CC 19-23

MICHAEL P. VICTORINO
Mayor

SANANDA K. BAZ
Managing Director

COUNTY OF MAUI
OFFICE OF THE MAYOR
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

December 30, 2022

Honorable Michael P. Victorino, Mayor
County of Maui
200 South High Street
Wailuku, Hawaii, 96793

APPROVED FOR TRANSMITTAL

Mayor 12/30/22 Date

For Transmittal to:

Honorable Alice L. Lee, Chair
and Members of the Maui County Council
200 South High Street
Wailuku, Hawaii, 96793

Dear Chair Lee and Members:

SUBJECT: **COUNTY OF MAUI VULNERABILITY ASSESMENT**

The Office of Climate Change, Resiliency, and Sustainability, under the Office of the Mayor, is pleased to share The County of Maui Vulnerability Assessment for your reference.

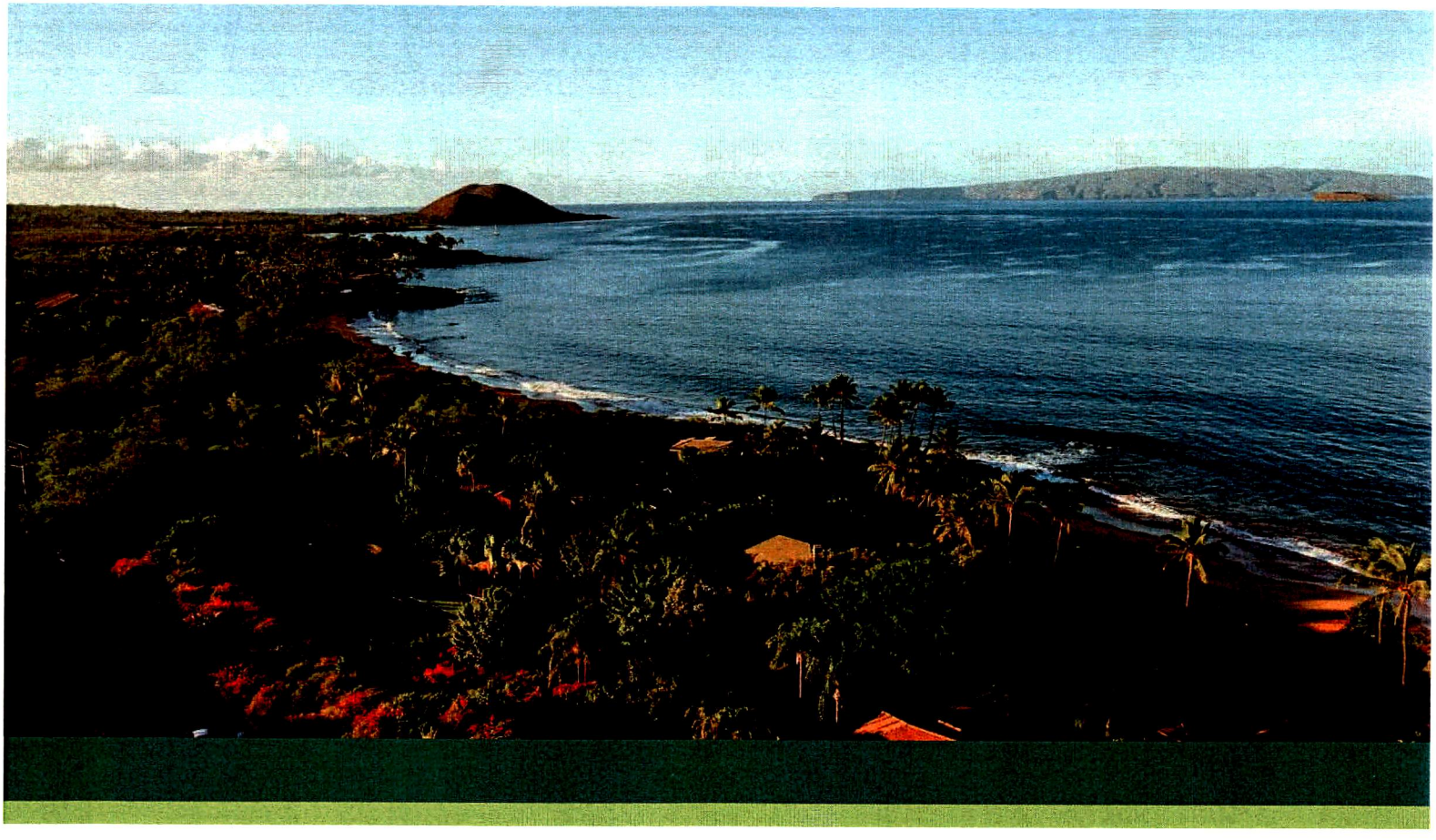
This assessment has been co-created alongside community members, our Climate Action and Resiliency Plan Advisory Committee, and the County of Maui's Resiliency Hui. This assessment helped shape the resiliency strategies and actions identified in the Draft Climate Action and Resiliency Plan.

Should you have any questions, please contact our office (808) 270-7855.

Sincerely,

Hannah Shipman
Green Building and Resilient Housing Specialist

Attachments



MAUI COUNTY CLIMATE CHANGE VULNERABILITY ASSESSMENT

December 2022

Prepared by the Geos Institute for the Office of Climate Change, Resiliency, and Sustainability (CCRS) County of Maui

Resilient MAUI NUI

GEOS INSTITUTE

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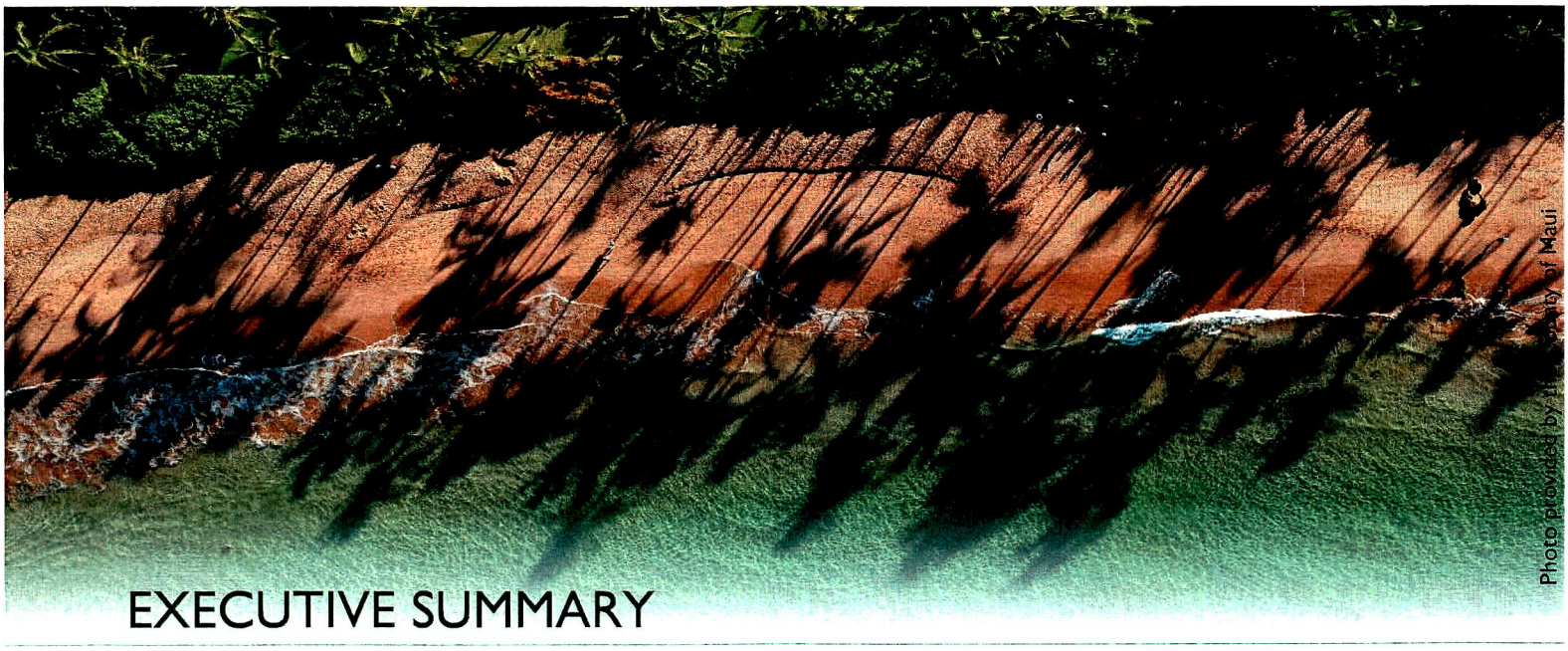


EXECUTIVE SUMMARY

Climate change poses significant and immediate threats to the people, communities, and natural systems of Maui County.

Residents of Maui County are closely linked to the natural environment due to its remote location, rooted culture, and unique environmental beauty. As climate change progresses and impacts become more severe, both people and nature will continue to be affected.

Climate change impacts, such as sea level rise, severe heat, and loss of marine and terrestrial species, have already and could continue to change the essential physical, demographic, and cultural characteristics of the community. In order to address the accelerating impacts of climate change, the County of Maui is developing strategies to curtail impacts and increase environmental and community resilience. As an initial step in this process, the Office of Climate Change, Resiliency, and Sustainability (CCRS) under Office of the Mayor led the dev elopement of this vulnerability assessment to provide information about which resources and populations in Maui County are most vulnerable to climate impacts. This overview of Maui County's climate change-driven vulnerabilities is based on the best available climate change science, local expertise and knowledge, and local community and stakeholder input.

Climate change is a global phenomenon with significant local impacts. It is often referred to as a threat multiplier since the increase severity of existing challenges often leads to the creation of new challenges. If global carbon emissions are not aggressively reduced, Maui County is expected to experience the following changes:

Projected Trends for Maui County	Mid-century (2050s)	Late-century (2080s)
Average temperature[5]	↑ +2 to +6°F	↑ +3 to +9°F
Number of days with extreme heat[9]	↑↑	↑↑↑
Percent change in wet season precipitation[7]	↓ −15%	↓ −23%
Percent change in dry season precipitation[7]	↓ −37%	↓ −52%
Drought severity and frequency[3,9]	↑	↑↑
Frequency of heavy rains and flooding	↑	↑↑
Northeasterly tradewinds[10]	↓↓	↓↓↓
Sea level rise (global average)[2]	↑ ~1 foot	↑ 2 to 3 feet
Ocean temperature (global average)[16]	—	↑ +5°F by 2100
Frequency of coral bleaching events[16]	↑ yearly	—
Declines in ocean fishery productivity[16]	↓ −15%	↓ −50%

The County of Maui's next step is to work with our local community to develop new and additional strategies for resilience across all sectors of our community, as well as to strengthen and enhance existing resilience strategies already being implemented within our community. The resilience strategies that are identified in this report will help to inform the Maui County Climate Action and Resilience Plan (CARP).

The success of this process depends on continued engagement with and input from the residents of Maui County to ensure that the needs of the community and the natural environment are addressed.

Information contained in this assessment came from many local sources, including the Climate Action and Resilience Plan Advisory Committee (CARPAC), the County of Maui's Resiliency Hui, and local community members through online public surveys, a cross-sector stakeholder workshop, public talk story sessions for the communities of Lāna'i, East Maui, and Molokai, and one-on-one interviews with key subject matter experts.

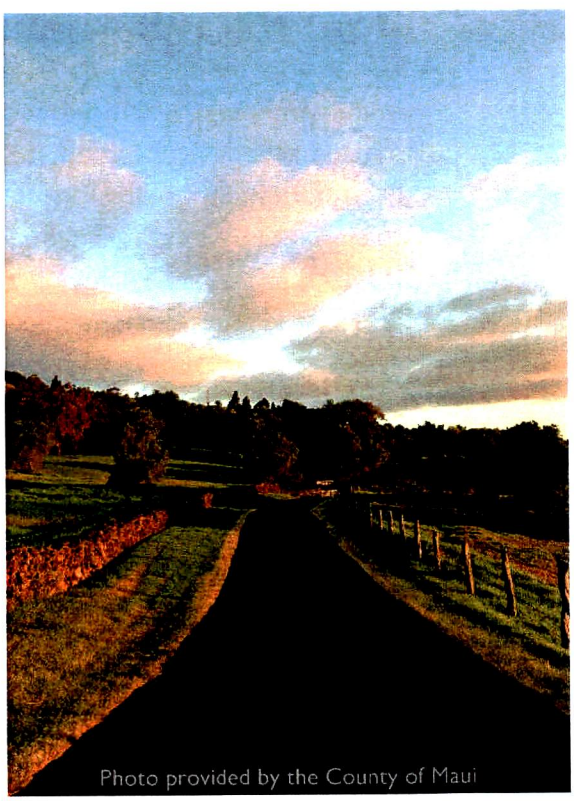


Photo provided by the County of Maui

Climate Change Vulnerabilities Across Maui County

(in community prioritized order)[1]

ʻāina (land), wai (fresh water), kai (ocean waters), and lewa (air)

- Loss of coral reefs due to warming waters, acidification, siltation, pollution, and invasive species
- Declines in native forest and alpine habitats due to warming temperatures, changes in precipitation, invasive species, drought, and wildfire
- Harm to shoreline habitats due to sea level rise and coastal flooding, inundation, and erosion
- Harm to watersheds due to invasive species, pathogens, and erosion
- Impacts to groundwater, seeps, springs, and freshwater wetlands due to larger storms and drought
- Threats to native and endangered species, especially keystone species, due to all climate change-driven hazards
- Harm to muliwai (estuaries) and tidal wetlands due to inundation
- Increase in landslides and erosion along steep slopes due to larger storms, drought, wildfire, and invasive species
- Impacts to anchialine pools (enclosed water bodies with an underground connection to the ocean) due to sea level rise and invasive species
- Impacts to seabirds and their habitats due to warming temperatures, invasive species, and climate change-driven habitat disruption

Cultural

- Loss of Native Hawaiian cultural practices, culture, and spirituality due to all climate change-driven hazards
- Loss of culturally important sites and customs due to sea level rise, coastal flooding, and severe storms
- Risks to food gathering and food production due to all climate change-driven hazards
- Subsistence fishing at risk due to acidification, sedimentation, and warming water

[1] For the sake of organization, specific risks are placed into categories. However, there is significant connectivity and overlap among these classifications. All systems are closely intertwined and interrelated, with natural systems at the center. This is especially the case for island communities.

- Displacement of Kānaka Maoli (Native Hawaiian) and destruction of resources leading to possible loss of identity due to all climate change-driven hazards
- Out migration displacing kama'āina and breaking family bonds due to all climate change-driven hazards
- In-migration due to climate-driven disruptions in other geographies furthers cultural divide
- Inundation of historical coastal graveyards and potential exposure of iwi kupuna (ancestral remains)
- Loss of easy-going, outdoor oriented, island way of life due to warming temperatures and economic burdens
- Loss of housing for multi-generational families and low-wage workers due to climate induced impacts.

Human Health

- Decrease in food access and food security due to drought, wildfires, and invasive species
- Increase in the overall cost of living due to all climate change-driven hazards
- Loss of power, water, and communication services during emergencies due to all climate change-driven hazards
- Negative health impacts due to extreme heat, changes in trade winds, and wildfire
- Negative mental health impacts due to all climate change-driven hazards
- Public safety and evacuation challenges due to larger storms, coastal flooding, wildfire, landslides, and extreme heat
- Increasing pests and diseases due to warming temperatures and larger storms
- Social service providers and emergency response overwhelmed due to all climate change-driven hazards
- Greater difficulty recruiting health care workers due to all climate change-driven hazards

Staff Sgt. Lonnie Wiram, US National Guard / CC BY 2.0

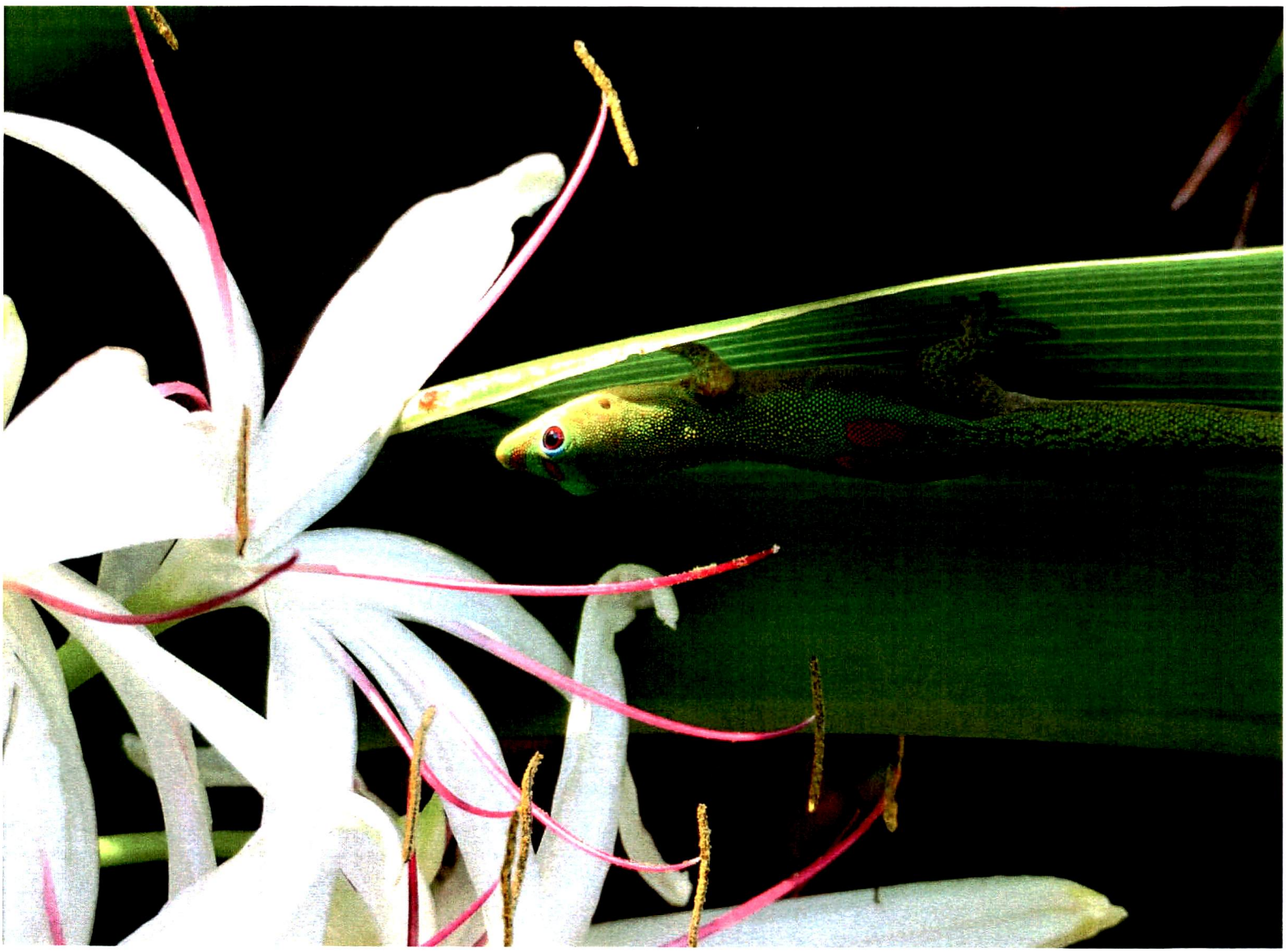
Infrastructure

- Damage to coastal roads due to larger storms, coastal flooding, erosion, and sea level rise
- Damage to drainage, reservoir, and other infrastructure due to inadequate stormwater systems in the event of larger storms
- Increased disruption of critical supply chains, including delayed barge shipments, increased fuel costs, and potential harbor damage due to all climate change-driven hazards
- Negative impacts to water supply and water infrastructure due to drought, wildfire, and larger storms
- Reduction in or damage to groundwater supply due to drought and larger storms
- Increased risk of electrical service disruption in isolated communities due to larger storms, flooding, landslides
- Buildings at risk due to all climate change-driven hazards
- Damage to park facilities and restricted beach access due to sea level rise, coastal erosion, and larger storms
- Increased damage to infrastructure due to wildfire
- Increased damage to large and small harbors due to sea level rise and larger storms
- Increased damage to utilities due to larger storms with higher winds
- Increased risk of brownouts due to higher temperatures and extreme heat
- Increased damage to electric, water, and wastewater infrastructure due to larger storms and inland flooding

Economy

- Increased risks to agriculture due to drought, increasing salinity, warmer temperatures, invasive species, and larger storms
- Government budgets stressed from cost of climate adaptation and responding to more frequent and severe disruptions due to all climate change-driven hazards
- Household and individual economics harmed by loss of subsistence lifestyles and resources due to all climate change-driven hazards
- Financial strain to service workers, especially in tourism, from employment interruptions due to all climate change-driven hazards
- Freshwater supply challenges due to less precipitation, larger storms, and higher temperatures
- Coastal businesses and resorts threatened by sea level rise and flooding

- Economic harm due to loss of coral reefs and other marine life
- Commercial operations at risk of economic shocks due to larger storms, floods, wildfires, and landslides
- Economic harm to agriculture, tourism, and businesses due to wildfire
- Goals of creating walkable, economically vibrant places increasingly difficult to meet due to all climate change-driven hazards
- Harm to local fisheries due to warming water and acidification



INTRODUCTION

Maui County encompasses four islands of the Hawaiian archipelago, Maui, Molokai, Lāna'i, and Kaho'olawe. The County has a strong sense of community, vibrant towns, spectacular coastal and natural areas, and active cultural practices and connections. Residents of Maui County are closely linked to the natural environment due to its remote location and historical cultural practices. As climate change progresses and impacts become more severe, both people and nature will continue to be affected.

Change has been occurring across the islands for millennia, yet climate change presents an unprecedented risk. It affects the basic qualities that define the communities of Maui County. Maintaining Maui County's character, culture, and integrity of natural systems are top priorities.

Many of the most severe impacts can be avoided if communities around the globe reduce greenhouse gas emissions quickly and aggressively.

Maui County has already experienced changes in temperature, trade winds, severe heat, drought, and sea level. As changes in the climate continue, it is expected that the severity and frequency of severe storms, storm surge, drought, wildfire, and heat waves will increase. In addition to affecting Maui County residents, these impacts will significantly affect the natural resources and species of the islands, many of which are already experiencing significant declines.

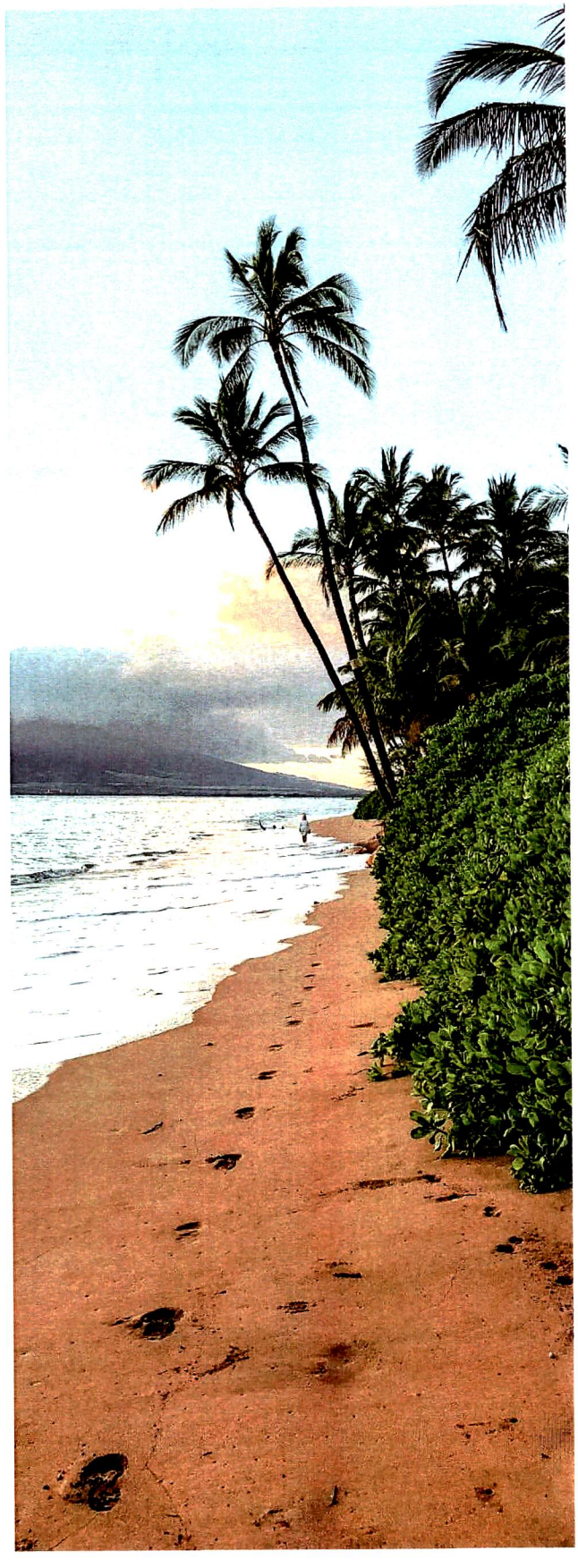
While climate change is already underway, many of the most severe impacts can be avoided if communities across the globe reduce greenhouse gas emissions quickly and aggressively. Cities and counties around the nation, including local government and community partners in Maui County, are working to reduce emissions and prevent warming greater than 1.5° C (2.7° F). This level of warming has been recognized by the international scientific community as an important threshold, below which catastrophic climate change can be avoided.

In addition to reducing greenhouse gas emissions, communities must respond to the changes already underway and plan for those yet to come. Because greenhouse gasses remain in the atmosphere for decades after release, communities across the globe will experience impacts for decades to come due to the volume of greenhouse gasses already in the atmosphere.

The work to build climate resilience takes place within the context of what is already happening in Maui County in terms of social and economic change. Rapidly rising housing, energy, food, and water costs make it difficult for many residents, particularly low-wage workers, to remain in Maui County. Post-pandemic pressure on the housing market from remote workers is likely to exacerbate the ongoing gentrification trend in Hawai'i (Lyte, 2021).

This vulnerability assessment provides information about how Maui County is already being affected by climate change and how it is expected to be affected in the future. In addition, it explores which populations and resources are most at risk. This information will serve as the foundation for developing robust resiliency strategies to protect the people, natural systems, and cultural heritage of Maui County from climate change impacts.

These resiliency strategies will inform the Climate Action and Resiliency Plan (CARP) under development by the County of Maui's Office of Climate Change, Resiliency, and Sustainability (CCRS). The CARP will address both climate adaptation (responding to and preparing for climate impacts) and climate mitigation (reducing greenhouse gas emissions)



METHODS

Whole Community Resilience

Climate change affects all people and natural resources throughout a community; thus, it is important to develop strategies that work across multiple sectors, create multiple benefits, and build new partnerships. Whole Community Resilience is a framework that ensures collaborative and cohesive solutions to climate impacts. Without consideration of resilience across all community systems, many impacts are simply shifted from one population or sector to another. Those who are already most vulnerable often bear the brunt of these impacts.

Whole Community solutions to climate change work collaboratively across five major systems:

- **Natural Systems (ʻāina, wai, kai, and lewa)**
- **Cultural Systems** (native and local people, practices, resources, and knowledge)
- **Human Health Systems** (healthcare, emergency response and preparedness, education, social services, etc.)
- **Built Environment** (buildings, roads, bridges, water distribution, sewage infrastructure, energy and communications utilities, etc.)
- **Economic Systems** (tourism, business, industry, farming, etc.)

Stakeholder Workshop

Vulnerabilities to the five major systems in Maui County were assessed during a virtual workshop split across two half-day sessions on March 22 and 24, 2022. This workshop involved CARPAC members, County of Maui Resiliency Hui members, and other local stakeholders from a variety of community sectors.

Stakeholders were asked to consider scientific information on climate change and identify impacts already underway or expected to affect people and resources in the

future. These current and future impacts were ranked by their potential impact to Maui County, their timeframe, and their existing capacity to respond. They were then prioritized within the five major community systems across Maui County.

For each identified impact to the community, the following information was collected:

- **Exposure** – The specific climate trend or projection that is already causing or is expected to cause the impact
- **Timeframe** – When the impact is expected to occur in Maui County
    - Near-term = current to 2030s
    - Mid-term = 2040s to 2060s
    - Long-term = 2070s to 2090s and beyond
- **Sensitivity** (High, Medium, or Low)- Given our understanding of the specific sector for each given impact, how much of a response or how great of an impact is expected (e.g. how disruptive is it, how serious are the consequences, and how much overall change is expected?)
- **Adaptive Capacity** (High, Medium, or Low) – To what extent there are already existing resources, programs, or policies in place to protect people or to respond to the changes with little disruption
- **Focal Populations** – The specific neighborhoods, populations, areas, or categories of resources or people that are expected to be especially affected by the impact, as well as any that are expected to be buffered due to special circumstances
- **Other Stressors** – Additional and ongoing stressors to the populations or resources to be affected
- **Secondary Vulnerabilities** – Other potential responses to or effects related to climate change that are likely to affect the impact under consideration

Once specific impacts to the community were assessed, they were ranked based on their relative level of vulnerability. Impacts expected in the near-term with high sensitivity and low adaptive capacity were classified as **high vulnerability** (e.g., increasing risk of wildfire to lives and homes). Those expected to occur over longer time frames, with lower sensitivity and/or higher adaptive capacity, were classified as **low or medium vulnerability** (e.g. changes in natural systems leading to degraded environmental conditions). All impacts identified in this vulnerability assessment are important to address, but some actions are more urgent than others, which is reflected in the rankings.

Community Engagement

In order to identify and communicate community concerns during the stakeholder workshop, a public survey was conducted to reach a large cross-section of Maui County's population. This survey included information about likely future climate change impacts and asked respondents to provide input on how life is likely to change and to identify some of the greatest risks across Maui County. The survey was distributed electronically through the County of Maui's online Climate Action Through Engagement (ClimATE) hub (www.resilientmauinui.org) in February 2022, and 475 residents completed it ahead of the stakeholder workshop.

Their responses were used to pre-populate the list of potential climate vulnerabilities in the sector-based breakout groups. Additional outreach in the form of personal interviews with County staff, subject matter experts, and community leaders was conducted to leverage community-based networks in order to reach community members who do not typically engage in local government planning. This ensured that participants in the stakeholder workshop considered potential climate vulnerabilities of concern to the larger community. See the survey response report in Appendix 1 for more details.

In addition to the survey, public talk story sessions were held for Molokaʻi, Lānaʻi, and East Maui with the assistance of local partners. These events were designed to help the County of Maui better understand how more remote communities are experiencing climate change in ways that are different than in Maui County overall. The draft of this report was reviewed and feedback was incorporated from the CARPAC and the Maui County Resiliency Hui.

Photo provided by the County of Maui

CLIMATE CHANGE TRENDS

Global Climate Change

Human-caused greenhouse gas emissions have been significantly influencing the global climate for over 140 years. As the quantity and rate of emissions have increased, it has become increasingly clear that our climate is changing quickly with global repercussions. Current levels of CO_2 in the atmosphere (over 420ppm) have not been experienced since the Pliocene era (3-5 million years ago), when seas were between 5-25 feet higher than they are today and temperatures were, on average, 5-7° F degrees warmer (EPA Office of Atmospheric Programs, Climate Change Division, 2012; NOAA, 2022).

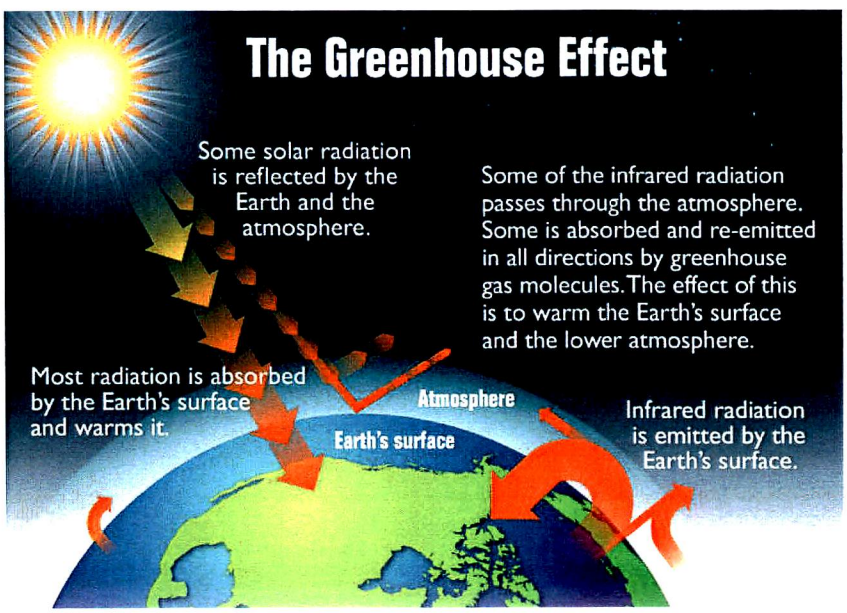


Figure 1. A diagram showing the Earth's greenhouse effect. Created by the US EPA.

Maui County Climate Change

Maui County's vibrancy stems from its culture, rich history, abundant natural resources, and ideal climate. Changes linked to human-caused climate change have already occurred (Fig. 2) and are accelerating over time (Fig. 3).

