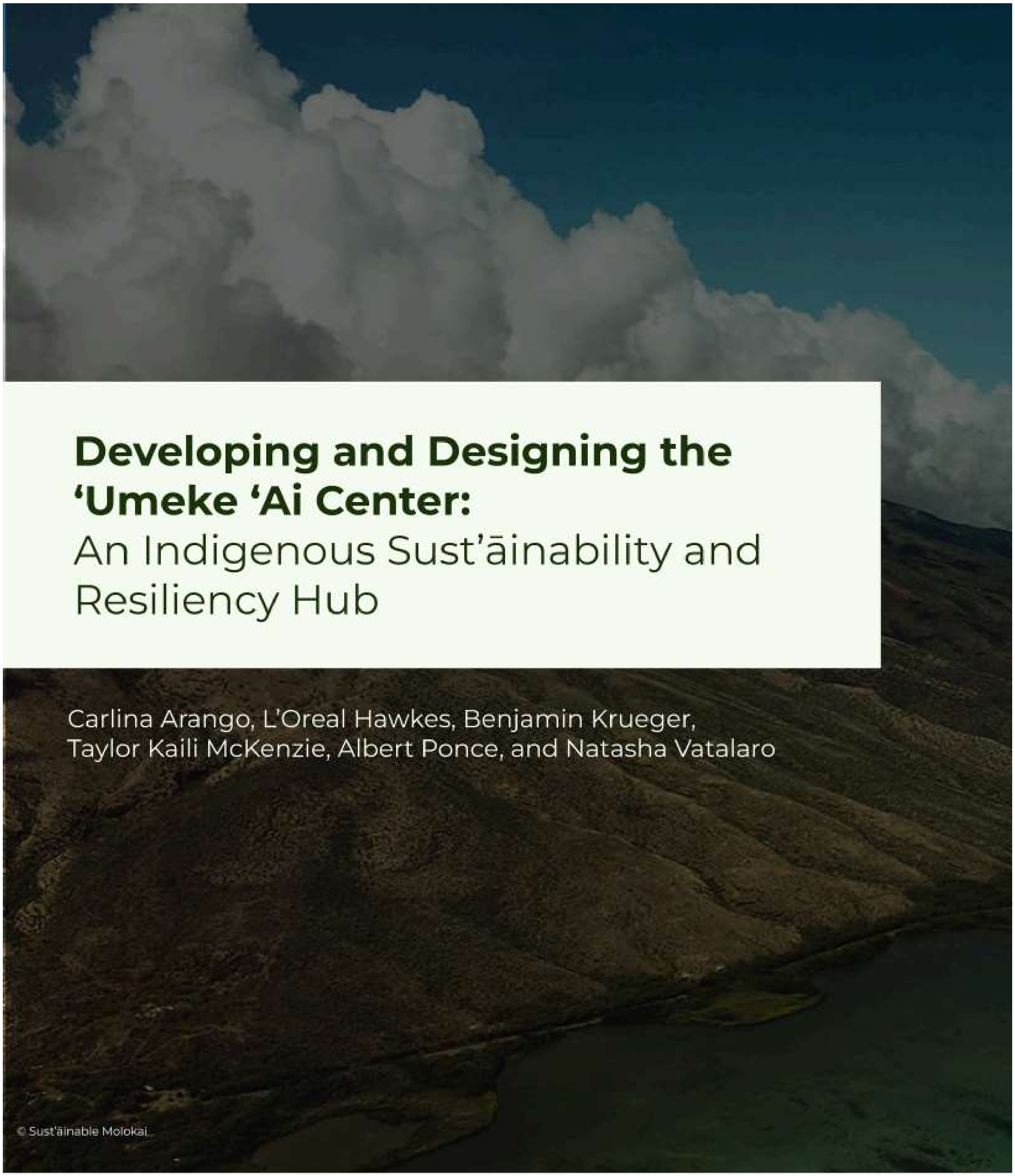


Developing and Designing the ‘Umeke ‘Ai Center:

An Indigenous Sust’āinability and Resiliency Hub

Carlina Arango, L’Oreal Hawkes, Benjamin Krueger,
Taylor Kaili McKenzie, Albert Ponce, and Natasha Vatalaro

SEAS SCHOOL FOR ENVIRONMENT AND SUSTAINABILITY
UNIVERSITY OF MICHIGAN

SUST’ĀINABLE MOLOKAI

Acknowledgements

We would like to express our deepest appreciation for the people of Molokai, Hawaiʻi for welcoming us onto their land and trusting us to participate in the momentous effort in building a more sustainable and resilient island. While we were visiting the island, we witnessed the emergency community action in response to the tragic Lāhainā fires, which has only reinforced the need for climate resiliency measures. We are forever grateful for your hospitality even in your own time of need.

