



**US Army Corps of Engineers
Responses to Climate Change Program**

Applying Risk Informed Decision-Making Framework for Climate Change to Integrated Water Resource Management Planning – West Maui Watershed Plan.

FINAL REPORT



Kā'anapali, West Maui, Hawai'i (photo courtesy of Aston Kā'anapali Shores)

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0. EXECUTIVE SUMMARY

As an island state, Hawai'i is at high risk to impacts from by anthropogenic-induced climate change. Climate change is predicted to significantly alter freshwater supplies, from anticipated reductions to mean annual rainfall to increased frequency and intensities of large storm events. With the majority of developable land occurring in the coastal lowlands, sea level rise threatens the populations of Hawai'i. Hawai'i's sensitive habitats already are threatened from development pressures, changing water demands and increased invasions of alien species. Changes in temperature and hydrology are expected to exacerbate existing threats. Coral reef habitats, critical to Hawai'i's economy, are in decline statewide. Climate change impacts from changes in wave and storm energies from sea level rise and rising ocean acidification may further impair coral reefs. In light of these potential threats, the State of Hawai'i recently passed legislation to require State agencies to consider climate change impacts and incorporate climate change adaptation into their planning processes.

To better address the current and future impacts to coral reefs, the State of Hawai'i is partnering with federal and state agencies, local government and non-governmental organizations in the West Maui Ridge to Reef (R2R) Initiative. Under Section 729 of the Water Resources Development Act (WRDA) of 1986, the U.S. Army Corps of Engineers (USACE) Honolulu District with the State of Hawai'i's Department of Land and Natural Resources (DLNR) is developing the watershed plan that will provide the comprehensive strategy to guide the West Maui R2R Initiative.

On the national stage, climate change has become of key focus for USACE Civil Works program. The Institute of Water Resources (IWR) established the Response to Climate Change (RCC) Program. The mission of the RCC Program is to develop, implement, and assess adjustments or changes in operations and decision environments to enhance resilience or reduce vulnerability of USACE projects, systems and programs to observed or expected changes in climate. The RCC program funded 9 pilot studies to evaluate and assess how a risk-informed decision making (RIDM) framework may be incorporated into different USACE projects at different stages. Selected as one of the 9 pilot studies, Honolulu District conducted a study associated with the West Maui Watershed Plan to assess how a RIDM framework could be incorporated at the beginning of a collaborative integrated water resource management (IWRM) planning process for a placed-based climate change adaptation strategy.

Using a Shared Vision Planning (SVP) Process, USACE worked with several federal and state agencies, the county of Maui, and key non-governmental organizations. Through the pilot study, a decision framework was developed to guide the West Maui R2R Initiative. Key lessons learned from the process were (1) in an interagency planning process – having a shared lexicon is critical to the overall vision; (2) decision making agencies must first have a clear understanding of the decision framework before engaging the broader stakeholders and community; (3) incorporating climate change early in the planning process provides a broader context for understanding of the key problems, constraints and opportunities; and (4) there are

many tools available to assess risk and uncertainty, in an interagency initiative it is important to have flexibility in using the tool that is most effective for the individual team.

1. BACKGROUND

The West Maui R2R Initiative is an all-encompassing approach across multiple agencies, organizations and jurisdictions to address adverse impacts to coral reefs in West Maui. The State recognized that an integrated and comprehensive approach to reduce land-based sources of pollution is one of the most important steps to help restore coral reef ecosystems. The R2R Initiative builds on already established efforts underway and leverages resources across a number of agencies and community groups to implement actions to reduce land-based sources of pollution. The Hawai'i Coral Reef Strategy identified the coral reef ecosystem along the West Maui region as a priority management area (Hawai'i DAR, 2010).

Under Section 729 of the WRDA of 1986, State of Hawai'i DLNR and USACE are sponsoring the development of the watershed plan for the West Maui Watershed R2R Initiative. The goal in the area is to restore and enhance the health and resiliency of West Maui coral reefs and nearshore waters through the reduction of land-based pollution threats from the summit of Pu'u Kukui to the outer reef.

In February 2011, the U.S. Coral Reef Task Force (USCRTF) designated the Kā'anapali – Kahekili area within the West Maui R2R Initiative as a priority watershed partnership, allowing for Federal agencies to provide funding and technical assistance to the State. The National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture – Natural Resources Conservation Service (NRCS), the U.S. Environmental Protection Agency (EPA), and the National Fish and Wildlife Foundation (NFWF) are all providing assistance to implement a suite of integrated activities to improve the health of West Maui's reefs.

The DLNR and USACE-funded comprehensive plan builds off the ongoing work by the other USCRTF partner agencies. The plan will provide a comprehensive plan to reduce land-based pollution. The plan will include activities that other agencies, organizations and the community can undertake to contribute to the goal and suggestions for further research. The plan for the West Maui R2R Initiative will be completed by 2015. The plan will also incorporate the wealth of existing information, past actions and lessons learned in the West Maui area.

The cost-share agreement between DLNR and USACE was executed on August 9, 2012. This pilot study was conducted during the final stages of reconnaissance to help develop a risk informed decision framework to guide the watershed plan.