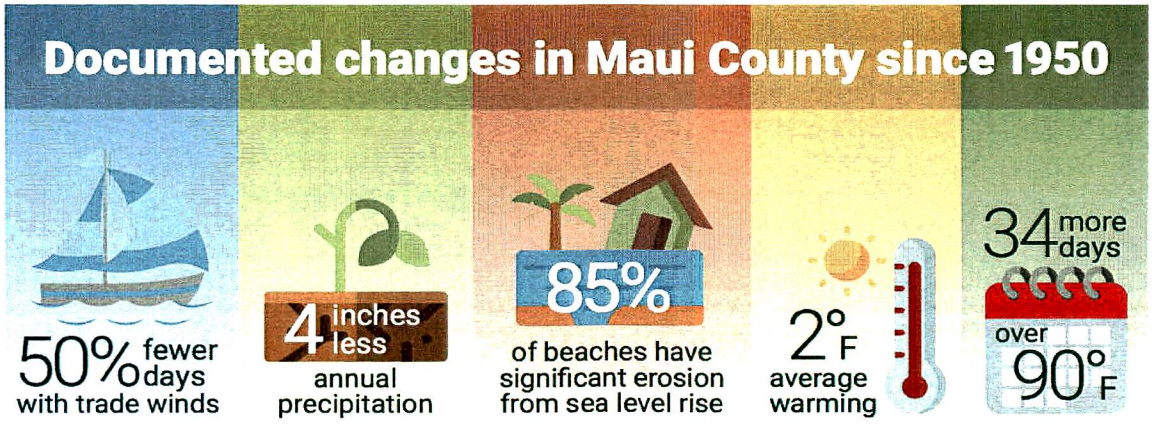


Figure 2. Changes have been documented across Maui County since 1950. Data from the Kahului Weather Station show overall warming, increasingly frequent days of severe heat, less precipitation, fewer days with northeasterly trade winds (Garza et al., 2012), and coastal erosion (*State of Hawai'i Sea Level Rise Viewer | PacIOOS*, n.d.).

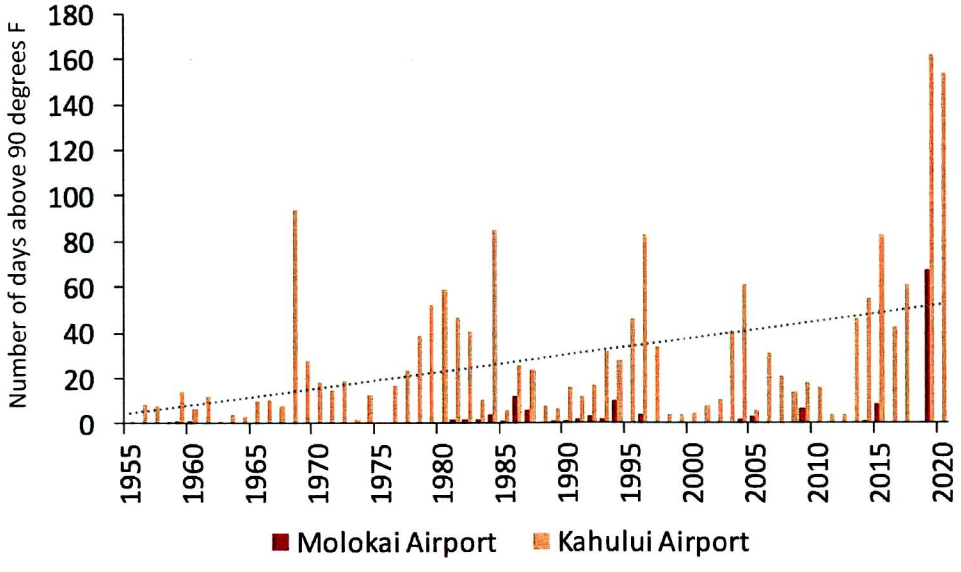


Figure 3. Weather data from Maui County airports show recent spikes in the number of very hot days.

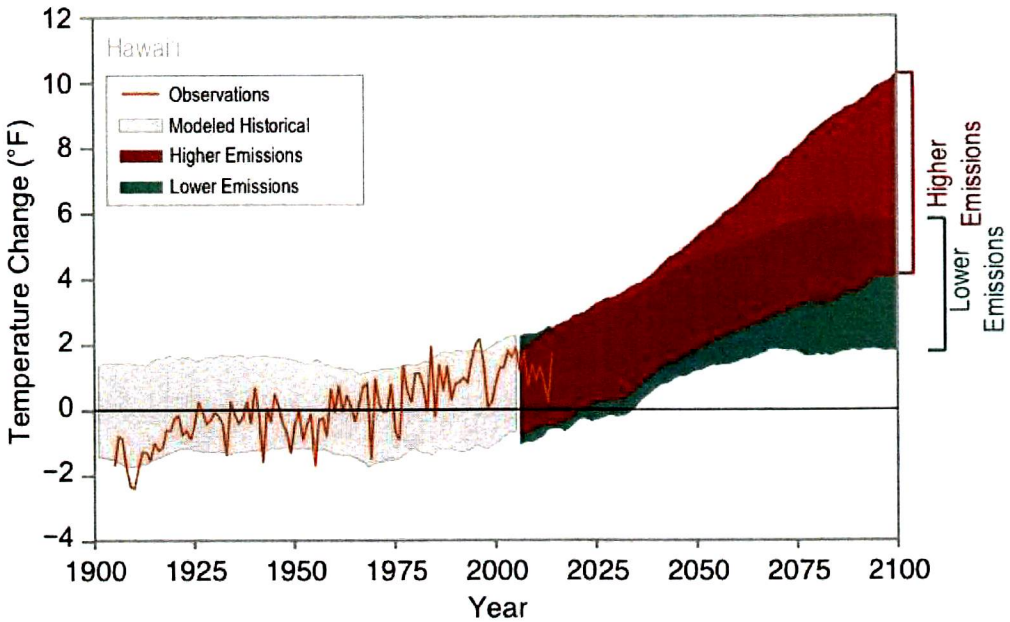


Figure 4. Observed and projected change in average temperature in Hawai'i (above), compared to the historical average from 1951-1980. Source: CICS-NC and NOAA NCEI.

The rate and magnitude of climate impacts depend on whether the global community collectively reduces greenhouse gas emissions, thereby limiting warming in Hawai'i to 1-4°F (Fig. 4). If emissions are not reduced, warming could reach 10°F by 2100 and continue to increase.

Changes to Maui County, including Maui, Moloka'i, Lāna'i, and Kaho'olawe, are expected to be increasingly significant across all parts of the islands. Climate change is expected to create more extremes – higher temperatures and more severe drought, as well as larger and more damaging storms (Chu et al., 2010; Hayhoe et al., 2018). El Niño events, which bring drought to the islands, could become more common (Wang et al., 2019). Some areas are more vulnerable than others, especially to impacts of sea level rise, storm surge, and erosion.

Projected Trends for Maui County	Mid-century (2050s)	Late-century (2080s)
Average temperature[5]	↑ +2 to +6°F	↑ +3 to +9°F
Number of days with extreme heat[9]	↑↑	↑↑↑
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Ocean temperature (global average)[16]	—	↑ +5°F by 2100
Frequency of coral bleaching events[16]	↑ yearly	—
Declines in ocean fishery productivity[16]	↓ −15%	↓ −50%

Figure 5. Projected trends for Maui County (Geos Institute & Sustainable Pacific, 2022).

CLIMATE CHANGE VULNERABILITIES

Many resources that residents are reliant on, including plentiful water, fisheries, coral reefs, wetlands, and high elevation forests are at risk. Marine organisms requiring carbonate for shells will be affected by ocean acidification (Keener et al., 2018). Native forest birds and plants are expected to be affected by drought, wildfire, and expanding mosquito range. Native Hawaiian cultural knowledge and heritage are also at risk from more severe storms and inundation, as are community systems and economies across Maui County. Vulnerabilities are identified below by community system.[2]

Natural Systems: ʻāina, wai, kai, and lewa

From its first inhabitants to the present day, the worship and protection of natural systems has been embedded in Hawaiian culture. Natural resources are intrinsically limited on the islands and are largely recognized as bounded and precious. Kapu (a system of governmental & religious regulations) was established through mindful observation and communal interdependence to ensure that resources are sustainably managed over long timescales.

Delicate island ecosystems are easily disrupted by invasive species and non-regenerative practices. The arrival of Europeans in 1778 and the influx of new residents has led to damaging land use practices, the results of which are still present today.

[2] These categorical distinctions are used only as a tool to organize climate impacts in this report. As the process moves from impacts to solutions in the next steps of the planning process, it will re-integrate across systems in a more holistic fashion.

In 2018, the Hawaiian Islands Climate Vulnerability and Adaptation Synthesis for Maui County (Gregg, 2018) ranked Maui's natural systems by their overall vulnerability to climate change based on exposure, sensitivity, and adaptive capacity. This assessment revealed that most habitats and services are moderately to highly vulnerable. The most vulnerable habitats and services included:

- **Coastal beaches** (due to erosion and inundation)
- **Anchialine pools** (due to salinity and water depth changes)
- **Dry forest** (due to changes in precipitation and soil moisture)
- **Cultural knowledge and heritage** (due to the potential loss of native ecosystems and species, and inundation of cultural sites)
- **Flood and erosion control** (due to flash floods, drought, and wildfire)
- **Freshwater supply** (due to more drought, changing precipitation, and sea level rise).

Existing stressors to natural systems, such as invasive species, the spread of disease, and development, have been greatly exacerbated by climate impacts (Eversole & Andrews, 2014). In the future, responses by residents and government to changing climate conditions may also exacerbate the challenges to natural systems unless the impacts of those actions are considered within the context of local and household decision-making processes.

Some of the most notable risks associated with climate change include the following:

▶ Loss of coral reefs due to warming waters, acidification, siltation, and invasive species

Hawai'i's coral reefs are a vital resource for residents and visitors. The risks from climate change are many. The delicate and productive coral reefs of Maui County are susceptible to warming waters, acidification, sedimentation, and damage from invasive species of algae. Erosion of upland areas is impacted by wildfire, invasive species, and increasingly large precipitation events, which results in sediment runoff into coastal areas that can smother the reefs. In some areas, loi (taro patches) have traditionally mediated the impact of sediment on reefs by trapping much of it before it reaches the ocean (Koshiba et al., 2013), but many have been replaced with development, and the remaining loi will continue to be impacted by changing climate conditions. These are in addition to existing threats from pollution (herbicides and pesticides from commercial/ residential operations and agriculture, nutrient loading from cesspools, injection wells, septic systems, erosion, and dumping), overuse, overexploitation, and damage from watercraft. Plantation farming has increased the sediment staged in watersheds, which is deposited on reefs during large precipitation events that cause surface flooding.

Some populations most impacted by coral reef decline include communities that rely on reefs for subsistence, cultural and historical practices, the tourism industry, the surfing industry, and shorefront properties and coastal infrastructure that depend on reefs for protection from storm surge. These risks affect the entire County, although some areas are threatened more than others. Reducing pollution, erosion, and sedimentation will be vital to maintaining coral reefs, even as ocean temperatures and acidity continue to rise.

Oceans have absorbed approximately 1/3 of global CO2 emissions since the industrial revolution, corresponding to a 26% increase in acidity.

Increased ocean acidity leads to a lack of available carbonate for corals and shells. This can disrupt corals, phytoplankton, lobsters, clams, and a variety of other species. (Keener et al., 2018)

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

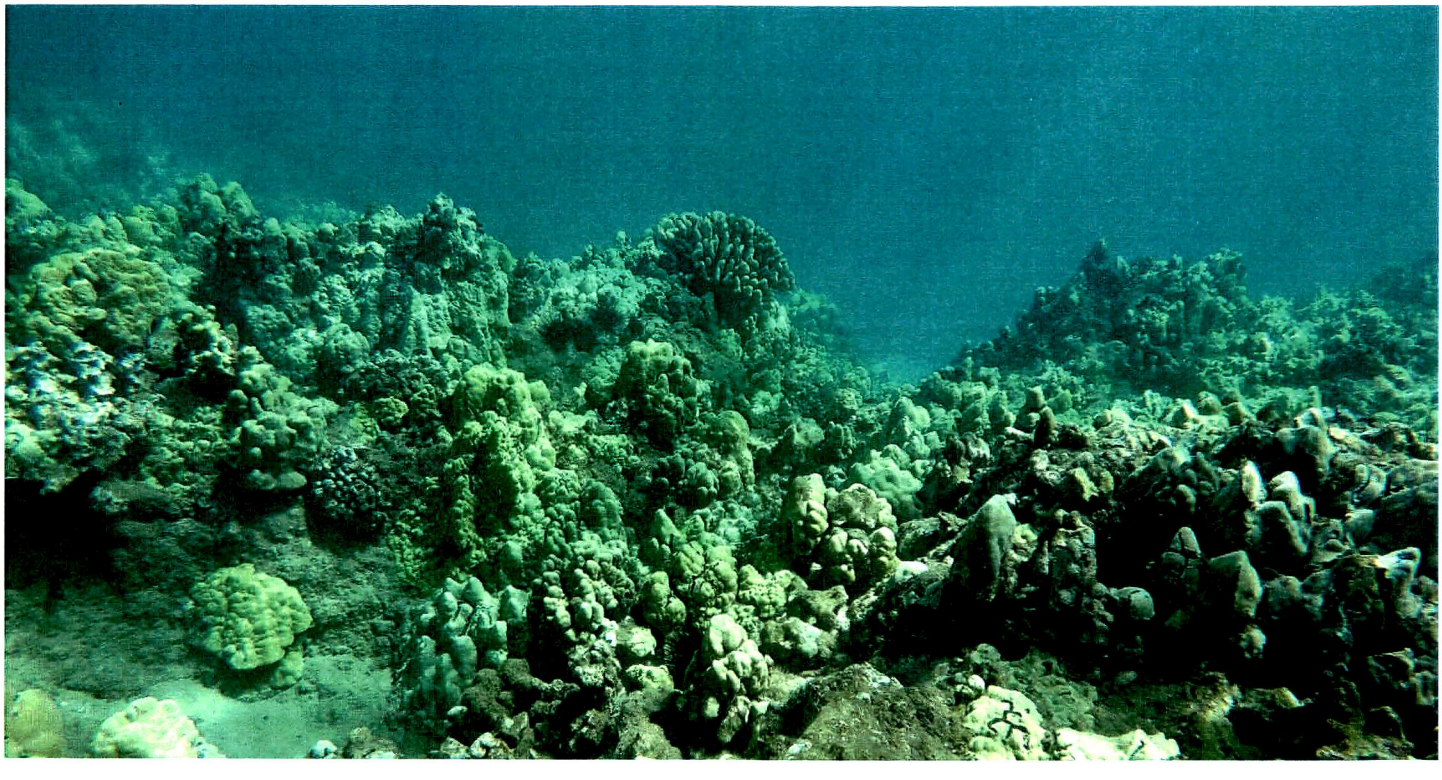


Photo provided by the County of Maui

► Declines in native forest and high elevation habitats due to warming temperatures, changes in precipitation, invasive species, drought, and wildfire

Maui is home to several microclimates, including desert, rainforest, and mountainous. Wet, dry, mesic, and subalpine forests and high elevation habitats were all identified as at-risk to climate impacts. Native forests are already heavily impacted by invasive species and development. There are few remaining dryland forests in Maui County, and those are struggling from impacts such as being overtaken by kikuyu grass used for

pasture and increasing erosion and wildfire risk (Kodama, 2021)[3]. Changes in precipitation, increases in wildfires, and loss of soil moisture are expected to further degrade and stress these important yet increasingly rare habitats. High elevation plants (such as the Haleakalā silversword), found only at higher elevations, are especially sensitive to changes in temperature and precipitation (Berio Fortini et al., 2022).

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Harm to beach and shoreline habitats due to sea level rise and coastal flooding, inundation, and erosion

Coastal habitats are expected to feel the pressure between existing development and sea level rise. Some developed coastal areas may be able to adapt, but others are bound by mountains, ravines, and other developments. These areas are also negatively impacted by nutrient loading from cesspools, injection wells, and septic systems that are captured by inundation and also released via underground seepage. Retired and abandoned landfills in the coastal inundation zone may become a source of future contamination as sea level rises in the coming years (see Figure 25).

Four miles of Maui's beaches have already been lost as a result of coastal armoring - the practice of placing human-made structures designed to either prevent erosion of upland property or protect structures from the effects of coastal wave and current action (Fletcher et al., 2012). Continued armoring of the coastline will exacerbate the loss of beach and shoreline habitats.

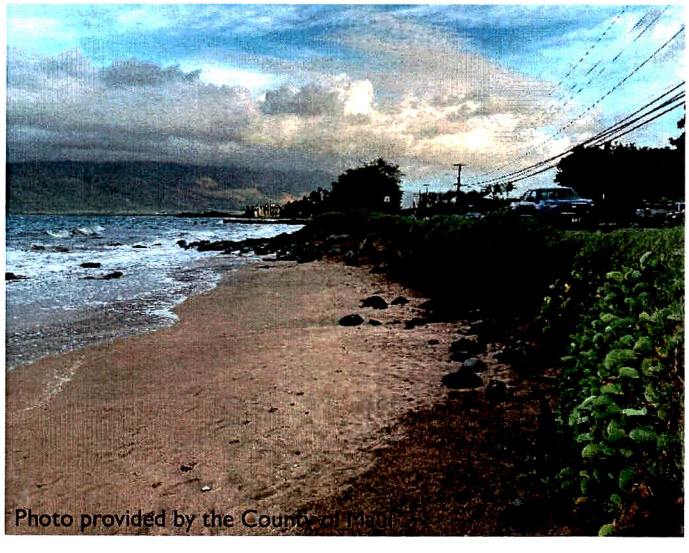


Photo provided by the County of Maui

At-risk areas include dunes, beaches, intertidal environments, native plants, seabird habitat, loko iʻa (fish ponds), Hawaiian homestead lands, and others. Sea level rise may uncover iwi kupuna, impact nearshore graveyards, and threaten coastal archaeological sites. The collection of limu and other coastal resources are already threatened, affecting local cultural practices, connections, nutrition, and diet. As shorelines migrate, people will be forced to move to higher locations, increasing development density and causing larger impacts.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

3 This was also raised as a concern in conversations with community members.

▶ Harm to watersheds due to invasive species, pathogens, and erosion

Watersheds from mauka to makai are at risk due to the spread of invasive species and pathogens, as well as the erosion caused by rampant invasive ungulates. As climate change further threatens native species and favors invasives, their populations will continue to flourish. These include kiawe in North Kīhei, miconia in Hāna, haole koa on Moloka'i, axis deer and pigs migrating across the islands, avian malaria moving to higher elevations, Rapid 'ōhi'a Death, and invasive grasses that exclude native plants and increase fire risk in many areas.

Timeframe – Near term **Sensitivity – High**
Adaptive Capacity – Medium

▶ Impacts to groundwater, seeps, springs, and freshwater wetlands due to larger storms and drought

With larger storm events, more intense flooding, and more frequent and severe drought, groundwater and freshwater seeps, springs, and wetlands will be impacted by climate change. These features are already stressed by development, degradation, channelization, invasive species (ungulates, ginger, grasses, others), and other land uses. Prolonged drought can reduce the ability of wetlands to hold water when precipitation occurs. Land conversion and continued development in areas with existing wetlands compromise the ability of wetlands to recharge groundwater and mitigate coastal flooding. Larger storms combined with certain land use practices (such as cesspools and septic systems), and more frequent wildfire, erosion, and landslides, are expected to reduce water quality. Wetland birds, lo'i farmers, 'o'opu (native goby fish), 'ōpae (shrimp), hīhīwai (freshwater snail) and others will be impacted by changes to both water quantity and quality.

Timeframe – Near term **Sensitivity – High**
Adaptive Capacity – Medium

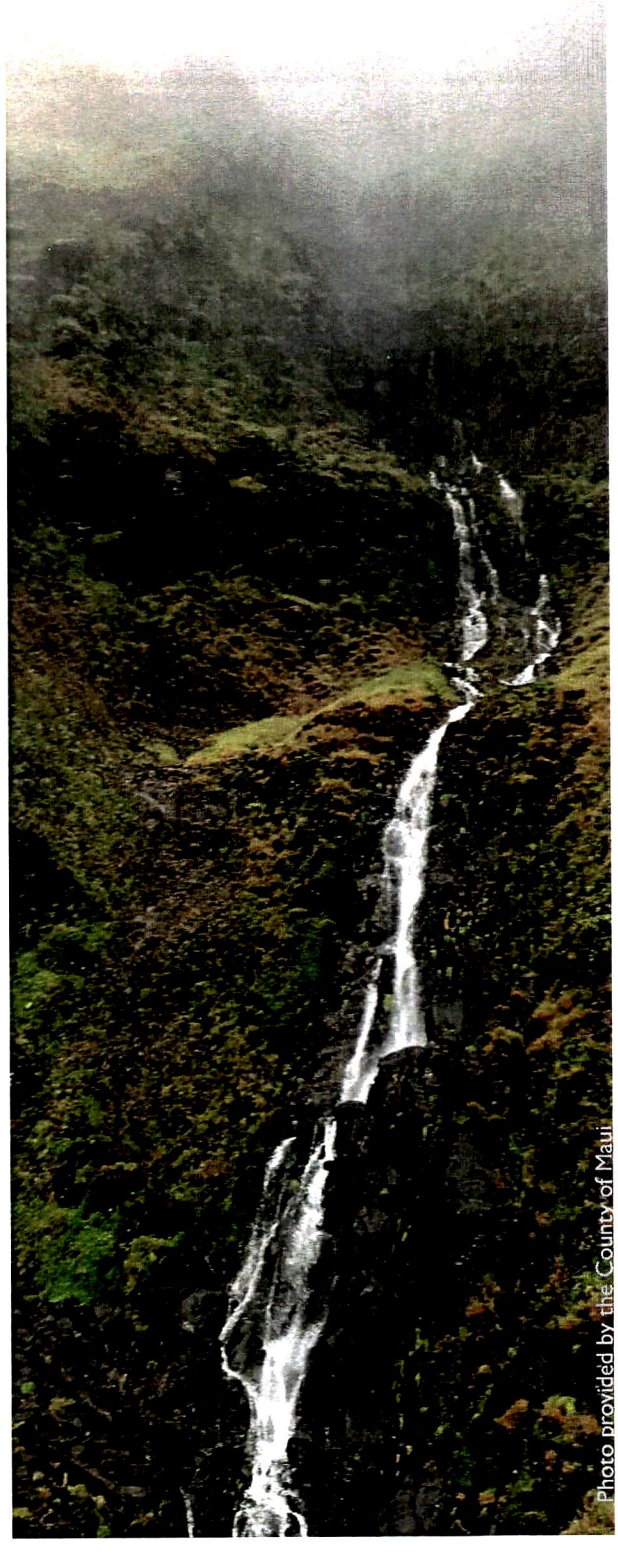


Photo provided by the County of Maui

► Threats to native and endangered species, especially keystone species, due to all climate change-driven hazards

Native and endemic species across Hawai'i are already highly impacted by the introduction of invasive species, diseases, and predators, as well as destruction of habitat. Hawai'i is the state with the highest number of endangered species in the United States. California is a distant second, despite its significantly larger geography, at 287. Maui County is home to 226 of these endangered species (U.S. Fish & Wildlife Service, n.d.). As the overall climate changes (warmer temperatures, drought, wildfire, and extreme rainfall), some species will no longer be able to survive aggressive invasive species and changing conditions. Native birds, for example, are being pushed to higher and higher elevations as mosquitoes move upwards, carrying avian malaria (Liao et al., 2015).

Keystone species are vital to the overall diversity and resilience of native ecosystems. The loss of these species can result in the degradation of native culture, connection to the natural environment, mo'olelo (successively transmitted narratives that help make up the cultural fabric of Hawai'i), and subsistence food resources. A loss of keystone species, such as koa or 'ōhi'a, will have wide ranging impacts on entire ecosystems.

Timeframe – Near term **Sensitivity – Medium** **Adaptive Capacity – Low**

► Harm to muliwai (estuaries) and tidal wetlands due to inundation

Muliwai and tidal wetlands provide vital habitat for juvenile fish, native and endemic birds, culturally important resources, and a variety of other critical species. These areas are highly biodiverse but are often constrained and impacted by urban development, increasing ocean temperatures, and concentrated land-based pollutants, making it difficult for them to adapt. They are already impacted by storm water runoff, which is expected to worsen with increasingly larger storms.

Timeframe – Near term **Sensitivity – Medium** **Adaptive Capacity – Low**

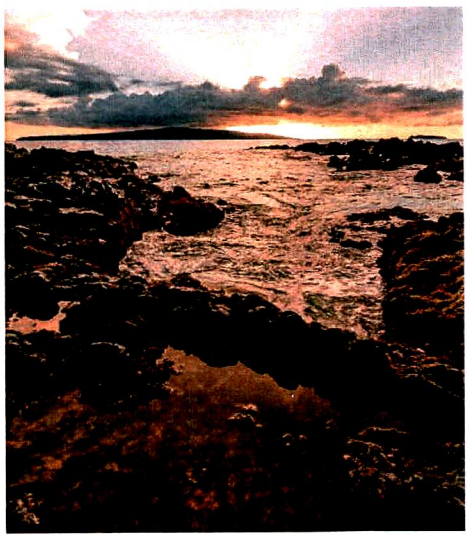
► Increase in landslides and erosion along steep slopes due to larger storms, drought, wildfire, and invasive species

The risks associated with steep slopes, erosion, and invasive species are increasing County-wide, mauka to makai. Some areas of the County are at high risk of landslides, especially as storms become larger and more destructive (e.g., Hāna Highway and Wailuku Heights). Steep watersheds and the wetlands below them are likely to

experience increasing instability and erosion. Invasive grasses, wildfire, drought, ungulates, and other invasive species exacerbate this risk.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Impacts to anchialine pools



Anchialine pools are found in limestone or lava rock formations, which are characterized by subsurface hydrological connectivity, but lack surface connection to the ocean (Gregg, 2018). Maui County has many anchialine pools, which support unique endemic species of shrimp, snails, damselflies, ʻōpae ʻula, and others. Changes in precipitation, storm surge, and salinity related to climate change are all threats to anchialine pools. Development and water diversions that alter groundwater recharge and withdrawal are additional stressors to these sensitive ecological features, as are the introduction of alien fish. Anchialine pool shrimp are also sensitive to both pollutants and water temperature. Anchialine pools face competing interests with development and upstream water uses (Gregg, 2018).

Timeframe – Mid term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Impacts to seabirds and their habitats

Seabirds are especially vulnerable to climate change because of their sensitivity to changes both on land and at sea. Sea level rise, higher air and water temperatures, ocean acidity, drought, and wildfire all affect seabirds in Maui County, including the ʻUaʻu kani (Wedge-tailed Shearwater), ʻAʻo (Newell's Shearwater), and ʻUaʻu (endangered Hawaiian Petrel). Seabird guano is a key nutrient in both terrestrial and marine ecosystems, supporting the health of both watersheds and coral reefs, so a decline in seabirds will add stress to those ecosystems (Honig & Mahoney, 2016)[4]. Ocean acidification is a risk to marine food resources for seabirds. Nesting seabirds are also at risk from invasive species like Mitred Conures that compete for cavities as well as species that prey on juvenile seabirds. Additional stressors include nighttime lighting, destruction of dunes and other habitats due to development, overfishing, and disturbances from people, dogs, cats, mongooses, and other predators. Impacts to seabirds exist across the County, but there are specific seabird habitats in Nākula, Kahikinui, Hoʻokipa, Kapalua, Lānaʻi, etc. that are particularly at risk (Young et al., 2012).

Timeframe – Near term **Sensitivity – Medium** **Adaptive Capacity – Low**

4 This was also raised as a concern in conversations with community members.

Culture

Native Hawaiian culture is inextricably linked to natural systems, so many impacts to cultural systems were identified in the previous section. Additional vulnerabilities are included here due to their specific importance to continued Native Hawaiian and cultural practices, family and ancestral connectivity, and community well-being. As island communities are subject to sea level rise, one of the largest cultural impacts will come from the displacement of coastal communities as those areas become uninhabitable over time. The impact of displacement on individuals in the community will depend on their existing resilience and access to resources.

Native Hawaiian Culture

About 11% of Maui County's population identifies as Native Hawaiian or Pacific Islander (*U.S. Census Bureau QuickFacts: Maui County, Hawaii*, 2022). Native culture is extremely important to the identity of the islands and the connection between native people, the land, generations of ancestors, and future descendants.

Native Hawaiian cultural customs and language were prohibited during the colonization of the islands, and Kānaka Maoli were often forced to assimilate to Western culture (*History of Hawaiian Education*, n.d.). Fortunately, Kānaka Maoli sustained their customs and languages, and today there is a resurgence of Native Hawaiian cultural recognition and protection across the islands. Connecting to that traditional knowledge is and will continue to be important in developing climate resilience across Maui County. Specific risks to Native Hawaiian culture include:

▶ Loss of Native Hawaiian cultural practices, culture, and spirituality due to all climate change-driven hazards

Native Hawaiian culture relies significantly on subsistence resources and intact habitats that are increasingly at risk. Without native plants, animals, coastal and marine species (limu, fish, 'opihi, and invertebrates), and the inherent ecological processes, many cultural practices could be lost. Residents' sense of place can also harmed or lost when places are impacted by erosion, fire, flooding, or condensed crowds. Families may be prevented from gathering due to heat or storms. Young people could be especially at risk of losing their connection to their culture, ancestors, and native lands. The local economy could suffer, especially on Molokai, where a subsistence economy is still strong.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Loss of culturally important sites and customs due to sea level rise, coastal flooding, and severe storms

Sea level rise and more intense storms both contribute to larger waves eroding coastal areas, local parks, and sacred grounds. This can be exacerbated if newly exposed sites and remains are further disturbed by local residents or visitors, causing emotional distress to descendants. Coastal hardening, development, beach renourishment, less permeable surfaces, and degradation of wetlands also exacerbate the issue. Important cultural sites threatened by these climate hazards include loko iʻa, loʻi kalo (irrigated taro patches), iwi kupuna, heiau (temples), pā ilina (burial sites), and other ceremonial sites and sensitive areas.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

Photo provided by the County of Maui

▶ Risks to food gathering and food production due to all climate change-driven hazards

Extreme heat, drought, and changing temperatures are expected to lead to a loss of subsistence food resources and threaten agricultural productivity. Drought increasingly affects agriculture throughout the County, especially in central and Upcountry Maui, West Maui, and Molokai. Upland erosion can also affect nearshore productivity and reduce subsistence gathering success. Limu are various types of edible algae that are significant in the traditional diet of Kānaka Maoli. Limu growth has already decreased tremendously due to warming water temperatures, pollution, improper harvesting, and coastal development. Rising sea level and coastal flooding are expected to impact loko iʻa kalo sites by shifting the balance of freshwater and saltwater. A loss of subsistence foods and local agriculture productivity will lead to more dependence on imported foods, which affects food security, the local economy, and residents' overall resilience.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Subsistence fishing at risk from acidification, sedimentation, and warming water

Populations that rely on subsistence hunting and gathering on Molokaʻi, Lānaʻi, East Maui, and other remote locations are expected to be disproportionately impacted as marine resources become less abundant. Overfishing and improper harvesting have severely damaged fish populations, and climate change is driving changes in spawning seasons. Additionally, sedimentation, water diversion, coral bleaching, and impacts to estuaries negatively affect local fisheries.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Displacement of Kānaka Maoli (native people) and destruction of resources leading to loss of identity due to all climate change-driven hazards

Climate change can exacerbate the level of stress residents feel related to limited local resources, including water, land, and species, which could lead to even greater divisions between various communities and socioeconomic groups. While Kānaka Maoli lived by subsistence practices built on an intimate knowledge of limited resources and interdependence, modern day culture typically does not. This creates a system that disconnects native people from their lands, practices, sites, and subsistence resources, further exacerbating agitation, polarization, and civil discord due to conflicting value systems. Those most at risk include the Native Hawaiian community, elders, those with health conditions, and those practicing traditional and subsistence lifestyles.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Out migration displacing kamaʻāina and breaking family bonds due to all climate change-driven hazards

The disintegration of family bonds can have significant impacts on overall community resilience, which can lead to even more emigration of local families. People with long family lineages on the islands and deep ties to the land, resources, and people of their community are at risk of being forced out due to climate impacts and rising costs that make basic subsistence and local survival extremely challenging. The combination of climate change and an increase in new residents further displaces local residents, many with long lineages in the islands

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

▶ In-migration due to climate-driven disruptions in other geographies furthers cultural divide

A likely influx of climate change migrants from other parts of the globe could lead to further cultural divides. Local customs, indigenous culture, and sustainability and subsistence practices could also be impacted. Such mass movements are influenced by sea level rise, heat, drought, wildfire, and larger storms affecting the mainland and other international locations. They are also influenced by higher income people working remotely as a result of the COVID-19 pandemic. Maui County has for many years been impacted by increasing housing prices, due in part to many wealthier individuals from outside of Hawaii owning part-time or investment homes in the islands. With many mainland companies now allowing workers to become permanently remote, Maui County is continuing to see housing prices increase significantly, making it more difficult for service workers and lower income families to maintain their housing.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

Prayitno Hadinata / CC BY 2.0

Other Cultures

Maui County is home to many diverse cultural groups that have lived on the islands for many generations. These communities' cultural and spiritual traditions are also threatened by climate change.

▶ Loss of culturally important sites and customs due to sea level rise and coastal flooding

Sea level rise and coastal flooding is a particular concern for Buddhist temples in Maui County. These sites will need to be assessed and prioritized, particularly as it is likely

that these sites will be involved in the process of re-interring human remains from exposed cemeteries.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

► Inundation of sand dune burial sites and exposure of human remains

Sand dune burial sites in Maui County are the final resting place of many early immigrants to the islands, particularly early immigrants from Japan and China. As sea level rises and coastal erosion intensifies, sand dune graveyards are at increased risk of being captured by the ocean causing human remains to be exposed. Changing wind patterns that shift the sand, and changing trade winds are also increasing the risk of exposure.

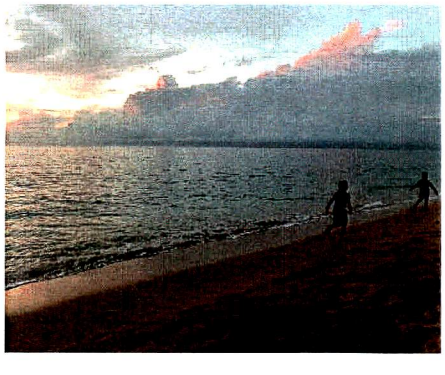
Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

Island Way of Life

There are several ways in which the island way of life in Maui County has been changing and is likely to continue to change as climate change adds stress to communities across Maui County. Community members have consistently shared that the island lifestyle meant that people took care of each other, spent leisure time at the beach, surfed and fished, hiked in the mountains, or simply gathered to cook and eat together. Community members indicate that that is changing as people from other cultures move to Maui County. Maui County has traditionally been a place where residents celebrated not only Hawaiian culture, but the multiple diverse cultures that grew from the plantation era, including Japanese, Chinese, Filipino, Portuguese, Korean, and others. With the increasing cost of living, especially in the housing market, and new residents moving to Maui County, the cultural norm of the more relaxed, island way of life is at risk.