We would also like to thank Sustʻāinable Molokai, and particularly our project leads, Katy Mokuau and Tanya Davis-Medija. We appreciate your time, guidance, and hospitality over the past two years. Mahalo nui loa e nā alakaʻi!

Special thanks is also extended to Uncle Hano and Kumu Tanya Mailelani Naehu at ʻŌhalahala Fishpond for leading us in fishpond restoration workdays in May and August 2023. A big mahalo to the team at ʻĀina Momona for guiding us in a gorilla ogo cleanup, fishpond restoration and mauna stewardship. Another thank you to the Molokai Hunting Club for inviting us to help restore your kalo field, and Puna and the Kalipi family farm for welcoming us to your homestead to work together in your kalo field. Mahalo nui loa Todd Yamashita from Hoʻāhu Energy Cooperative for talking to us about the energy crisis on the island and showing us the Co-op's efforts to mitigate energy insecurity. We are extremely excited to be a part of your growing partnership with the University of Michigan (UM).

Thanks to the UM's School for Environment and Sustainability (SEAS) and the Tishman Center for Social Justice and the Environment for providing a space that nurtures Indigenous relationships; our advisor, Dr. Kyle Whyte, and P.h.D Candidate Malu Castro for embarking on this important research that allows for interdisciplinary collaboration.

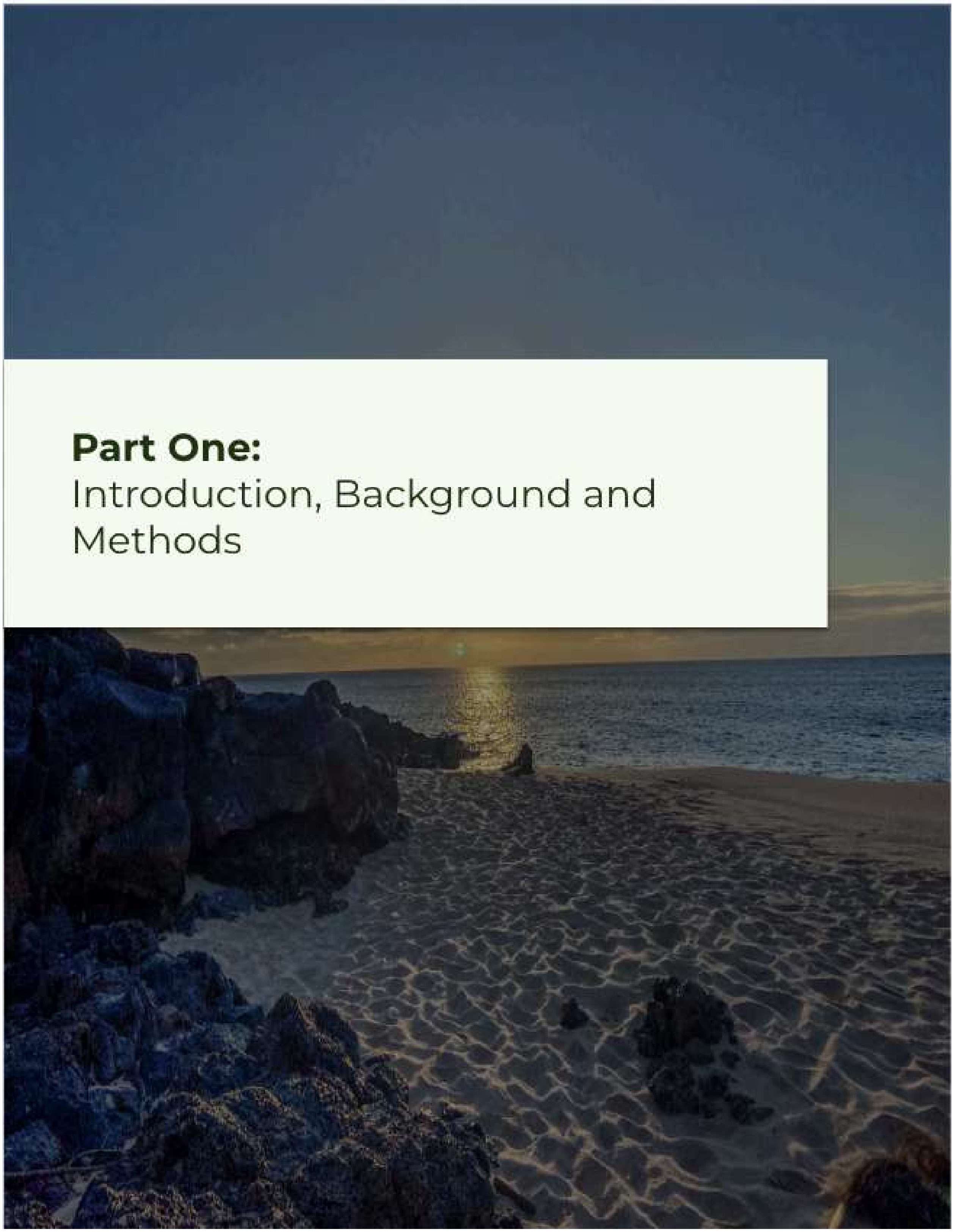
Acknowledgements also go to the following entities for their generous funding: UM's National Center for Institutional Diversity's Anti-Racism Collaborative, Rackham Graduate School, and the Association for the Study of Food and Society.