Study Area

The 24,000-acre West Maui Watershed study area extends from Kā`anapali northward to Honolua and from the summit of Pu`u Kukui to the outer reef. It includes the watersheds of Wahikuli, Honokōwai, Kahana, Honokahua, and Honolua (See Figure 1).

The watershed includes multiple resources and uses – the upper watershed is designated as a conservation area focused on preserving and restoring native forests; the middle watershed is dominated by agricultural uses but is in transition as agricultural business in West Maui have experienced significant economic declines; and resorts and residential areas dominate the lower watershed and are continuing to expand into the middle watershed. The nearshore waters include sensitive coral reef ecosystems and are designated as part of the Hawaiian Humpback Whale National Marine Sanctuary.

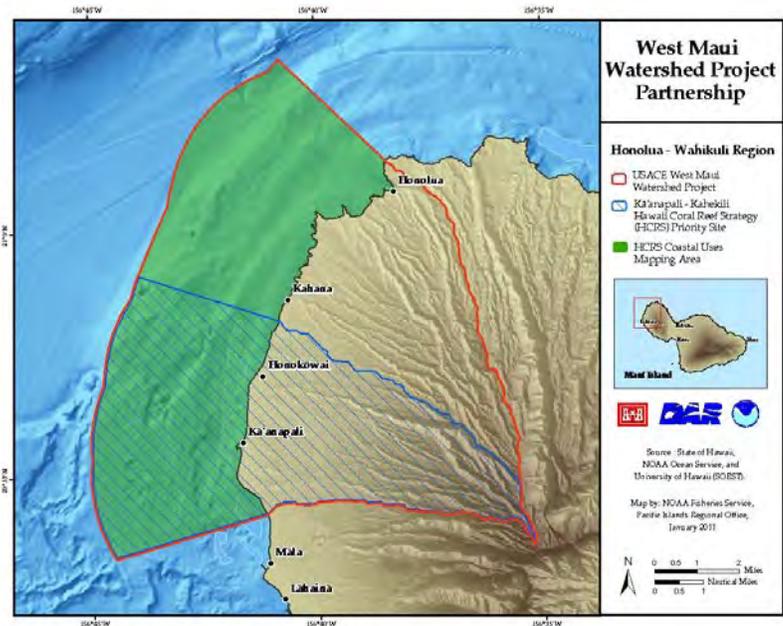


Figure 1: West Maui Ridge to Reef Initiative Study

Current Climate

The Hawaiian Islands are tropical systems with two dominant seasons – a dry season or “summer” is from May through September and a wet season from October through April. During the wet season, there are two rainfall peaks in the fall and spring. The temperatures are relatively mild throughout the year with moderate humidity and fairly consistent trade winds. Storms are more frequent in the winter months (NOAA, 2012). Within these two seasons however, there are significant differences in island climate due to elevation and aspect. West Maui study area is on the leeward side of the island, in the rain shadow of Pu`u Kukui. The summit of the West Maui Mountains is one of the wettest spots on earth with 366 inches of rain annually (Juvik, 1998, Giambelluca, et al., 2011). However, Kā`anapali area only receives 20 inches of rain annually and Honolua receives 46 inches of rain annually (Giambelluca, et al, 2011). With the significant variation in rainfall across the watershed, planning for climate change becomes a challenge.

Current Problem/Concern

Coral reefs are declining across the world. In West Maui, Hawai`i, nearly one-fourth ($\frac{1}{4}$) of all living corals have been lost in the last thirteen (13) years alone (DAR & HCRI, 2008). Studies of neighboring areas confirm coral reefs were already degraded when the monitoring began. If anything, recent observations underestimate the overall long-term deterioration. Substantial losses can occur quickly. Without dramatic steps to restore favorable conditions, reefs statewide — and around islands generally — risk rapid degradation.



Degraded Coral Reef



Healthy Coral Reef

Contrasting Maui Reefs: Molokini and Mā`alaea Reef. Dense growths of macroalgae dominate, remaining corals are in poor condition and reef physical structure is deteriorating, as coral growth does not keep pace with the rate of erosion. To see time series video on the changing health of Maui reefs, go to:

<http://www.hawaii.edu/kahekili/videopage.html>.

Coral reefs and fisheries are integral to ocean environments and to marine life itself. Coral reefs support complex food systems, diverse biological life, recreation, commerce, and shoreline protection. Healthy coral reefs are vital to the island lifestyle, economy and a thriving Native Hawaiian culture. The total net benefits of Hawai`i coral reefs are estimated at \$360 million annually, and the overall asset value conservatively estimated to be nearly \$10 billion (Cesar and Van Beukering, 2004; Karl et al., 2009). The University of Hawai`i (UH) estimates that coral reefs contribute up to \$800 million/year in gross annual revenue for the State. An economic valuation study sponsored by the Hawai`i Coral Reef Initiative in 2002 estimates Maui County loses more than \$20 million/year from coral reef decline (Cesar, et al., 2002).