► Loss of easy-going, outdoor oriented, island way of life

Sea level rise, coastal flooding, and disruptions to supply chains that increase the cost of living will continue to exacerbate the social and market trends that are pushing the people of Maui County away from the cultural norm of the relaxed, island way of life. As sea levels rise, competition for existing land will increase, as will disruptions to infrastructure that serve both residents and visitors.



Timeframe – Near term **Sensitivity – High**
Adaptive Capacity – Low

▶ Loss of housing for multi-generational families and low-wage workers

Sea level rise, along with increased coastal flooding, extreme storms, and wildfire, will continue to put pressure on the amount of land available for housing and the ability of locals (i.e. long-term residents of Maui County who identify with the island way of life and the local culture), particularly low-wage workers, to remain in communities across Maui County. Locals are increasingly unable to compete for available housing with home buyers coming in from the outside, particularly those who are purchasing homes as second homes and investment properties (Tanigawa, 2018). This is particularly concerning given the new reality of remote workers who have jobs in large urban centers on the mainland, but now live in Maui County. While data is not available regarding this phenomenon yet, there is a clear trend as employees resist going back to the office. This is particularly true for professionals with high paying jobs (Molla, 2022). In addition, the conversion of housing units to tourist accommodations has affected long-term housing rentals in Maui County, leading to decreased rental inventory and unaffordable rents. This squeeze in the real estate market is causing rents to skyrocket. At the same time, multi-generational families are being taxed out of coastal properties as a result of increasing property taxes.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

Human Health

Existing health threats are expected to be exacerbated by climate change, while new and emerging threats are expected to take hold. Extreme events are already occurring more frequently and emergency services will be increasingly taxed.

> *"Climate change is among the greatest health risks of the 21st Century. Rising temperatures and more extreme weather events cost lives directly, increase transmission and spread of infectious diseases, and undermine the environmental detriments of health, including clean air and water, and sufficient food."*
>
> - World Health Organization

Health and exposure to climate risks are closely linked to socioeconomic status. The island of Molokai was identified in the County Hazard Mitigation Plan as the most vulnerable in the County due to household composition and socioeconomic status. Second to Molokai is the Wailuku-Kahului area (Maui Emergency Management Agency, 2020).

For Kānaka Maoli, pono (balance) frames the concept of mauli ola (overall health & wellbeing), consisting of physical, mental, emotional, and spiritual health. Mauli ola is also embedded in values that honor kūpuna (ancestors), ʻāina (land & environment), and ʻohana (family).

Health disparities are closely linked to social, economic, and/or environmental disadvantages (Braveman & Gottlieb, 2014). Maui County is experiencing a serious shortage of healthcare professionals, with certain communities reporting much higher shortages than others, decreasing critical access to health care. Having a primary care provider is associated with better health outcomes. Between 2008-2010, 13.4% of adults in Hawaiʻi did not have a primary health care provider, with Pacific Islanders most affected ("Chapter 2: System-Level Issues," 2014). The east side of Maui and the islands of Molokaʻi and Lānaʻi have significant primary care and dental professional shortages, deeming these areas Health Professional Shortage Areas (Health Resources & Services Administration, 2022).

Some of the most notable risks associated with climate change include the following:

▶ Decrease in food access and food security

The shortage of locally produced food and lack of processing facilities means that the islands are heavily reliant on imported supplies. Currently, Hawaiʻi imports 85% - 90% of its food (Office of Planning, Department of Business Economic Development and Tourism, 2012). Recent and ongoing disruptions in the supply chain from COVID-19 demonstrate the vulnerability of critical food imports for Maui County. Conditions including severe storms, drought, wildfire, and flooding can exacerbate existing supply chain issues. The island of Maui carries only about 5-7 days of food at a time; any disruptions in distribution could lead to shortages and civil discord (McGregor, 2020). Those most vulnerable include low-income residents and children receiving subsidized meals and government food benefits. Water shortages and invasive deer and pigs, although a food source from hunting, make local food production more challenging for both farmers and subsistence gardeners, exacerbating the existing challenges with food imports.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

Provided by the County of Maui

► Increase in the overall cost of living due to all climate change-driven hazards

People most affected by higher costs include seniors on fixed incomes, families with children, and low-income households. Higher gas prices especially affect those reliant on transportation and energy for their employment, such as commuters, bus tour companies, mobile fleet owners, and construction and yard maintenance workers. Higher prices for petroleum also contribute to higher home electric and water bills since approximately 50% of electricity in Maui County comes from imported petroleum (Hawaiian Electric Company, Inc, 2021). In addition, rising temperatures increase the demand for air conditioning and other cooling technologies, further increasing energy costs (McCann, 2022). Retrofitting homes for cooling is a significant expense and is unavailable to most renters and many low and moderate-income (LMI) homeowners. Higher water costs particularly affect homesteaders, gardeners, and small farming operations. As costs continue to rise, these residents may be forced to move off island affecting demographics, cultural diversity, local food production, and indigenous populations.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

► Loss of power, water, and communication services during emergencies due to all climate change-driven hazards

Increasing frequency and magnitude of extreme storms, wildfires, mudslides, landslides, and flash floods put Maui County residents at risk. Rural and remote areas are most affected and the most difficult to assist in emergencies, particularly when communication infrastructure is affected, making it difficult for residents to

communicate with emergency services outside of their community. East Maui and Moloka'i communities, for instance, often get cut off for extended periods of time following a natural disaster. Sometimes, families can be separated during these periods of time, which adds psychological strain to already difficult situations. Strengthening the culture of self-reliance among many segments of the population is necessary to increase resilience in the face of increasingly severe storm events and loss of utility services. This includes adapting existing housing, power supply, food supply, and water supply to be increasingly self-sufficient and localized, while at the same time hardening and strengthening centrally supplied utilities and resources. Additionally, investing in regional resources such as locally sited resilience hubs can add to local community resiliency. The County of Maui has established a resiliency hub network initiative intended to facilitate the deployment of resilience hubs across Maui County.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

► Health impacts due to extreme heat, changes in trade winds, and wildfire

Changes in trade winds and increasing temperatures have serious consequences for local health. Higher temperatures also exacerbate air quality issues, along with wildfires and vog (volcanic smog). Those most vulnerable and exposed to air quality issues and heat include outdoor workers (agriculture, landscaping, construction, etc.), older adults, low-income households, infants and children, and people who are unhoused. With severe heat, people spend more time indoors, which can further affect their physical and mental health. Some areas that already experience hotter temperatures and are particularly at risk include Kahului, Pukalani, Kīhei, West Maui, and the Central Valley. The County of Maui is undertaking a concurrent heat map index study to identify elements of the population who are particularly vulnerable to the urban heat island effect and to wildfire risk.

Timeframe – Mid-term **Sensitivity – Medium** **Adaptive Capacity – Medium**

► Mental health impacts due to all climate change-driven hazards

Natural disasters and extreme events are closely linked to mental health issues. All residents are at risk. However, risks to residents who already experience disenfranchisement are especially exacerbated by the impacts of climate change. The high cost of living and low wage jobs available to many long-time residents of the region are coupled with people moving from the mainland and outcompeting local residents for jobs and housing. As opportunities decline and strife grows, so do mental health challenges. Providing additional social health and mental health services, especially for

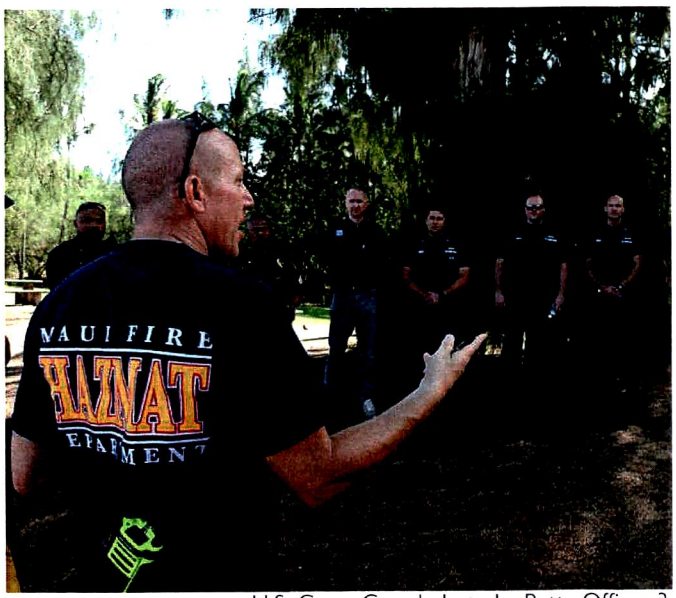
difficult to reach and remote communities should be prioritized to help address these needs.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

▶ Public safety and evacuation challenges due to larger storms, coastal flooding, wildfire, landslides, and extreme heat

Many impacts of climate change pose a risk to public safety, including more severe and frequent flooding, erosion, sea level rise, heat waves, and wildfires. Rural areas dependent upon single evacuation routes are lacking in resilience. While emergency services have not yet had an evacuation failure, the risk for such a failure is increasing due to climate change. West Maui, East Maui, and Kīhei are at particular risk. A shortage of evacuation routes caused by geography and land ownership challenges, as well as outdated hospital and emergency facilities, add to this risk.

Timeframe – Near term **Sensitivity – High**
Adaptive Capacity – Low



U.S. Coast Guard photo by Petty Officer 3
Class Matthew West / CC BY-NC-ND 2

▶ Increasing pests and disease due to warming temperatures and larger storms

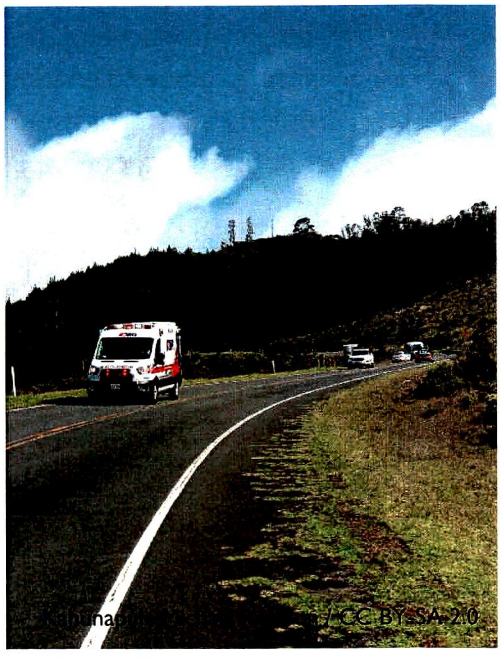
Increased levels of vector-borne diseases such as Dengue fever or Zika virus, water-borne diseases such as cholera, fish poisoning, respiratory diseases and other non-communicable diseases are expected to increase with climate change (Eversole & Andrews, 2014). Due to the state's robust sanitation and healthcare infrastructure, Hawai'i residents are less vulnerable to many of these threats than many other Pacific Island locations (Canyon et al., 2016). Climate change is expected to exacerbate these problems and will require extra diligence in monitoring for changes to disease and climate-related illness (Mora et al., 2022). Some vector-borne diseases are correlated with wet, warm conditions because of increased availability of stagnant water and shorter incubation periods for vectors. Three outbreaks of dengue fever in Hawai'i have been documented (Kolivras, 2010). The high volume of foreign visitors and imports may also increase the risk. While low lying and coastal areas are especially likely to have standing water, disease remediation strategies can also cause damage to natural ecosystems; careful consideration of costs vs. benefits is needed.

Leptospirosis is a documented infectious disease presently affecting Hawai'i's surface waters, with increased infection rates during the wetter winter season (Katz et al., 2011). Ciguatera and other marine pathogens may extend their range as a result of warming oceans, resulting in more toxins in seafood (Gingold et al., 2014).

Timeframe – Mid-term **Sensitivity – Low** **Adaptive Capacity – High**

► Social service providers and emergency response overwhelmed due to all climate change-driven hazards

The Covid-19 pandemic stressed many social service providers throughout Maui County. As heat waves, severe storms, and disruptions to daily life become more common, these services, as well as emergency services, will become increasingly taxed and potentially overwhelmed. Those most impacted include low-income households, people with disabilities, families with children, and those who are unhoused. This risk is closely linked to mental health risks.



Timeframe – Near term **Sensitivity – High**
Adaptive Capacity – Medium

► Greater difficulty recruiting healthcare workers due to all climate change-driven hazards

Healthcare recruitment is already challenging in Maui County and increasing natural disasters that exacerbate the existing high cost of living are expected to make recruitment more difficult, even as demand increases. Smaller towns and remote areas have a harder time recruiting; Lāna'i, Hāna, and Moloka'i are most vulnerable. Those in rural areas with longer travel distances to health care are most at risk from failure to recruit adequate healthcare staff. Having adequate supply of affordable or attainable workforce housing should be a high priority to ensure that our essential workforce residents can find a way to secure home ownership in Maui County.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

Infrastructure

Maui County's infrastructure includes roads, bridges, homes, businesses, harbors, potable water and sewer systems, stormwater systems, energy generation and distribution, communications infrastructure, harbors, and more. Sea level rise poses a significant threat to coastal infrastructure and communities. Extreme events in Hawai'i (from a combination of sea level rise, high tides, and storms) have increased in frequency from every 20 years to every 5 years (Firing & Merrifield, 2004). As these events continue to encroach on developed areas, infrastructure will need to be strengthened (to withstand), moved (aka managed retreat; preferably in a planned rather than emergency manner), or otherwise adapted to changing conditions.

Many coastal resilience initiatives and tools have been developed, including the State of Hawai'i's Sea Level Rise and Adaptation Vulnerability Report (Hawai'i Climate Change Mitigation and Adaptation Commission, 2017), the Sea Level Rise Viewer (*State of Hawai'i Sea Level Rise Viewer | PacIOOS*, n.d.), and the West Maui Community Plan for Climate Change and Sea Level Rise (Maui County Department of Planning and Sea Grant, 2018). The Sea Level Rise viewer allows visualization and site assessment of impacts associated with passive flooding, annual high wave flooding, and coastal erosion. See Critical Assets section for maps indicating vulnerabilities of different infrastructure types to sea level rise.

While sea level rise poses the greatest threat to much of Maui County's infrastructure, other climate-related impacts also pose new risks. Wildfire in Hawai'i, for instance, has increased 4-fold within the last century (Trauernicht et al., 2015).

Some of the greatest risks across the county include:

► Damage to coastal roads due to larger storms, coastal flooding, erosion, and sea level rise

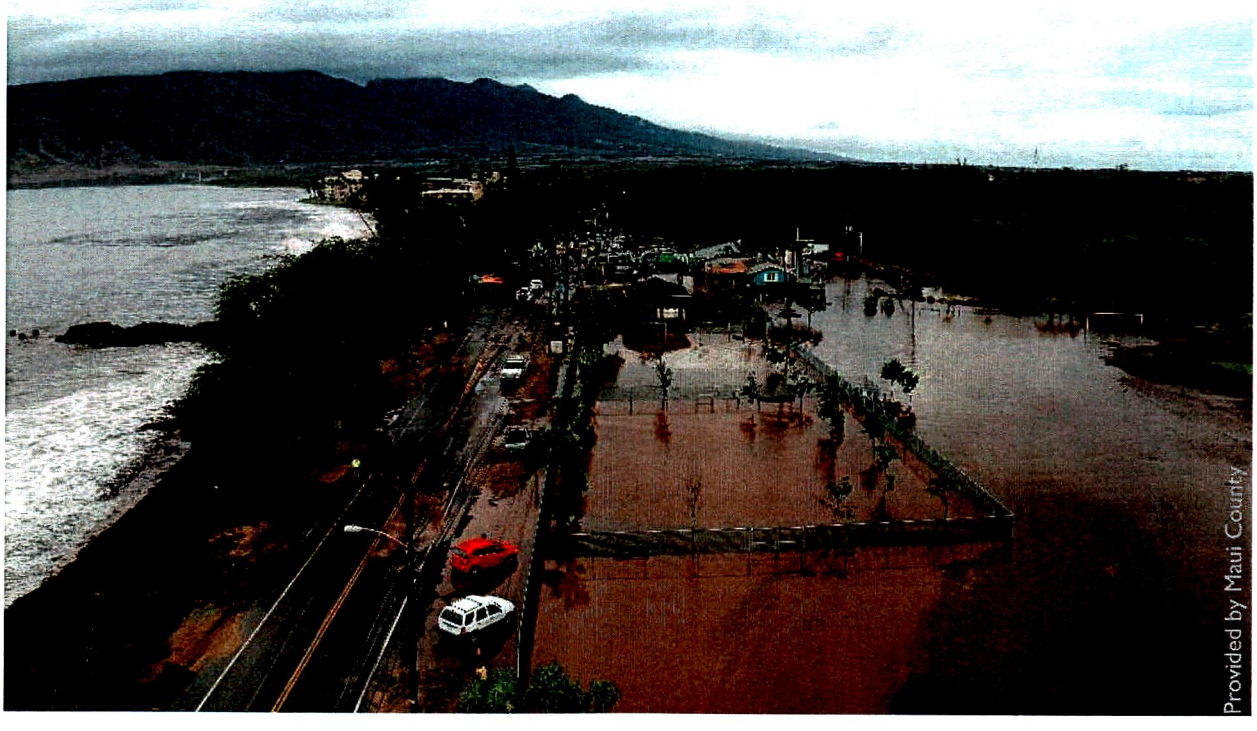
Larger storms, higher storm surge, coastal erosion and sea level rise all impact coastal roads, which often are the only access routes for many towns and properties across Maui County. Areas identified as at risk include Moloka'i – Kaunakakai, the rest of the southern and eastern Moloka'i coastline; Maui – including Honoapi'ilani Highway, Kīhei, Mā'alaea, Lahaina, Mākena, Kā'anapali, Nāpili, old Kīhei road, Kīpahulu, and sections of Waihe'e and Waiehu. The State of Hawai'i has completed an assessment of state-owned coastal roads (Hawai'i Department of Transportation Highways Division, 2021), and the County of Maui Department of Public works has a similar vulnerability assessment underway to identify vulnerable coastal roads as the first step in developing an action plan to address those risks.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

▶ Damage to drainage, reservoir, and other infrastructure because stormwater systems are inadequate to handle larger storms

Larger storms and inadequate stormwater infrastructure often lead to severe erosion and damage to reefs and roads. The pressure for development has led to steep areas being developed, exacerbating the issue. Areas with inadequate sewer systems can become flooded and pollute coastal waters and wetlands. Kīhei and Wailea have dense residential areas at risk of flooding. Haʻikū, upcountry areas, and the Hāna Highway have experienced landslides and flooded roads. The County of Maui Department of Public Works manages the County's MS4 Program and is studying innovative approaches to reduce the volume of stormwater that ultimately ends up flooding coastal areas. This includes exploring ways to slow the speed at which stormwater travels down steep topography to allow stormwater to infiltrate and be retained at higher elevations.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**



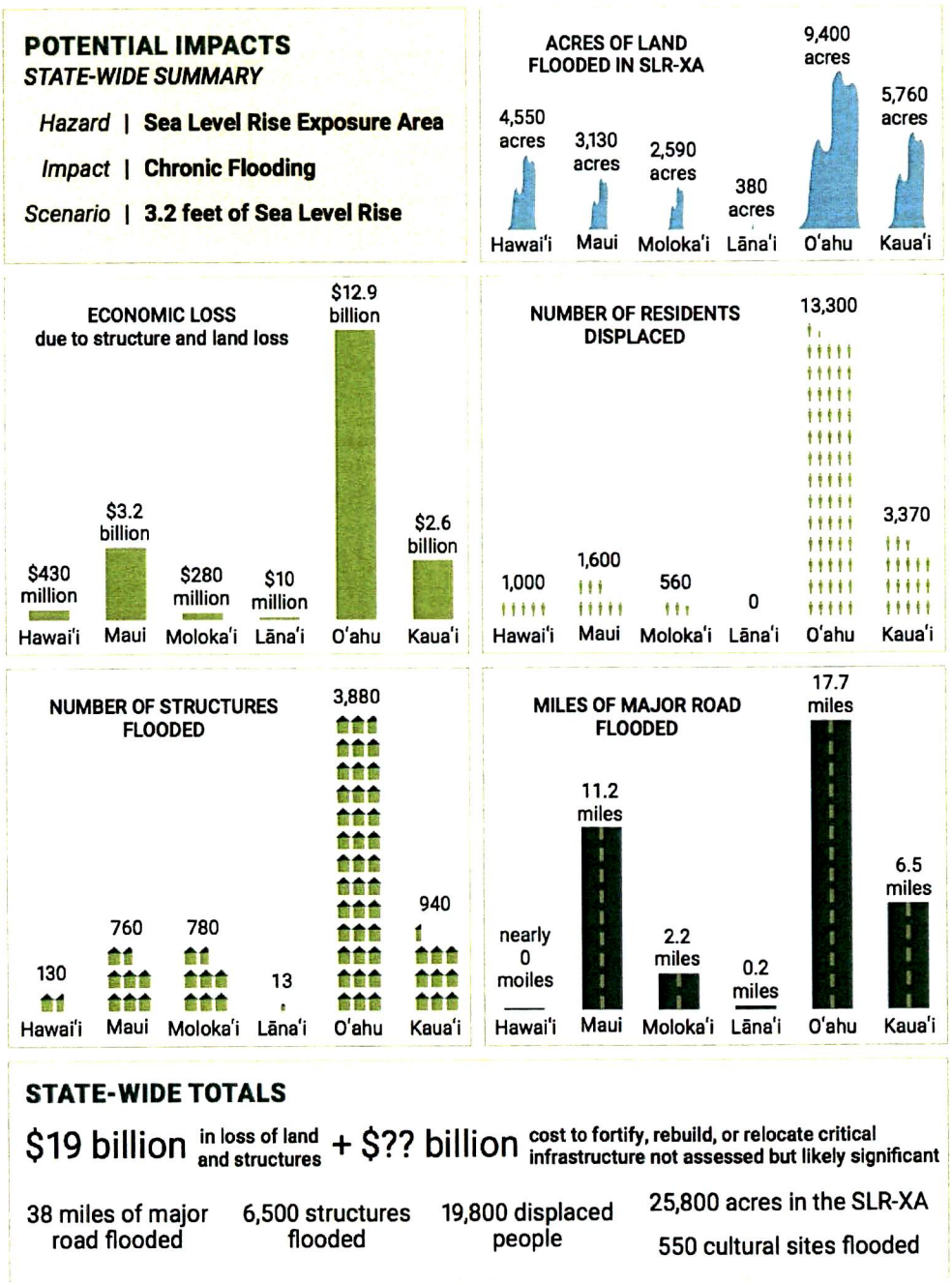


Figure 6. Potential impacts in the Sea Level Rise Exposure Area from chronic flooding under the 3.2 foot sea level rise scenario.

► Increased disruption of critical supply chains, including delayed barge shipments, due to all climate change-driven hazards

Importation of most supplies and goods, as well as limited storage and the remoteness of the islands, makes Hawai'i more vulnerable to global supply chain shortages. Smaller and more rural areas are more vulnerable and have fewer adaptation options. Supply chain issues can also contribute to higher prices that affect access to food and quality of life, particularly for low-income residents. This also includes the risk of damage to harbors and ports from threats such as sea level rise and storm surge.

Timeframe – Near term **Sensitivity – High**
Adaptive Capacity – Medium

► Impacts to water supply and water infrastructure due to drought, wildfire, and larger storms

With more frequent and severe droughts occurring, streams, reservoirs, and catchment systems that provide drinking water are likely to become insufficient. This could lead to considerable impacts to nearly all sectors, including agriculture, tourism, food processing, home gardens, wells, and access to fresh water for local residents. Saltwater intrusion into wells along the coast will exacerbate the issue. Wildfire may impact reservoirs, while larger but less frequent storms may impact groundwater stores, as well as damage water distribution systems during flash flood and high wind events. Less reliable water supply also means less opportunity to grow local food. As water becomes more restricted, prices for delivery during droughts are likely to increase and affect the local economy and households that rely on water catchment. Housing will increasingly compete with local agriculture for water, and equity issues around water quality and pricing are likely to increase. Some areas at risk include Central and Upcountry Maui, Central valley agricultural lands, homes on the leeward side, homestead agriculture, local farmers (e.g. Ho'olehua area), West Maui, Molokai, and Lāna'i. There are community concerns that more water from East Maui watersheds could be diverted to support central Maui, preventing central Maui from becoming more self-sufficient and conservation oriented.

Timeframe – Mid-term **Sensitivity – High** **Adaptive Capacity – Medium**

▶ Reduction in groundwater supply due to drought and larger storms

Groundwater recharge is threatened by larger storms, saltwater intrusion, and increased drought and erosion. Flooding can occur when precipitation is not absorbed into the soil due to drought and invasive species, resulting in sedimentation, erosion, and lost opportunities to recharge groundwater. Existing development, particularly in aquifer recharge areas, exacerbates this risk. Areas at particular risk include Molokaʻi, Lānaʻi, remote communities, and leeward communities with more reliance on groundwater due to lower rainfall and less opportunity for catchment.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Increased risk of electric service disruption in isolated communities due to larger storms, flooding, and landslides

More frequent and severe storms, floods, wildfires, and landslides, could cut off electrical service to residents and business with increasing frequency and duration. Those in more isolated areas, such as Honokōhau Valley, Keʻanae, Hāna, Kīpahulu, Kaupō, East end of Molokaʻi, Kahakuloa, Upper Kula, and on Lānaʻi, may be cut off for significant periods of time before crews can repair their infrastructure. This can especially affect lower income residents, older adults, and people with health conditions.

Timeframe – Near term **Sensitivity – High**
Adaptive Capacity – High

▶ Buildings at risk due to all climate change-driven hazards

Coastal development and homesteads are affected by sea level rise and storm surge. Molokai faces significant risks to native Hawaiian homesteads, health care facilities, first responders (fire, EMT, etc.), and the main business district, which are all located in low-lying areas. On Maui, many hotels, condos, beachfront businesses and homes are at risk. Even buildings located near coastal areas that are not directly impacted by sea level rise can exacerbate the problem by preventing beaches and wetlands from shifting upland as sea level rises. Inland, buildings are increasingly threatened by larger storms, higher winds, landslides, and wildfire.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

► Damage to park facilities and restricted beach access due to sea level rise, coastal erosion, and larger storms

Parks and beaches, such as those at Puamana, Ukumehame, Baldwin Beach Park and Kahana Beach, are already experiencing severe impacts of climate change. Some have had to be closed as conditions deteriorate, while in other areas, actions have been taken to move facilities, such as lifeguard towers, showers, and restroom facilities. The loss of these community recreational facilities has an impact on community life and pushes people to go to other locations, which adds strain to those areas. Increasingly, unhoused people are using park facilities for showers and sanitation. As more coastal parks close, there will be increasing pressure on other facilities for unhoused people to meet their basic needs.[5]

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

► Increased damage to infrastructure due to wildfire

The leeward sides of the islands are at higher risk of wildfire. Invasive vegetation on fallow lands from ranching, farming, and other land use, combined with increasing drought, have increased the incidence of wildfire, which now occurs in places that have not previously experienced fire. Ignition from electrical utility infrastructure is a particular concern as steep terrain makes it difficult to maintain power lines and saltwater/salt air cause power lines to corrode more quickly than on the mainland. Some areas identified as being particularly at risk include Makawao/Pukalani, central plains (fallow sugar cane fields), Kanaio, Kaupō, Wailuku, Waiehu, Kīhei, Makena, Lahaina, Upper Kula/Haleakalā, Hāna Highway, and West Maui. Many areas have limited water pressure for fire suppression, particularly those with standpipes. Cultural sites are also at risk.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

► Increased damage to commercial ports, harbors, and other boating facilities harbors

Sea level rise, coastal erosion, and larger storms are expected to damage harbors across the islands of Maui County, impacting the timely arrival of food and critical supplies,

[5] The County of Maui is completing a climate vulnerability assessment of beach park facilities to develop strategies to address those risks.

particularly if they are damaged due to larger storms or coastal flooding. This is particularly true for ports needed for barge shipments.

Timeframe – Mid-term **Sensitivity – High** **Adaptive Capacity – Medium**

► Increased damage to utilities due to larger storms with higher winds

The risk of larger storms is heightened with climate change and is expected to bring stronger winds to the islands. These winds can damage utility infrastructure and cause power outages. All of the islands of Maui County are vulnerable. Some adaptive capacity is already in place, including extra power poles and equipment stored on the islands, retrofits to infrastructure are planned, and increasing numbers of residents own generators or battery energy storage systems to use as back-up power. Lower income residents and renters are most at risk because generators and battery energy storage systems are expensive. Landlords/landowners often do not maintain trees on their property, increasing the risk of downed trees on power lines and homes.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – High**

► Increased risk of brownouts due to higher temperatures and extreme heat

A brownout is a reduction in or restriction on the availability of electrical power in a particular area, generally caused by demand for electricity outstripping supply. The risk of brownouts is increasing due to more extreme heat episodes driving up the use of electricity for air conditioning and water pumping. Brownouts disproportionately impact elders, infants, and those with existing health conditions who cannot afford backup generators or batteries.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – High**

► Increased damage to electric, water, and wastewater infrastructure due to larger storms and inland flooding

This risk is increasing due to larger storms and greater potential for landslides and flash floods. East Maui, Honokōhau, and Honoapi'ilani Highway are especially at risk as is the wastewater facility in Kaunakakai. Upcountry water quality has been increasingly affected by flash flooding, and some wastewater facilities are at high risk of damage, including Waiehu, South Kīhei, and Wailea. Wastewater facilities at North Kīhei, South Wailea, Stables-Spreckelsville, and Pā'ia are at moderate risk (Amato, 2022). Facilities have not yet been assessed on Moloka'i or Lāna'i. The Kahului power plant, wastewater treatment facilities along shorelines, and the Kahului Port are all vulnerable to disruption. Impacts to the ports can affect critical deliveries of diesel oil that powers most of Maui County. The County of Maui has conducted a number of vulnerability assessments in recent years, including vulnerability assessments for County roads, wastewater treatment facilities, fresh water supply infrastructure, and beach parks. These studies will help to guide CIP planning and managed retreat decisions as climate change impacts to County infrastructure increase over time.

Timeframe – Near term **Sensitivity – Low** **Adaptive Capacity – Medium**

Economy

Tourism is the largest economic driver in Maui County, and the core economic engine of Maui, Lāna'i, and Moloka'i. Approximately 80% of every dollar generated directly or indirectly across Maui County is from the visitor industry (Maui Economic Development Board, n.d.). The following industries had the highest Gross Domestic Product for the County (Hawaii Department of Business, Economic Development & Tourism, 2019):

- Accommodation and food services – 25%
- Real estate and rental leasing – 22%
- Retail trade – 12%
- Government – 11.3%
- Health care and social assistance – 8.7%

Another important part of Maui County's economy is agriculture and food production. Much of Hawai'i's food production for local consumption has been displaced by imported foods. Hawai'i is dangerously reliant on imported food, increasing residents' risk of food shortages in the event of natural disasters, economic disruptions, and/or other external factors (Office of Planning, Department of Business Economic

Development and Tourism, 2012). While all residents are encouraged to keep a 14 day supply of food and water, there is no indication that residents are heeding that request or are easily able to implement it. In addition, purchasing additional food to create that 14 day supply is very difficult for low-wage workers. Support for the local agricultural industry to increase food security is of vital importance to Maui County. Food processing is also largely absent from the islands and represents an important opportunity for growth to support local resilience and the economy.

Some of the greatest risks identified for the economic sector across Maui County include:

► Increased risks to agriculture due to drought, increasing salinity, warmer temperatures, invasive species, and larger storms

Not only is drought a risk to local agriculture, but plants also require more water during evapotranspiration with higher temperatures, which increases the need for water even when the county is not experiencing a drought. Agriculture is also impacted by storm damage and sea level rise. Invasive species, such as axis deer, feral pigs, sheep, and noxious weeds are moving into agricultural fields as wild areas become drier. Axis deer have already caused significant crop loss and soil erosion in agricultural areas. Soil erosion affects the land from mauka to makai. The axis deer problem is present on all inhabited islands in Maui County, but most pronounced on Molokaʻi and Lānaʻi. The move towards sustainable farming and local production is threatened by these various climate impacts and overpopulated invasive ungulates. Kalo (taro) production is also at risk from increased temperatures, severe flooding, and increased tension between water users, especially during a drought.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

► Government budgets stressed from cost of climate adaptation and responding to more frequent and severe disruptions due to all climate change-driven hazards

Infrastructure hardening (burying utilities, elevating HVAC, etc.), implementing flood and wind mitigation actions, and planning for sea level rise, among other adaptation actions, will need to be included in ongoing budgeting processes alongside the standard local government infrastructure and public safety responsibilities. Some state and federal funds are available to support resilience measures, and additional recovery funding often becomes available following natural disasters. However, The County of Maui's budget will be increasingly constrained as it works to respond to these various risks. Investing in preventative measures and hazard mitigation will ultimately cost less than rebuilding after major damages are incurred as a result of natural hazard events. Therefore, the County of Maui should prioritize investments in reducing the vulnerability of municipal and household infrastructure to the impacts of climate change.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

► Household and individual economics harmed by reduction of subsistence lifestyles and resources due to all climate change-driven hazards

Whether through gardening, hunting, fishing, gathering marine resources, traditional agriculture, or other means, some residents live primarily off the land in Maui County. By living off the land, they can avoid the high prices of imported food. However, higher temperatures, increasing drought, larger storms, and other climate change impacts threaten this subsistence way of life.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

► Financial strain to service workers, especially in tourism, due to all climate change-driven hazards

Lower income workers, especially those working in the visitor industry, are likely to be most impacted by climate change-driven disruptions impacting the availability of work over time. This financial strain is exacerbated by the cost of living rising due to other climate change impacts and market factors. Climate impacts, such as higher

temperatures, lack of water, and larger storms, are likely to affect the number and reliability of tourists visiting the region. Many jobs are outsourced to employees from the mainland and elsewhere due to the inability to find trained local workers in certain fields. In addition, some local residents also relocate to seek new opportunities for work outside of the islands and a lower cost of living. Because much of the training and credentialing is not available in Maui County, residents have to travel to Oahu for certifications at a greater cost. These impacts are highest for Asset Limited, Income Constrained, Employed (ALICE) populations.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Freshwater supply challenges

Drought, increasing temperatures, and sea level rise all affect freshwater availability. Water limitations will affect the ability to build affordable housing, as well as increase the cost of water for lower income residents, small scale farmers and ranchers, stream ecosystems, and hotels and golf courses, all of which may result in significant economic harm. Traditional uses and practices could be limited as water demand increases for housing and other competing uses. For instance, Section 7 of the Kuleana Rights Act of 1850 established access to roads, water sources, and other natural resources for Hawaiian tenant farmers (*The Kuleana Act of 1850*, n.d.). As sea level rises and water availability shifts, those rights could become challenging to uphold.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Coastal businesses and resorts threatened by sea level rise and flooding

Larger storms, storm surge, and sea level rise pose significant threats to coastal infrastructure, beaches, and other resources important for business. Those in flood zones and future inundation zones are most at risk. Some outdated infrastructure is already failing and in need of maintenance or relocation.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Economic harm due to loss of coral reefs and other marine life

Coral reef ecosystems are of vital importance for local subsistence, tourism, and coastal protection. Visitors and residents are drawn to Maui County's coastlines by the diversity of marine ecosystems and coral reefs. Coral reefs contribute $364 million dollars in goods and services each year to Hawai'i's local economy (Keener et al., 2018).