Executive Summary

Hawaiʻi, due to its position as an actively colonized island state in an era of worsening climate change, is faced with myriad challenges. Climate adaptation and resilience are critical to combat these issues and increase equity for Native Hawaiians. Molokai, in particular, is an exemplar of Hawaiian frontline communities. Many community members struggle with food and energy insecurity, and the island lacks adequate resources to prepare for the climate crisis and emergencies like wildfires and hurricanes. Sustʻāinable Molokai (SM), a local and Indigenous-run nonprofit organization, is seeking to change this through the development of the ‘Umeke ‘Ai (*food bowl*) Center, a resilience and food hub that will serve the whole of Molokai. The ‘Umeke ‘Ai Center will be multifunctional: disaster shelter, food bank, sustainable building model and supplier, an off-grid renewable energy system, a community and ‘ohana gathering space, a sustainable farm, and a business incubator. The overarching objective of this project is to establish precedent studies, site assessments, feasibility studies, and a conceptual green building design to inform the construction of this multifaceted hub.

We performed simultaneous research methods toward these objectives, including but not limited to: site visits on Molokai, literature reviews focused on Indigenous resilience and food frameworks, NREL energy modeling and greywater model comparisons, GIS mapping of proposed sites, and general data collection on best practices and precedents. We used pre-existing Maui County data and information collected by SM to support our analysis. Our final deliverables consist of a 45-page precedent study report; an ESRI GIS Web App and accompanying site assessment spreadsheet; energy, cost, and integrated water conservation analysis spreadsheets; a for-profit research spreadsheet; and an educational Gala case study. These deliverables are summarized in this report. Our deliverables provide a data-driven research foundation for future work on the ‘Umeke ‘Ai project, and we endeavor to follow the lead of activists and community members already pursuing these objectives in Hawai’i. Our results show that the ‘Umeke ‘Ai Center can address Molokai’s infrastructure needs while promoting access to locally grown food, clean energy, and water, all rooted in Native Hawaiian environmental stewardship frameworks.

Table of Contents



Part One: Introduction, Background and Methods

Chapter I. Introduction

Background

ʻĀina Momona is a phrase in *ʻŌlelo Hawaiʻi* (Native Hawaiian language) meaning “bountiful land.” This phrase is often used by residents on Molokai to depict their goals for the natural environment and its return to historical Native Hawaiian ecological practices. The island of Molokai has gone through many stages of occupation and ownership, from being a relatively independent agricultural center, to part of the unified Hawaiian Kingdom and most recently as a small component of the state of Hawai’i under the United States. Today, a third of the island is owned by Molokai Ranch, a group based out of Hong Kong. Many people on-island also work under Bayer (formerly Monsanto).

