



Food & Fiber

Climate Change Adaptation Summary for Maui, Lānaʻi, and Kahoʻolawe

An Important Note About this Document: This document represents an initial effort to identify adaptation actions for food and fiber on Maui Nui¹ based on stakeholder input and existing information. Specifically, the information presented below comprises stakeholder input,² peer-review comments and revisions, and relevant examples from the literature or other similar efforts. The aim of this document is to expand understanding of possible adaptation actions for Maui Nui food and fiber in response to climate change.

Ecosystem Service Vulnerability



Food and fiber on Maui Nui were evaluated within two distinct groups: 1) canoe plants, other moveable plants, and non-native animals; and 2) reef/nearshore ecosystems and native forest plants. Overall, food and fiber ecosystem services were evaluated as having moderate-high vulnerability to climate change due to moderate sensitivity to climate and non-climate stressors, high exposure to projected future climate changes, and moderate adaptive capacity. Climatic changes such as water temperature, ocean acidification, and drought are likely to impact water supply and quality, increasing stress in cultivated and native species. These species may also be directly impacted by extreme events (e.g., storms) or disturbances (e.g., wildfire, insects, disease), which can impact water resources and damage infrastructure. Non-climate stressors introduce pollutants and diminish surface water and groundwater sources, degrading habitat quality and availability for harvestable species. Additionally, invasive plants and wildlife alter native ecosystems harboring species harvested for food, fiber, and other materials. In many cases, invasive plants and wildlife outcompete native species for resources or lead to the damage or decline of cultivated and/or wild plants and animals. This can change the structure and function of Hawaiian ecosystems, affecting conservation efforts as well as food and fiber availability. Although food and fiber ecosystem services are highly valued by the public, societal support for management is relatively low, and little funding is available to accomplish this. Food security in the Hawaiian Islands is low, but some efforts to restore fishponds and increase traditional taro cultivation have been successful.

Adaptation Strategies and Actions

Table 1 presents a summary of possible adaptation strategies and actions for Maui Nui food and fiber ecosystem services, and consists of stakeholder input during an adaptation workshop as well as additional options from the literature or other similar efforts. Stakeholders identified ways in which current management actions could be modified to reduce ecosystem service vulnerabilities as well as future management actions that are not currently implemented but could be considered for future implementation.

Resilient management requires implementing a range of adaptation options within these different categories in order to achieve short-, mid-, and long-term resilience. These adaptation strategies and actions can generally be grouped according to one of five categories:

¹ The vulnerability assessment workshop approach was not applied to Molokaʻi as the PICCC funded Ka Honua Momona between 2014-2016 to host a workshop series to identify climate-related risks and vulnerabilities, and brainstorm potential solutions and partnerships. EcoAdapt and the PICCC were invited to participate in a one-day workshop with the Molokaʻi Climate Change Network in April 2017 to discuss adaptation options. Members of the network are continuing to meet to discuss potential next steps, including developing an implementation and funding plan.

² This information was gathered during a climate adaptation planning workshop in April 2017 (<http://www.ecoadapt.org/workshops/mauiadaptationworkshop>). Further information and citations can be found in the *Hawaiian Islands Climate Vulnerability and Adaptation Synthesis* and other products available online at www.bit.ly/HawaiiClimate.

1. **Resistance.** These strategies can help to prevent the effects of climate change from reaching or affecting a resource.
2. **Resilience.** These strategies can help a resource withstand the impacts of climate change by avoiding the effects of or recovering from changes.
3. **Response.** These strategies intentionally accommodate change and/or enable resources to adaptively respond to changing and new conditions.
4. **Knowledge.** These strategies are aimed at gathering more information about climatic changes, impacts, or the effectiveness of management actions in addressing climate change.
5. **Collaboration.** These strategies may help coordinate efforts and/or capacity across landscapes and agencies.

Table 1. Summary of possible adaptation options for Maui Nui food and fiber ecosystem services. All strategies and actions were identified by Maui Nui workshop participants unless noted otherwise. Adaptation approaches are classified by implementation timeframes (*Near-term*: 0-5 years; *Mid-term*: 5-20 years; *Long-term*: >20 years).