Widespread coral bleaching has become more common, with mass events in 2014, 2015, and to a lesser extent in 2019. By mid-century, coral bleaching is projected to occur every year (Keener et al., 2018). With warmer and more acidic ocean waters, corals are expected to disappear from the coasts by the end of the century (Keener et al., 2018) unless an adaptation approach can be developed that allows corals to grow in warmer, more acidic water. This decline in coral reefs could pose serious economic challenges to local businesses that offer tours or guides. Local fisheries and subsistence harvesting could also be increasingly negatively impacted.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Commercial operations at risk of economic shocks due to larger storms, floods, wildfires, and landslides

The operations of many local commercial businesses are threatened by a variety of climate hazards, including larger storms, landslides, floods, and wildfires. West Maui, Kahakuloa, and the Hāna area can be cut off from resources when landslides or other climate-related disasters occur. International disruptions that increase the costs of goods, such as fuel, can also negatively affect commercial operations. Property insurance costs are likely to increase, making the cost of operations higher. There is some potential for certain high-risk areas to become uninsurable over time. Larger businesses may have more resilience than smaller operations with little redundancy or flexibility.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Economic harm to agriculture, tourism, and businesses due to wildfire

Wildfire puts many businesses at risk - directly when they are in the path of fire and indirectly based on the disruptions they can cause to travel routes, production, evacuation, water and electrical infrastructure, and other resources. Increasing periods of wildfire smoke also have a negative impact on the tourist economy. Areas especially at risk include Molokaʻi, Lānaʻi (esp. Miki Basin), and Maui (West, South and Central Maui where there are fallow lands).

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Low**

▶ Goals of creating walkable, economically vibrant places increasingly difficult to meet due to all climate change-driven hazards

Higher temperatures and extreme heat will make it more difficult for people to be outdoors walking, biking, or taking the bus. Goals for increasing walking paths and high density, and low impact development could be hampered by cost and less willingness to take alternative transportation with higher temperatures. When more people drive personal vehicles, more parking and asphalt are needed, creating more heat. Lower income and workforce populations are most likely to be impacted.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – High**

▶ Harm to local fisheries due to warming water and acidification

As the coral reefs decline, local fisheries are expected to experience similar declines. This can lead to significant economic impacts to commercial fishing operations, as well as the households practicing subsistence fishing. Declines in commercial fisheries could also lead to encroachment onto Molokaʻi and Lānaʻi fishing grounds and increase local conflict over the fisheries. Local fishermen and women who are engaged in subsistence fishing are likely to be in increasing conflict with commercial fishing operations as the fisheries that support both lose vigor over time and populations decrease.

Timeframe – Near term **Sensitivity – High** **Adaptive Capacity – Medium**

VULNERABILITIES TO SPECIFIC COMMUNITIES

As a series of islands, Maui County is home to diverse communities that are experiencing the impacts of climate change in ways that differ from how climate change is affecting the County as a whole. As part of this process, our team conducted Talk Story sessions with Moloka'i, Lāna'i, and East Maui communities to learn from residents about the climate impacts they are experiencing and what they perceive to be the most vulnerable aspects of their communities related to changing climate conditions. This does not lessen the recognition of the significance of climate change impacts to other communities across Maui County, but does recognize the particular challenges faced by more remote communities who face more difficult access to centralized services.

Moloka'i

Molokai is the fifth largest island in the State of Hawai'i. It is home to the highest sea cliffs in the world and the longest continuous fringing reef in Hawai'i. The most recent Census data available for the island shows a strong presence of Kānaka Maoli or other Pacific Islanders. At that time, 36% of the population was Native Hawaiian or Other Pacific Islander, 31% were two or more races, 19% were Asian, and 16% were White (Research and Economic Analysis Division, 2011).

Many families on Moloka'i rely on subsistence strategies, such as fishing, hunting, and small-scale farming (Graham, 2019). In a recent study, Sust'āinable Molokai, a nonprofit organization on Moloka'i, found that Ho'olehua Homesteaders on the island produce roughly 38% of the food used by their families (Ronzello et al., 2018).

The importance of Moloka'i's biodiversity is illustrated by the amount of land that is set aside for conservation on the island. The East Molokai Conservation Area is made up of a combination of private and public protected areas, including Kalaupapa National Historical Park, Pu'u Ali'i State Natural Area Reserve, Oloku'i State Natural Area Reserve, the State Forest Reserve System, and the State Conservation District.

Provided by Maui County

The largely agrarian focus of communities on Moloka'i, combined with large tracts of coastline that are difficult to access and a smaller tourism economy than the other Hawaiian Islands, have allowed the communities of Moloka'i to maintain a more traditional Hawaiian way of life (Graham, 2019). The island is well-suited for fish ponds, which were more plentiful and active in the past than they are today.

Moloka'i residents are seeing significant changes due to climate change, including higher temperatures, increased drought, larger flooding events, and shoreline erosion.

These changing conditions are directly related to other visible changes, such as:

- Less limu in general and fewer limu species available
- Animals dying from malnourishment and dehydration
- Invasive weeds spreading across the landscape
- Less frequent, but much larger, rain events than in the past, especially along the south shore and Ranch Camp
- Warmer water changing the movements of fish and water currents
- Loss of ground vegetation in mid-elevation areas
- Crops affected by extreme heat and reduced water availability
- Changes happening in crop seasons with some plants flowering and fruiting at different times than in the past, especially avocados and mangos, and insects arriving at different times as well
- Axis deer entering residential areas in higher numbers and destroying subsistence gardens

- Far fewer clams available than in the past
- More erosion in the watersheds leading to water quality issues for the reef and shoreline ecosystems
- Shoreline erosion, especially on the south shore
- Streamflow much lower and slower island-wide, affecting cold water species
- Ability of students to learn in local schools and the health of residents affected by increasing temperatures
- Shorelines are muddier when it rains than in the past
- Erosion of the main highway where it is reduced to one lane in some areas
- Trade winds are decreasing, but wind speeds during storms are often higher, affecting gardens and agriculture
- King tides go over the wharf
- Roads are made impassable by flooding rivers
- Clouds are changing, exposing the forest to more heat

Residents have noted increased storms with heightened energy and quick moving rainwater from mauka to makai. There is growing concern about drawing water from the aquifer faster than it can be recharged, leading to saltwater intrusion and affecting all aspects of their communities.

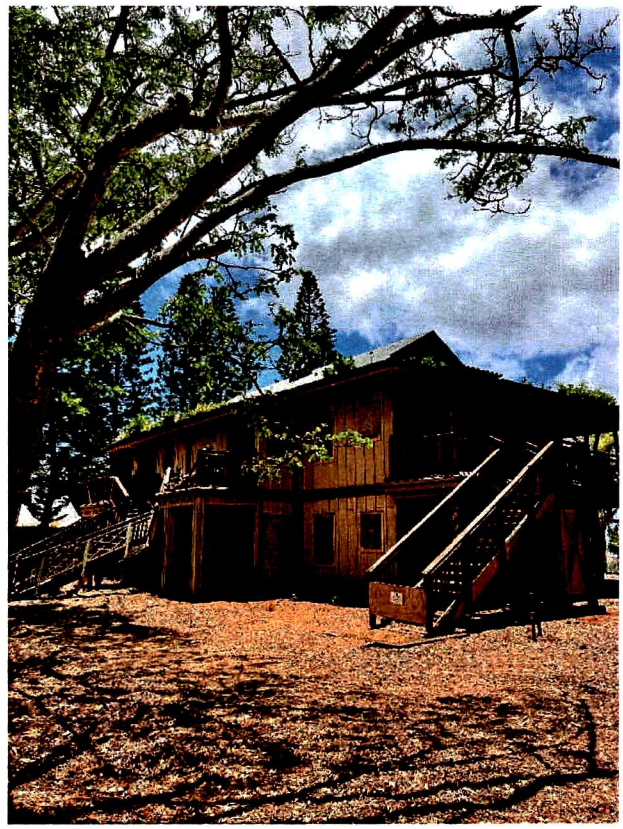
On the North Shore, where restoration projects are underway, residents notice that the area is receiving significantly less rain, impacting their ability to restore the area successfully.

Two years ago, Kaunakakai School installed air conditioning due to prolonged high temperatures; even with a cooling system, users still complain about comfort levels. Temperature conditions in the schools are making it difficult for students to learn and teachers to teach.

Emergency shelters are lacking on Moloka'i, mainly because the schools are not hurricane rated. The fire station was moved to a higher elevation out of the tsunami inundation zone and the threat posed by sea level rise; however, the police station is still at risk.

Residents recognize the threat posed by infrastructure, such as powerlines and the state highway, built close to the shoreline, particularly on the island's East side. When large storms occur in that area, it creates rivers that cross the highway, stranding people on either side, which causes socioeconomic disruptions as children cannot get to school and adults cannot get to work. In addition, these strandings are happening for longer periods and more frequently than seen in the past. As a result, there is the potential that children could be isolated from their families for an extended period if the flooding starts during school hours.

Community members are concerned about their ability to continue to live on Molokaʻi as these challenges combine with significant increases in costs for energy, housing, water, and food. As housing prices soar, owning a home on Molokaʻi becomes unattainable for most residents. Coupled with high energy costs, warming temperatures increase the need for air conditioning in homes, which many residents cannot afford.



Provided by Maui County

Residents are also concerned with the impact of cutting mature trees in Kaunakakai and not planting new ones, further exacerbating the existing issues with erosion, watershed health, and deer.

Fortunately, the people of Molokaʻi are already well on their way to addressing the impacts of sea level rise through Sustʻāinable Molokai's efforts to develop a community-driven Climate Change and Sea Level Adaptation and Resiliency Plan. This effort has been engaging the Molokaʻi community to better understand and address community vulnerabilities related explicitly to sea level rise. Because this work is happening concurrently, our team focused the Molokaʻi Talk Story session on vulnerabilities caused by other climate change impacts, such as drought, higher temperatures, larger storms, inland flooding, increased wildfire, etc. We intend to integrate the solutions the Molokaʻi community develops to address sea level rise into the County's Climate Action and Resiliency Plan.

In addition to the issues listed above worsening over time, attendees of the Talk Story session identified the following climate-driven or related vulnerabilities:

- Infrastructure close to shoreline, including the police station and schools, vulnerable to coastal erosion
- Coastal flooding and erosion impact to coastal roads
- Extreme heat and drought affecting farmers
- Need for fencing to protect crops and vegetation from axis deer
- Slower aquifer recharge rates due to drought and larger storms affecting availability of freshwater
- Lower stream flows and slower water causing impacts to stream life
- Larger storms and overgrazing from deer and pigs causing erosion and sedimentation of shorelines and coral reefs

- Less frequent mild rains, but larger storms creating floods that block coastal roads stranding community members on both sides, especially on the East end of the island
- Closed or abandoned landfills exposed by sea level rise and/or inland flooding after large storms
- Extreme heat affecting residents' health
- Sea level rise affecting wastewater systems
- Drought impacts on native forests causing forest recession and wildlife death
- Extreme heat and drought favoring invasive plant species that are driving out native species, creating food security issues, and making restoration efforts more difficult
- Warmer water negatively affecting freshwater and marine life, including limu, which impacts natural systems, subsistence living, and cultural practices
- Increasing wind speeds causing damage to structures and natural systems
- Axis deer eating crops, disturbing neighborhoods, exposing soil, and causing erosion
- Mental health stress on residents due to all climate hazards
- Extreme heat requires air conditioning for at-risk residents, which increases energy costs for local residents
- Diversity of limu species dwindling due to coral bleaching, extreme heat, and sedimentation
- Water coming onto the pier during king tides
- Saltwater intrusion into potable wells
- Saltwater intrusion in underground water sources that trees rely on for freshwater
- Not enough emergency shelters for large storm events
- Drought and extreme heat affecting natural systems
- Less habitat available for sea birds migrating from other islands due to invasive species and sea level rise
- Schools and other public buildings becoming too warm to function without air conditioning
- Beach erosion affecting natural systems
- Drought impacts on water supply for the community
- Flowering and fruiting happening at different times than in the past – seasons are less predictable for subsistence growing
- Subsistence food production requiring more water, which adds expense to residents
- Increasing likelihood of areas being isolated/cut off because of large storms and flooding
- Warmer water and ocean acidification causing coral bleaching

Lānaʻi

Lānaʻi is the smallest inhabited island travelers may visit in Hawaiʻi. It is almost entirely privately owned, with 98% of the island's land held by a single owner and managed by Pūlama Lānaʻi Company (Encyclopedia Britannica, 1998; Pulama Lanai, 2022). The focus of the management company is to draw visitors to the island while fostering sustainability. Development efforts include building high-end tourism facilities while implementing conservation programs, developing hydroponic gardens, and expanding essential services for Lānaʻi residents.

The island was purchased by James Dole in 1922, and for a time, was home to the largest pineapple plantation in the world (Encyclopedia Britannica, 1998). Immigrants arrived on the island primarily from Asia to work in the fields. As a result, the residents of Lānaʻi are very diverse, with 51% Asian, 20% White, 16% two or more races, and 10% Native Hawaiian or Pacific Islander (*Lanai City, Hawaii Population 2022*, n.d.). Since the original purchase in 1922, Lānaʻi has been sold twice (Encyclopedia Britannica, 1998). This novel ownership structure, and the resources that are being invested in the island, create unique circumstances on Lānaʻi that must be integrated into the development of climate resilience strategies related to the island.

Forest and Kim Starr / CC BY 2.0

The island's historical development as an agricultural plantation has had lasting impacts on the island's natural health and communities. These heritage impacts, combined with rapidly changing climate conditions, create significant challenges for the future of Lāna'i.

At the Talk Story session, residents shared that they are observing increased drought, higher temperatures (especially in the lowlands), and more significant coastal erosion than in the past.

They see these changing conditions as directly related to other visible changes, such as:

- Roads washing out, which dumps sediment that affects the reef and limu, and creates a safety concern for both residents and visitors
- Keomuku, an abandoned village on the east side of the island, has burials along the coastline that are being exposed due to coastal erosion
- An historical church in Keomuku is also being impacted by sedimentation

Some residents are concerned about future groundwater use and availability, but current estimates indicate that they are still well below the sustainable yield for the island of 6 million gallons per day. However, the aquifer that provides all the freshwater for the island is not as well-understood as it could be.

Ongoing drought and the continued infrastructure and operations of the harbors, including Kaumālapa'u and Mānele Small Boat Harbor, are of particular concern as they are necessary for supply barges and transport for visitors and residents alike.

Community members have noticed that the number of trade wind days has decreased. They are concerned that further decline may impact the ability of homes and buildings designed to utilize trade winds for cooling to remain comfortable. This is particularly true in lower elevation areas rather than Lāna'i City because the City is at a significantly higher elevation.

Future climate change-driven disruptions are likely to cause further increases in the cost of food and basic needs, which will especially impact kūpuna. The loss of fog drip over time is also a significant concern as it relates to maintaining vegetation on the windward side of the island as well as drawing water from the clouds that help recharge the aquifer.

East Maui

The Eastern region of Maui is considered separately in this assessment because its characteristics are significantly different from the rest of the island of Maui due to its remote geography and limited access. East Maui is characterized by wild areas and small, rural communities, which differs from the denser populations in other parts of Maui Island.

The "Road to Hana" (Hwy 360) allows residents and visitors access to the East Maui region. Much of the wilder areas of East Maui are found within the East Maui Conservation Area, which is made up of various private and public protected areas, including Haleakalā National Park, Hanawī State Natural Area Reserve, The Waikamoi Preserve of The Nature Conservancy, the State Forest Reserve System, and the state Conservation District. These protected areas make East Maui a prime tourist destination, which can at times overwhelm the small communities of the region and cause strain on resources, such as water and energy. Housing availability is also a challenge in this region due to low supply, high demand, increase in building materials, and escalating rental prices.

Provided by Maui County

As residents of rural communities, the people of East Maui are generally adapted to its remoteness and understand the potential of being cut off from the more populous areas of the island due to natural disasters, such as large storms, flooding, and wildfire. Infrastructure, particularly roads and bridges, in East Maui needs significant upgrades to make residents less vulnerable to extreme weather events. Communication infrastructure that supports Internet connections and phone coverage is also an existing challenge in East Maui communities, particularly in the event of an emergency.

East Maui residents are observing significant changes due to climate change, including higher temperatures, more severe heat, increased drought, larger storms and flooding, and increasing shoreline erosion.

They see these changing conditions as directly related to other visible changes, such as:

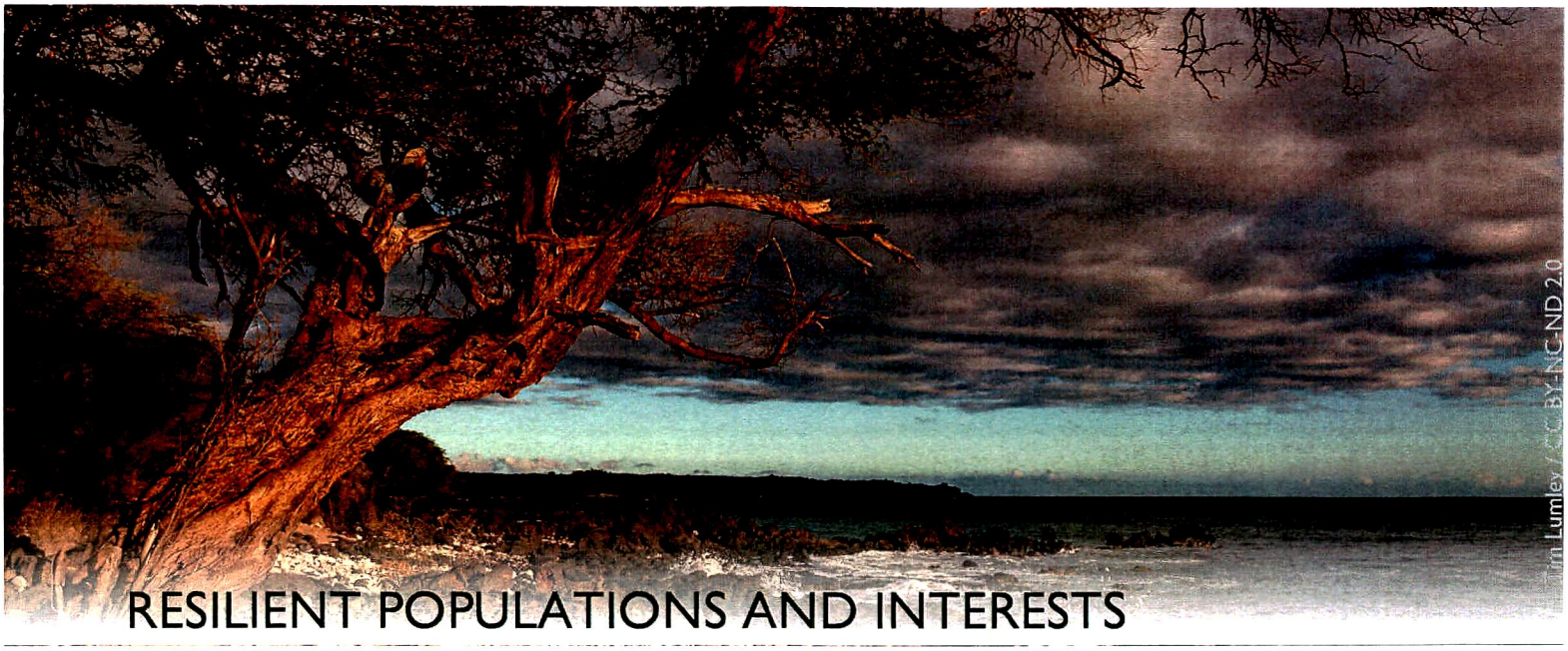
- Invasive species, especially Miconia, taking over the forests
- Less ability to grow food due to heat and drought for both farmers and residents
- Large-scale flooding closing roads and bridges (especially the Kukui'ula Bridge), interrupting daily life, affecting emergency response, and limiting access to medical care and supplies

- Subsistence gathering of limu and other plants becoming more difficult
- Ke'anae homes and infrastructure already impacted by sea level rise
- Impacts to native species, such as Hīhīwai
- Elders, infants, and those with chronic health problems harmed by extreme heat
- Erosion is a particular problem in 'Ula'ino, Maka'alae, Haneo'o, Waikōloa, Paehala, Kaihalulu, Ka'uiki hill, and Kaupō
- Palapalai ferns dying back, impacting cultural practices
- Floods getting more extreme
- Coral reef bleaching affecting marine life and subsistence food supplies

In addition to the issues listed above worsening over time, attendees of the Talk Story session identified the following climate-driven or related vulnerabilities:

- Increased risk of landslides and falling trees damaging infrastructure and cutting off East Maui residents from the rest of the island
- Overall watershed health declining making natural system vulnerabilities worse
- Gathering from streams will be more difficult because of the impact of increasing temperatures on aquatic life
- Potential community conflicts over water if water systems continue to degrade and shift
- Multi-generational families with shoreline properties impacted by sea level rise with some losing their homes and being displaced
- Groundwater recharge not able to keep up with withdrawals due to larger but less frequent storms
- Impacts to residents' ability to be more self-sufficient
- Higher temperatures making it more desired for residents, especially kūpuna, to install air conditioning, which is a challenge for low income residents who cannot afford to install the appliance or pay the additional operating costs

Provided by Maui County



RESILIENT POPULATIONS AND INTERESTS

As part of this project's scope, the County of Maui has identified the need to include conversations specific to resilient populations and interests as well as critical assets. The following two sections address those needs and use maps to articulate risks. Note that there is repetition between this section and the vulnerabilities listed above.

Natural disasters and chronic stressors caused by changing climate conditions disproportionately impact people who are already struggling in any community. Those struggles can be due to various reasons, including but not limited to age, disability, historical and ongoing inequities, racially-driven disempowerment, and low income. When multiple characteristics intersect, the result is often extreme vulnerability for those individuals. The amount of personal support from family, friends, and community services can dramatically impact their vulnerability to changing climate conditions and climate change-driven natural disasters. This is another reason why it is important to hold strong family and community connections during climate resilience planning processes.

Understanding and building upon the resilience already present in low-income and/or otherwise marginalized communities is critical. Without monetary wealth, individuals must rely on their family, friends, and neighbors to meet basic needs. Sharing resources and caring for each other builds a social cohesiveness and underlying resilience that shows its strength in times of crisis or emergency. Social cohesiveness can be a strong foundation upon which to build the personal resilience of those in the community who are already struggling and may be considered, in some instances, to be more vulnerable to changing conditions.

Communities with wide income gaps are more likely to experience increasing social strife as climate change unfolds over the coming decades. Because of this, efforts to ensure that all residents have the means to provide for their basic needs and build personal resilience is a valid approach to building climate resilience. In some sense, community resilience is the aggregate of the personal resilience of all community

members, particularly in areas where some communities are geographically distinct and easily isolated in the event of natural disasters.

Community cohesiveness is also an important element of climate resilience. Maui County is ethnically diverse with over 18% of its population identified as foreign born by the U.S. Census. The demographics of the county are as follows (*U.S. Census Bureau QuickFacts: Maui County, Hawaii*, 2022):

- White – 34.9%
- Black or African American - .8%
- American Indian and Alaska Native - .6%
- Asian – 29%
- Native Hawaiian and Other Pacific Islander – 10.6%
- Two or More Races – 24.2%
- Hispanic or Latino – 11.6%

Diversity can bring many strengths to a community, and it can also make it difficult to engage residents in developing climate resilience strategies. Differences in language, community decision-making customs, and cultural approaches to threats can present specific challenges, particularly related to emergency management and long-term investment in resilience.

Provided by Maui County

Certain populations may be resistant to participating in community discussions, being counted in official processes, or taking advantage of informational resources. Because of this, Kānaka Maoli, citizens of Compact of Free Association countries, and unhoused populations are almost certainly undercounted in estimates of social and economic need, so it should be a high priority to engage and address their needs as the climate resilience process moves forward over time.

Roughly nine and a half percent (9.5%) of Hawaiians live in poverty (*U.S. Census Bureau QuickFacts: Maui County, Hawaii*, 2022). In addition, Maui United for ALICE has completed an assessment to identify ALICE (Asset Limited, Income Constrained, Employed) households. That assessment shows the residents of Maui County who fall under the ALICE designation. Forty-two percent (42%) of Maui County residents are identified as meeting the thresholds for ALICE designation (*Hawai'I | UnitedForALICE*, 2018). In Maui County, both homeowners and renters are often struggling financially even when they are working regularly. In addition, recent spikes in housing prices and rents are exacerbating the existing high cost of living challenges, making it even more difficult for lower income people to make ends meet in Maui County.

The County of Maui is currently using the ALICE data set to identify populations particularly vulnerable to urban heat island effects and in danger of wildfire. Information from that assessment will be used to guide implementation of strategies to address those risks.

Another key climate hazard is coastal flooding and inundation. Distribution of ALICE households related to these sea level rise hazards show several areas where households with the ALICE designation are particularly vulnerable to sea level rise across Maui County (Figure 7). Note that ALICE data corresponds to zip codes, which makes the analysis coarser than what is necessary to target strategies to address sea level rise hazards to community members who meet the ALICE or poverty line thresholds. In

addition, this analysis focuses attention on total economic loss, which will be greater in wealthier areas of Maui County.

To address this, we also analyzed the 3.2 foot sea level rise scenario against Census block data that shows the density of impoverished households as a better indicator of the vulnerability of communities and neighborhoods to sea level rise. (See Figure 8)

The combination of low-income residents, potential supply chain disruptions, and likely continued increases in the cost of food, housing, and energy together form a key element of community well-being that must be strengthened and monitored over time.

The Maui Nui Food Alliance is conducting a Food System Needs Assessment to examine food systems across Maui County to identify the barriers that prevent Maui County from having a food supply that is self-sufficient, secure, and sustainable. It will identify where low-income residents are getting their food, how much is coming from foraging, and how much they are spending. This assessment will be used to inform the Maui County Food Security Plan, which will guide Maui County to improve nutrition security, and climate and emergency resilience while providing opportunities for local food producers, with targets identified over the next 5, 10, and 20 years. This assessment is being conducted concurrently with the climate planning process underway. In addition, Maui United Way is developing a Food Security Dashboard, and Hawai'i Health Matters is tracking food insecurity. (See Figure 9). Integrating these efforts into future strategy development will be essential to addressing food security issues for Maui's most vulnerable residents.

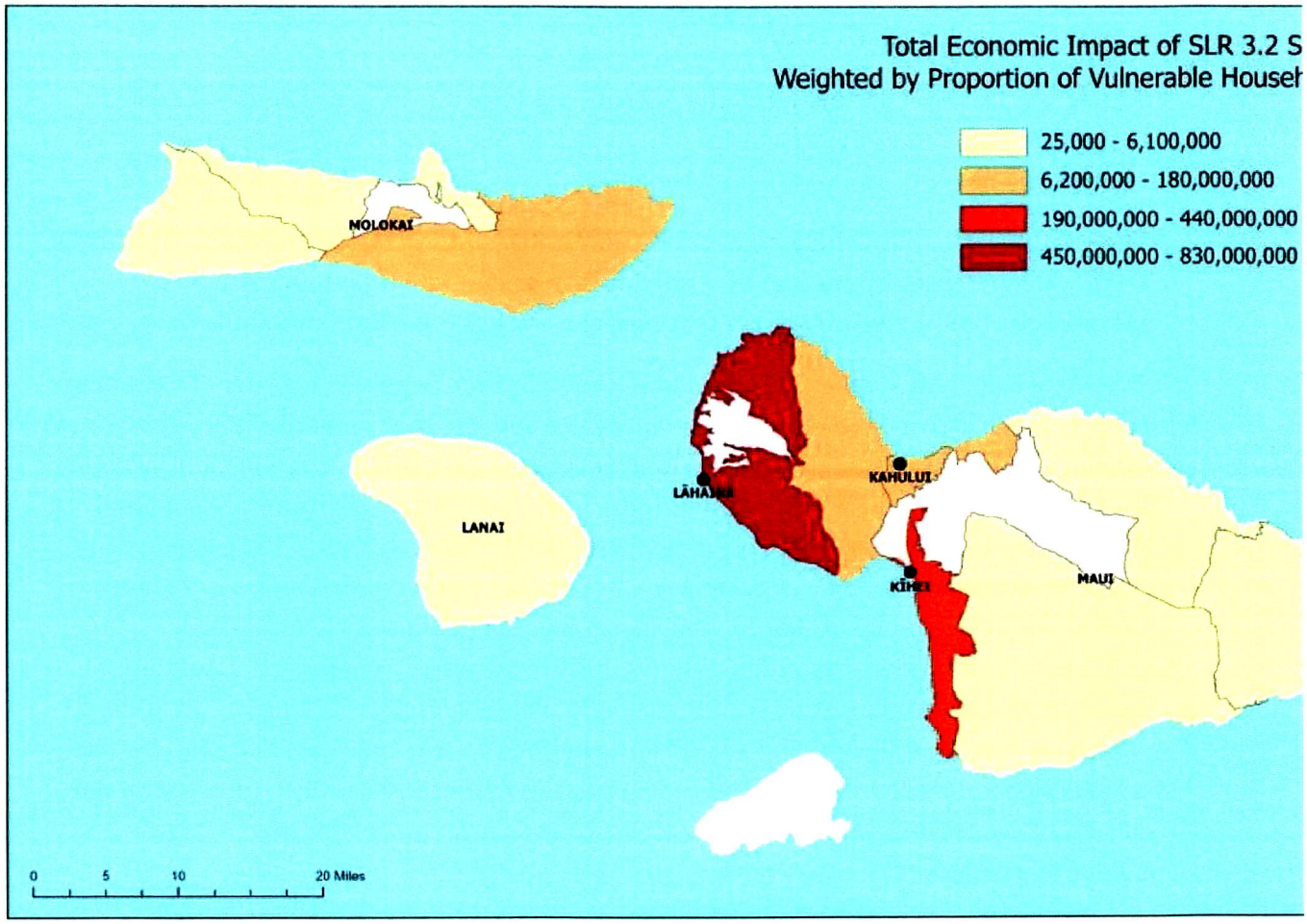
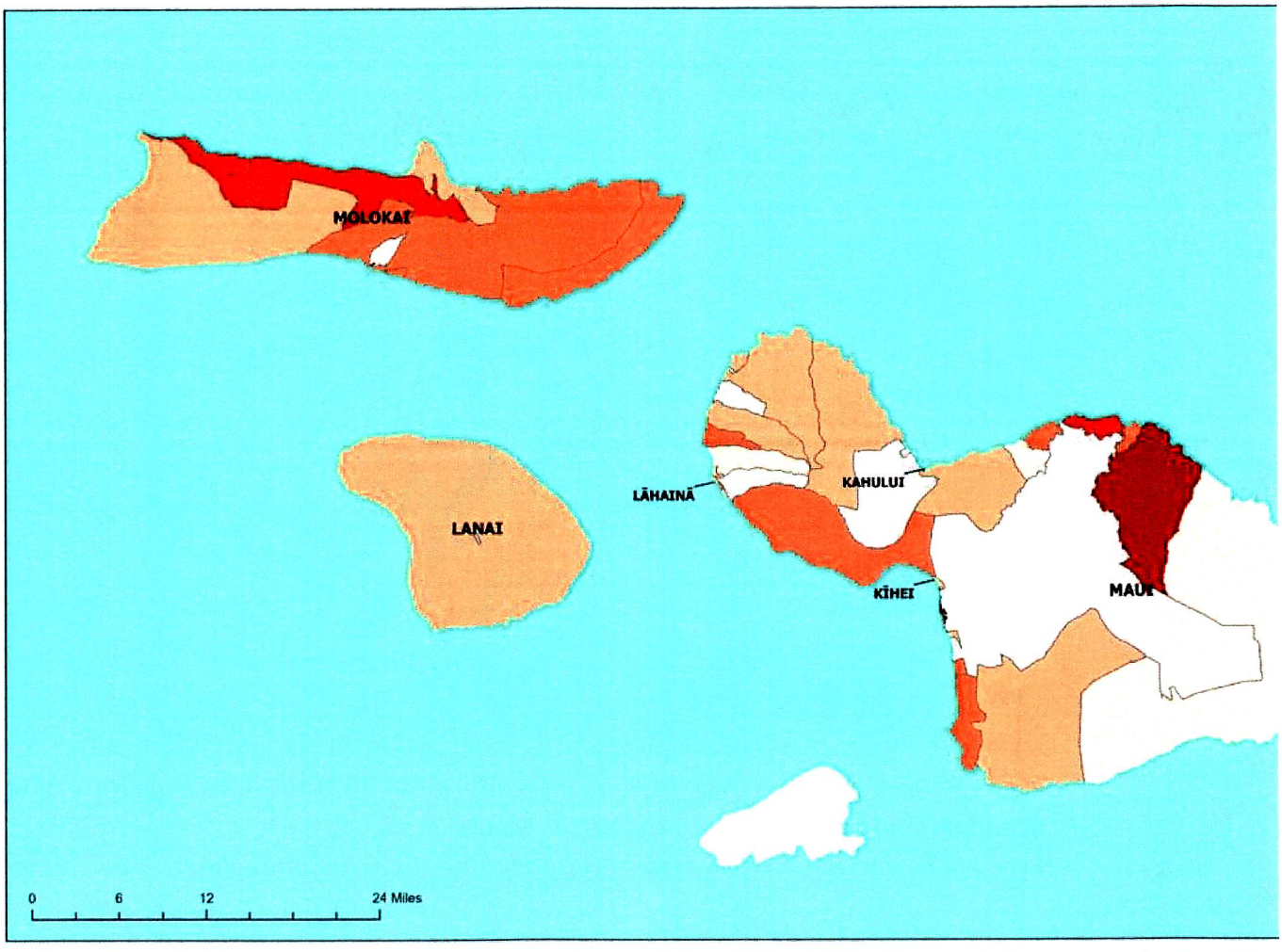