The Indigenous people of Molokai have a long agricultural and fishing history. This can be seen today in the still-standing fishponds maintained over hundreds of years, as well as homesteading efforts. Some areas are still farmed for traditional crops like kalo, and organizations like Sustʻāinable Molokai and ʻĀina Momona, among others, are promoting the continuation of traditional farming. Today there are approximately 7,500 people on the island, many of whom are described by Sustʻāinable Molokai as “racially or socially disadvantaged” (State of Hawaiʻi Department of Business, Economic Development & Tourism Research and Economic Analysis Division, 2011). The island’s community has retained its identity with respect to Indigenous Hawaiian histories, spirituality, and culture. At present, a significant portion of the food that the community eats arrives monthly on a ferry. Local food systems are not integrated enough to create resilience to climate change and global food supply volatility. An Indigenous land sovereignty movement has been steadily growing on the island of Molokai, but faces many barriers. The main issues facing the island are a lack of capital and comprehensive planning to seize the current momentum and turn it into a permanent pathway for survival in the island chain. One essential aspect of a path toward addressing these challenges is the planning and designing of a resiliency hub to coordinate local farmers and resources to support the nutritional needs of Native Hawaiians on the island.

Sustʻāinable Molokai is a 501(c)(3) non-profit community development organization committed to restoring `āina momona (abundant land) by uniting traditional practices with responsible and modern sustainability solutions. Sust’āinable Molokai has been fighting to restore the land back to the Indigenous peoples of Hawai’i since 2017 and has become a rallying organization for other issues threatening Indigenous sovereignty on the island. Due to grassroots efforts the program has been steadily growing and the organization would like to expand its efforts through the creation of a centralized Resiliency Center and Food Bank, which would serve the entire island of Molokai. This project would allow students to support the planning and creation of this facility, which will be an important gathering place for cultural, community and ʻohana gathering and learning.

Demographics

Molokai is the fifth largest island in the Hawaiian archipelago and has a unique history involving acts of resistance and cultural revitalization. At 38 miles in length and 10 miles at its width, the island of Molokai is split into two subdivisions under the Census County Divisions (CCD) of Maui county, labeled “West Molokai CCD” and “East Molokai CCD.” Molokai is one of the least developed of the Hawaiian islands and boasts a strong Indigenous population who strongly resists outside development that threatens to destroy or harm their ecosystem and way of life.

East Molokai

According to the 2022 United States Census, East Molokai CCD has a population of 4,441. Of this population, 35.2 percent identify themselves as “Native Hawaiian” and “Other Pacific Islander” (United States Census Bureau, 2022). There are a total of 1,529 households on East Molokai with 20.5 percent report being below poverty level and 27.9 percent receiving Supplemental Nutrition Assistance Program (SNAP) from the government (United States Census Bureau, 2022). See Table 1 for more details about the demographics of East Molokai.

TABLE 1. East Molokai 2022 Census Data.

Total Population for East Molokai	4441
% Native Population	35.2%
# of Households	1529
# of Households off-grid	500+ (East and West Combined)
Average Family Size	3.87
% Below Poverty Level	20.5
% Percent of Households Receiving SNAP	27.9

Source: United States Census Bureau, 2022.

West Molokai

The 2022 United States Census, reports West Molokai CCD as having a population of 2,846 people, of which 48.9 percent report identifying as “Native Hawaiian” and “Other Pacific Islander” (West Molokai CCD). There are a total of 844 households on West Molokai with 16.2 percent being below poverty level and 28.4 percent receiving SNAP (Supplemental Nutrition Assistance Program) from the government.

TABLE 2. West Molokai 2022 Census Data.

Total Population for West Molokai	2843
% Native Population	48.9
# of Households	844
# of Households off-grid	500+ (East and West Combined)
Average Family Size	3.5
% Below Poverty Level	16.2
% Percent of Households Receiving SNAP	28.4

Source: United States Census Bureau, 2022.

Race, Ethnicity and Housing

On the island as a whole, 60 percent of the population identify as being Native Hawaiian and Other Pacific Islander, while 42 percent identify as “Caucasian/Part Caucasian” (Molokai Community Health Center, 2024). According to the United States Census Bureau in 2022 only 2.1 percent of West Molokai and 0.7 percent of East Molokai utilized house heating fuel from utility gas while nearly 77.6 percent and 72.9 percent reported using no fuel at all respectively (United States Census Bureau, 2022). The housing vacancy rate was the highest among the islands at 30.5 percent in 2010, which was an increase of 6.5 percentage points from 2000 to 24.0 percent (State of Hawaiʻi Department of Business, Economic Development & Tourism Research and Economic Analysis Division, 2011).

