Food & Fiber

Climate Change Adaptation Summary for Hawai'i

An Important Note About this Document: *This document represents an initial effort to identify adaptation actions for food and fiber on the island of Hawai'i based on stakeholder input and existing information. Specifically, the information presented below comprises stakeholder input,[1] 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 Hawai'i food and fiber in response to climate change.*

Ecosystem Service Vulnerability

Food and fiber ecosystem services on the island of Hawai'i were evaluated as having high vulnerability to climate change due to high sensitivity to climate and non-climate stressors, high exposure to projected future climate changes, and low-moderate adaptive capacity. Climate-driven changes and disturbance regimes such as altered precipitation regimes, increased air temperature, tropical storms and flooding, sea level rise, saltwater intrusion, changes in wind and circulation patterns, wildfire, insects, and disease are likely to impact both cultivated crops and native species used for food and fiber on Hawai'i. These factors may reduce water supply and quality, stressing native ecosystems and limiting crop irrigation and plant growth. Food and fiber species may also be impacted by disturbances that damage habitats and infrastructure and cause direct species injury or mortality (e.g., tropical storms, wildfire, insects, disease). Non-climate stressors reduce habitat extent, introduce pollutants, and diminish surface- and groundwater sources, degrading habitat quality and availability for harvestable plant and animal species. Additionally, invasive plants and wildlife alter native ecosystems harboring species harvested for food, fiber, and other materials, in many cases out-competing native species for resources or leading to the damage or decline of cultivated and/or wild plants and animals. Although food and fiber ecosystem services are highly valued by the public, societal support is relatively low and the Hawaiian Islands have low food security due to their isolated location and dependence on imported goods and energy which drives up the price of local agricultural products, and in turn increases the competitiveness of cheap imported food. Changes in climate may encourage a shift in focus towards sustainable land use and locally produced food, but little work is being done to specifically alleviate the impacts of climate change on food and fiber ecosystem services.

Adaptation Strategies and Actions

Table 1 presents a summary of possible adaptation strategies and actions for Hawai'i 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. **Resistance**. These strategies can help to prevent the effects of climate change from reaching or affecting a resource.

[1] This information was gathered during a climate adaptation planning workshop in June 2017 (http://www.ecoadapt.org/workshops/hawaiiadaptationworkshop). 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.

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 Hawai'i food and fiber ecosystem services. All strategies and actions were identified by Hawai'i 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 *Near-term approach*	Maintain/improve water quantity and quality	• Provide incentives for Hawaiian field systems to not be developed or grazed by cattle
	Manage soil health and stability	• Provide erosion control by using fencing to exclude invasive species from upland areas[2]
Resilience *Near- to mid-term approach*	Preserve water supplies by increasing water use efficiency	• Improve rainfall capture to decrease groundwater withdrawals • Increase use of alternative water sources (i.e. stormwater, gray water, recycled reclaimed water, capture fog drip) • Investigate alternative agricultural crops that have economic benefit and capture water
Response *Long-term approach*	Promote climate-adapted agricultural practices	• Investigate alternative agricultural crop varieties and mixes with economic value • Consider innovative locations to grow crops under future climate conditions
Knowledge *Near- to long-term approach*	Increase understanding of water resources and their value	• Investigate automated groundwater monitoring techniques and organizations/agencies that could act as data managers • Utilize citizen science and increase community involvement to expand monitoring efforts
Collaboration *Near- to long-term approach*	Strengthen conversations about water as public trust	• Create and/or enhance water groups (e.g., watershed partnerships)
	Support whole systems approaches to agricultural production	• Increase support for community-supported agriculture (CSAs)

Table 2 identifies key Hawai'i 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,

[2] Developed by Maui adaptation workshop participants in April 2017

fencing may benefit native forest ecosystems by limiting ungulate access and activity, but may increase ungulate stress on other habitats. For more information about Hawai‘i 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 Hawai'i 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	Climate Stressors						Disturbance Regimes			Non-Climate Stressors				
		Δ Precipitation (amount/timing); ↓ Soil moisture; ↑ Drought	↑ Air temperature	Δ Tropical storms/hurricanes	↑ Sea level rise; ↑ Saltwater intrusion	Δ Streamflow	Δ Wind & circulation	Δ Riverine flooding	↑ Wildfire	↑ Insects & disease	Residential/commercial development; Energy production;	Population growth	Agriculture & aquaculture; Pollution & poisons	Roads/highways/trails; Recreation	Groundwater development; Water diversions	Invasive species
Land Use Planning Activities	Provide incentives for Hawaiian field systems to not be developed or grazed by cattle										✔	✔	✔		
	Investigate alternative agricultural crops that have economic benefit and capture water	✔										✔			
	Investigate alternative agricultural crop varieties and mixes with economic value	✔	✔		✔		✔			✔					
	Consider innovative locations to grow crops under future climate conditions	✔	✔		✔		✔			✔					
Habitat Management Activities	Provide erosion control by using fencing to exclude invasive species from upland areas			✔				✔	✔						✔
Water Resource Management Activities	Improve rainfall capture to decrease groundwater withdrawals	✔												✔	
	Increase use of alternative water sources (i.e. stormwater, gray water, recycled reclaimed water, capture fog drip)	✔		✔		✔		✔						✔	✔

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

- *High*: There are no obvious barriers and it has a high likelihood of being implemented
- *Moderate*: It may be possible to implement the action, although there may be challenges or barriers
- *Low*: There are obvious and/or significant barriers to implementation that may be difficult to overcome

Action Effectiveness at Reducing Vulnerabilities

- *High*: Action is very likely to reduce vulnerability and may benefit additional goals or habitats
- *Moderate*: Action has moderate potential to reduce vulnerability, with some limits to effectiveness
- *Low*: 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.