Figure 7. Total economic impact of sea level rise 3.2 scenario weighted by proportion of vulnerable hou



Tetra Tech, Inc. 2017. Sea Level Rise - Potential Economic Loss. http://planning.hawaii.gov/gis/download-gis-data/; ALICE dataa: http://www.auw.org/United-For-ALICE; Esri, HERE, Garmin, SafeGraph, FAO, METI/NA

Figure 8. Passive flooding risk from 3.2 foot sea level rise for impoverished households by census block

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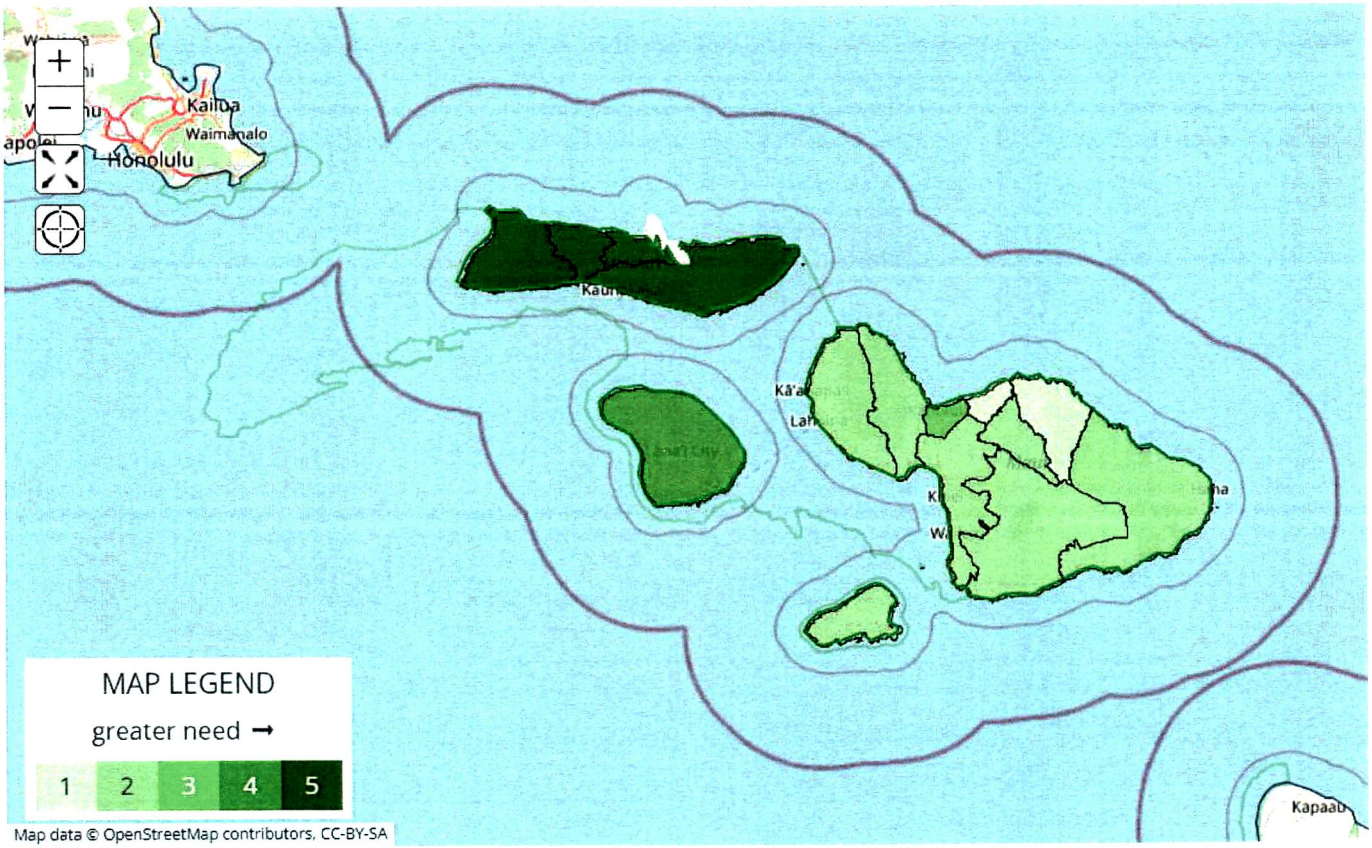


Figure 9: Hawai'i Health Matters Food Insecurity Index 2021 provides a measure of food access correla economic and household hardship across Maui County.
https://www.hawaiihealthmatters.org/indexsuite/index/foodinsecurity

Key Takeaway

Residents with the ALICE designation or identified as living under the poverty line are most likely to be at increased risk due to changing climate conditions. Residents experiencing situations that would typically make them more vulnerable, but are not struggling financially, can often access other assistance that significantly reduces their vulnerability. Because of this, Maui County should continue to focus on identifying and meeting the climate resilience needs of low-income residents, unhoused residents, and populations that are geographically or culturally isolated and resist participation in local government processes. There will be significant overlap in these populations. At the same time, it will be critically important to act to prevent the number of Maui residents who fall under the ALICE designation or the poverty line from increasing over time or falling into homelessness.

Capacity

Maui County has many programs underway to strengthen its residents' personal and family resilience. State and county level programs exist alongside the efforts of organizations, such as Maui United Way, Ka Hale A Ke Ola Homeless Resource Centers, Hawaiian Community Assets, the Maui Nui Food Alliance, Sust'āinable Molokai, and others, and can be strengthened through community-based partnerships. In addition, Hawaiian Electric has analyzed areas most vulnerable to power outages and prioritizes those communities when outages occur. That analysis is proprietary, but the County of Maui should consider partnering with Hawai'i Electric to have a consistent process for prioritizing the needs of communities during emergencies.

CRITICAL ASSETS

Critical assets in a community include hard infrastructure assets (e.g., roads, buildings, etc.), the ecosystems that provide resources and services to the community, and the cultural resources necessary to sustain a community's physical, mental, and spiritual well-being. This analysis focuses on the interaction of these various infrastructure systems with sea level rise. Analysis of wildfire risk on hard community assets has been completed as part of the County of Maui Hazard Mitigation Plan Update. Intact native ecosystems appear to be outside the regions where increases in wildfire are expected as those areas correspond with dense human populations and land converted to agricultural production. (See Figure 10) Extreme heat is not expected to have an impact on cultural or hard community assets. While it is likely to impact how the community interacts with those assets, it is not expected to impact the assets themselves. Finally, increasingly severe storms are difficult to analyze in relation to the physical geography of the islands of Maui County. However, coastal areas at risk from sea level rise are also likely to be particularly vulnerable to increasingly severe storms.

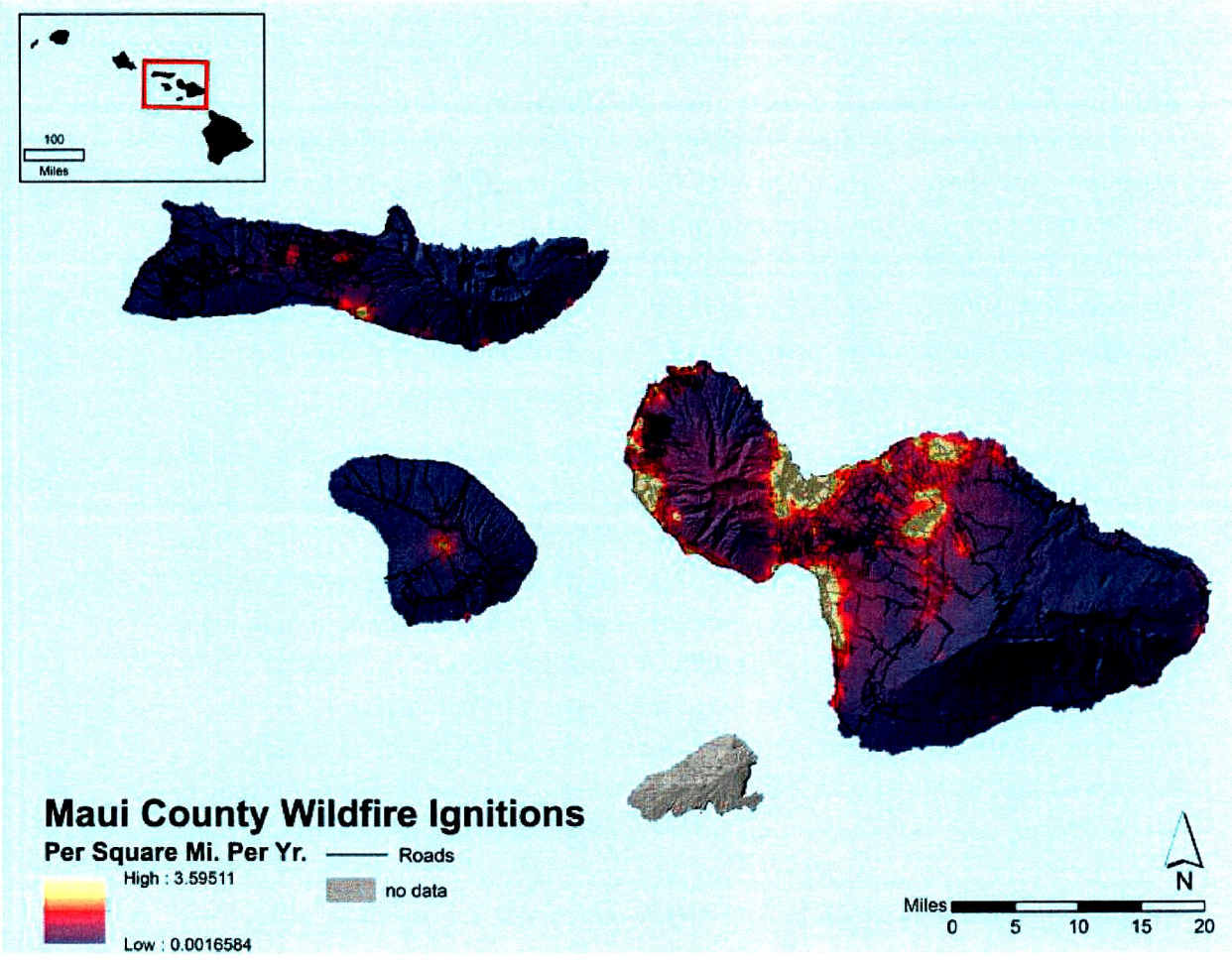


Figure 10. Maui County Wildfire Ignitions 2016. University of Hawai'i - Manoa College of Tropical Agriculture and Human Resources. Wildfire Ignition Density Maps for Hawai'i (2016)

Sea Level Rise Scenario

The analysis of natural, cultural, and community infrastructure related to sea level rise is conducted using the 3.2 foot sea level rise scenario, which is considered best practice for climate change planning in the Hawaiian Islands. The following information regarding this scenario and the methods used to develop it, is available from the State of Hawai'i, Office of Planning:

> *Modeling, using the best available data and methods, was conducted to determine the potential future exposure of each of the main Hawaiian Islands to multiple coastal hazards as a result of sea level rise. Three chronic flooding hazards were modeled by the University of Hawai'i Coastal Geology Group (CGG): a. passive flooding, b. annual high wave flooding, and c. coastal erosion (see descriptions of individual hazard layers for further details). The footprint of these*

three hazards were combined by Tetra Tech, Inc. to define the projected extent of chronic flooding due to sea level rise, called the sea level rise exposure area (SLR-XA). Flooding in the SLR-XA is associated with long-term, chronic hazards punctuated by annual or more frequent flooding events. Each of these hazards were modeled for four future sea level rise scenarios: 0.5 foot, 1.1 foot, 2.0 feet and 3.2 feet based on the upper end of the IPCC AR5 RCP8.5 sea level rise scenario. This particular layer depicts SLR-XA using the 3.2-ft (0.9767-m) sea level rise scenario. While the RCP8.5 predicts that this scenario would be reached by the year 2100, questions remain around the exact timing of sea level rise and recent observations and projections suggest a sooner arrival.

Assumptions and Limitations: The assumptions and limitations described for the three chronic flooding hazards apply to the SLR-XA. Not all hazards were modeled for each island due to limited historical information and geospatial data. The SLR-XA for the islands of Hawai'i, Molokai, and Lāna'i is based on modeling passive flooding only. Additional studies would be needed to add the annual high wave flooding and coastal erosion to the SLR-XA for those islands. The SLR-XA is an overlay of three hazards and does not account for interactive nature of these hazards as would be expected by natural processes. As with the individual exposure models, the SLR-XA maps hazard exposure on the present landscape. The modeling does not account for future (unknown) land use changes, including any adaptation measures. The SLR-XA also does not include impacts from less frequent high wave events (e.g., a 1-in-10 year event), storm surge, or tsunami.

Cultural Assets

While there is no comprehensive, singular map that shows significant cultural sites across the County of Maui, efforts to create one are underway. The Principal Archaeologist for the County of Maui has been identifying the data necessary to develop a cultural overlay map to display various forms of data via a Geographical Information Systems platform. This cultural overlay map will identify above ground resources (historic architecture), archaeological sites, and burial sites. Land commission awards and grants, battles and mythological events, as well as real and projected sea level rise, soils, topography, flood zone maps, etc. Using a holistic, cultural landscape approach, the cultural overlay map will create discrete layers for the various types of data displayed. Of particular concern in this effort is the impact of climate change and the vulnerability of pre- and post-contact burials, which continue to be exposed by erosion along with inland cultural sites impacted by larger flooding events on county, state, and privately owned parcels. Once the cultural overlay is developed, the process will involve assessing a range of potential risks to significant cultural sites or landscapes. Note that several assets listed as Ecosystem Assets below are also cultural assets.

Ecosystem Assets

Because Maui County is made up of four islands surrounded by the Pacific Ocean, the relationship between its communities and the natural environment is closely connected, and the health of the environment directly impacts the health of the residents. As identified in the sections above, coral reefs, native forests, and anchialine pools are of particular importance to the community. In 2015, an extensive effort was undertaken by EcoAdapt to synthesize the information generated by the partners of the Pacific Islands Climate Change Cooperative. The final report, the Hawaiian Islands Climate Vulnerability and Adaptation Synthesis, was reviewed by over 200 community leaders and technical experts, including many from Maui County (Gregg, 2018). It was published in 2018 and identifies current conditions, primary climate risks, and potential adaptation solutions for natural systems across the state, with separate sections for each of the islands (Gregg, 2018). As these are the same ecosystems identified in the stakeholder workshop held as part of this process, this report integrates the results of that earlier assessment. The strategy development phase of this planning process with the County of Maui will build upon the information provided by the assessment as well.

At the same time, systems developed by Kānaka Maoli in concert with local ecosystems, such as loko kuapā (walled fishponds) and loko iʻa kalo (Fishpond in which taro is cultivated), are also critically important, as are loʻi kalo that capture sediment and protect coral reefs. Because of their synergistic relationship with ecosystems, these community systems are included in the ecosystem assets section, but they are also important cultural assets. Lists of locations of these ecosystem-based food systems are unavailable, but once they are, it will be important to map them against climate-driven hazards, such as sea level rise and inland flooding. Because of their location, all fishponds are expected to be at risk from sea level rise.

Coral Reefs

Healthy coral reefs provide habitat for diverse marine life, food for residents, protection from large storms, and a draw for tourists. Unfortunately, the coral reefs are particularly vulnerable to various forces acting on them concurrently, including warming waters, ocean acidification, sedimentation, pollution from fertilizers and pesticides, and damage from watercraft. While local action is not likely to affect the issues of warming water and ocean acidification, efforts to address the concurrent stresses to the coral reefs can have a significant positive impact on coral reef health.

Forest Ecosystems

Hawai‘i is home to several native forests: dry, mesic/wet, and alpine/subalpine. All forest types have been severely disrupted by various forms of development and are at increased risk due to climate change.

Native forests are key to the freshwater cycle in Maui County as many native forest tree species have evolved to collect moisture from clouds touching their leaves, condensing and dripping water down to the soil. This process, known as fog drip, happens even on days without rain. “On the leeward slopes of Haleakalā, mesic forests of koa and ‘ōhi‘a once grew at the same elevations where clouds banked against and around the mountain each day, encircling it in a lei of green. Alien grasses break the localized water-cycling, and today, the lei is broken. Only 5% of native leeward forests remain.” (Hawai‘i Department of Land and Natural Resources., 2019)

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW), and local partners have been working to return the leeward side of Haleakalā to native forests to provide habitat for native birds and protect reefs from erosion.

In addition, DOFAW’s 30X30 Watershed Initiative aims to protect thirty percent (30%) of high priority watersheds by 2030, to protect this important source of freshwater and increase water security across the state (*Watershed Partnerships Program*, 2022). Maui County is home to four Watershed Partnerships that implement the initiative through management actions, such as fencing to keep ungulates out of important watershed forests, control invasive species, and plant more native species (see Figure 11). Through collaborative management, Watershed Partnerships are voluntary efforts by public and private landowners to protect forested watersheds for water recharge, conservation, and other ecosystem services. Protecting forested watersheds buffers communities against drought, flooding, erosion, and loss of drinking water.

Finally, DOFAW is working with state and federal partners to develop a single landscape-scale plan that integrates multiple recovery plans for all species at risk of extinction on Maui, Moloka‘i, and Lāna‘i.

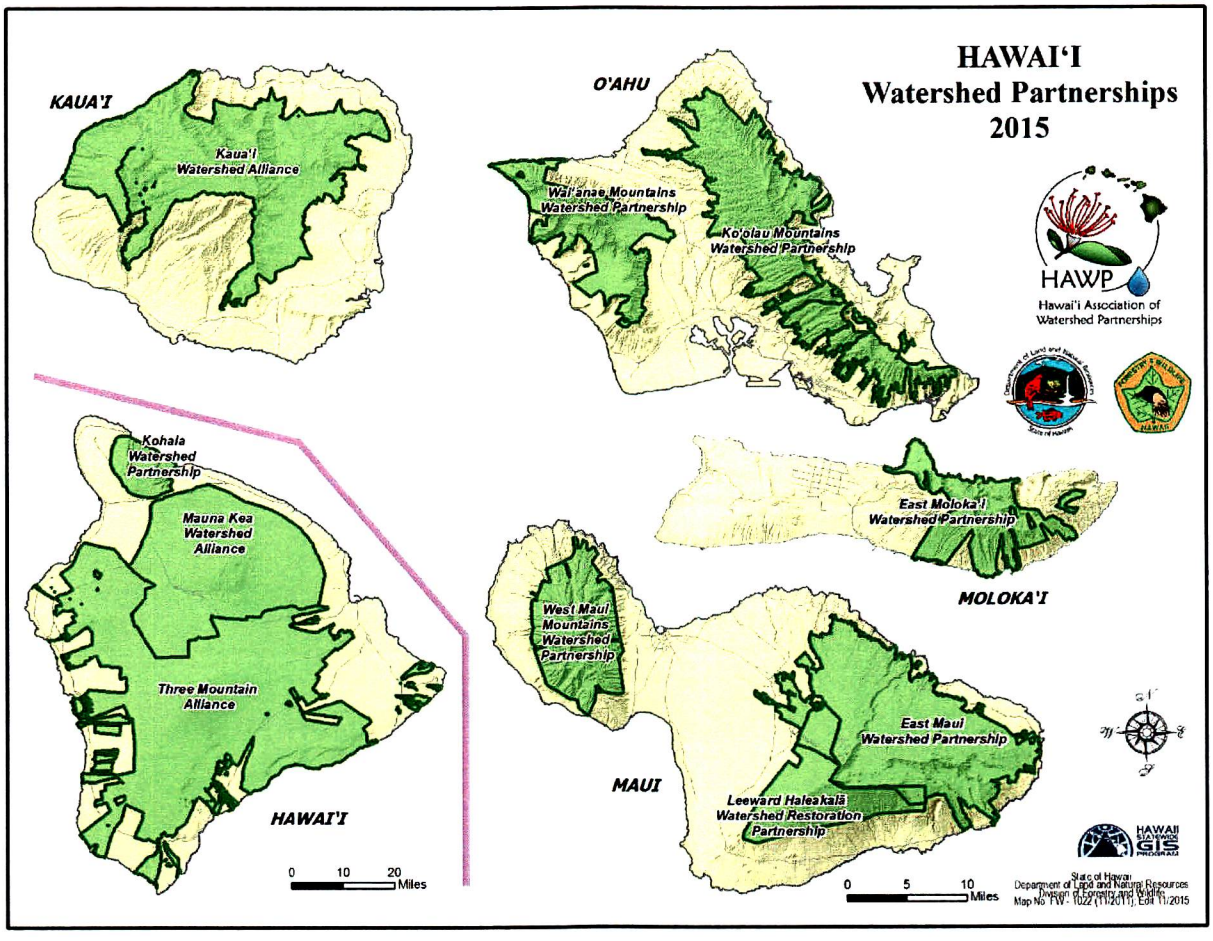


Figure 11. Watershed Partnerships underway in Hawai'i as of 2015. Source: Department of Forestry and Wildlife. https://dlnr.hawaii.gov/ecosystems/wpp/

Critical Habitat Ecosystems

"Maui Nui Critical Habitat Ecosystems: These data identify, in general, the areas where final critical habitat occurs for 135 species known historically from Maui Nui, on the islands of Maui, Molokai and/or Kahoolawe. A total of approximately 63,537 hectares (ha) (157,002 ac) of land on Maui Nui fall within the boundaries of the critical habitat units designated for the 135 species." (Pacific Islands Fish and Wildlife Office, Office of Planning and Sustainable Development, State of Hawaii, n.d.)

Wetlands

Wetlands serve several critical roles for native wildlife and human communities. Wetlands are highly biodiverse in both flora and fauna species and often provide safe rearing grounds for a wide range of species. Wetlands also filter pollutants and grow

plants that provide protection from coastal flooding and erosion. Many wetlands are located right along the coast making them particularly vulnerable to sea level rise.

Anchialine Pools

Anchialine pools are landlocked bodies of water with a subterranean connection to the ocean. They are unique ecosystems that support biodiversity, endemic species, cultural practices, and tourism. Because of their physical structure and proximity to the ocean, all anchialine pools are at risk due to rising sea levels and other stressors. This report identifies threats to anchialine pools as a specific vulnerability.

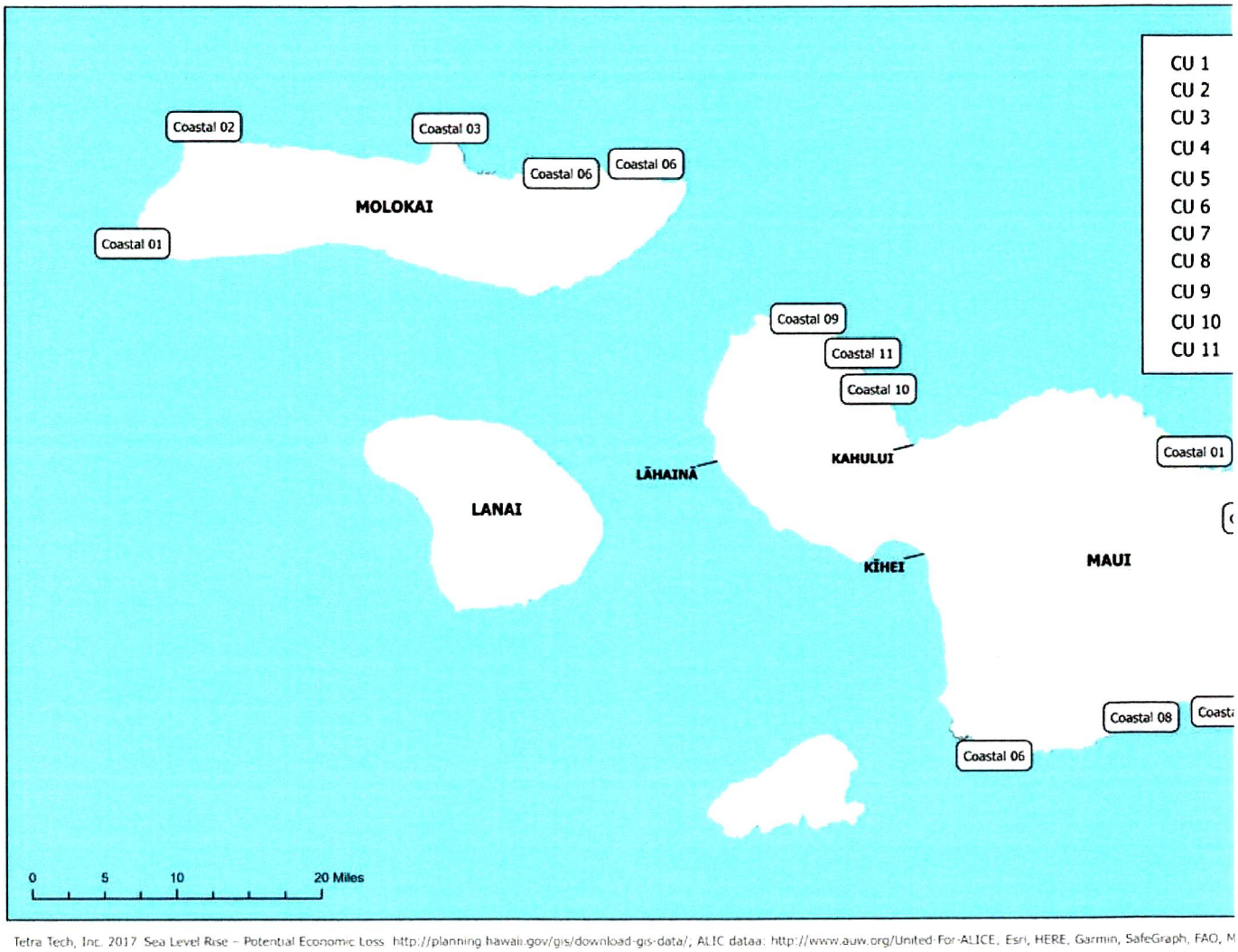
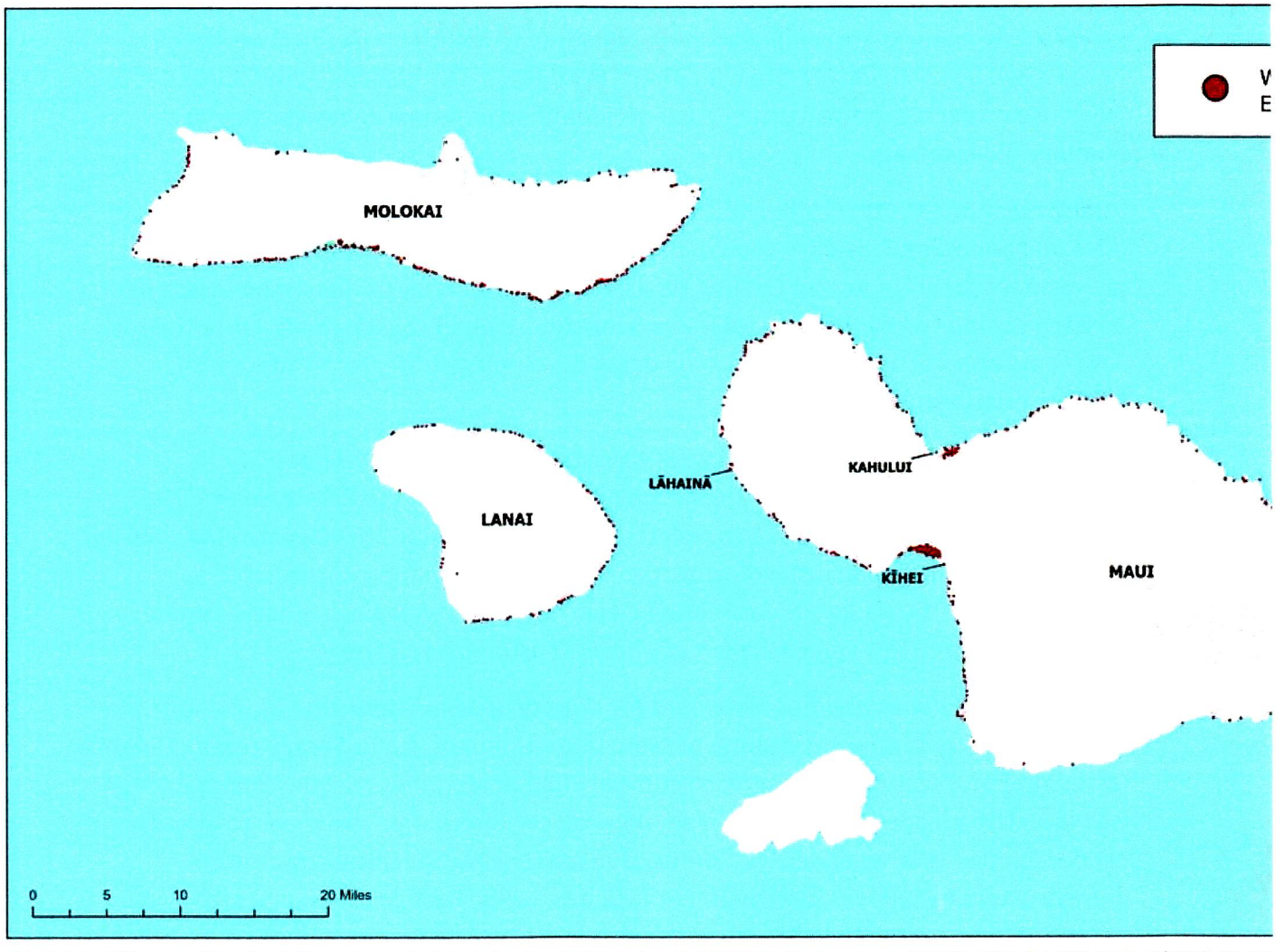


Figure 12. Critical habitat ecosystems endangered by sea level rise of 3.2 feet in Maui County. https://histategis.maps.arcgis.com/home/item.html?id=f1c109608df7445886daae2801f4a615



Tetra Tech, Inc. 2017. Sea Level Rise - Potential Economic Loss. http://planning.hawaii.gov/gis/download-gis-data/, ALIC dataa: http://www.auw.org/United-For-ALICE; Esri, HERE, Garmin, SafeGraph, FAO, ME

Figure 13. Wetlands endangered by sea level rise of 3.2 feet in Maui County.
https://histategis.maps.arcgis.com/home/item.html?id=2250370303ef44c8becf4fbe549e3f43

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Hard Infrastructure Assets

Several assessments are underway in Maui County to identify the critical assets threatened by changing climate conditions. In addition, our analysis of the impact of sea level rise on various infrastructure systems identified potential vulnerabilities to a number of key assets.

Assessment of County of Maui Coastal Roads for Effects of Climate Change, Sea Level Rise and Shoreline Erosion – The County of Maui Public Works Department has an assessment program for the County's coastal roads underway to match the assessment already completed by the State of Hawai'i for state-owned coastal roads. Once the road segments are assessed, the County will begin developing strategies to address the highest priority vulnerabilities.

Maui County Department of Parks and Recreation Beach Park Vulnerability Assessment – An assessment of the beach parks operated by the County of Maui is underway, and a draft has been completed. This study assesses the climate vulnerability of the County's beach parks and categorizes them based on their particular vulnerabilities. The Parks and Recreation Department is developing six basic climate adaptation strategies, and each park will have a customized strategy.

Sea Level Rise Vulnerability Assessment for County of Maui Department of Water Supply Infrastructure – The County of Maui Department of Water Supply completed this assessment for water supply infrastructure in 2020. It identifies facilities vulnerable to sea level rise, needed capital improvement projects, alternative strategies to address vulnerabilities, and synergies with other county agencies. Specifically, water infrastructure includes water treatment facilities, wells, storage tanks, pipes, and water meters. There are multiple private water purveyors on Maui, none operating a surface water treatment facility. To what extent private water purveyors identify climate vulnerabilities to their systems is unclear. This analysis indicated that no water treatment facilities are located in the sea level rise exposure zones. The next step is for the Department of Water Supply to develop strategies to address vulnerabilities identified in this report and integrate them into the County of Maui's Capital Improvement Projects planning process.

County of Maui Wastewater Infrastructure Inundation Study – This completed study evaluates the potential impacts of sea level rise and storm surge on the County of Maui's wastewater system. Since it was conducted prior to any directives to plan for climate change, it utilized existing background documents and directives issued by the Hawai'i Climate Change Mitigation and Adaptation Commission and the City and County of Honolulu as the baseline for the evaluation. As part of the process, the Maui County Department of Environmental Management Wastewater Reclamation Division staff met

to determine the allowable risk related to sea level rise and inundation. The report identifies hazard scenarios and adaptation options.