Because of Hawai`i's geographic isolation, over 25% of its coral reef species are found nowhere else in the world. Degradation is not just a loss of coral cover. Habitat quality and topographical complexity also decline. The biodiversity that supports ecosystem services, biological resources, and social benefits are diminished. The recreational and commercial value of reefs declines. Fish stocks migrate away or die. Related ocean resources decline. Changes to lifestyle, inability to rely on sustenance from ocean resources, impacts to the Native

Hawaiian culture which hold coral reefs in high esteem and many other critical social effects can occur with decline in coral reef resources.

The causes of coral reef decline are complex and not yet fully understood. However, land-based pollution (increased sediment, nutrients, and other pollutants) is a clear and serious threat to coral reef ecosystems. Surface water run-off from storm events and ground water discharge both transfer pollutants into the near shore marine environment. Elevated nutrient levels from surface water run-off and groundwater discharge into nearshore waters has been linked to an increase in alien invasive algal species in the nearshore. Increased sedimentation associated with loss of forestland, historical plantation agriculture, stream channelization, and rapid development have clearly impacted coral reef health.

2. PURPOSE & SCOPE

The primary purpose of the West Maui Watershed RCC Pilot Study is to incorporate a RIDM framework that addresses climate change threats at the onset of a planning process for an IWRM plan. Risk-informed decision making is a process that incorporates uncertainty into decision making and assesses what the consequence and risk of making the “wrong decision” or not addressing an “uncertainty” in a transparent manner and throughout the project life-cycle – planning, implementation, and operations and maintenance (IWR, 2010). The pilot study outcomes included:

- Understanding the key considerations that need to be incorporated early in a climate change decision framework.
- Provide lessons learned on incorporating climate change framework within the USACE watershed planning process.
- Provide lessons learned on communicating and collaborating on climate change adaptation within a diverse interagency management team, in terms of interest, technical background, and organizational missions.

Central Question

The central question that the West Maui Watershed RCC Pilot Study aims to address is:

- *How can a RIDM framework be incorporated at the beginning of a collaborative planning process for a place-based climate change adaptation strategy?*

3. METHODOLOGY

Using a SVP process, the USACE Plan Delivery Team (PDT) facilitated a series of three workshops with the West Maui R2R Funding Agency Support Team (FAST) and associated key climate change partners. The workshops were used to establish a RIDM context that considers climate change risks to the study goals. With the USACE assistance, the interagency team developed a

decision framework to guide the watershed plan development and identify a prioritization strategy for incremental decision-making.

Prior to the initial workshop, USACE conducted a literature review to identify the primary risks from climate change associated with the study goals and objectives (Appendix A). Within the first workshop, the concept of risk informed decision-making was presented and discussed. The climate change risks were reviewed and revised. The second workshop (which included a site visit) focused on developing a decision framework for the study. The third and final workshop was used to prioritize key actions and data gaps based on the risk and uncertainty around the current threats, including climate change.

In parallel to the pilot study, the State and USACE developed the public involvement plan (PIP). While focusing on the interagency management team, the RIDM framework identified when and how to engage stakeholders and the public in the decision process as the PIP was being developed by the State and USACE.

Participants

The USACE PDT was responsible for facilitating the workshops and meetings among the participants. The USACE PDT also developed the majority of the deliverables associated with the pilot study. Through a SVP process, the participants reviewed all deliverables and provided direction to the USACE PDT. The participants in the pilot study include:

West Maui R2R FAST. These are governmental agencies directly involved in funding, policy oversight and plan management for the West Maui R2R Initiative.

- USACE
- DLNR Commission on Water Resource Management (CWRM)
- DLNR Division of Aquatic Resources (DAR)
- DLNR Division of Forestry and Wildlife (DOFAW)
- NOAA
- NRCS
- State Department of Health – Clean Water Branch (DOH CWB)
- EPA
- The West Maui Watershed and Coastal Management Coordinator (funded by NFWF)

West Maui R2R Hui. These are agencies, organizations, communities, businesses, landowners and other key stakeholders participating at the level of project implementation, research, support, and action planning to promote or implement actions associated with the R2R Initiative:

- Maui County
- The West Maui Mountains Watershed Partnership (WMMWP).
- The Nature Conservancy (TNC)

Hawai'i Climate Change Partners. These are key partners working on climate change issues statewide that would have relevant input and expertise related to the pilot study.

- Fish and Wildlife Service (FWS), Pacific Islands Climate Change Cooperative (PICCC). PICCC is the landscape conservation cooperative (LCC) that is supported by FWS. PICCC is the lead interagency initiative on addressing climate change research and management questions for the Pacific region.
- State of Hawai'i, Office of Planning Coastal Zone Management (Hawai'i CZM). In 2012, the State of Hawai'i passed climate change policy – requiring that all state agencies address climate change as part of compliance with the State Planning Act. Hawai'i CZM is the lead State agency for developing policy and planning tools to assist the State in meeting this requirement.

Participatory Survey

A participatory survey was administered at the beginning and end of the pilot study. The purpose of the survey was to assess the participants' knowledge, attitudes and perceptions of:

- Theory of risk informed decision making,
- Importance of climate change issues within the watershed,
- Importance of addressing risk and climate change within an IWRM planning process, and
- Views of the USACE planning process.