Adaptation Approach	Adaptation Strategy	Specific Adaptation Actions
Resistance <i>Near-term approach</i>	Manage invasive species	<ul style="list-style-type: none"> • Provide erosion control by using fencing to exclude invasive species from upland habitats
	Increase food security to build resilient cultural communities	<ul style="list-style-type: none"> • Preserve cultural foods³
Resilience <i>Near- to mid-term approach</i>	Protect cultural practices (e.g., fishing, gathering, farming, fiber collection and processing)	<ul style="list-style-type: none"> • Create policies that maintain public access to coastal, forest, and wetland areas • Protect and restore culturally appropriate taro farming areas and fishponds
	Increase food security to build resilient cultural communities	<ul style="list-style-type: none"> • Use community gardens as pilot sites to test resilient crops³
	Preserve water supplies by increasing water use efficiency	<ul style="list-style-type: none"> • Investigate alternative agricultural crops that have economic benefit and capture water⁴ • Improve rainfall capture to decrease groundwater withdrawals⁴
Response <i>Long-term approach</i>	Increase ecosystem resilience, connectivity, and integrity	<ul style="list-style-type: none"> • Acquire land for mauka migration in anticipation of sea level rise, increasing temperatures, and precipitation changes
	Promote climate-adapted agricultural practices	<ul style="list-style-type: none"> • Investigate alternative agricultural crop varieties and mixes with economic value⁴
Knowledge <i>Near- to long-term approach</i>	Increase understanding of water quantity, quality, and allocations under changing climate conditions	<ul style="list-style-type: none"> • Research options for water allocations under changing climate conditions³ • Identify, map, and quantify groundwater and surface water conditions^{Error! Bookmark not defined.}
Collaboration <i>Near- to long-term</i>	Increase direct community restoration	<ul style="list-style-type: none"> • Conduct place-based community education, organizing, management, and action focused on native habitat restoration, cultural practices, and climate change


³ Developed by Kaua'i adaptation workshop participants in June 2017.

⁴ Developed by Hawai'i adaptation workshop participants in June 2017.

Adaptation Approach	Adaptation Strategy	Specific Adaptation Actions
<i>approach</i>		impacts
	Create healthy communities	<ul style="list-style-type: none"> • Increase cultural community input on water use decisions • Create/build relationships within the community, non-profit, and government sectors

Table 2 identifies key Maui Nui food and fiber ecosystem service vulnerabilities that may be reduced and/or addressed by various adaptation actions. Linking vulnerabilities to adaptation options can help managers decide which actions to implement and aid prioritization based on multiple factors (e.g., habitat type, observed or projected changes, ecosystem service). However, when selecting adaptation actions for implementation it is also important to consider secondary effects on other resources, both positive and negative. For example, fencing may benefit native forest ecosystems by limiting ungulate access and activity, but may increase ungulate stress on other habitats. For more information about Maui Nui adaptation strategies and actions developed by workshop participants, many of which are relevant to resilient management of food and fiber ecosystem services, including where and how to implement adaptation actions, implementation timeframe, collaboration and capacity required, and secondary effects on other resources (both positive and negative), please see the report *Hawaiian Islands Climate Vulnerability and Adaptation Synthesis*.

Table 2. Key vulnerabilities of Maui Nui food and fiber ecosystem services linked to specific adaptation actions and management activities (linkages are based on expert opinion); implementation of adaptation actions (central column) may help to directly reduce and/or address the impacts of identified climate and non-climate stressors and disturbance regimes (right columns). Actions highlighted in **red** represent adaptation strategies that enhance resistance, those highlighted in **orange** promote resilience, and those highlighted in **green** facilitate response. Adaptation actions aimed at increasing knowledge and collaboration are not included in this table as they address vulnerability indirectly. Adaptation actions listed in this table include those identified by stakeholders, in the scientific literature, and in other similar efforts.