The Maui Island Water Use and Development Plan – This plan was updated in 2020, with similar efforts currently underway on Molokai. The Lāna'i plan will be developed once the plan for Moloka'i is complete. It is critically important that these plans address the impacts of climate change on both freshwater and groundwater supply in their respective planning areas.

Assessment of Groundwater Availability – Groundwater availability to meet future needs is a concern across Maui County. In addition to the impacts of climate change related to less precipitation, increased drought, and larger storms that impact groundwater recharge, increasing population, greater demand for groundwater, and changes in land cover caused by humans or invasive species stress groundwater supply. To better understand groundwater resources, the County of Maui Department of Water Supply entered into an agreement with the U.S. Geological Survey, Pacific Islands Water Science Center, and the U.S. Department of the Interior to assess groundwater availability under scenario-based recharge changes on the island of Maui. That assessment is expected to be completed in March of 2023.

County of Maui Multi-Hazard Mitigation Plan – This plan specifically addresses increasing risks to residents due to sea level rise, coastal erosion, drought, extreme heat, landslides, and wildfire. Detailed information was available regarding sea level rise and coastal erosion, with the other risks noted as already present and increasing due to climate change. In addition, the plan identifies wildfire risk areas as low, medium, and high and identifies 248 potential at-risk critical facilities within Maui County wildfire risk areas.

Electric utilities in many regions of the U.S. assess maintenance of their electrical lines specifically to prevent the ignition of wildfires during storm events. Several areas of Maui County transmit electricity through electrical lines that cross through challenging terrain, which makes maintenance of those lines costly and difficult. At the same time, salt water corrosion can make those electrical lines fail sooner than they would in other conditions. Since lightning is not a typical ignition source in Hawai'i, focusing attention on reducing ignitions can be particularly helpful in reducing wildfire risk.

The plan notes that flooding risk assessment is based on FEMA mapping, which integrates future climate projections.

Residential and Commercial Wastewater Infrastructure

A growing concern in an era of sea level rise is wastewater pollution from cesspools, injection wells, and septic systems. If damaged or exposed to groundwater or surface

water, these systems release pollution that has detrimental effects on shoreline and reef habitat due to nutrient loading. It also can lead to negative health consequences for residents and visitors that go in the ocean for a variety of purposes. The State of Hawai'i passed Act 125, which bans the installation of new cesspools and provides assistance for upgrades of existing cesspools in sensitive areas. The state has also set a goal of upgrading more than 88,000 cesspools in the state by 2050. In a recent report to the Hawai'i State Legislature, the University of Hawai'i shared the results of the State-wide Assessment of Wastewater Pollution Intrusion into Coastal Regions of the Hawaiian Islands, concluding that wastewater discharge to coastlines was significant on all the main Hawaiian Islands included in the study (Smith et al., 2021). (see Figure 14)

In a report recently released by the Maui Nui Marine Resources Council, research showed that Nitrate levels far exceeded Department of Health standards at Kapalua, Ka'ōpala, Nāpili, Pōhaku, and Hanaka'ō'ō Canoe Beach. In addition, turbidity and nitrate levels were consistently low in the coastal waters adjoining Keālia Pond, likely due to the wetlands' ability to filter nitrates and sediment from freshwater flows including from stormwater runoff (Reed et al., 2022).

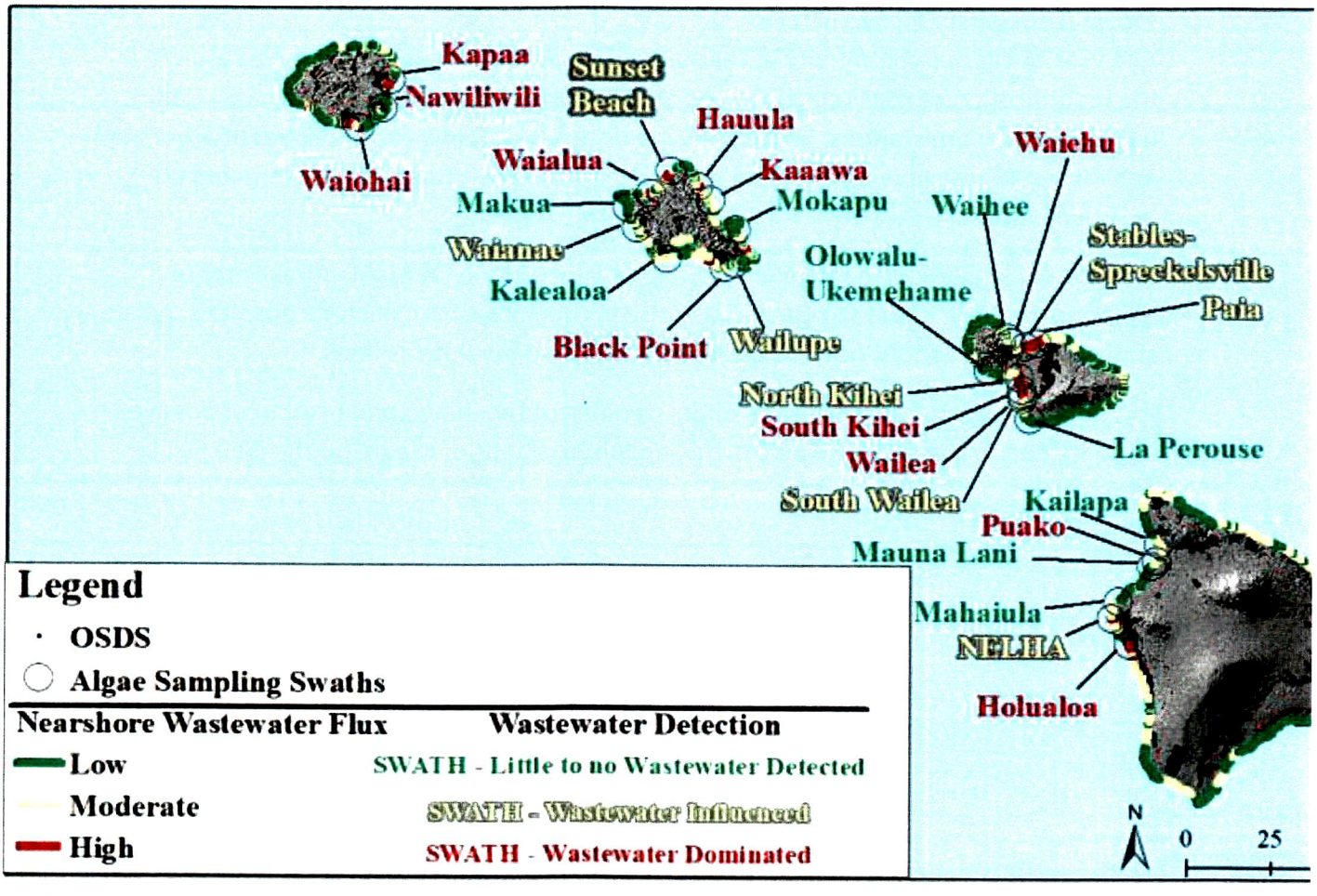

Figure 14. Results of nearshore wastewater assessment for four largest islands in the State of Hawai'i. Sta Wastewater Pollution Intrusion into Coastal Regions of the Hawaiian Islands https://danielwamato.com/a biological-characterization-of-cesspool-wastewater-in-hawaiian-coastal-regions/

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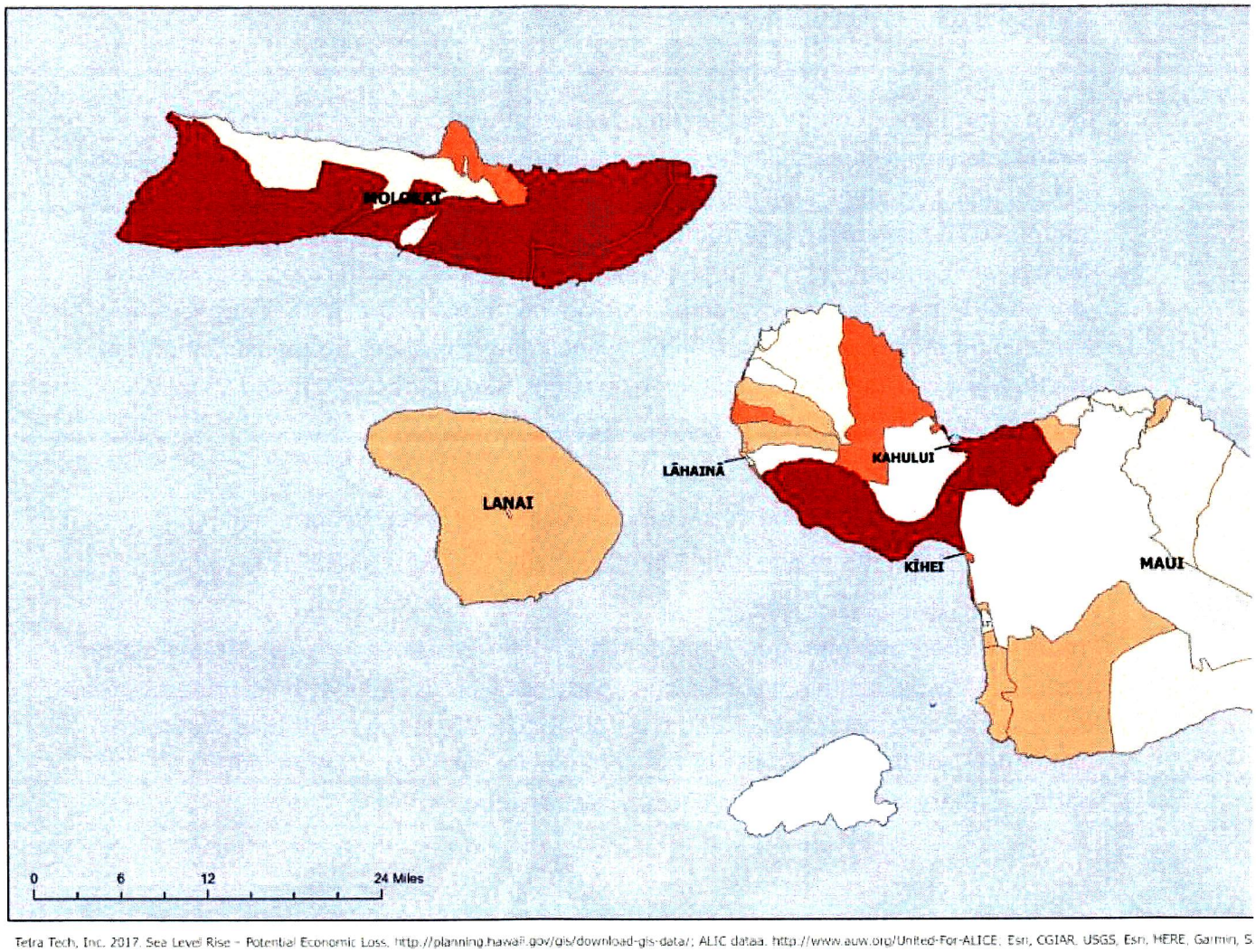
Other Community Infrastructure

Analyses of various community infrastructures related to sea level rise have resulted in the identification of risks related to airports, boating facilities, bridges, commercial harbors, dams, fire stations, hotels, sewage disposal systems, and small boat harbors and ramps. Maps showing sea level rise related to these infrastructure elements are included below.

Based on an analysis of data layers provided by the County of Maui, infrastructure elements that are not at risk of sea level rise in the 3.2 scenario include hospitals, police stations, public schools, hospice facilities, and skilled nursing facilities.

It is helpful to also have a baseline understanding of the inland penetration of passive flooding due to sea level rise across the inhabited islands of Maui County. (See Figure 15)



Tetra Tech, Inc. 2017. Sea Level Rise - Potential Economic Loss. http://planning.hawaii.gov/gis/download-gis-data/; ALIC dataa. http://www.auw.org/United-For-ALICE. Esri, CGIAR, USGS, Esri, HERE, Garmin, S

Figure 15. Average inland penetration of passive flooding due to sea level rise of 3.2 feet.

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The following maps show various hard infrastructure assets and their relative risk due to sea level rise.

Commercial Harbors, Small Harbors, and Boating Facilities

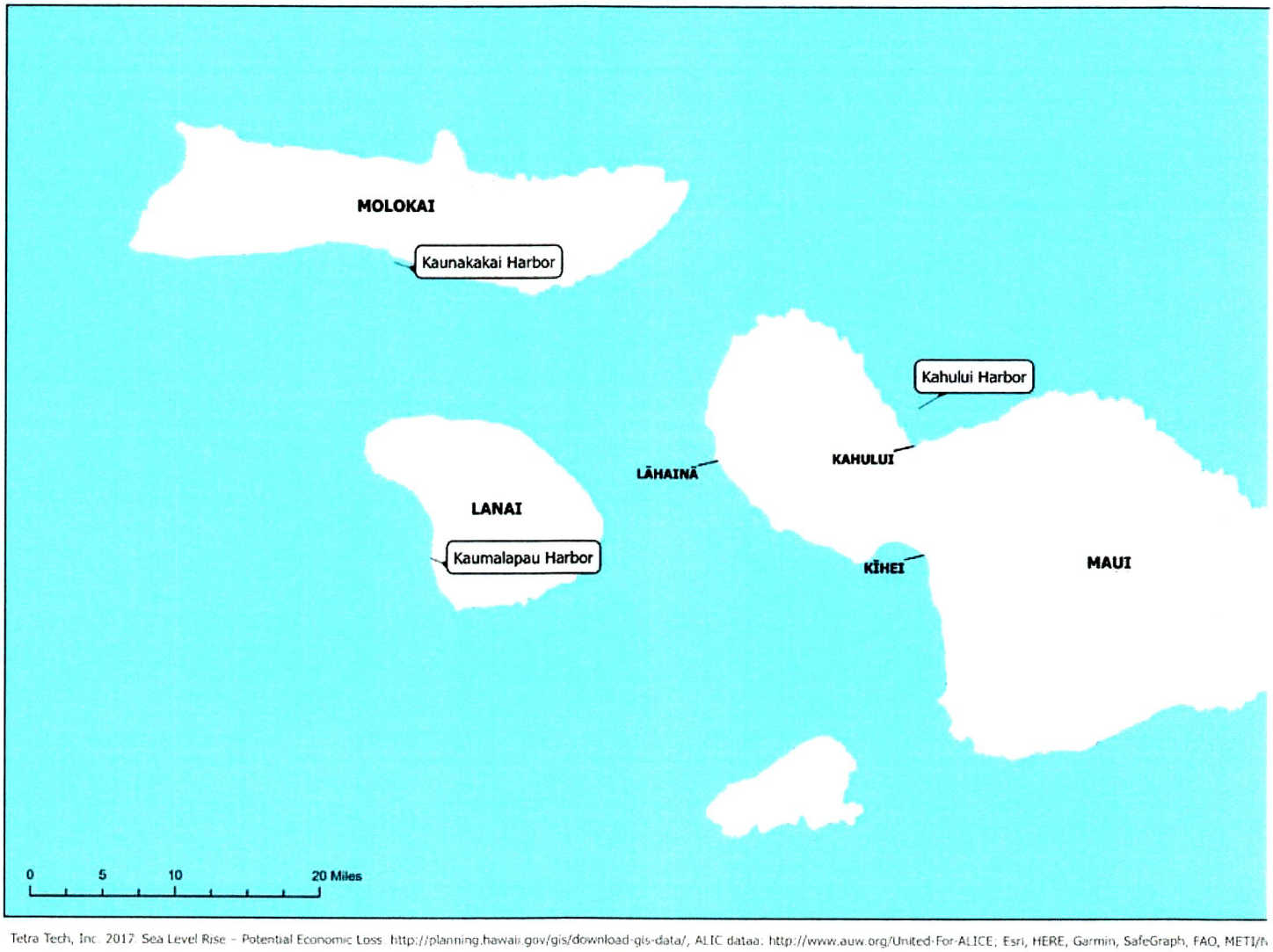
The islands of Maui County are particularly susceptible to sea level rise impacts to coastal boating facilities of all sizes. Commercial harbors are critical to the importation of food, fuel, and other supplies, while small harbors and boating facilities are critical to commercial fishing operations, tourism, subsistence food systems, and recreation. While there have been some efforts to assess climate change on specific projects associated with these types of facilities, to date, there are no formal efforts at the state level to assess commercial harbors, small harbors, and boating facilities for the impact of sea level rise and coastal flooding on their operations. See Figures 16, 17, and 18 for locations of at-risk harbors and boating facilities.

Other Infrastructure Systems

Figures 19, 20, 21, 22, 23 and 24 identify risk due to sea level rise for other infrastructure systems across Maui County for which GIS data is available.

Retired and Abandoned Landfills

Properly retired and improperly abandoned landfills are a concern across Maui County because many old landfills were located near coastal areas and may be captured by sea level rise and coastal erosion or flooding. (See Figure 25) In the event that a retired or abandoned landfill is captured, there is potential for significant contamination of marine, estuary, and possibly even freshwater systems.



Tetra Tech, Inc. 2017. Sea Level Rise – Potential Economic Loss. http://planning.hawaii.gov/gis/download-gis-data/, ALIC dataa: http://www.auw.org/United-For-ALICE; Esri, HERE, Garmin, SafeGraph, FAO, METI/N

Figure 16. Commercial harbors endangered by sea level rise of 3.2 feet in Maui County.
https://histategis.maps.arcgis.com/home/item.html?id=cf77f4efd6a74493a0bc2dad96c54031

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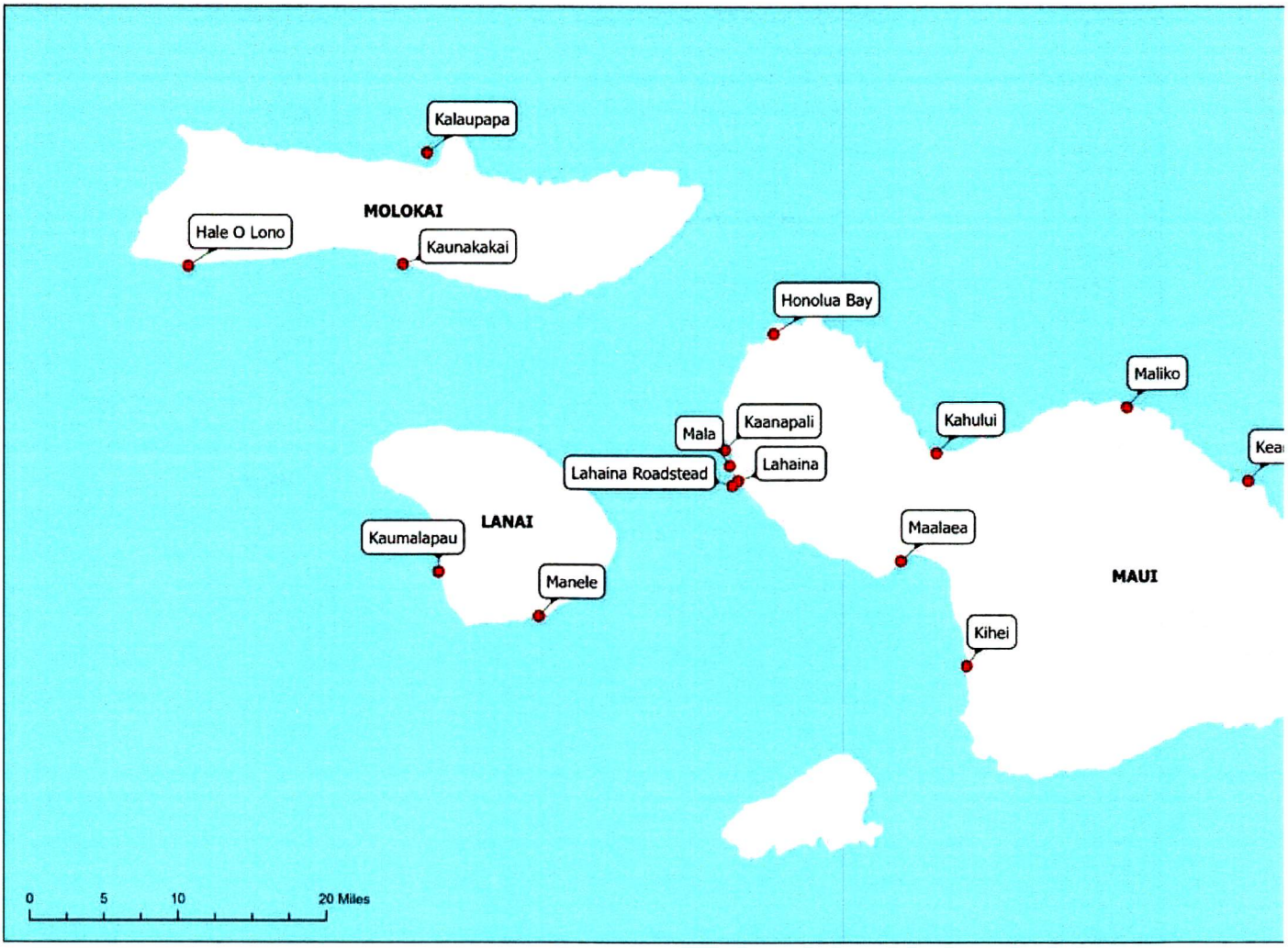

Figure 17. Boating facilities endangered by sea level rise of 3.2 feet in Maui County. https://histategis.maps.arcgis.com/home/item.html?id=e157c6e5304c4711afb7138127610364

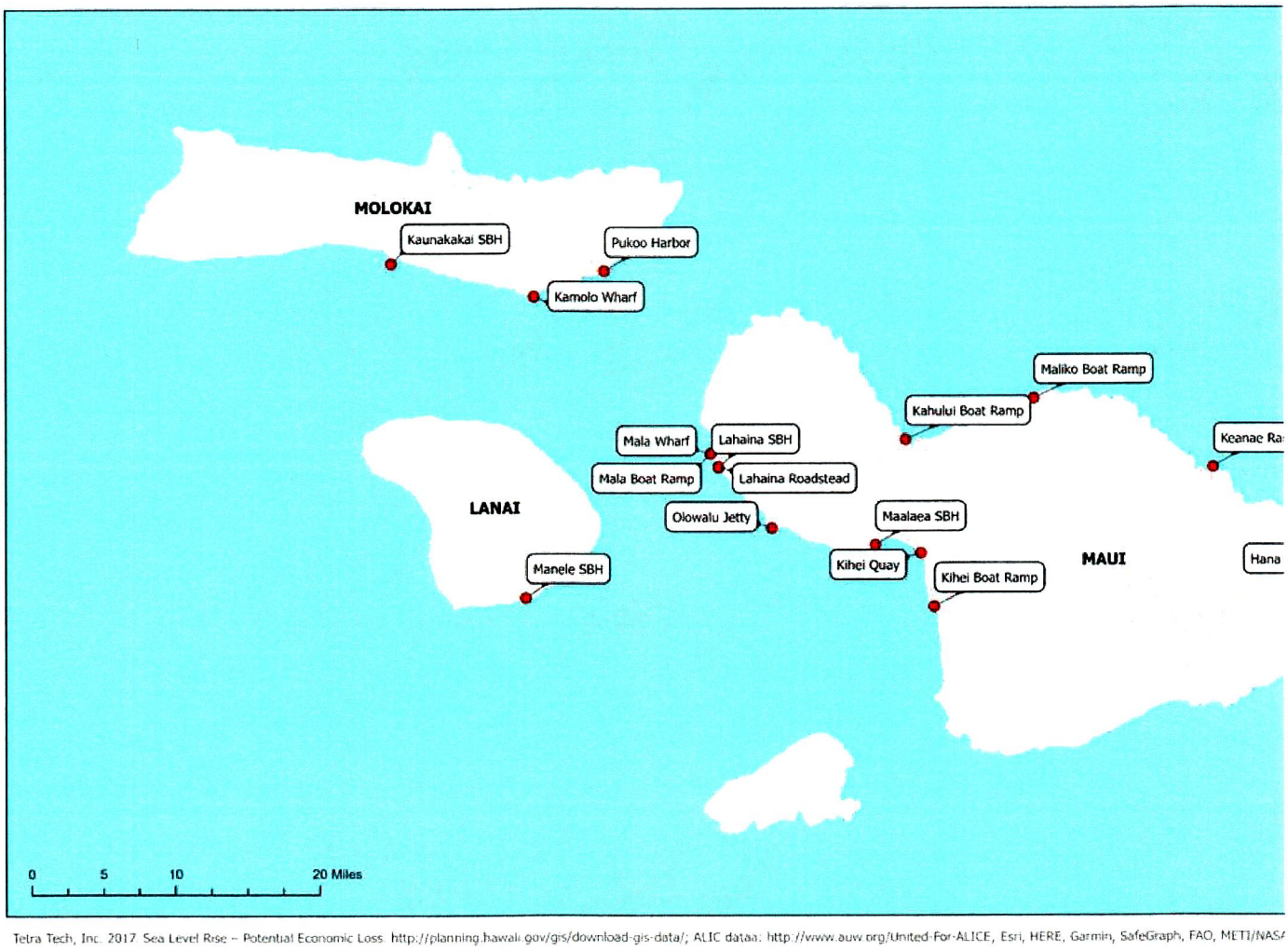

Figure 18. Small boat harbors endangered by sea level rise of 3.2 feet in Maui County.
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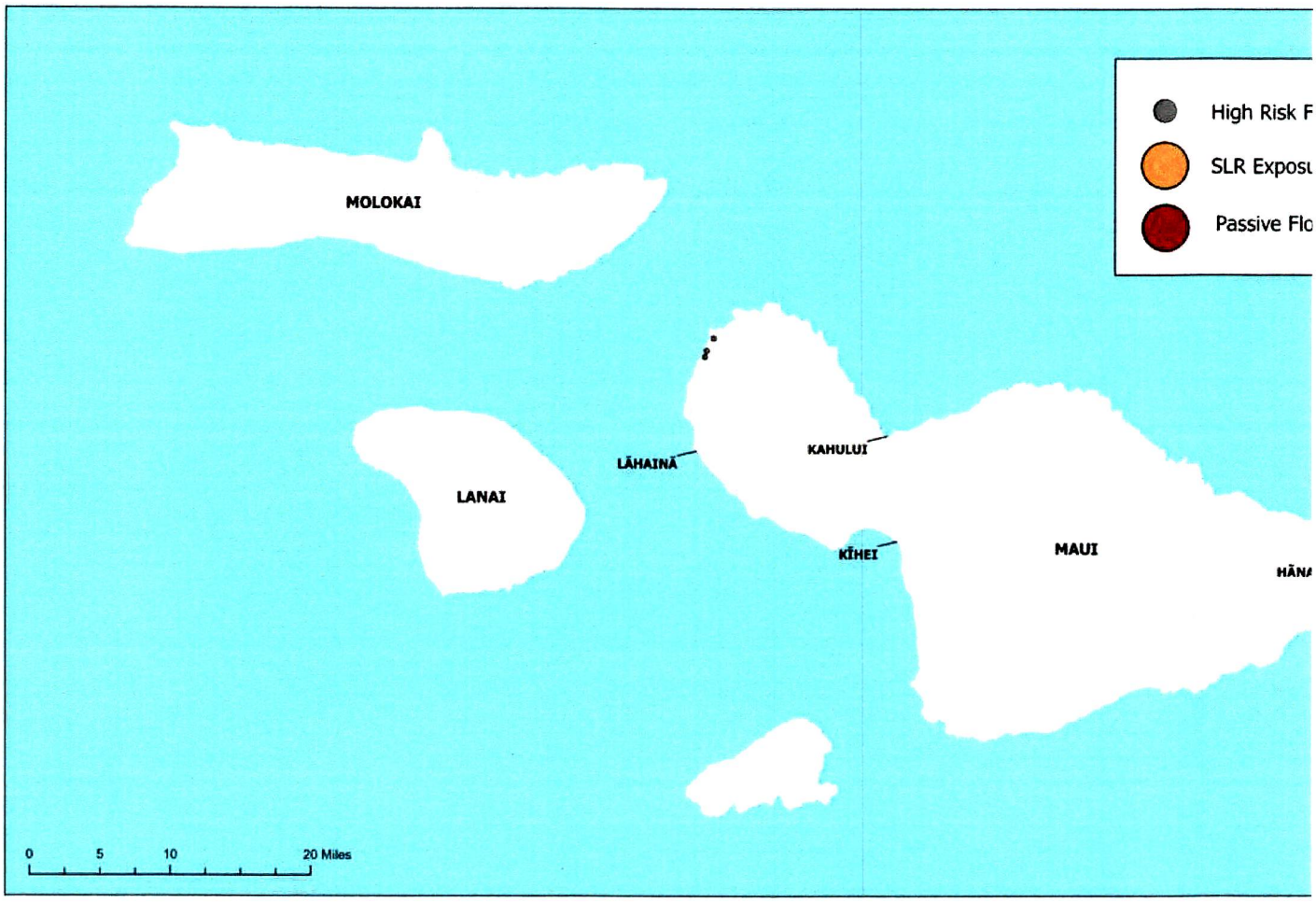

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Figure 19. Regulated dams endangered by sea level rise of 3.2 feet in Maui County.
https://histategis.maps.arcgis.com/home/item.html?id=ddbd915b4cf844b5be692f3d91e328f1

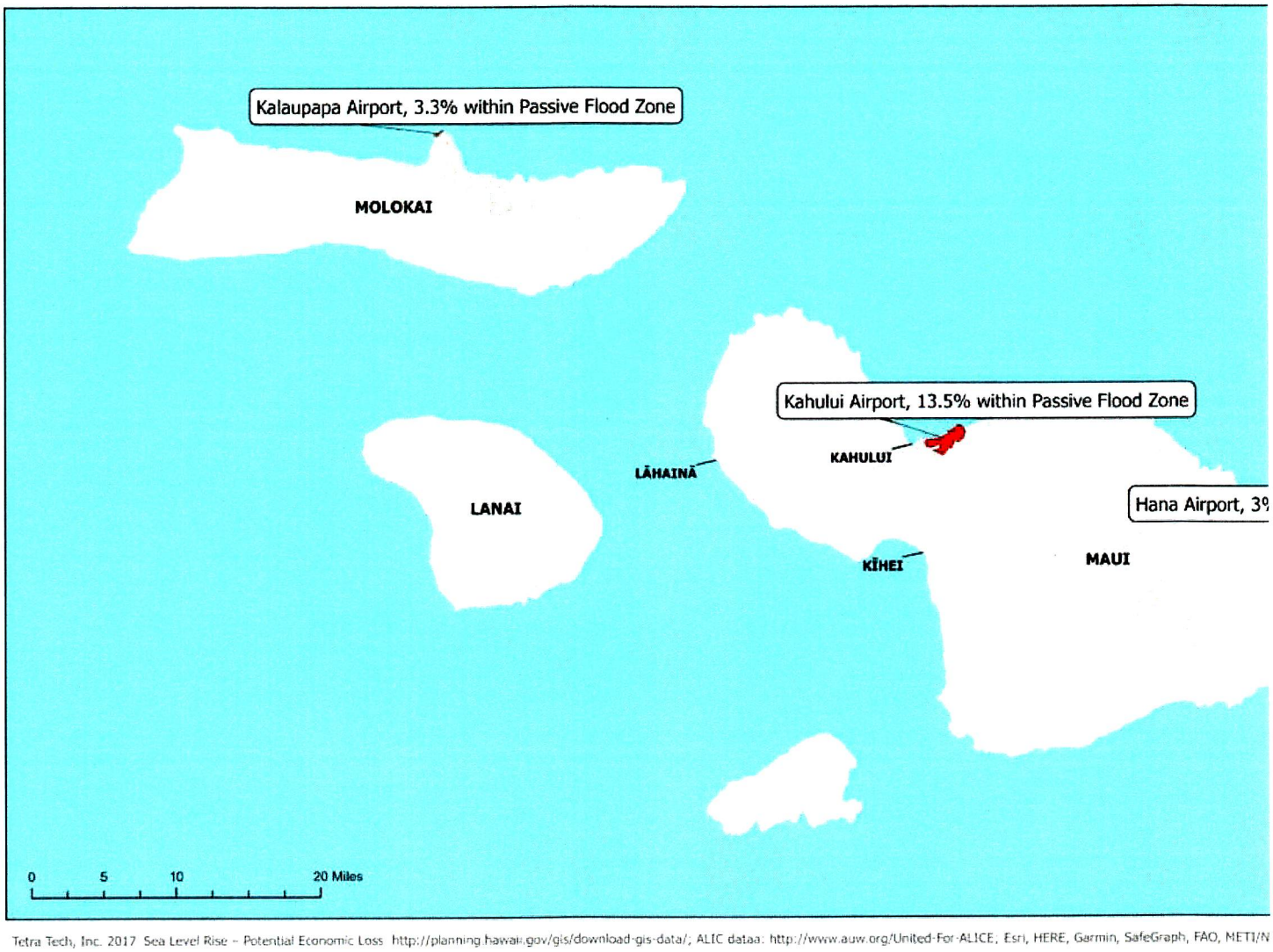

Figure 20. Airports endangered by sea level rise of 3.2 feet in Maui County.
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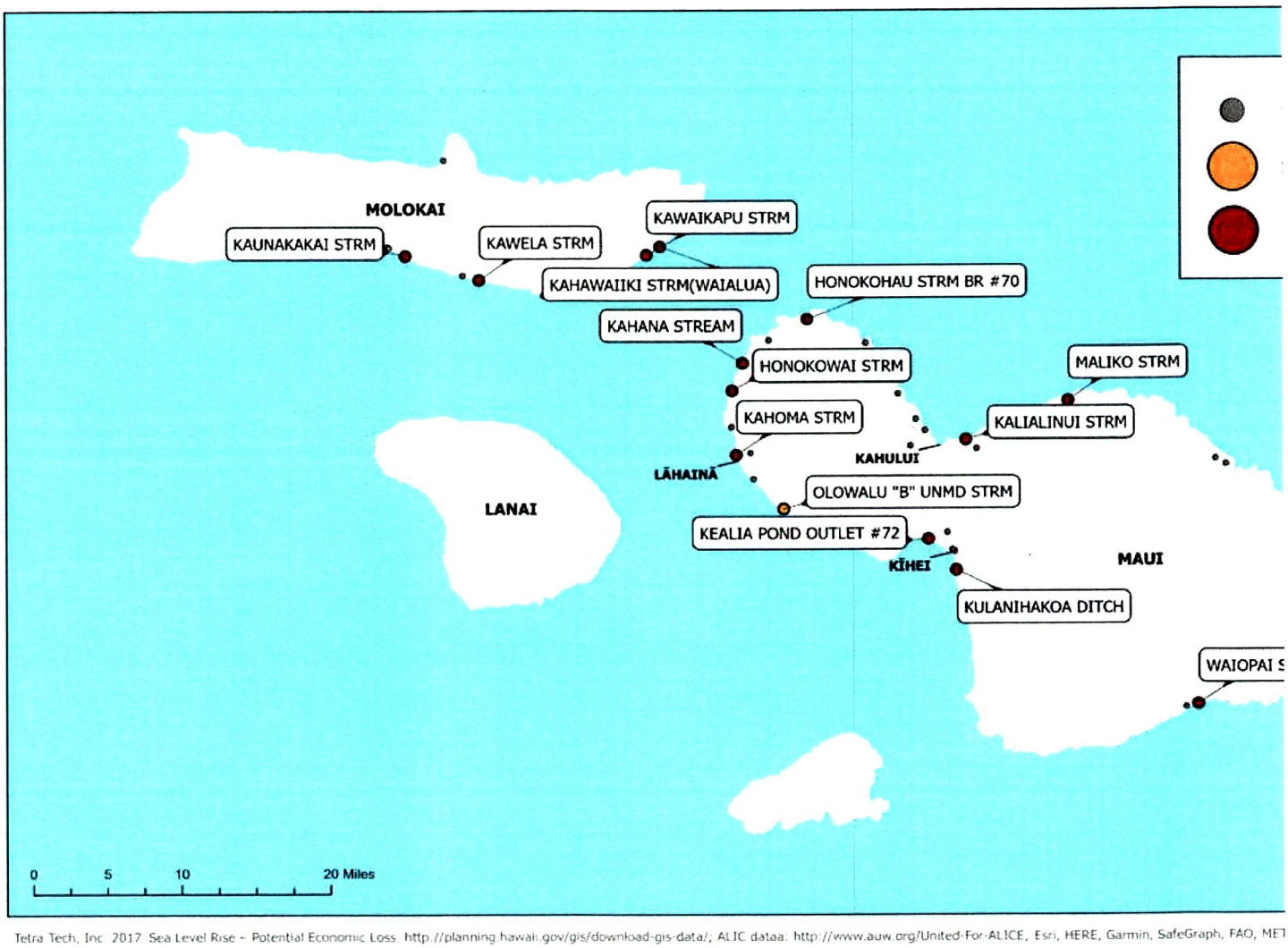