Of the 13 participants, only nine participants were from non-federal organizations. The majority of the participants had not partnered with USACE in a feasibility study or watershed plan prior to this pilot study. As an outcome of the survey, the PDT assessed the benefits of the pilot study in educating the participants on the USACE process, RIDM framework, and collaborative planning. In addition, the surveys included questions about other planning processes that the participants use to see if there may be benefits for USACE to consider how other organizations address climate change and risk within their planning process. The initial survey was administered in February 2012. The final survey was administered in September 2012. The summary of the survey findings is provided in Section 4. The detailed survey results are shown in Appendix B.

4. RESULTS

Identifying Climate Change Risks in West Maui.

As islands, Hawai'i is experiencing unique threats from human-caused changes in climate in relation to the continental United States. Anticipated physical changes include changes in rainfall frequency, duration, and intensity, reduction in freshwater stream base flows, changes to groundwater recharge capacity, rise in sea level, changes in wind and wave patterns and energies, ocean acidification, degradation of coral reefs, changes in invasive species distribution and numbers, increase spread of wildlife diseases, potential increased extinctions in rainforest species, and increased population pressure with "climate change refugees" from other Pacific

islands. Long-term temperatures for Hawai'i at higher elevations are rising at a higher rate than the global average (Giambelluca, et al, 2009). Annual rainfall has decreased over the last 15-20 years by 15% with drier leeward areas being more affected (Chu and Chen 2005; Diaz, et al, 2005). Heavy rainstorms, defined as the heaviest 1% of all daily rain events, have increased by 12% from 1958-2007 (Karl, et al, 2009). The 5% chance storm event is expected to be between 10 to 25% heavier by the end of the 21st century (Karl, et al., 2009). There is an estimated decrease of 0 to -5% in annual rainfall for Hawai'i due to estimated temperature increase in the North Pacific by 2080-2099 (Christensen, et al, 2007). The estimated decrease is -5 to -10% for the winter months of December, January, and February (Christensen, et al, 2007, Timm and Diaz, 2009).

There is no anticipated increase in hurricane frequency or movement, but the intensity of hurricanes that occur could be greater (Christensen, et al, 2007; Meehl, et al, 2007). Over the 21st century, average sea surface temperatures in Hawai'i may increase by 2°F to 4°F (Vecchi and Soden, 2007). Based on regional studies, the Main Hawaiian Islands are likely to experience a rise of 0.42 to 1.33m by 2100 due to thermal expansion and accelerated glacial ice melting (Fletcher, 2010; Fletcher, 2009).

The primary objective of the West Maui Watershed plan is to reduce land-based pollution impacts to nearshore coral reefs by addressing sedimentation, erosion and contamination sources throughout the watershed. Considering this objective, a literature review was conducted to assess the potential climate change threats with respect to the West Maui Watershed Plan goals and objectives (Appendix A). These threats are incorporated into the decision framework. The participants used their best professional judgment to interpret how climate change may exacerbate existing problems within the watershed. Through the workshops, the participants identified and prioritized data gaps necessary to address the problems with a clear consideration of how climate change may influence these data gaps. A summary of the findings is presented below.

Upper Watershed. The upper watershed of West Maui is managed by the WMMWP, one of the pilot study participants. Through management efforts by the WMMWP, pristine native forests and tropical montane bogs are protected. The upper watershed supports a variety of rare indigenous flora and fauna. Many of these species are listed as threatened or endangered under the Endangered Species Act (ESA). The WMMWP has been successfully working to conserve these areas and to restore adjacent habitat. Invasive species, both aggressive plant species and introduced ungulate species, such as pigs, goats and increasingly deer, pose a primary threat to the native forests and bogs. These habitats have very specific ranges and are sensitive to relatively small changes in temperature and precipitation. With the potential for significant increases in temperature, especially in higher elevations, and reduced mean annual precipitation, it is likely that the range that native species can inhabit will be reduced and the potential for increases in ranges of invasive species, especially plant species will increase. This is a concern for the overall stability of the ecosystem, as well as rare and endangered species which may become further stressed. Impacts to the stability of the forested ecosystem are also

a concern for water resources. As forest cover quality declines, the quality and quantity of water may also decline.

The hydrology in Hawai`i forests that are dominated by invasive species, such as strawberry guava, significantly changes from the native forests. The non-native forests are typically associated with increased sedimentation and erosion as the invasive trees canopy, water uptake rates, and chemistry prevent the establishment of understory vegetation. Climate change is likely to result in an increase spread in invasive species in the upper watershed and thereby an increase in sediment and erosion inputs into the lower watershed and nearshore. The increased dry periods may also render the forest more directly susceptible to fire. Once a fire moves through this area, the native forest is permanently degraded and can no longer provide the same ecosystem services (Chris Brosius, WMMWP Coordinator, *personal communication*, September 24, 2012).

Middle Watershed. The middle watershed is currently dominated by invasive grass species. Wildland fires are not part of the natural disturbance regime of Hawai`i and the island of Maui. With the increase of invasive species, wildland fires have increased. As increase in temperatures and decreases in mean annual rainfall are likely to occur with climate change, the invasive grasses are likely to increase as in the upper watershed, increasing the fuel source for wildland fires. The drier conditions are likely to result in increase climatic conditions that may trigger wildland fires or enhance the ability of the fire to spread once started.