Employment

The combination of Pacific climate and fertile soil on Molokai creates the optimal conditions for the growth of commercial crops. Historically, several agricultural industries settled on the island, particularly in the pineapple industry. “In 1923, Libby, McNeil & Libby began to grow pineapples on land leased from Molokai Ranch,” with 16,800 acres being planted by 1968 (Molokai Community Health Center, 2024). Another company, Dole, also started growing pineapples on the island in 1927. The economy of the island expanded at a tremendous pace with other industries becoming profitable to support the plantations, like processing and shipping, while local development through stores, markets, restaurants, and even a movie theater created towns where the locals' entire economic lifestyle was enmeshed with the survival of the plantations. “The plantation supplied housing, electricity, water, the paycheck—basically, a man's whole life was wrapped up in the plantation” (Seiler, 1979). The California Packing Corporation, now known as Del Monte Corporation, acquired the pineapple plantations in 1970, but deemed the operation unprofitable and closed the plantations by 1989. The California Packing Corporation blamed the cost of labor and following reports stated that, “labor represented half of Hawai’i’s cost of production and that Hawai’i’s hourly labor costs ranged from $2.64 to $3.69, whereas the labor cost for growers in the Philippines and Taiwan ranged from $0.08 to $0.24 per hour” (Bartholomew, 2012). The phasing out of the pineapple plantations proved to be an economic disaster for the community due to the fact that all of the towns were built around the pineapple economy. To this day, the area sits desolate and exists in a museum-like state showing what used to be.

Today, Molokai has the highest unemployment rate of the entire state of Hawaiʻi at 13.9 percent as of June of 2022 (Maui Food Bank). Due to this high level of financial insecurity, as much as 90 percent of residents experience food insecurity. This means after essential living expenses like rent and utilities are paid there is little to no money left for food (Maui Food Bank, n.d.).

Food Insecurity

Nearly 40 percent of the population on Molokai rely on subsistence farming, hunting, and fishing to feed their families and access to imported food is limited due to the high cost of shipping (Molokai Community Health Center, 2024). The USDA Economic Research Service also considers about 90 percent of the island as “Low Income and Low Access.” This means that many residents require some level of food assistance. The Maui Food Bank strives to meet this need, increasing their food deliveries in 2023 to include donations of over 20,000 pounds of food every month (Maui Food Bank). Despite this high level of assistance, there is still a tremendous amount of food insecurity that is currently being addressed without a permanent food bank on the island of Molokai. The formation of a well researched and planned resiliency hub would greatly support the current food assistance initiatives while also encouraging innovation to meet the needs of struggling residents.

Energy Landscape: Molokai’s Sustainable Shift

Molokai's current energy infrastructure heavily relies on diesel generators at Hawaiian Electric's Pala'au power plant, accounting for about 85% of the island's energy consumption. The other 15% comes from individual rooftop solar panels. Given this system’s environmental, economic, and resiliency challenges, as well as the State of Hawai’i’s goal of 100% renewable energy by 2045, the community is prompted to seek alternatives (Pactol, 2022).

Over decades, Molokai residents have advocated for their energy needs, often in opposition to proposed projects that did not align with community values (Pactol, 2023). Residents’ passion was demonstrated during our team’s conversations with Sust’āinable Molokai’s Energy Coordinator, Leilani Chow. The island’s history of activism laid the groundwork for the formation of SM’s Molokai Clean Energy Hui, inspired by a proactive approach to addressing energy issues rather than merely opposing external proposals.

The Molokai Clean Energy Hui spearheaded the creation of the Molokai Community Energy Resilience Action Plan (CERAP) through an extensive community-driven process. This involved many conversations, surveys, focus groups, and workshops to gather input and educate residents on renewable energy options. Collaborations with experts and organizations, such as the University of Hawai’i's Hawaiʻi Natural Energy Institute and Molokai’s Hoʻāhu Energy Cooperative, have also ensured technical accuracy and feasibility in the development of the comprehensive island-wide plan (Pactol, 2023).

