hazards in the State of Hawaii. Reston, Virginia: U.S. Geological Survey, Scientific Investigative Report 2007-5208, 38pg.