The middle watershed was dominated by agricultural activities such as pineapple that require large amounts of water to support. Past agricultural practices altered the surface water supply, diverting surface flow from streams to irrigate lands. Agricultural activities in the watershed are in decline due to the cost of growing commercial crops in Hawai`i compared to other areas. In the watershed, when agricultural lands are abandoned, the maintenance practices of those lands to reduce sediment and erosion by properly maintaining service roads, irrigation systems, sediment basins and riparian buffers are also abandoned. The watershed is experiencing increased sediment and erosion from the abandoned lands. Agricultural lands are often replaced with urban development. Depending on the type of development, urbanized areas may increase the introduction of sediment, erosion and contaminants with an increase in impervious surface and storm-water run-off.

As climate change continues, it is likely that groundwater and surface water supplies may decrease due to a decrease in mean annual rainfall and hydrologic shifts associated with increase in invasive species. If groundwater and surface water supplies decline, the cost of maintaining agricultural activities may continue to increase and the agricultural practices decline further. As seen presently, an increase in abandoned fields and/or shift to land uses with greater amounts of impervious surface will result in an increase in sediment, erosion and contaminants into the nearshore waters. The agricultural areas (when maintained) provide a greenbelt that helps protect the upper watershed from wildland fire. An increase in abandoned fields could also result in an increase in wildland fires and associated erosion. In addition,

monotypic field provide a managed landscape which insulates the native forest from the incursion of invasive species, such as weeds.

Stream and Wetland Habitat. Similar to native forests, riparian habitat is threatened by invasive species. With the presence of native species and alterations to stream channels from land use activities, several reaches of the streams in the watershed are currently unstable resulting in increased erosion and sediment deposits to the nearshore areas. Anticipated changes in climate for Hawai'i include a decrease in mean annual precipitation that will likely reduce low flow conditions and increase opportunities for invasive species expansion. In-stream flow has already been impacted by historic and existing irrigation systems. The large storm events are likely to become more frequent and with a greater intensity. As the stream and riparian habitat changes, unstable banks and areas of exposed soils are likely to increase. With more large and intense storm events, erosion of these unstable areas is likely to increase. The shifts in the upper and middle watersheds will also contribute more sediment to the system and to the nearshore reefs.

In addition, coral reef habitats have a constrained range of tolerance for freshwater inputs. Constant, diffuse, low flows of freshwater into the nearshore are typically tolerated by coral reefs. Where streams have been altered – low flow conditions are reduced and high flow conditions increase. This change in water flow has resulted in damage to coral reefs as the freshwater input is increased to episodic events above the tolerance levels of coral reefs. Expected changes to hydrology from climate change are likely to cause similar conditions – reduced low flow and increased episodic high flows. The coral reef habitat may experience greater decline near stream mouths.

Historically, wetlands occurred throughout the watershed, primarily in areas adjacent to the streams and in the lower flatlands of the watershed. Native Hawaiians converted many of the wetlands to taro lo'i ponds and fishponds. While altered, these ponds continued to provide wetland functions for floodwater retention and sediment catchment. Today several of the high montane bogs remain but many of the wetlands in the middle and lower watershed have been drained and converted to different land uses. There is an effort within the watershed to re-establish wetlands, mainly taro lo'i ponds, for both their cultural and natural habitat functions. Changes in precipitation are likely to alter the surface hydrology and physical shift and reduce the ranges where wetlands may be able to establish. Shifts in precipitation and temperature patterns are likely to reduce groundwater availability. Associated increases in invasive species are likely to exacerbate these shifts.

Since European introduction, alterations and fill to the coastal areas of Hawai'i resulted in significant loss of coastal wetlands. Kaealia Pond National Wildlife Refuge, south of the study area, supports one of the few remaining coastal wetland areas in Maui. Sea level rise may allow for the establishment of coastal wetlands in new areas that currently do not have adequate tidal influence. Existing recently restored or potential wetland re-establishment areas will likely result in increased sedimentation to the lower watershed.

Lower Watershed. The lower watershed is dominated by coastal development. As sea level rises, it is likely that shoreline hardening will increase to protect existing development. As the shoreline is hardened, isolated processes, including littoral sediment transport, are altered. Typically this results in reduced sediment availability and increased erosion to either side of the hardened shoreline. Engineered solutions to adapt to sea level rise could potentially increase impervious surfaces and storm-water discharge to nearshore areas. Many of the current utilities, including wastewater, occur in the coastal fringe. Presently, the coral reefs in the watershed are stressed from the introduction of contaminants from wastewater discharge, landscaping and agricultural activities that are introduced into the groundwater and enter the nearshore at natural freshwater submerged discharge areas. As sea level rises and the salt water influence in the groundwater moves landward, there is a potential for more of these sources to intercept submerged groundwater discharge routes.