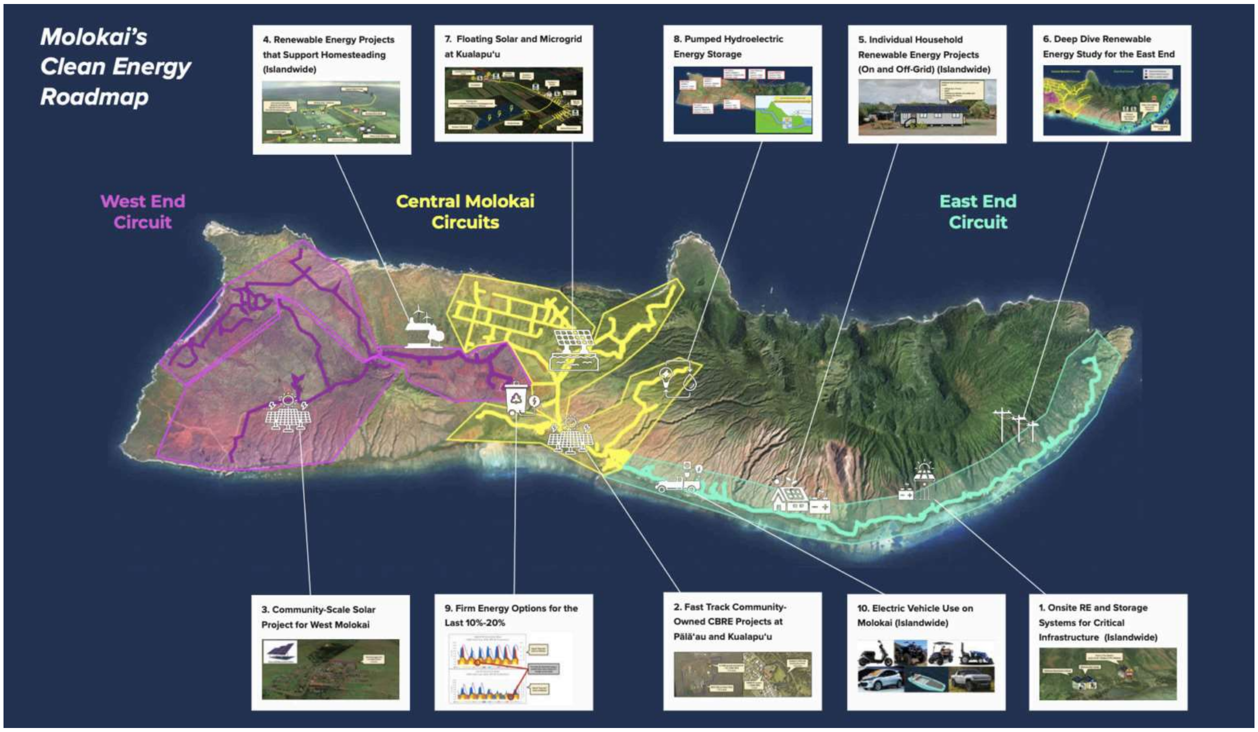


Figure 1. *Molokai Clean Energy Hui’s Clean Energy Roadmap*. Screenshot from Sustʻāinable Molokai. 2023.

CERAP outlines a portfolio of projects aimed at increasing energy resilience and emergency preparedness while transitioning Molokai to 100 percent renewable energy, and it also provides a framework for a fair and reliable renewable energy access for all. Some of the projects highlighted in the first version of the CERAP report include decentralized energy generation, critical infrastructure strengthening, and exploration of various renewable energy sources such as solar and hydroelectric. But what sets CERAP apart from most other top-down energy planning is its community-led process. The plan’s mission is “to be a model for how energy planning can be done in communities that value local decision-making,” making the energy system more equitable and just in addition to being resilient (Molokai Clean Energy Hui, 2023).

Currently, all 10 proposed projects under CERAP have received support from state and federal entities. The initiative has garnered attention as a model for community-led energy planning, with ongoing dialogue between the Molokai Clean Energy Hui, regulatory bodies, and utility providers. Moving forward, the focus will be on implementation, with federal grants supporting further exploration and execution of the proposed projects.

Legacy of Food Sovereignty in Molokai

On the island of Molokai, many residents are homesteaders and/or farmers who cultivate traditional crops like kalo in some areas. Organizations such as Sust’āinable Molokai and ‘Āina Momona are actively promoting the continuation and strengthening of these traditional farming practices. This work contributes to their overarching goal to strengthen the island’s Indigenous identity, with a particular focus on increasing awareness of Native Hawaiian histories, spirituality, and culture, all of which are closely tied to the current and historical food systems. However, despite these efforts, there is much work to be done to regain sovereignty and revive practices for food production. At present, a significant portion of the food that the community eats arrives on a ferry roughly once a month, highlighting the island’s heavy reliance on imported goods (Terrell, 2021). This dependency on external food sources leaves local food systems vulnerable to climate change and global food supply volatility, emphasizing the need for greater integration and resilience.