Figure 21. Bridges endangered by sea level rise of 3.2 feet in Maui County.
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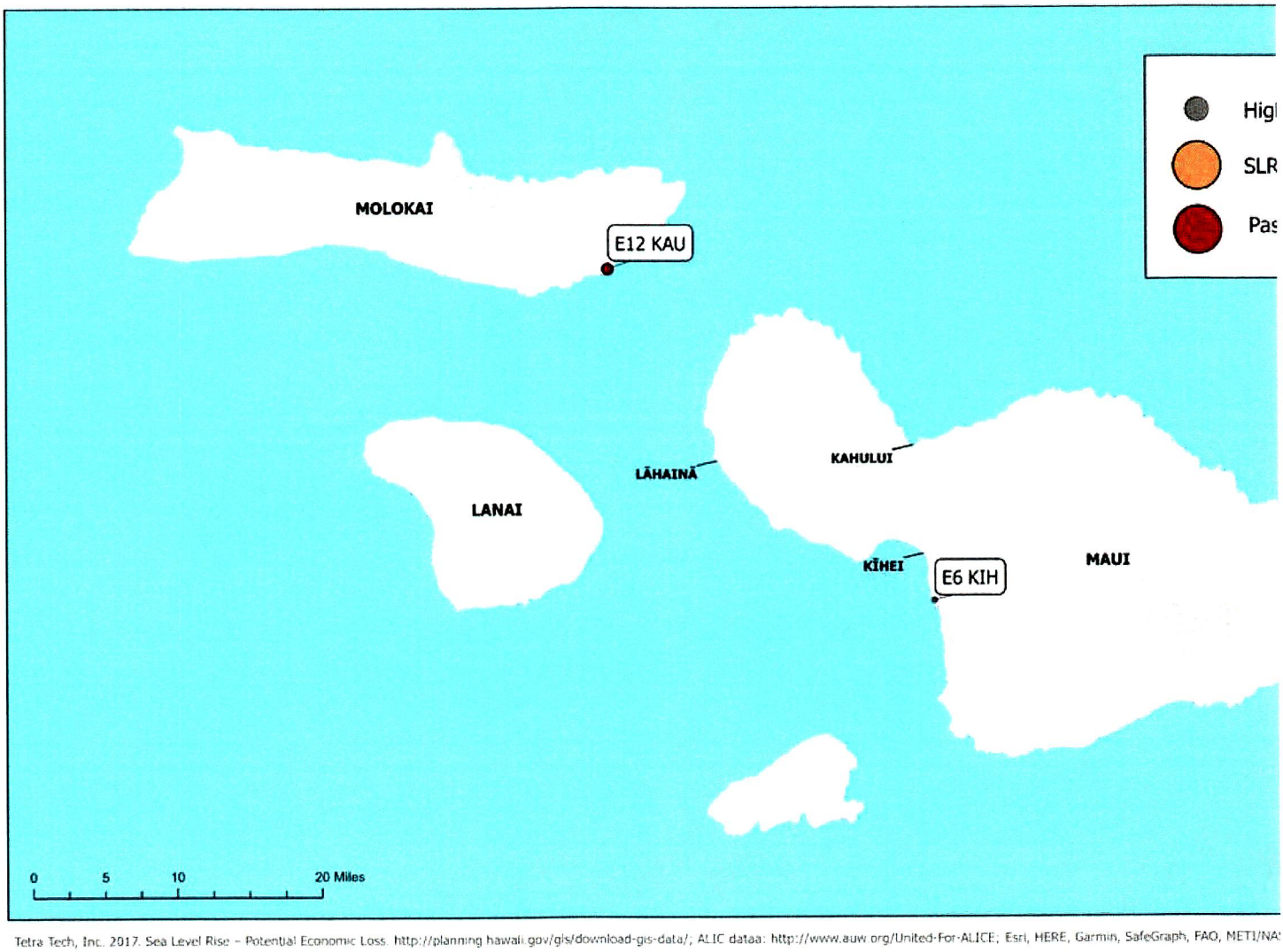

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Figure 22. Fire stations endangered by sea level rise of 3.2 feet in Maui County. https://histategis.maps.arcgis.com/home/item.html?id=f93f82c85783493386712c438134ea30

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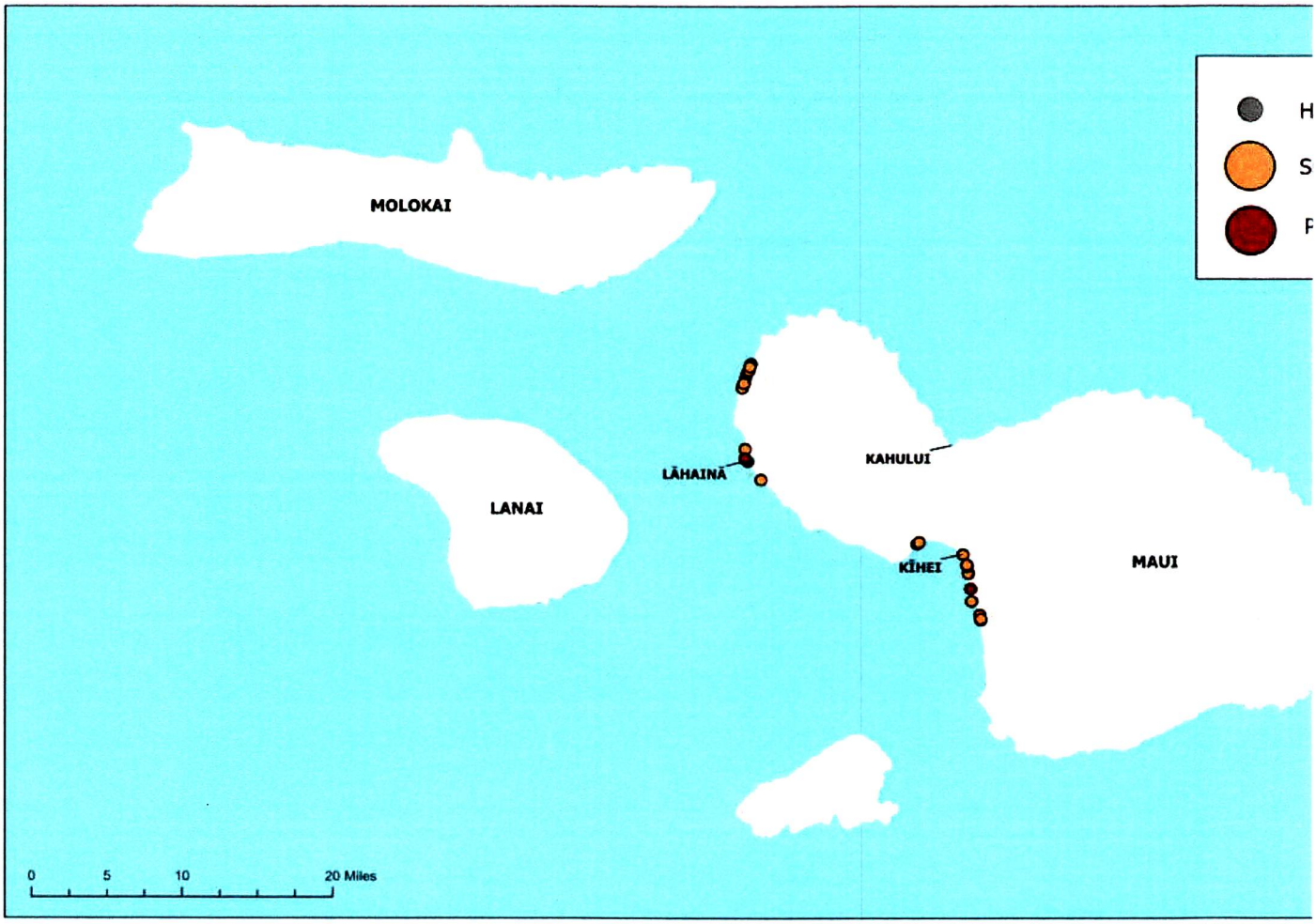

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Figure 23. Hotels endangered by sea level rise of 3.2 feet in Maui County.
https://histategis.maps.arcgis.com/home/item.html?id=2fe00ca2e74f47dbb0f2dd88ba27cc4d

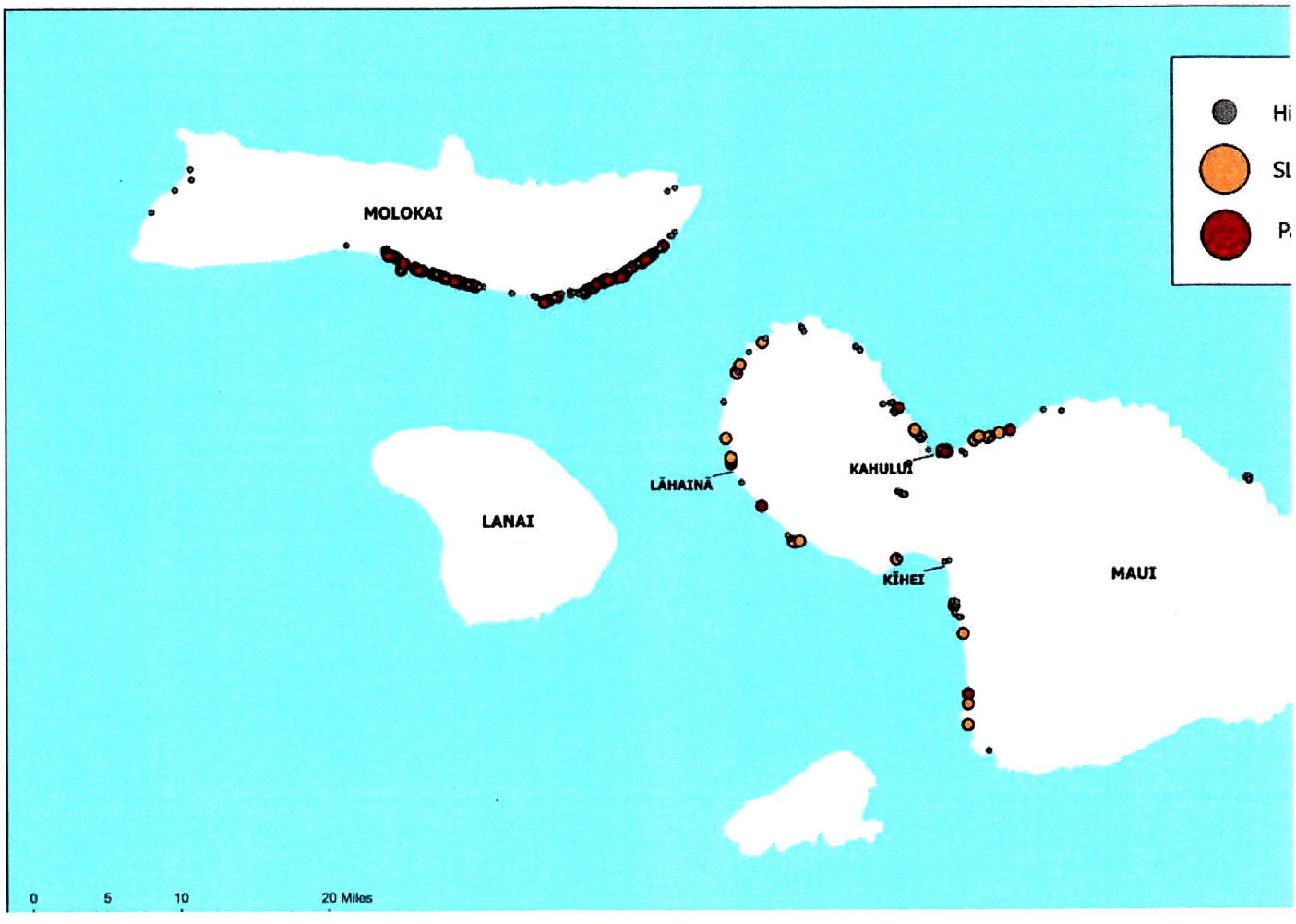

Figure 24. Onsite sewage disposal systems endangered by sea level rise of 3.2 feet in Maui County. (Moloka
https://histategis.maps.arcgis.com/home/item.html?id=d5dd71c0b4b0444080b2eadff3edbf77) (Maui data
https://histategis.maps.arcgis.com/home/item.html?id=108b8d29611a4a5e8bed2f7c658ddf68

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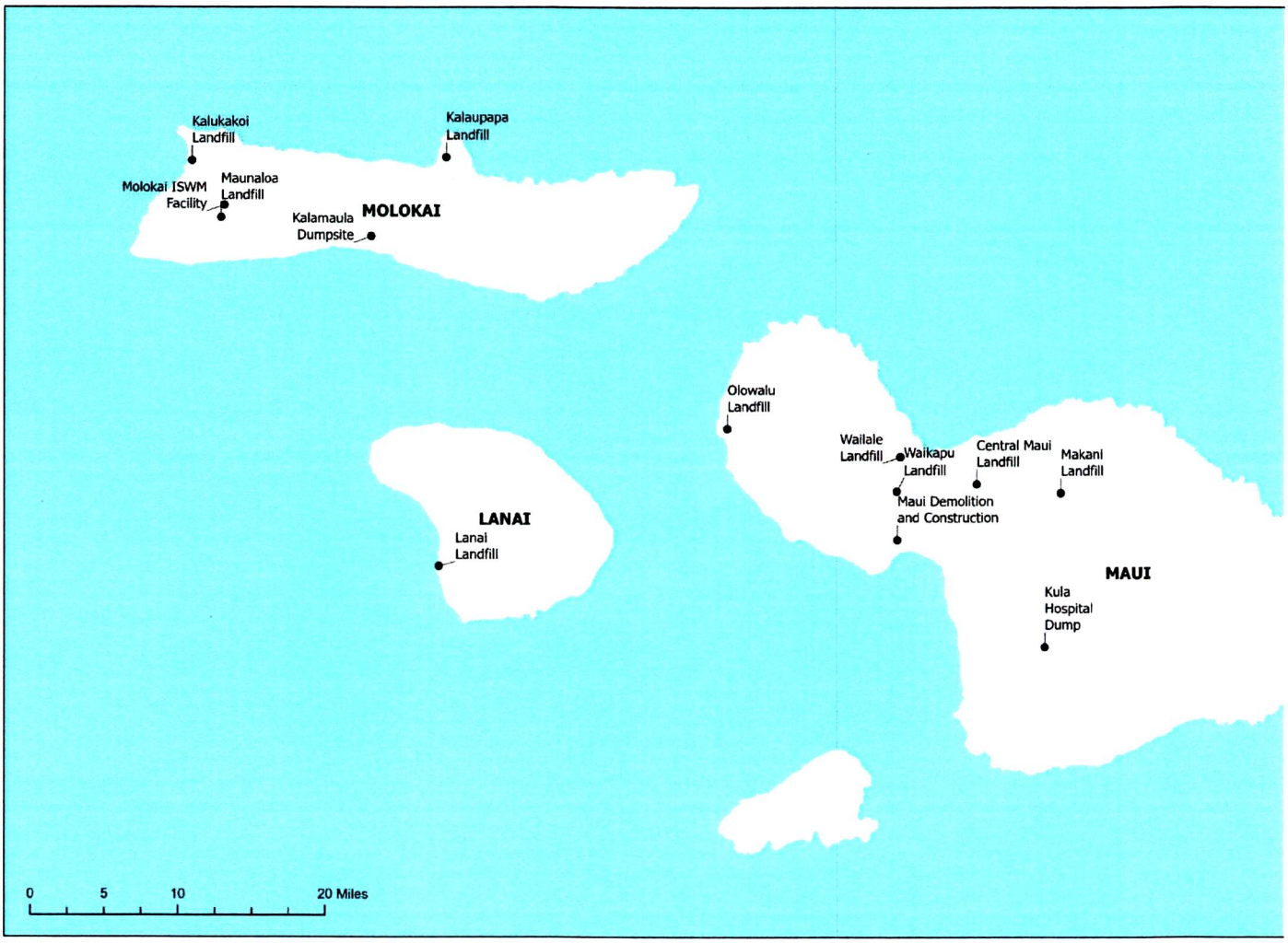

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Figure 25. Decommissioned landfills and dumps

Electric Utility Systems

Hawaiian Electric has recently worked to address climate change through its Power Supply Improvement Plan issued in 2016. This plan details the actions planned to accelerate the transition to 100% renewable energy by 2045. Their efforts surpassed Hawai'i's 2020 Renewable Portfolio Standard (RPS) of 30% in 2020 with a Renewable Portfolio Standard (RPS) of 35%. While moving to renewable energy, particularly distributed systems, is a climate resilience strategy, electrical systems across the nation are re-assessing their infrastructure to address the added strain caused by increasingly large storms and more extreme fire conditions. As a result, Hawaiian Electric has indicated that it is undertaking a climate change assessment as part of its asset management planning process. Hawaiian Electric is also engaged in an Integrated Grid Planning (IGP) effort guided by a directive from the Hawaii Public Utilities Commission (PUC). This IGP effort includes considerations for increasing the resiliency of electric generation and distribution systems.

Communications Infrastructure

Telecommunications infrastructure is critically important in the event of climate change-driven natural disasters, particularly for communities that may become isolated during emergency situations. Several telecommunications companies operate cell towers across Maui County, including T-Mobile, Verizon, and Global Tower LLC on Maui Island; Nextel West Corp. on Lāna'i; and Maui Electric Company on Moloka'i. Information about efforts underway to build emergency resilience has not been made available to this project. However, it will be important to partner with these companies (and others) moving forward to ensure the safety of Maui County residents. Significant efforts are underway to address broadband access by a Statewide group known as the Broadband Hui. Hawaiian Telcom is also engaged in a number of efforts focusing on telecommunications distribution expansion and infrastructure resiliency.

STAKEHOLDERS AND SECTOR EXPERTS

This report is part of a larger effort to develop the County of Maui's Climate Action and Resiliency Plan. The larger process is being guided by the Climate Action and Resiliency Plan Advisory Committee in collaboration with the County of Maui Resiliency Hui.

Climate Action and Resiliency Plan Advisory Committee

The CARPAC was composed of 20 members, including residents, subject matter experts, government, business, and cultural representatives.

- Makale'a Ane, Community-Based Program Manager, The Nature Conservancy
- Lauren Armstrong, Executive Director, Maui Metropolitan Planning Organization
- Lori Buchanan, Coordinator/Commissioner Moloka'i: Maui Invasive Species Committee, Planning Commission
- Gary Bulson, Chief Engineer (Retired), Hyatt Regency Maui
- Kainoa Casco, Project Manager-Farming and Sustainability, Mahi Pono
- Scott Crawford, Executive Director, Kipahulu Ohana
- Frank DeRego, Director of Business Development Projects, Maui Economic Development Board
- Scott Fisher, Director of 'Āina Stewardship, Hawai'i Land Trust
- Kainoa Horcajo, Principal, mo'olelo Group
- Sol Kaho'ohalahala, Hawaiian Culture and Community Environmental Steward
- Mahina Martin, Director, Government and Community Affairs, Hawaiian Electric Company
- Dick Mayer, Coordinator, Alliance of Maui Community Associations; Professor (Retired), Maui Community College

- Gail Miyahira, Maui County Area Coordinator (Retired), Hawai'i Healthcare Emergency Management
- Tyson Miyake, Chief of Staff, County of Maui Office of the Mayor
- Tara Owens, Extension Faculty, Coastal Processes Specialist, University of Hawai'i Sea Grant Program
- Keani Rawlins-Fernandez, Council Vice-Chair, Maui County Council
- Jonathan Stenger, Analyst, Kamehameha Schools
- Nicolette Van Der Lee, Program Manager, Hana Career Pathways/University of Hawai'i
- Nicholas Winfrey, President /Chief Professional Officer, Maui United Way
- Jenny Worth, Disaster Program Manager, American Red Cross

Resiliency Hui

County of Maui Resiliency Hui comprises more than 50 personnel from 11 County of Maui departments and agencies.

- Office of the Mayor (including the Office of Climate Change, Resiliency, and Sustainability (CCRS))
- Corporation Counsel
- Department of Environmental Management
- Department of Housing and Human Concerns
- Department of Management
- Department of Parks and Recreation
- Department of Planning
- Department of Public Works
- Department of Transportation
- Department of Water Supply
- Maui Emergency Management Agency
- Maui Metropolitan Planning Organization

Workshop Participants

This report was provided to participants at a day-long stakeholders workshop held virtually over two days, March 22 and 24, 2022. These participants helped identify and prioritize the vulnerabilities expected across Maui County due to climate change

- Makale'a Ane, The Nature Conservancy
- Lauren Armstrong, Maui Metropolitan Planning Organization
- Sandy Baz, County of Maui Department of Management
- Lori Buchanan, Molokai Planning Commission/Sust'āinable Molokai/MoMISC
- Gary Bulson, Hyatt Regency Maui (retired)
- Malia Cahill, Maui Huliau Foundation
- Hailey Campbell, City and County of Honolulu
- Kainoa Casco, Mahi Pono
- Allison Cleghorn, County of Maui Office of Climate Change, Resiliency, and Sustainably
- Scott Crawford, Kīipahulu Ohana
- Frank DeRego, Maui Economic Development Board
- Robert DeRobles, County of Maui Department of Water Supply
- Erin Derrington, County of Maui Department of Planning
- Lily Diamond, Maui Sustainability Initiative
- Pam Eaton, County of Maui Department of Planning
- Joy Galatro, Pacific Biodiesel Technologies
- Kainoa Horcajo, mo'olelo Group*
- Olena Horcajo Alec, Haleakalā Conservancy *
- Robin Kaye, Lāna'i Community
- Sally Kaye, Lāna'i Community
- Mahina Martin, Hawaiian Electric
- Dick Mayer, Alliance of Maui Community Associations; Professor (Retired), Maui Community College
- Michelle McLinden-Nuijen, County of Maui Department of Environmental Management
- Gail Miyahira, Hawai'i Healthcare Emergency Management (retired)
- Tyson Miyake, County of Maui Office of the Mayor

- Katy Mokuau, Sust'āinable Molokai
- Chase Nomura, Maui County Workforce Development Board
- Tara Owens, University of Hawai'i Sea Grant Program*
- Heather Place, Sust'āinable Molokai
- Keani Rawlins-Fernandez, Maui County Council
- Brad Romine, University of Hawai'i
- David Sellers, Hawai'i Off Grid
- Hannah Shipman, County of Maui Office of Climate Change, Resiliency, and Sustainably
- Janet Six, County of Maui Archaeologist
- Johnathan Stenger, Kamehameha Schools
- Dave Taylor, County of Maui Department of Management
- Rob Weltman, Sierra Club Maui Group
- Nicholas Winfrey, Maui United Way
- Jenny Worth, American Red Cross
- David Yamashita, County of Maui Parks and Recreation
- Stuart Zinner, University of Hawai'i

** Thank you to the volunteer breakout group facilitators.*

Thank you to community partners who assisted with the development of the Talk Stories events that were instrumental in developing this vulnerability assessment:

- Scott Crawford - Kipahulu 'Ohana for East Maui
- Katy Mokuau – Sust'āinable Molokai for Molokai
- Heather Place- Sust'āinable Molokai for Molokai
- Roxanne Morita – Lāna'i District Office – Maui County Council for Lāna'i

The following County staff and subject matter experts offered one-on-one feedback to this process:

- Jeff Bagshaw, Department of Land and Natural Resources – Division of Forestry and Wildlife – Maui Nui Branch
- Jeff Beasy, Maui County Fire Department
- Eva Blumenstein, Maui County Department of Water Supply

- Tova Callender, West Maui Ridge to Reef Initiative
- Kamalu Carroll , County of Maui Office of the Mayor
- Allison Cleghorn, County of Maui Office of Climate Change, Resiliency, and Sustainability
- Stuart Coleman, Wastewater Alternatives and Innovations
- Scott Crawford, Kīipahulu Ohana
- Jeff Dack, County of Maui Department of Planning
- Alex de Roode, County of Maui Office of Climate Change, Resiliency, and Sustainability
- Scott Fisher, Hawai'i Land Trust
- Paul Hanada, Business owner, fisherman, diver, farmer - retired
- Yayoi Hara, Lahaina Jodo Mission
- Monique Ibarra, Ka Hale A Ke Ola Homeless Resource Centers
- Joe Imhoff, Skyline Hawai'i
- James Jensen, County of Maui Department of Public Works
- Cheryl Kaiaokamalie, Limu Hui
- Negus Manna, Kaumalapa'u Harbor, Hawai'i Farms Union United
- Michelle McLinden-Nuijen, County of Maui Department of Environmental Management.
- Roxanne Morita, County of Maui
- Liliana Napolean, Ho'āhu Energy Cooperative Molokai
- Lauren Nelson, Hawai'i Public Health Institute/Maui Nui Food Alliance
- Cody Nemet, Nu Kahawai, Aina Ku Koa
- Gregg Okamoto, Maui County Police Department
- Tara Owens, University of Hawai'i Sea Grant College Program
- Heather Place, Sust'āinable Molokai
- Hannah Shipman, County of Maui Office of Climate Change, Resiliency, and Sustainability
- Janet Six, County of Maui Principal Archaeologist
- Jonathan Sprague, Pūlama Lāna'i
- Bradford Ventura, Maui County Fire Department
- Tapani Vuori, Maui Ocean Center

- Harmonee Williams, Sustʻāinable Molokai
- Kapua Weinhouse, Lānaʻi High School
- Nicholas Winfrey, Maui United Way
- David Yamashita, Maui County Department of Parks and Recreation
- Todd Yamashita, Hoʻāhu Energy Cooperative - Molokai
- Julie Yunker, Hawaiʻi Gas

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GLOSSARY

Hawaiian Terms

ʻaʻaliʻi – Native hardwood shrubs or trees (Dodonaea, all species), 30 cm to 10 m high, more or less sticky at branch tips; leaves narrow, 2 to 10 cm long; flowers small; fruit a yellow, red, or brown papery capsule about 1 cm long and with two to four wings.

ʻāina – Land; often synonymous with "environment."

ʻālaʻa – A large endemic tree (Planchonella spp.) with smooth, oblong leaves, shiny-green above, bronze beneath, the fruit yellow or black, to 5 cm long. The sticky, milky sap was used to trap birds, the wood for spears and ʻōʻō handles.

alaheʻe – A large native shrub or small tree (Canthium odoratum; synonym Plectronia odorata) with shiny leaves and small, fragrant, white flowers. The wood is hard and was formerly used in making the ʻōʻō digging stick; also used medically.

heiau – Place of worship

hīhīwai – Freshwater snail

hui – A union or association of persons designated for a common purpose

iwi kupuna – ancestral remains

kai – ocean water

kamaʻāina – Native-born

Kānaka Maoli – Native Hawaiians

kalo – Taro

kapu – A system of governmental & religious regulations

kāwelu– An endemic lovegrass that occurs in the Hawaiian Islands on sand dunes, grasslands, open sites in dry forests, and exposed slopes and ridges or cliffs from sea level to approximately 3,700 feet.

kiawe – Algaroba tree (Prosopis pallida), a legume from Peru, first planted in 1828 in Hawaiʻi

koa – The largest of native forest trees (Acacia koa), with light-gray bark, crescent-shaped leaves, and white flowers in small, round heads.

kuleana – Privilege or rights

kūpuna – Ancestors

lama – All endemic kinds of ebony (Diospyros, synonym Maba), hardwood trees with small flowers and fruits.

limu – A general name for edible plants living under water

loʻi – Irrigated patch traditionally created for taro cultivation

loʻi kalo – Irrigated taro terrace

loko iʻa – Fishpond

loko iʻa kalo – Fishpond in which taro is cultivated

loko kuapā – Walled fishponds

mauka – Mountain

makai – Ocean

moʻolelo – Successively transmitted narratives that help make up the cultural fabric of Hawaiʻi

muliwai – Estuary

ʻohana – Family

ʻōhiʻa – Flowering evergreen tree

ola – Health

ʻōlapa – Several native species and varieties of forest trees (Cheirodendron), with opposite leaves, each leaf divided palmately into three to five (rarely six or seven) leaflets, and with flowers borne in umbels.

olopua – A large native tree (Osmanthus sandwicensis), to 19 m high, in the olive family. It bears narrow or oblong leaves, yellowish flowers, and blue 1.3 cm- long fruits. The hard wood, dark-brown with black streaks, was used for spears, adze handles, and digging sticks.

ʻōpae – Shrimp

ʻōpae ʻula – Small, endemic, brackish water shrimp used for ʻōpelu bait.

ʻoʻopu – Native goby fish

ʻopihi – Limpets

pono- Balance

wai – Fresh Water

wiliwili – A Hawaiian leguminous tree (Erythrina sandwicensis, formerly called E. monosperma), found on dry coral plains and on lava flows, somewhat spiny, with short thick trunk. Each leaf has three ovate leaflets; flowers are clustered near branch ends and range in color from red to orange, yellow, white; pods contain red, oblong seeds, used for leis. The wood is very light and formerly was used for surfboards, canoe outriggers, net floats.

English Terms

Climate Change Adaptation – Actions that protect people or nature from, or prepare them for, the current and future impacts of climate change.

Climate Change Mitigation – Actions that reduce greenhouse gas emissions (primarily from fossil fuels combustion) or increase the storage of carbon (primarily in soils, forests, and other natural systems).

Contaminant/toxin/pollutant – a substance that makes something less pure or makes it poisonous (contaminant); any substance poisonous to an organism (toxin); any substance, as certain chemicals or waste products, that renders the air, soil, water, or other natural resource harmful or unsuitable for a specific purpose (pollutant).

Ecosystem services/function – Represent the many and varied benefits of a healthy natural environment. They include the production of food and water, the control of climate and disease, nutrient cycles and oxygen production, and spiritual and recreational benefits.

Equity – Achieving the same level of opportunity based on variable levels of support and assistance depending on the difference in historical disparity and current need. Some types of equity of concern include racial, economic, social, and intergenerational.

Fossil fuels – a group of energy sources that were formed when ancient plants and organisms were subject to intense heat and pressure over millions of years. There are three major types of fossil fuels: coal, oil, and natural gas.

Greenhouse Gas (GHG) – A gas that absorbs infrared radiation (heat) in the atmosphere and contributes to climate change. Greenhouse gases include carbon dioxide, methane, water vapor, nitrous oxide, and others.

Impervious surfaces – These are land surfaces that repel rainwater and do not permit it to infiltrate (soak into) the ground. Impervious surfaces are mainly artificial structures—such as pavements that are covered by water-resistant materials such as asphalt, concrete, brick, stone—and rooftops. Soils compacted by urban development are also highly impervious. (Also see “Pervious surfaces”).

Infrastructure – refers to the built environment such as buildings, energy generation and distribution systems, water delivery, storm- and wastewater, floodwalls, roads and highways, bridges, culverts, and many other basic structures.

Pervious surfaces – Surfaces that allow water to percolate through to the area underneath rather than becoming runoff (Also see "Impervious surfaces").

Resilience – the ability of people and their communities to anticipate, accommodate and positively adapt to or thrive amidst changing climate conditions and hazard events.

Sustainability – A broad concept that refers to meeting the needs of the present without compromising the ability of future generations to meet their needs.

Urban Heat Island – The increase in temperature within an urban area as compared to the surrounding rural and naturally vegetated areas. This additional heat comes from heat-absorbing buildings, impervious surfaces, channelization of waterways, and the removal of canopy cover.