Nearshore Habitat. Research has shown that healthy well-established coral reefs have a greater resiliency to withstand physical changes to the environment. Coral reefs in the study area are already impaired by the variety of threats, including land-based pollution. Because of its cooler and deep waters, Hawai'i is only recently beginning to experience coral bleaching associated with increased sea temperatures. Predicted changes in sea temperatures are likely to have an increase in coral bleaching. Increasing ocean acidification associated with climate change will also impair the corals growth and health. As the corals continue to decline from increased land-based pollution from the watershed exacerbated by climate change, their ability to recover will significantly decrease. Coral reefs are also impacted by the re-suspension of fine sediments by certain wave patterns and energies. Modeling of sea level rise on the island of Molokai predicts that with changes in sea level, wave energies will change and there is a high potential for increased re-suspension of nearshore sediments, exacerbating the coral decline.

In summary, climate change is likely to increase sources of land-based pollution beyond existing conditions throughout the watershed if no action is taken to reduce these threats.

Land-based pollution is one of the key threats are impacting coral reefs in Hawai'i along with fishing pressure, overuse from recreational activities, spread of coral disease and aquatic invasive species (Hawai'i DAR, 2010). Understanding the potential climate related shifts and their influences may provide important information in identifying, prioritizing and implementing actions to reduce land-based pollutions and aid the recovery of coral reefs in the study area.

Developing a Risk Informed Decision Context and Framework.

To better incorporate climate change into the decision process for West Maui, the pilot study conducted three workshops with the participants to develop a risk-informed decision context and framework to guide the planning process from the beginning.

Workshop #1 – Brainstorming Risk.

In February 2012, the PDT brought together all the participants to introduce the pilot study, the RIDM theory and concepts and start brainstorming how to address climate change risk within the watershed. The objectives of the workshop were to receive comments and recommendations on the draft climate change risk assessment discussed above and gain a common definition of risk and uncertainty among the participants. The detailed meeting minutes are included in Appendix C.

The key outcomes of the first workshop were:

- The participants agreed to revise the goal and objectives to more closely align with the focus of land-based pollution reduction and to incorporate climate change.
- The participants needed to gain a clear understanding of the decision context prior to engaging the broader stakeholder group, including how the various activities, member agencies, and subgroups interrelated.
- The PDT proposed the use of a “risk register” to identify all the potential threats to the watershed plan goals and objectives, including climate change and rate the risk and uncertainty of each threat as “high, medium and low”, identifying potential consequences if the risks are not addressed. The PDT’s intent was for the “risk register” tool to be used to help decision makers understanding the potential outcomes of some decisions and guide prioritization processes in a more informed manner. However, the participants were reluctant to do any additional analysis beyond the ranking of threats until further information was available. In general, the participants saw the concept of transparently documenting and ranking risks as beneficial. The USACE risk register tool though was too complex and time consuming.
- The participants agreed that the PDT should review the threat analysis conducted under TNC’s Conservation Action Plan for the Kahekili nearshore and fisheries area to see (1) how to build off these previously identified threats and (2) review the TNC methodology to see how it may be adjusted to meet the proposed Corps approach. Many of the participants were engaged in the TNC planning process and are familiar with those definitions and approaches.
- The participants agreed that to better understand risk, including climate change, the next workshop should include a site visit on Maui and should include the local experts for each region.

Workshop #2 – Decision Framework.

In April 2012, the second workshop was held with one day on Maui and one day on O`ahu. As an outcome of the first workshop, the interagency team identified a need to see the threats to the watershed firsthand and hear from local subject matter experts what may be the issues exacerbated by climate change. A two-day workshop was proposed with an overall workshop objective to provide a decision tool that will help the West Maui FAST:

- Provide a road map to guide decisions needed for implementation;
- Prioritize actions when funds are limited:

- Understand decision processes of each partner;
- Identify potential conflicts, duplications, or superfluous decision points/questions for early for resolution; and,
- Develop a shared lexicon of terminology to make communication clearer.

The key outcomes of the second workshop included:

- The participants held a clear understanding of the land-based pollution threats from each region of the watershed and how climate change could potentially exacerbate these issues.
- Using a climate change lens, the participants identified key overarching risks and threats facing the watershed in the next 100 years. Many of these problems seem currently out-of-reach, but identifying them now allows for the dialogue to begin to find innovative solutions.
- The participants developed a decision framework for the R2R initiative including:
 - A timeline of activities that are occurring or will need to occur in the next year;
 - A focused vision for designing a watershed plan to develop engagement by stakeholders with end goal having it stakeholder driven;
 - The R2R initiative is action-oriented. As actions are identified, they will be implemented as the larger strategy is being developed. Implementing activities or data gaps will be prioritized by (a) completeness – no further information is needed; (b) efficiency – it allows for future actions to be implemented; and (c) synergy – it informs the broader goals and objectives of the R2R initiative.
 - The R2R initiative is incorporating adaptive management throughout the process. Typically adaptive management occurs after the plan is complete and during implementation. Because the R2R initiative will be implementing actions while during the development of the DLNR/USACE watershed plan, a process will be incorporated within the decision framework where lessons learned on the implementation process, techniques, and effectiveness will regularly inform the plan development.
 - Decision relevance is critical to choosing which data gaps to address – Is there value added to gathering the additional data? What is the level of information that is “acceptable” or “adequate” to move forward?