Historically, Native Hawaiians had their own systems for food generation that relied upon traditional knowledge for harvesting, planting, and consumption of locally harvested foods. These systems allowed for holistic wellness and disease prevention through balanced, nutritious diets, active lifestyle, and a strong emphasis on social wellbeing. However, Western settler colonialism has drastically changed the health and well-being of Native Hawaiians through land theft, oppression, and cultural disruption (Look et al., 2020). Consequently, this historical trauma and oppression has resulted in Native Hawaiians experiencing a drastically higher rate of chronic diseases than many other ethnic groups and the general population in Hawai’i and the larger US, which is linked to unhealthy diets and food insecurity. Moreover, these public health disparities compound with Hawaiʻi's high food imports, geographical isolation, and climate change risks creating a vulnerable food system, especially for low-income Native Hawaiians (Look et al., 2020).

In Molokai, there is a particularly strong need for addressing food insecurity. To address these disproportionate food insecurity issues among Native Hawaiians, a significant paradigm shift is occurring, especially in Molokai. Specifically, there is a transition from food self-sufficiency to food sovereignty, which is focused on reclaiming control over local cultural food systems. This shift is seen as an essential step toward ensuring the long-lasting health of Native Hawaiian people and communities.

It is estimated that 80-90% of the food in Molokai’s grocery stores is imported via barge, and families bear the transportation costs in high food prices (Terrell, 2021). Additionally, in Molokai, Native Hawaiian, and Pacific Island populations, constituting 72% of the island’s population, have a disproportionately high rate of obesity, diabetes, and other chronic diseases attributed to unhealthy dietary choices, particularly insufficient consumption of fresh fruits and vegetables (Hawaiʻi Good Food Alliance, 2021). These food security issues show the need for increased availability of and access to healthier food for Molokai’s low-income and disease-prone populations, as well as the need for enhanced financial viability and more jobs for Molokai island farmers and food producers.

The paradigm shift from food self-sufficiency to food sovereignty has sparked solutions around returning to ancestral foodways as a form of food security and sustainability. This shift has led to a growing momentum to revive traditional Hawaiian governance systems, which are rooted in concepts such as *kapu* (people, places, and things held under strict regulation) and *noa* (people, places, and things free of restriction). These traditional governance notions play a crucial role in determining how natural resources are accessed, utilized, and managed, as well as shaping societal behavior and relationships. As a result, this governance system enables Native Hawaiians to access a well-balanced and nutritious diet, contributing to Indigenous peoples' overall health and well-being. Alongside promoting an active lifestyle for holistic wellness and disease prevention and fostering a well-ordered society, these traditional principles are integral to Indigenous people’s way of life (Look et al., 2020). With this critical paradigm shift underway, there arises a pressing need to support the facilitation and to implement traditional Hawaiian knowledge and principles in the development of agricultural systems that align with modern contexts.

Molokai also faces unique challenges in distributing food because it is one of the few Hawaiian Islands that does not already have a dedicated food hub and food bank facilities. Instead, Sust’āinable Molokai must operate their activities from several small facilities located in multiple areas, with only limited access to the resources they need, such as refrigerators. Consequently, the creation of a centralized Food Hub and Food Bank on the island of Molokai would generate significant social benefits by supporting local food production and ensuring that fresh produce and protein are distributed to community members who need it. In essence, this project will not only increase food security but also further efforts towards food sovereignty in Hawai’i.

Green Design: The Food Bowl, Energy, and Greywater

The vision for ʻUmeke ʻAi is to build a center that is able to support the island’s transition from its current, fragile, infrastructure to one that can withstand a changing climate. This requires a clear vision for how sustainable food, energy, and water access can be facilitated in every aspect of the center’s design.

There is a strategic push for creating a *resilience* hub on Molokai— not just a *food* hub, but rather a space that centers the many intersecting factors that influence community well-being. SM has identified energy access, clean water, agriculture knowledge, and land access as being central to a stronger Hawai’i. Resilience hubs are centered on equity-based strategies that prioritize the lived experiences of the most vulnerable populations within the community they are working with (Baja, 2018). These spaces are used to promote community trust, act as emergency centers during environmental crises, and to provide access to shared resources such as community gardens and internet connection. It is important to note that resilience hubs are not *only* emergency shelters—they are meant to build resilience so that in the case of disasters they are one of many resources available to a community. To amplify community cohesion, resilience hubs are used year-round and not only in sporadic moments of disaster and recovery. The following section analyzes how these components can work together to advance the economic, nutrition, and social security of Molokai residents.