Management Activity	Adaptation Actions	<div> <div>Δ Precipitation (amount/timing); ↑ Drought</div> <div>↑ Air & water temperatures</div> <div>↑ Ocean acidification</div> <div>↑ Sea level rise; ↑ Coastal flooding; ↑ Shoreline change</div> <div>Δ Wind and circulation</div> <div>Δ Tropical storms/hurricanes</div> <div>↑ Wildfire</div> <div>Δ Riverine flooding</div> <div>↑ Insects & disease</div> <div>Residential/commercial development; Energy development</div> <div>Agriculture & aquaculture; Pollution/poisons</div> <div>Roads/highways/trails; Recreation</div> <div>Groundwater development; Water diversions</div> <div>Invasive species</div> </div>														
		Climate Stressors						Disturbance Regimes			Non-Climate Stressors					
Habitat Management Activities	Provide erosion control by using fencing to exclude invasive species from upland habitats															✓
	Use community gardens as pilot sites to test resilient crops	✓	✓			✓	✓		✓	✓						
Cultural Protection Activities	Preserve cultural foods											✓				
	Protect and restore culturally appropriate taro farming areas and fishponds	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	
Water Management Activities	Investigate alternative agricultural crops that have economic benefit and capture water	✓														
	Improve rainfall capture to decrease groundwater withdrawals	✓												✓		
Land Use Planning & Policy Activities	Create policies that maintain public access to coastal, forest, and wetland areas										✓					
	Increase cultural community input on water use decisions			✓										✓		
	Investigate alternative agricultural crop varieties and mixes with economic value	✓	✓		✓	✓				✓						
	Acquire land for mauka migration in anticipation of sea level rise, increasing temperatures, and precipitation changes	✓	✓		✓											

In addition to directly reducing vulnerabilities (Table 2), some adaptation actions may indirectly address vulnerabilities. For example, utilizing invasive species exclusion fencing for erosion control may also help maintain groundwater infiltration processes that occur in healthy native forests, which in turn, may help maintain irrigation water supplies during drought periods.

Two other important considerations when selecting adaptation actions for implementation include feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability; Figure 1). An adaptation action with high feasibility has no obvious barriers and a high likelihood of implementation whereas an action with low feasibility has obvious and/or significant barriers to implementation that may be difficult to overcome. An adaptation action with high effectiveness is very likely to reduce associated vulnerabilities (listed in Table 2) and may benefit additional management goals or resources whereas an action with low effectiveness is unlikely to reduce vulnerability and may have negative impacts on other resources.

Feasibility of Implementing the Action	Action Effectiveness at Reducing Vulnerabilities
<ul style="list-style-type: none"> • <i>High</i>: There are no obvious barriers and it has a high likelihood of being implemented • <i>Moderate</i>: It may be possible to implement the action, although there may be challenges or barriers • <i>Low</i>: There are obvious and/or significant barriers to implementation that may be difficult to overcome 	<ul style="list-style-type: none"> • <i>High</i>: Action is very likely to reduce vulnerability and may benefit additional goals or habitats • <i>Moderate</i>: Action has moderate potential to reduce vulnerability, with some limits to effectiveness • <i>Low</i>: Action is unlikely to reduce vulnerability

Figure 1. Description of action feasibility and effectiveness rankings.

Figure 2 plots adaptation actions listed in Table 1 according to feasibility and effectiveness (rankings described in Figure 1). Figure 2 can help managers prioritize actions for implementation (e.g., actions with high feasibility and high effectiveness), better target management efforts toward specific challenges (e.g., actions with low or moderate feasibility but high effectiveness), and/or evaluate whether to proceed with implementation (e.g., actions with high feasibility but low effectiveness). For the latter two purposes, managers may consider the following questions:

- **Low or Moderate Feasibility/High Effectiveness Actions:** What steps can be taken to increase the likelihood of this action being implemented in the future?
 - *Example:* Would improving public outreach and education or enhancing public/private collaboration facilitate increased management access and activity on private lands (e.g., to remove invasive species)?
- **High Feasibility/Low or Moderate Effectiveness Actions:** Does this action still make sense given projected climate changes and impacts?
 - *Example:* If conditions are projected to become drier, should groundwater pumping still continue to support lowland wetland hydrology?