Workshop #3 – Prioritizing Actions.

The final workshop was held in June 2012. As an outcome of the second workshop, there was a need to prioritize actions to allow the watershed initiative to move forward quickly after the West Maui Watershed Section 729 Assessment Agreement was signed between USACE and DLNR in August 2012. The objective of the workshop was to provide a decision tool that would help the West Maui R2R FAST:

- Prioritize key decisions and data gaps needed for implementation;
- Prioritize actions when funds are limited;
- Identify lead organizations for priority actions; and,
- Agree to a shared lexicon of terminology to make communication clearer.

This workshop was able to apply the decision framework developed in the second workshop.

The key outcomes of the third and final workshop included:

- The participants agreed to final revised goal and objectives that incorporated climate change.
- New terminology that better communicates the decision framework and process was accepted and adopted.
- Several tools were developed and adopted through all three workshops that help communication the decision context including the timeline/chronology chart, the flow chart of the West Maui R2R Initiative Process, and the West Maui R2R Initiative Matrix, and an organization chart.
- A strategy for facilitating regular communication between the West Maui R2R FAST members and the State was developed and adopted to help guide the decision-making process.
- A set of key research and planning focused topics (data gaps) were identified that will become the basis of the West Maui R2R comprehensive strategy were vetted and discussed by the group.

Participatory Survey

The initial survey showed that many of the participants were either somewhat or fairly familiar with the climate change threats within the study area. For the majority of the agencies and organizations represented, risk and uncertainty is not well incorporated into their planning process, with even fewer tools to address climate change. Most of the organizations planning processes provide avenues for collaborative interagency decision frameworks. All organizations, except for one, were not very familiar with the USACE planning process but did see the USACE planning process as incorporating risk and uncertainty, including climate change, more than their organizations.

Based on the pre-study survey results, the workshops were designed to (1) help the participants better understand the USACE planning process as it relates to West Maui, (2) investigate the methods within the West Maui R2R FAST and Hui members for interagency collaboration to apply to the West Maui R2R Initiative and (3) begin to create a risk-informed framework for the West Maui R2R Initiative.

A key finding within the Decision Framework workshop was that most of the organizations are able to incorporate interagency collaboration because their planning efforts end with the formulation of alternative strategies and the identification of potential partners to help with the strategies. Within the USACE planning process for watershed assessment, the final plan evaluates and compares these strategies with a specific lead and complete action to be implemented. These final stages often occur within the implementation processes of the partner organizations rather than within the planning stages.

Seven of the 13 participants completed the post-study survey. With limited numbers it was difficult to assess any major trends in the ranking questions. There was a slight improvement in the understanding of climate change threats in West Maui and the understating of the USACE planning process. In the post-survey results, there were no “don’t know” responses or “not at all” responses to any of the ranked questions.

The open-ended questions in the closed survey focused on what the participants found useful in the pilot study. The participants found the site visits and raising awareness of climate change impacts within the West Maui R2R FAST and partner agencies useful as well as developing the shared lexicon and shared overall vision. The participants saw the pilot study and USACE planning very process heavy with confusion on the key objectives of the pilot study. When asked about their opinion of RIDM concepts, they found these concepts useful but were not sure if it would be useful within their programs. As mentioned before, based on the first workshop, the PDT decided not to focus on the risk register and utilize other tools to discuss risk. With the limited exposure to the risk register, the participants had mixed feedback on its benefits. When asked if they would recommend RIDM processes within their organizations, many said that they would need more information or exposure to see if it adds significant value and/or information.

5. LESSONS LEARNED

Physical System/Climate Findings

Of the physical changes in hydrology and sea level rise, the greatest concern for the West Maui areas is the potential impact of changing precipitation in the watershed. *A primary root of the problems within the watershed is fragmented water systems with increasing demands on water for all uses.* Maui has been experiencing drought conditions since 2006. Drought conditions are likely to increase in frequency with climate change. While smaller storm events are expected to decrease in frequency, the large storm events are expected to increase in both frequency and intensity.

In addition, there is a significant amount of uncertainty around how species and ecosystems will respond to climate change shifts in Hawai`i. The complexity of the system with the various microclimates makes downscaling of global climate models difficult. The rare and unique species in Hawai`i and the West Maui watershed are relatively specialized. Their ability to respond to sudden shifts is uncertain. However, these same microclimates may create opportunities for safe-havens if restored and strengthened today. In American Samoa, coral reefs in some areas are experiencing bleaching on an annual basis due to warming sea temperatures. However, these reefs are relatively pristine. Initial studies are showing that these coral reefs are currently able to recover from the bleaching events. If the reefs and watersheds in West Maui are able to recover to more pristine conditions, they may show similar resiliency for future climatic shifts.