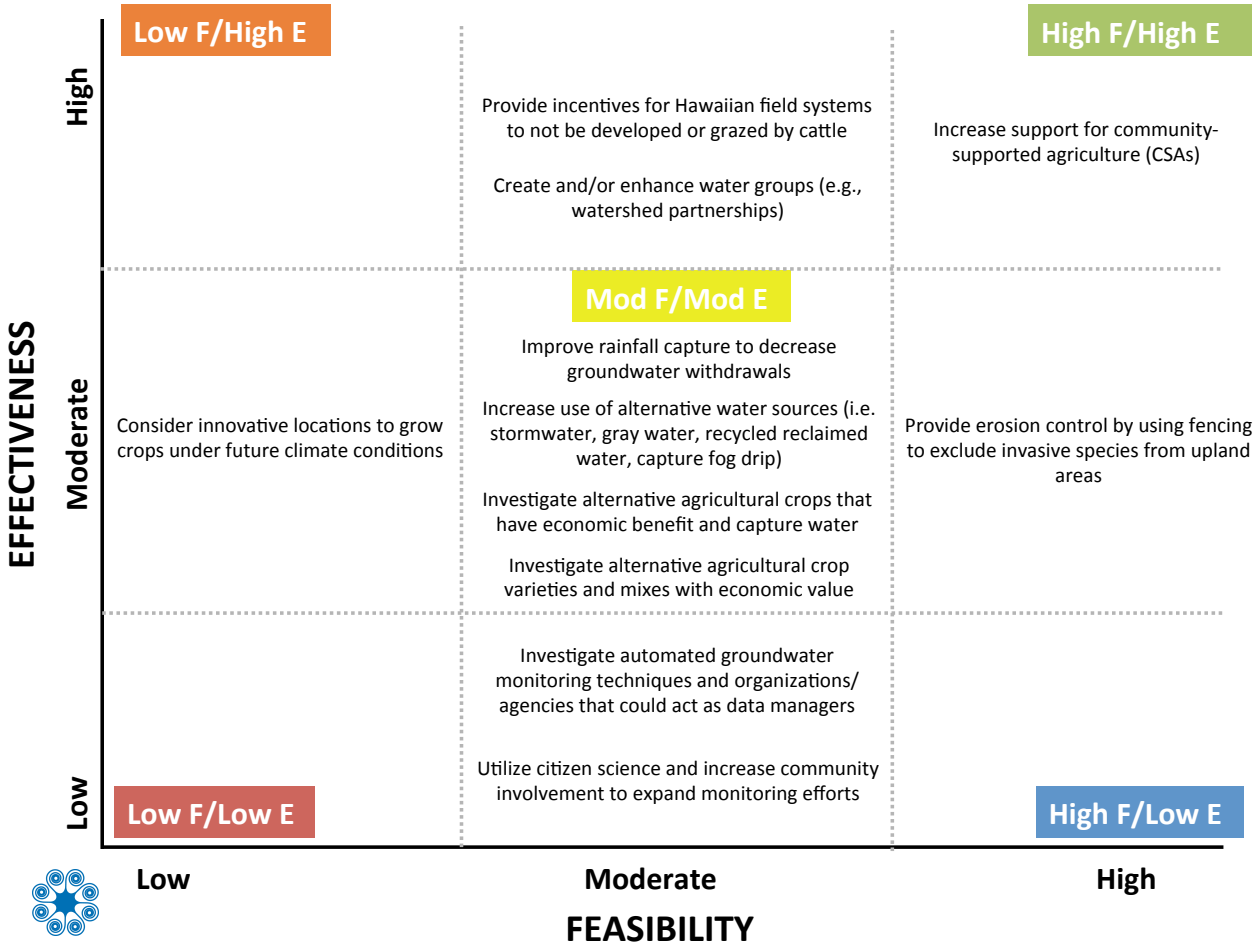

Figure 2. Hawai‘i food and fiber ecosystem service adaptation actions plotted according to implementation feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). Those actions having high feasibility and effectiveness appear in the upper right corner and those 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. Hawai'i 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
Increase support for community-supported agriculture (CSAs)	High	High	Easy
Provide erosion control by using fencing to exclude invasive species from upland areas	High	Moderate	Easy
Provide incentives for Hawaiian field systems to not be developed or grazed by cattle	Moderate	High	Easy
Create and/or enhance water groups (e.g., watershed partnerships)	Moderate	High	Moderate
Increase use of alternative water sources (i.e. stormwater, gray water, recycled reclaimed water, capture fog drip)	Moderate	Moderate	Easy
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
Improve rainfall capture to decrease groundwater withdrawals	Moderate	Moderate	Easy
Investigate automated groundwater monitoring techniques and organizations/agencies that could act as data managers	Moderate	Low	Moderate
Utilize citizen science and increase community involvement to expand monitoring efforts	Moderate	Low	Easy
Consider innovative locations to grow crops under future climate conditions	Low	Moderate	Moderate

This document presents a range of adaptation options available for Hawai'i 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.

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