Alternatively, there may be some actions that do not reduce vulnerability directly but could provide important information, tools, or support to address vulnerability down the line. For example, actions aimed at increasing knowledge through monitoring or modeling could provide key information for future restoration activities (e.g., creating detailed species genetic profiles to select genetically and ecologically suitable plant species for future conditions). Managers may want to weigh the costs and benefits of implementing actions with the timeframe required to reduce vulnerability directly. Additionally, actions focused on coordination and collaboration may not directly address vulnerabilities, but these remain important steps toward better planning and management.

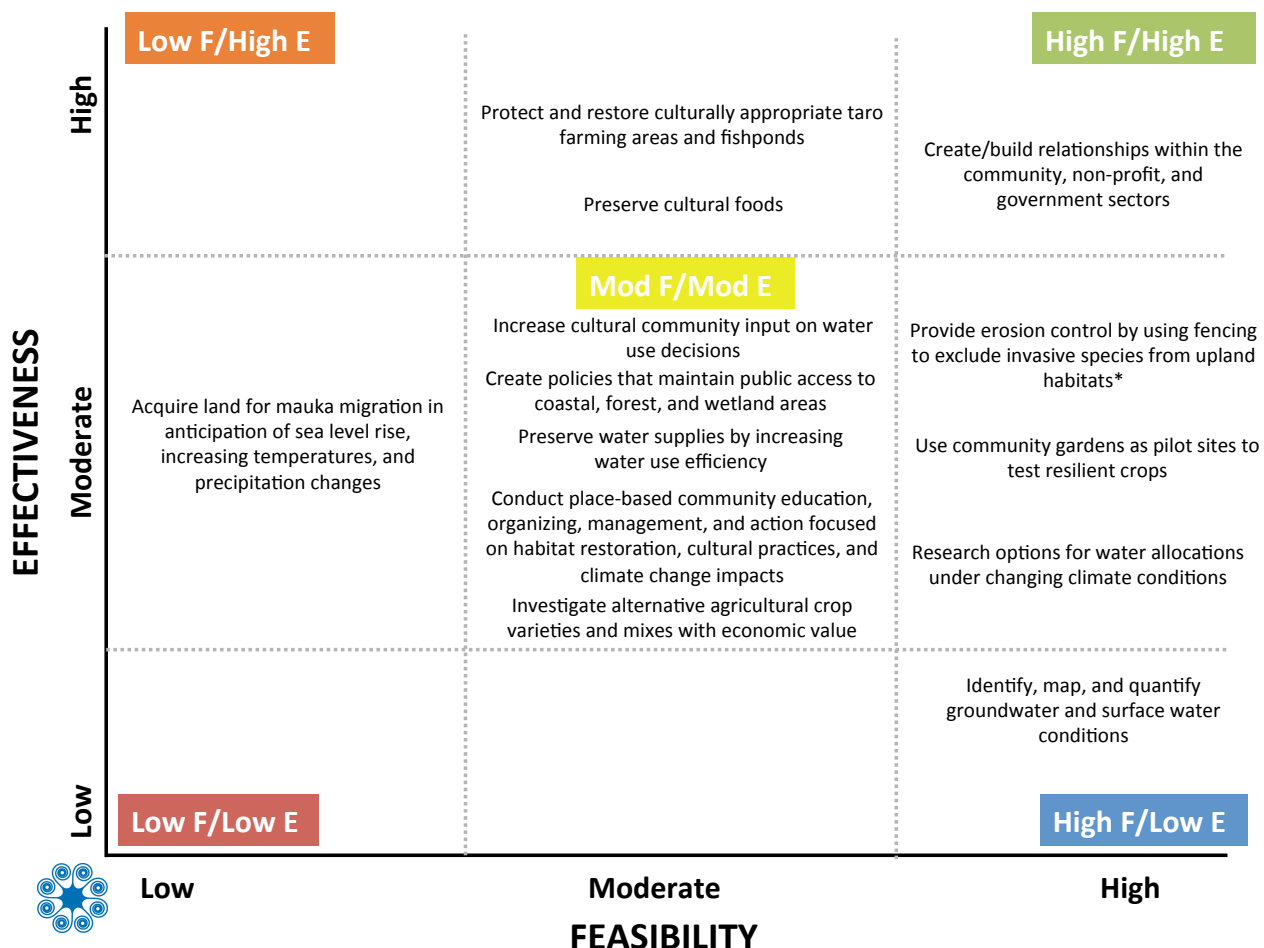


Figure 2. Maui Nui food and fiber ecosystem service adaptation actions plotted according to implementation feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). Those actions having high feasibility and effectiveness appear in the upper right corner and those actions having low feasibility and effectiveness appear in the bottom left corner. An asterisk (*) denotes adaptation actions evaluated for feasibility and effectiveness by workshop participants. All other adaptation action evaluations are based on expert opinion.

Lastly, it is important to consider long-term consequences of implementing adaptation actions. One way to evaluate this is to consider how easy it would be to reverse a management action once it has been implemented in case of unintended consequences. When considering action reversibility, managers should consider cost, personnel time, overall time required to reverse an action, and other relevant factors. For example, it would likely be easy to reverse an action focused on altered outplanting timing; outplanting timing could simply be changed to a more favorable time. Alternatively, it would likely be hard to reverse the successful introduction of a new biocontrol agent, requiring significant personnel time and funding. Generally, actions involving infrastructure installation, policy or legislative change, or new species introductions may be moderately difficult or hard to reverse.

Table 3 lists adaptation actions identified in Table 1 according to ease of reversibility, as well as feasibility and effectiveness. This table can help managers evaluate whether to proceed with implementation (e.g., easily reversible actions) and/or identify actions that may need more research, small-scale testing, careful planning and implementation, and/or heightened adaptive management (e.g., moderately difficult or hard to reverse actions).