Methods for Collaborative Planning

The main lesson learned to date is that developing an effective RIDM framework to support an IWRM strategy is complex. It is critical for the key agencies in the decision making process to understand how to work together and be strategic in conducting work to ensure that activities support each other and the larger vision rather than duplicate or conflict with each other. Specific lessons learned to date include:

- Stakeholder Involvement. Originally the pilot study planned to include key stakeholders in the study process. The State realized that with variety of stakeholders and potential conflicting uses, they needed to take the time to conduct some investigations to ensure the stakeholder involvement process is set up well, engages all appropriate stakeholders, and can clearly articulate the planning process to the stakeholders with clear expectations of how stakeholder information and involvement will be incorporated into the decision process. Accordingly, the stakeholder participation was reduced to only a few active partner organizations that were very familiar with the watershed planning vision.
- Decision Process. While all the partner agencies and organizations held the same vision for the outcome of the watershed plan, there wasn't a clear understanding of the process to reach that vision. This type of collaborative planning is relatively new to Hawai'i. In order to promote local and community engagement and stewardship, all actions under an IWRM need a shared identity for the public that through a common logo, vision, process, and timeline. As such, the PDT determined it was important to make sure the key partners, primarily the West Maui R2R FAST, have a common understanding of the decision process. At the end of the pilot study, all participants were able to articulate a common process to stakeholders with a shared identity.
- Defining Risk. Through the first workshop, the team found that the participants all had slightly different definitions of risk and uncertainty based on their organization's planning processes and knowledge base. RIDM concept and the USACE process are complex and not easily understood, especially among natural resource managers. A shared understanding of decision frameworks and definitions facilitates increased integration of organizations and actions. Additional time was added to reach this goal. Threats were easier to understand than general risk. Discussing "decision relevance" of different analysis and data gaps provided a better method of RIDM. Additional work needs to be done as the watershed planning officially begins in Fiscal Year 13 to work with the key questions in the West Maui Watershed Plan risk register.
- Complexity of Threat Analysis. Originally the PDT anticipated that a "brainstorming activity" could be done within a workshop setting to identify the array of threats within the watershed as seen by the participants. Because the watershed is a complex system with a wide array of sources contributing to the problem of land-based pollution, this assumption was overly ambitious. Over the last year through funding from NOAA, TNC

had conducted a CAP with key stakeholders to identify threats to the Kahekili Fisheries Management Area only. As part of this process, the CAP participants identified an initial threat assessment that identified key issues to fisheries including land-based pollution. This information was incorporated into the pilot study, saving the PDT significant time and effort for this pilot study.

- Time-frame for Problem Solving. Because of constraints with funding, programs, and the complexity of existing issues for a watershed approach to ecosystem restoration, often the time-frame for solutions are focused on the near-term. By considering climate change and risk early in the process, interagency teams more easily see the key long-range issues, common threats across the watershed – e.g. fragmented water system, and identify innovative solutions to these issues.
- Variations in Planning Outcomes. Many non-federal and federal agency planning processes end at formulation of alternative strategies and have minimal specific requirements to consider long-term feasibility, sustainability, and operations and maintenance, and climate change adaptability. USACE process provides this additional analysis and technical assistance.
- Multiple tools and methods: There are a variety of tools and methods across agencies and organizations that address risk and uncertainty, including climate change, at some level and are tested to various degrees. For each collaborative watershed study, there is a unique set of issues and capacity within the interagency team. In many cases, there may be tools outside of what USACE or the participants are familiar with to better suit the needs of the study. The USACE SVP provides a collaborative process for selecting and adjusting the technical analysis tools to fit the unique needs of each IWRM.

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ACRONYMS

AIS	Alien Invasive Species	NOAA	National Oceanic and Atmospheric Administration
CAP	Conservation Action Plan		
CWRM	State of Hawai`i, DLNR Commission on Water Resource Management	NOC	National Ocean Council
		NPP	Net Primary Productivity
CZM	Coastal Zone Management	NRCS	U.S. Department of Agriculture, Natural Resources Conservation Service
DAR	State of Hawai`i, DLNR, Division of Aquatic Resources	Pacific RISA	Pacific Regional Integrated Sciences and Assessment Program
DLNR	State of Hawai`i, Department of Land and Natural Resources		
DOFAW	State of Hawai`i, DLNR, Division of Fish and Wildlife	PACIS	Pacific Climate Information Systems
DOH CWB	State of Hawai`i, Department of Health, Clean Water Branch	PICCC	Pacific Islands Climate Change Cooperative
EPA	U.S. Environmental Protection Agency	PIP	Public Involvement Plan
ESA	Endangered Species Act	PDT	Project Delivery Team
FAST	West Maui R2R Federal Agency Support Team	R2R	West Maui Ridge to Reef Initiative
FWS	U.S. Fish and Wildlife Service	RCC	IWR Responses to Climate Change Program
ICAP	University of Hawai`i, Center for Island Climate Adaptation Policy	RIDM	Risk Informed Decision Making
IPCC	Intergovernmental Panel on Climate Change	SVP	Shared Vision Planning
IWR	USACE Institute of Water Resources	TNC	The Nature Conservancy
		USACE	U.S. Army Corps of Engineers
IWRM	Integrated Water Resource Management	USCRTF	U.S. Coral Reef Task Force
LCC	Landscape Conservation Cooperative	WMMWP	West Maui Mountains Watershed Partnership
NFWF	National Fish and Wildlife Foundation	WRDA	Water Resources Development Act