APPENDIX 1: COMMUNITY SURVEY RESULTS

Overview

In February 2022, the Office of Climate Change, Resiliency, and Sustainability (CCRS), housed under the Office of the Mayor, launched a community survey to learn more about how residents of Maui County feel about climate change and identify specific community concerns related to climate change impacts. The responses collected through March 20, 2022, were used to help shape and inform the climate change vulnerability stakeholder workshop held on March 22 and 24, 2022. In addition, results collected through April 8, 2022, were used to help inform the writing of the Maui County Climate Change Vulnerability Assessment report and are summarized below.

Methodology

The survey was conducted online through the SurveyPro platform. CCRS distributed the survey via social media channels and included a link on the County of Maui Climate Action Through Engagement (ClimATE) Hub (https://www.resilientmauinui.org/). The questionnaire included several conditional questions which would only appear based on the response to a previous question so that an individual would only need to answer the relevant questions for their situation.

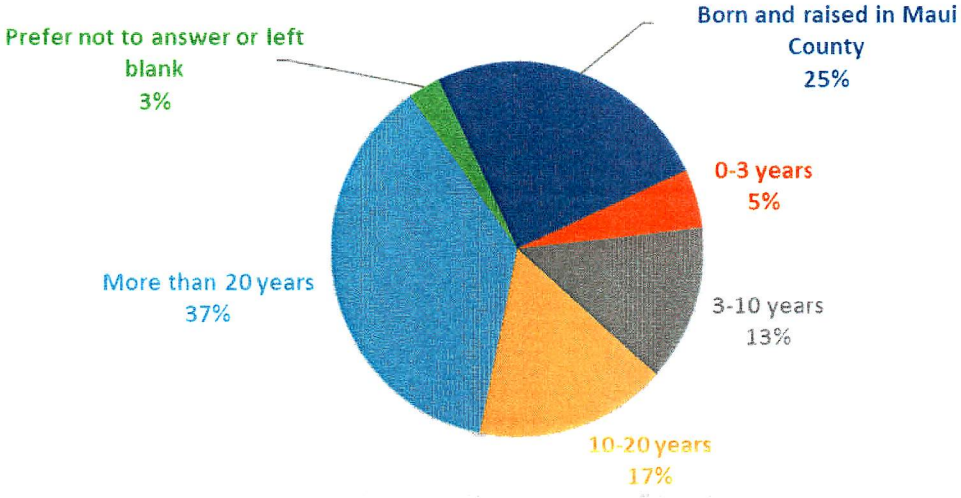
Results were downloaded into Microsoft Excel and the test responses entered during development of the survey were removed. While the SurveyPro platform collected information on responses entered but not actually submitted, this analysis only includes the information from submitted responses. However, it is noted where there is a distinct difference in attitudes or information between submitted and non-submitted responses.

Survey Respondents

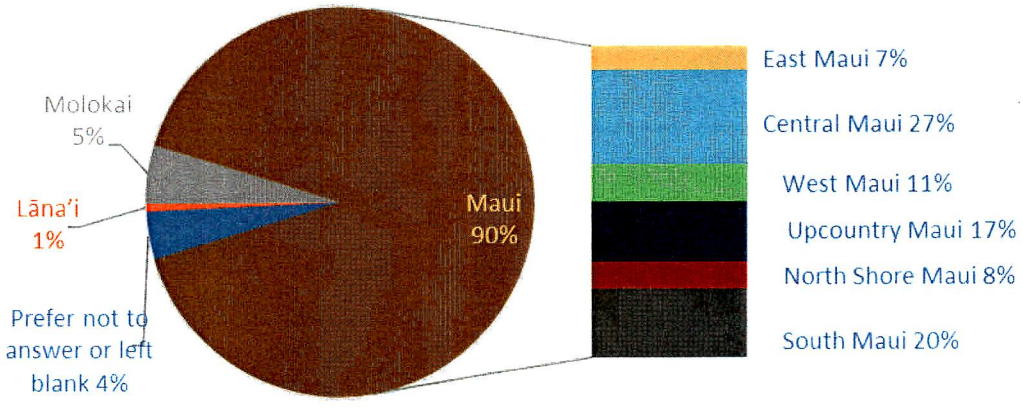
- Total incomplete responses: 215
- Total submitted responses: 475
- Total responses: 690

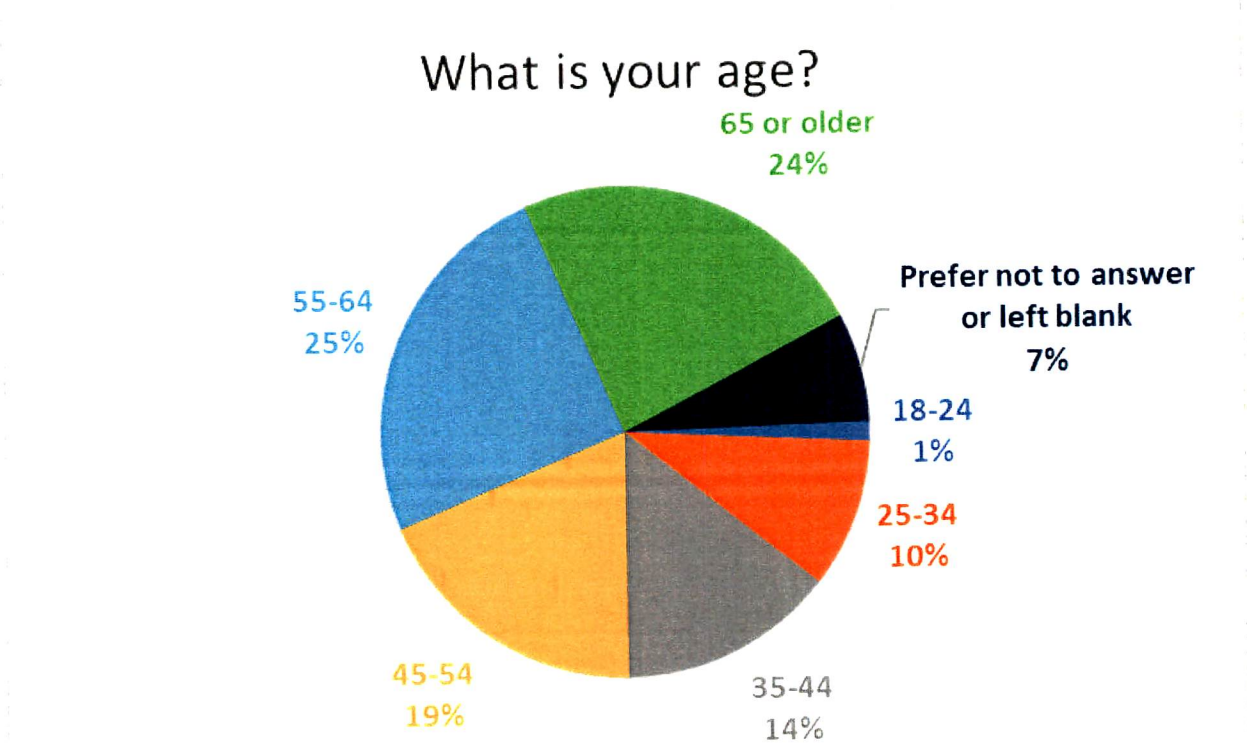
Of the 475 submitted responses, 95% identified as a full-time residents of Maui County, residing in the County for at least 200 days per year. When asked about the respondents' length of residency, 25% identified as being born and raised in Maui County, while another 37% have lived in the County for more than 20 years. Almost all respondents reported spending most of their time on Maui (90%). Approximately half of all submitted responses were from respondents over the age of 50. There were no submissions from residents under age 18. The majority of respondents identified as white (47%), Asian (17%), and/or Native Hawaiian or Other Pacific Islander (16%)

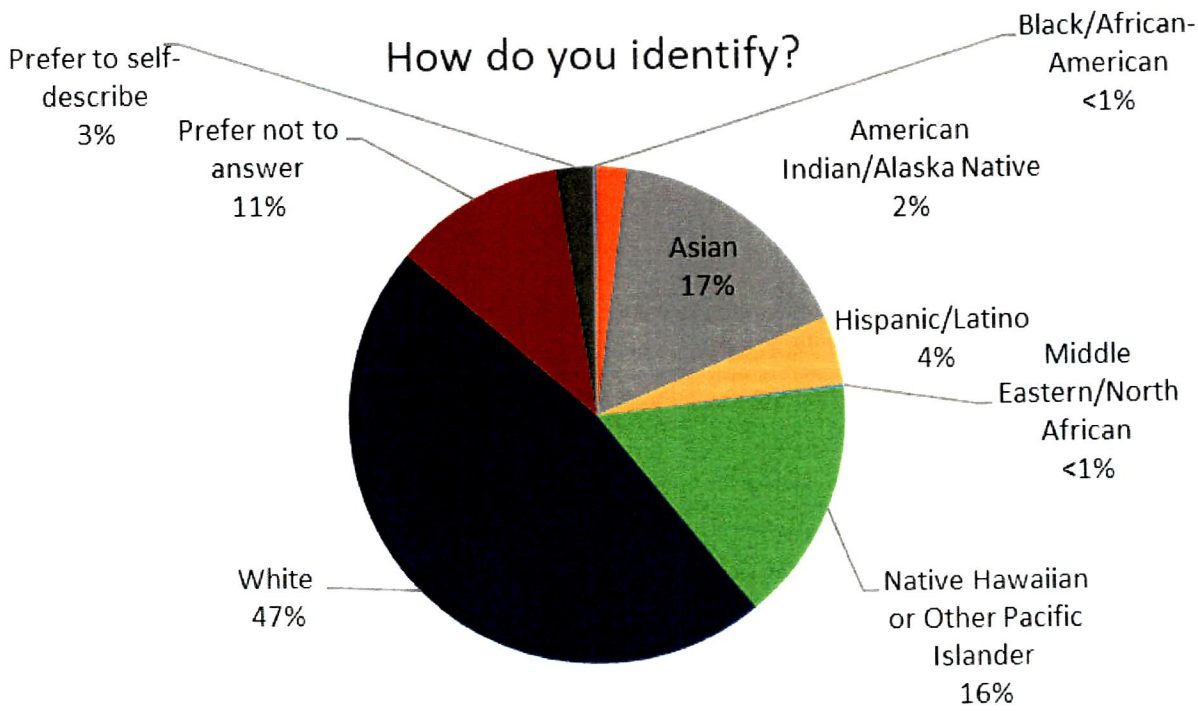
How long have you lived in Maui County?



Where do you spend most of your time?




What is your age?
65 or older
24%
Prefer not to answer or left blank
7%
18-24
1%
25-34
10%
35-44
14%
45-54
19%
55-64
25%


How do you identify?
Black/African-American
<1%
American Indian/Alaska Native
2%
Asian
17%
Hispanic/Latino
4%
Middle Eastern/North African
<1%
Native Hawaiian or Other Pacific Islander
16%
White
47%
Prefer not to answer
11%
Prefer to self-describe
3%

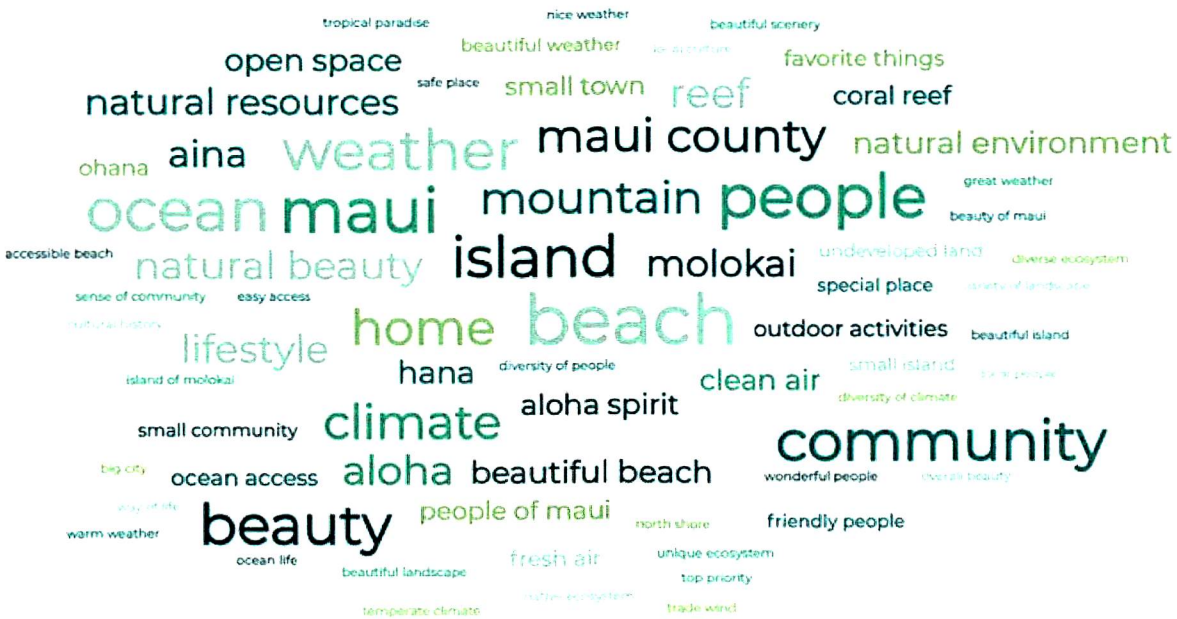
Most respondents own their residence (62%), followed by rent (22%), live with family members (8%), described other arrangements (3%), or preferred to not answer or left the question blank (5%).

Most respondents are employed full time (64%), followed by retired (22%). A small number are employed part-time (6%) or not employed (3%), or preferred to not answer/left the question blank (5%).

Survey Response Details

Question 1. What is one of your favorite things about Maui County? What about Maui County is special to you?

469 people submitted responses to this open-ended question. The primary themes in responses were related to Maui County's natural resources, the people and diversity across the County, and that the islands are home.

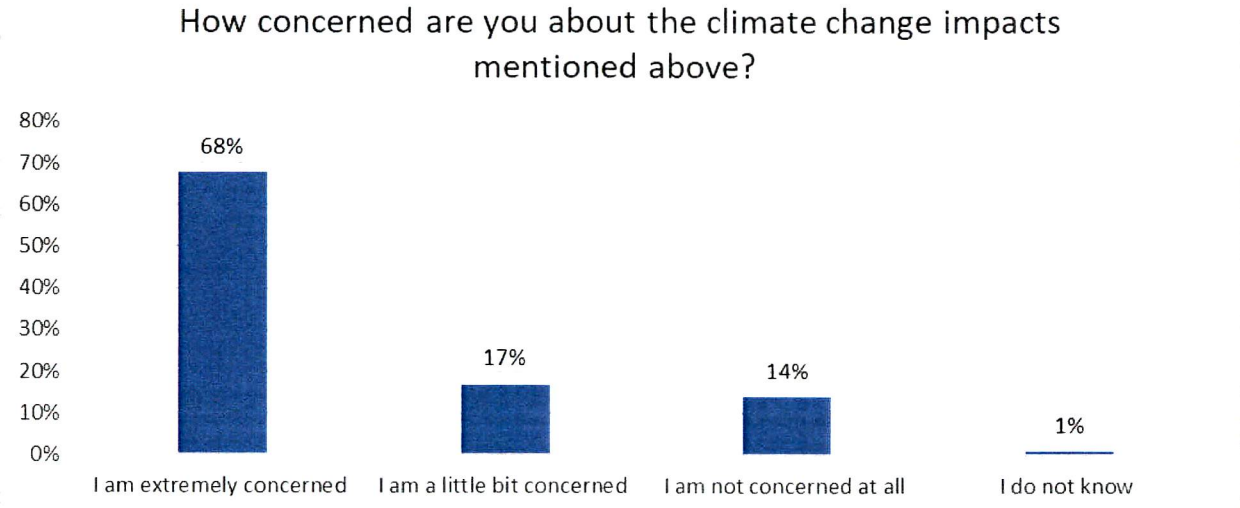


Question 2: How concerned are you about the climate change impacts mentioned?

Community members are largely concerned about climate change and the expected impacts to Maui County. When presented with a list of climate change impacts already experienced across the County, 68% said they were extremely concerned.

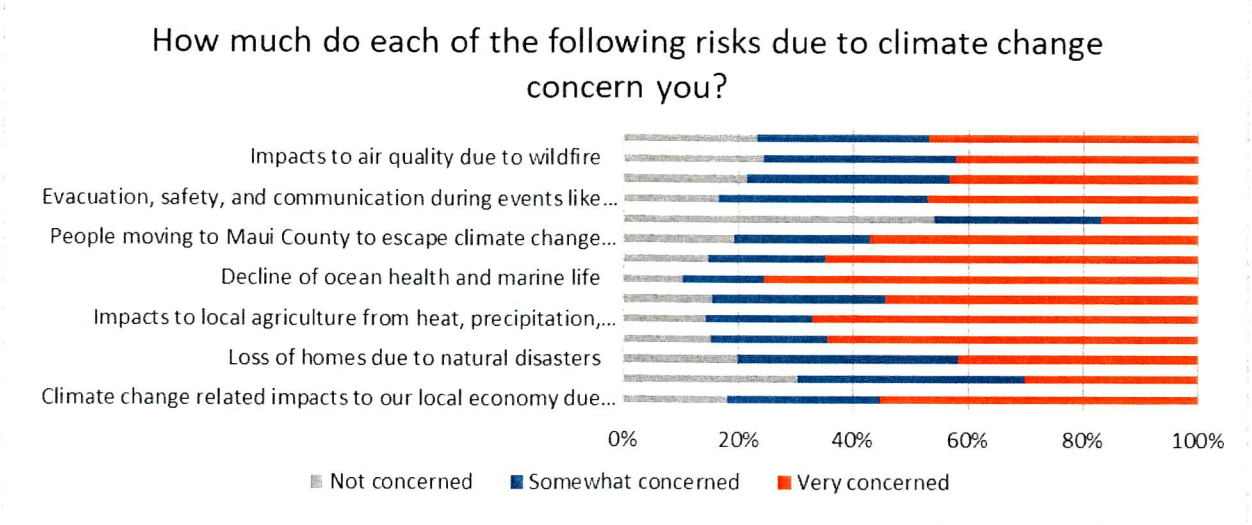
Overview of Climate Change Impacts in Maui County

- The area has already warmed 2 degrees and has seen an increase in 34 more days per year over 90F
- 85% of beaches have significant erosion from sea level rise
- We have 50% fewer days with trade winds per year
- We receive less annual precipitation and the dry sides of the islands, are expected to get drier
- Wildfire risk is expected to increase



Question 3: How much do each of the following risks due to climate change concern you?

Respondents were most concerned about climate impacts to ocean health and marine life, and the least concerned about climate migration away from Maui County due to climate change. High concern was also expressed about food supply and impacts to agriculture.



Respondents were also asked to provide additional comments on their responses and to identify specific locations, communities, neighborhoods, etc., that are more at risk to extreme heat and/or wildfire. A sample of the 321 responses are provided below without editing: (this is a random sample as to prevent any bias in selecting what to include)

· *Kaunakakai and the Heights area (in Kamiloloa) on Molokai.*

· *Drought in Kula that affects the last of the local farmers as well as food security for Maui Nui, increase of invasive species threats and disease, rising sea levels affecting outdated infrastructure, price increases on real estate and basic necessities that force kama ʻaina out*

· *Upcountry flooding and damages. Hana road landslides*

· *We should develop heat maps to more robustly define these risk areas.*

· *I live and farm in Nahiku, which is supposed to be one of the wettest areas on the island. The past couple of years seem to have been significantly drier than normal. Folks out here who rely on catchment for drinking water are suffering. We never had to irrigate crops until recently. The streams, including the ones with recently restored flow, are not making it all the way to the sea, which impacts not only stream life (and opens them up to invasive species) but also affects the health of the reefs, muliwai, and near-shore ocean. It will have serious impact on the folks here who practice traditional Hawaiian subsistence, and will open the door for 'dry' invasives like goats and deer the so far are staying out.*

· *Since the island was developed in ignorance and with disregard for how the `aina actually works from mauka to makai its going to be a rough ride.*

· *Areas as risk to extreme heat and/or wildfire - central valley and south shore and Lahaina. Shoreline loss in the Kīhei, Maalaea, Lahaina, Makena, Kaanapali, Napili, etc. area. The old Kīhei road, as well as the Lahaina highway 4-5 mile section that is still VERY CLOSE to the water and already getting over-run by king tides The basic problem of affording a house is what is driving local people to leave....we presently have the HIGHEST COST OF LIVING in the nation.....the influx of people of high incomes is certainly contributing to the cost of living. Low-cost housing in the Wailea and Ka'anapali areas were NOT developed in the 1970's as planned and the workforce on maui has an extremely long commute on basically fossil fuels from the central part of Kahului to work and back which adds to the problem.*

· *Coastal erosion and impacts on roads, structures, etc.*

· *We don't have anywhere else to go in Lahaina if there is an emergency. When our power goes out it takes a while to get it on. Most power seems to be used for tourists and ours comes on last*

· *All shorelines and properties adjacent to drainage ways are at higher risk. Maui County is experiencing water shortages and need to make adjustments like communities on the mainland. We need to stop focusing on requiring trees and other vegetation in residential communities and move toward water conservation measures. Currently 40% of Maui's potable water is being used to maintain landscaping nonessential to the preservation of life and food supply. Yet, policies such as the requirement of tree planting and landscaping whether by law or homeowner association rules place a high burden on water supply. I personally use WAY more water keeping the County trees and landscaping on my property to the standard of the association than I use to shower, laundry, cook and wash dishes. Many communities on the mainland now only allow turf, rock gardens and the like to reduce the burden on potable water supplies. We are already there but politicians will not acknowledge the problem because it would be unpopular to cut down on what are deemed precious trees and beautification. The current laws are antiquated. Heard of the tipping point? It is already too late for the climate and water shortage problems in Maui County. The mild suffering should have started decades ago so that at least two generations by now would have been educated about water conservation.*

· *The central valley is a fire risk to Kīhei where I live. Flood control projects east of our town can serve duel purposes. Fire brake and flood control*

· *I am more deeply concerned about the effects to our watershed, native plants, birds, etc.*

· *Place a cap on how many people are moving to maui*

· *Very concerned about the erosion and sea levels rising. I've seen it first hand over in Kahana by S turns, the beach is barely there. Sand bags and caution tape are part of the views. I'm worried about the erosion along the Pali, since there is only one way in and out. Everything is brown from lack of rain. I worry about farmers being able to grow produce and animals finding water.*

· *I live on Molokai in a low lying area on the east end. SMA or special management area designations have made it really hard or even impossible for me to improve on properties that has been in my family for generations. Because of climate change, certain regulations have been set in place that prevent native hawaiian families like mines the opportunity to build dwellings, bathrooms, or even clear land for farming. The issue of sea level rise is being used to control insurance rates for homes in these areas and are also affecting the monetary process at which someone is able to get permits for building in these areas. Basically you can't build or improve unless you can afford to get special permits. Native hawaiian families are struggling while real estate companies are selling homes in these low lying areas for upwards of 1 to 2 million dollars, raising property value and taxes. Hawaiians are being forced into a lifestyle that they did not choose or in most cases, did not want. Something needs to change, and using climate change as a means of raising the monetary processes that you are legally obligated to abide by is a challenge that the rich who are moving here can afford, and the indigenous people who's families lived here for hundreds and even a thousand years can't live here anymore.*

· *Everyone and the entire island will be affected.*

· *I am an avid diver at Olowalu and am concerned about the trash that enters the nearshore areas there from human consumption as well as the condition of the coral there. During Covid, there was much recovery of the wildlife in the area, which was great to witness. I believe it had alot to do with the lack of tourists in the area.*

· *When they close the Pali due to wildfires. I think building should be farther away from the ocean, I dont think they should be able to repair, just relocated their buildings, especially their accessory buildings and swimming pools, etc.*

· *Damage to watersheds, water collection and flood control, endangered plants, and open and forestry lands due to rampant deer overpopulation.*

· *People are resilient and will find ways to cope with impacts like less jobs and higher heat. The shoreline, coral reefs and fisheries will be greatly impacted. Places down hill from leeward slopes are in more danger from floods as drought, deer and ranching land create less live vegetation to hold soil. The flooding that hit Kīhei in 2021 will happen more often and in places like West Maui. Landslides on Hana highway will be more common due to sever weather. Wildfire will start in places normally not normally associated with fire like Wailuku/Waiehu. Due to drought, Wailuku/Waiehu gets less*

rain and the grasses can be seen turning brown. The other major concern is people moving here to escape climate change issues in other places. The west coast of the Mainland is already moving to Maui to escape drought and wildfires. They cause higher housing prices, use up valuable water, and move to places that should be available to local families as we persevere though climate change.

· *Stop the government/AB Baldwin and Mahi Pono from stealing and diverting water and we won't have these problems.*

· *I'm unconcerned by all of the perceived climate change events you mention above.*

· *Anthropological climate change claims is a hoax*

· *I am particularly concerned about the airport and Kahului. I think this area is starting to experience some of the effects of urban heat, which will only be amplified by rising temperatures. I also am concerned for Kīhei and Lahaina, which was similarly developed and do not have enough native plant life to help dissipate the urban heat from buildings, roads and sidewalks. For wildfire, I am primarily concerned for Kīhei and Wailea because if you get stuck down there on the La Perouse side, there's no road to escape to Kaupo or connect up to Ulupalakua. This evacuation road would be crucial in my opinion. Same with the road from Lahaina to Waihee. This road is untenable at best and definitely not safe for the average car. This again is an evacuation risk should Lahaina experience a major fire, which has happened frequently in recent years.*

· *Climate change resulted in bipedal-ism in early hominids when forest habitats turned into dry savannas. Climate change has always resulted in migration of people. If you don't understand history you can be easily be misled by the 'science' of anything. Climate change is a tool of the elites to change our behavior and control us.*

· *Wear Maui, due to over tourism, too many cars, not enough water capacity abs too much. Holding causing erosion issues*

· *We have TOTALLY mismanaged our ocean reefs. The mass taking of fish has been ridiculous. I do not think we (Maui and Hawai'i) can do much to change the ocean temps.*

· *I believe that I am less impacted at home now that I've moved to Makawao*

· *Very concerned about our sustainable living here on Molokai with freight and grocery cost being high we rely heavily on our natural resources to survive. Most of Molokai took a hit last year due to drought conditions and it affected our deer population quite heavily, and our homesteaders who rely on crops also took a hit from starving livestock throughout the island.*

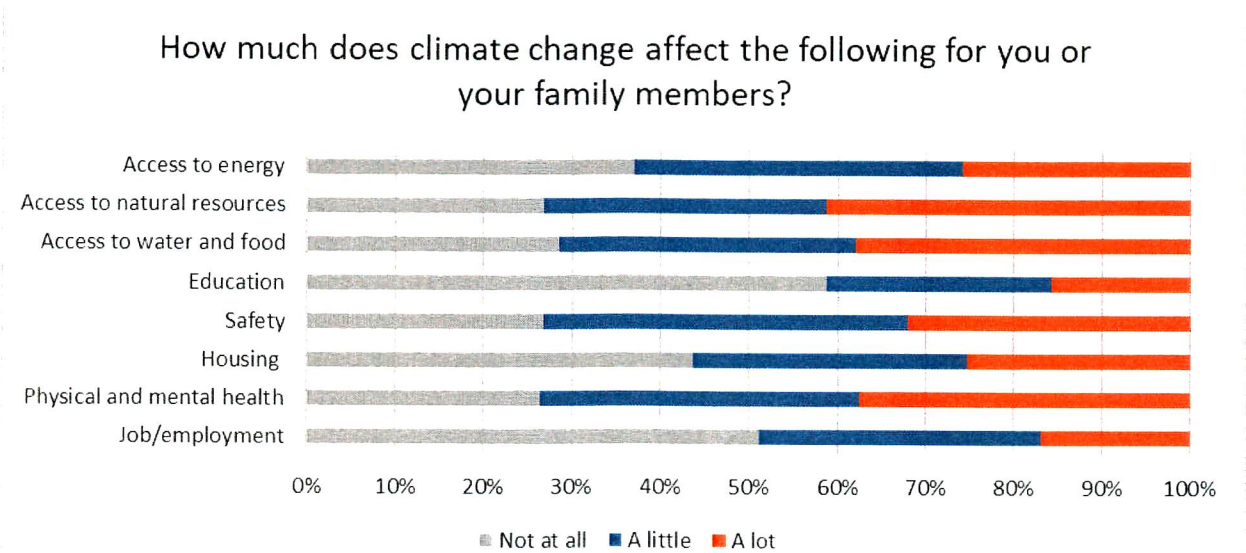
· *Seems to me that there's unlimited fishing island wide. There needs to be a moratorium on vacation rental and enforcement of existing law. Traffic management is*

sorely lacking. The new high-school roundabout will only impede traffic and kill children. Evacuation and emergency vehicle transportation will be severely limited. Very poor planning.

- *Kīhei heat; upcountry drought*
- *All of Maui Nui is endangered by climate change.*

Question 4: How much does climate change affect the following for you or your family members?

Responses showed that education and jobs were seen as least affected by climate change, while access to natural resources and access to water and food were seen as the most affected by climate change.



Respondents were also asked to share more about how they or their families have experienced climate change impacts in Maui County, including how they felt at the time and how they feel about it now. A random sample of the 291 responses are listed below: · *Again worry about access to energy and food since nobody stores food for over 2 weeks and access to energy since the power plants are too close to the ocean.*

- *Climate change affects how often we get sick*
- *Climate change is real, and ppl need to start doing things now. We have installed solar panels and two batteries on our house. We have also ordered a new EV, we will soon be fully electrified. The downside to this is that going green is extremely expensive*

and most families cannot afford these high costs. Federal and state need to step in and offer significant financial assistance in this area.

· *Drier season directly impacts our farm. We have experienced crop loss and emerging pests due to draught conditions in the past year and worry the it will only continue to get worse*

· *Employment is not an issue for me personally, as I am retired. And energy is not an issue for me personally as I have solar and batteries. The only direct effect of climate change that I personally have experienced is beach erosion.*

· *Gathering healthy deer was non-existent as they were all starving and weak.*

· *I am fortunate to not really be that impacted.*

· *I feel climate change is a problem but also an opportunity for long-range planning. Unfortunately I think many environmentalist feel the carrying capacity of Maui is maxed out now. What about our children and grandchildren. Developing our water, wastewater, food, and shelter increases our carrying capacity. I'm an optimist.*

· *I have not felt many impacts of climate change. Most of the negative impacts I have experienced are from the response to climate change. Government waste. High taxes. Over-regulation.*

· *I think the biggest thing we will feel is rising costs of living from importing more and more food if the food security does not get figured out locally. I also think unless Maui county commits to 100% renewable energy we will continue to see rising energy costs for families, whereas I believe even with climate change, renewable power is our best bet combined with energy storage.*

· *in Molokai a lot of families are effected by climate change. for example the crops and food we grow here take a hit because of it. jobs are lost because its to hot or no jobs because certain plants cant grow right to sell.*

· *It is just getting hotter and drier and already affecting water supplies and agriculture.*

· *Just watching the beaches along Honoapi'ilani Highway become smaller and smaller over the years due to sea level rise is very sad. I feel like one day the beaches will all disappear and it will be too late for a change.*

· *Man made climate change isn't real, according to climate 'experts' 70 years ago we are suppose to be in an ice age right now, there are tons of other failed climate change predictions. Stop supporting and wasting tax payer money on pseudoscience.*

· *Most noticeable is sea-level rise/beach erosion at my grandparents house, drier land, hotter days. It's disheartening and scary to experience these changes. Hawai'i is home*

for my entire family and we're all worried about how these changes could result in loss of land/resources/culture and even make it unlivable here.

- *No one likes to be put in difficult situations. Its important to check and try to work something out before things get out of hand. I feel scared and aware now that this subject may cause an effect on everyone. ' Lets try to figure out something'.*

- *Oceans/reefs have been decimated since I was young, Rain forest not raining. Overuse (tourism) and lack of education (tourists). We need better balance of tourism and quality of life. Very very sad. Especially for our keiki and future generations*

- *Over 40 years ago fish was more plentiful and the ocean was a place we went to cool off during the dog days of summer. Now the water temperature has risen and the ocean waters are not as cool as when we were younger. I don't enjoy going to the beach as much now.*

- *Same*

- *Some places where I used to catch fish cannot be accessed anymore because of erosion and it is underwater. Also, where I live in Kahului, it is getting hotter and hotter. Like you folks stated earlier, more days of temps in the nineties. Back in 2019 was especially bad. Because of the heat, more artificial cooling methods (ac, fans) are being utilized, thus more energy use. More energy use only exacerbates the problem, because more greenhouse gases are produced. More use of solar power might be a solution.*

- *The biggest impact are brush fires, heat, and access to roads which are near the ocean. With so many vehicles on the road we cannot afford to lose any major roads of travel. Brush fires a few years back left me stranded in Kahului until very late at night with nowhere to go. Do we have enough fresh water with all the new developments coming up? There was a shortage for years.*

- *The heat in Pukalani past 2 years-necesity for a/c impacting rental prices - but now I moved to Makawao its a way better climate and micro-climate where I live:)*

- *The rising cost of food & housing puts a serious pinch on our discretionary spending. It gets more difficult every month to make ends meet. I'm on a fixed income & cannot imagine 20 million for a house let alone afford it.*

- *There is continuing concern about the long term effects of rising sea levels. As Maui County moves away from being an agricultural community to a more tourism based economy. It is important to develop infrastructure that supports the current tourism and mitigates the effects on the locals.*

- *Unsure*

- *We are on water catchment so the increase in dry weather in our windward areas is especially concerning to my family.*
- *We live on water catchment. Need rain.*
- *We work in Olinda on a succulent farm and I have noticed the succulents are EXTREMELY happy with the lack of wind and rain. That's a problem. We have plenty of fail safes for succulent death but this year didn't have to rely on any of it. There just wasn't enough rain and that is NOT good. We are stressed and concerned. I live on a farm in Keokea and we have noticed significant drought in the summer months. It is stressful to think we might not be able to sustain ourselves with just rain water as we had done for years.*
- *Worried what is going to happen in the future if nothing is done or no changes made.*
- *Central Maui was green and lush with sugar cane and pineapple, water for these crops came from the rain and ground water back then. With the population growth and the lost of sugar and pineapple Central Maui is like a dust bowl, recharge of the ground water non-existence.*