Table 3. Maui Nui food and fiber ecosystem service adaptation actions listed according to ease of reversibility, as well as feasibility and effectiveness. Actions that have high feasibility/effectiveness and are easy to reverse appear at the top of the list, and actions that have low feasibility/effectiveness and are hard to reverse appear at the bottom of the list. All adaptation action evaluations are based on workshop participant and expert opinion.

Adaptation Action	Feasibility	Effectiveness	Reversibility
Create/build relationships within the community, non-profit, and government sectors	High	High	Hard
Provide erosion control by using fencing to exclude invasive species from upland habitats	High	Moderate	Easy
Research options for water allocations under changing climate conditions	High	Moderate	Easy
Use community gardens as pilot sites to test resilient crops	High	Moderate	Moderate
Increase cultural community input on water use decisions	High	Moderate	Moderate
Preserve cultural foods	Moderate	High	Moderate
Protect and restore culturally appropriate taro farming areas and fishponds	Moderate	High	Moderate
Investigate alternative agricultural crops that have economic benefit and capture water	Moderate	Moderate	Easy
Investigate alternative agricultural crop varieties and mixes with economic value	Moderate	Moderate	Easy
Create policies that maintain public access to coastal, forest, and wetland areas	Moderate	Moderate	Moderate
Improve rainfall capture to decrease groundwater withdrawals	Moderate	Moderate	Moderate
Conduct place-based community education, organizing, management, and action focused on habitat restoration, cultural practices, and climate change impacts	Moderate	Moderate	Moderate
Identify, map, and quantify groundwater and surface water conditions	High	Low	Easy
Acquire land for mauka migration in anticipation of sea level rise, increasing temperatures, and precipitation changes	Low	Moderate	Hard

This document presents a range of adaptation options available for Maui Nui food and fiber ecosystem services. When applying adaptation principles in existing management frameworks, general best practices include:

- ✓ Utilizing a range of adaptation categories to promote short-, mid-, and long-term resilience.
- ✓ Thinking critically about which climate vulnerabilities an action can directly address versus those it may address indirectly.
- ✓ Identifying where opportunities overlap (e.g., actions that address multiple vulnerabilities or benefit multiple resources), and being cognizant of actions that could create detriments to other resources.
- ✓ Prioritizing actions for implementation based on 1) how effective an action will be in reducing identified vulnerabilities; 2) how feasible implementing the action will be, and; 3) how easy it would be to reverse an action in case of unintended consequences.

Recommended Citation

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