The Food Bowl

The modern food system of Hawai’i is not one that happened by accident, but was instead altered to favor financial return rather than local resilience. The University of Hawai’i at Hilo found that, in the case of disaster, an island would need to grow 50% of staple crops to be self-sufficient (Terrell, 2021). However, the islands have not grown this amount of food since the 1960’s, shortly after becoming a state. To reach a level of growth that allows Hawai’i to be resilient and self-dependent, there needs to be a strategic reinvestment in local farms and food businesses. SM is seeking to do this by establishing a resilience hub on Molokai that can generate its own energy, water, and food while helping the community do the same.

The vision guiding this development of a resilience hub on Molokai is its name “‘Umeke ‘Ai,” or Food Bowl in ʻŌlelo Hawaiʻi. The imagery of a food bowl informs the multiple goals of a resilience hub, including supporting the local agriculture economy, addressing food access and a dependency on importation, high energy costs and inconsistent power, and the restoration of Indigenous land relationships. Additionally, the island lacks any building that is certified to withstand hurricanes—a resource that will only become more crucial as climate change exacerbates natural disasters—so the resilience hub will also serve as an emergency shelter in times of need. Ultimately, the hub also aims to strengthen community ties by providing indoor and outdoor gathering and event spaces, which will bring Molokai residents to the hub and familiarize them with its many intended resources. The'Umeke 'Ai Center would address all of these goals by providing a certified kitchen for entrepreneurs to utilize to grow their food business, a centralized food bank facility that could help food bank satellites throughout the island coordinate aggregation and distribution, open indoor and outdoor gathering spaces, a sustainable agriculture educational farm with native plants and crops, an emergency preparedness area, and an office for SM, as well as supporting the growth of green design principles on the island.

While not strictly necessary to the construction of all resilience hubs, ‘Umeke ‘Ai is intended to be a green building that utilizes pre-existing materials and is powered through renewable energy sources. So-called green buildings are those constructed with sustainability principles, such as biomimicry and adaptive capacity, at every step of the process. This process requires planners to learn about available resources that can be reused throughout the construction process, access to clean water, and renewable energy sources that work best for the location.

Energy

Solar was chosen as the renewable energy source best fitted for ‘Umeke ‘Ai because it uses space and the island’s plentiful amount of sun available efficiently (Look et al., 2020). ‘Umeke ‘Ai can build upon pre-existing partnerships developed through SM’s Clean Energy Hui and their Clean Energy Resilience Action Plan (CERAP) with public, shared solar models like the NREL REopt Model to estimate the necessary dimensions for a solar microgrid that will support various functions of the hub and provide an emergency power source to the island.

Greywater

Traditionally, water was allocated through a hierarchical system put in place by the *ali’i* (kings) and a delegation of *konohiki* (head of a Hawaiian land division under the ali’i) who coordinated where water should go to ensure that there was a consistent flow of fresh water to the *kalo lo’i* (taro fields) and the *loko i’a* (fish ponds). Water was recognized as a vital resource that needed to be shared by all to ensure the health and wellbeing of Native Hawaiians (Teves, 2015). This was explicitly stated in the word for wealth in ʻŌlelo Hawaiʻi, *waiwai* or “water water,” the greatest source of wealth to Native Hawaiians. However, with the introduction of colonialism and capitalism to the islands, this system was overturned and replaced with property laws that prioritized those who could afford higher prices rather than ensuring all had access to water. A sustainable alternative to these high water prices is implementing a greywater reuse system that redirects untreated wastewater from low contamination sources like bathtubs, bathroom sinks, and some cloth washing systems (Allen et al., 2010). Greywater can be used for non-consumption activities, including maintaining non-edible plants and lawns and redirected to toilets. This system is recommended for ʻUmeke ʻAi because it holds the potential to reduce long term water costs and waste, while ensuring that the green spaces around the resilience hub are nourished. Greywater would also allow for the resilience hub to be built in the more arid zones that comprise most of Molokai’s habitable regions and would limit the hub’s reliance on external irrigation systems.

Native Stewardship & Green Building

Also central to the design of ‘Umeke ‘Ai is the Aha Moku system, a guideline for collaborative governance based on Native Hawaiian values and history. Historically, ‘Aha councils were determined by the community as the experts within vital areas, such as water distribution, food production, and environmental stewardship, and could therefore make decisions on the behalf of the people and the ʻāina (Akutagawa, M. K. H., n.d.). Using the council’s knowledge, they would examine problems and implement solutions based on the criteria of: “honor our ancestral wisdom; address the needs of the present; establish abundance and sustainability for future generations,” (Akutagawa, M. K. H., n.d.). This thoughtful approach has guided SM’s identification of the intersecting problems facing Molokai and their community-centered approach to solving them.

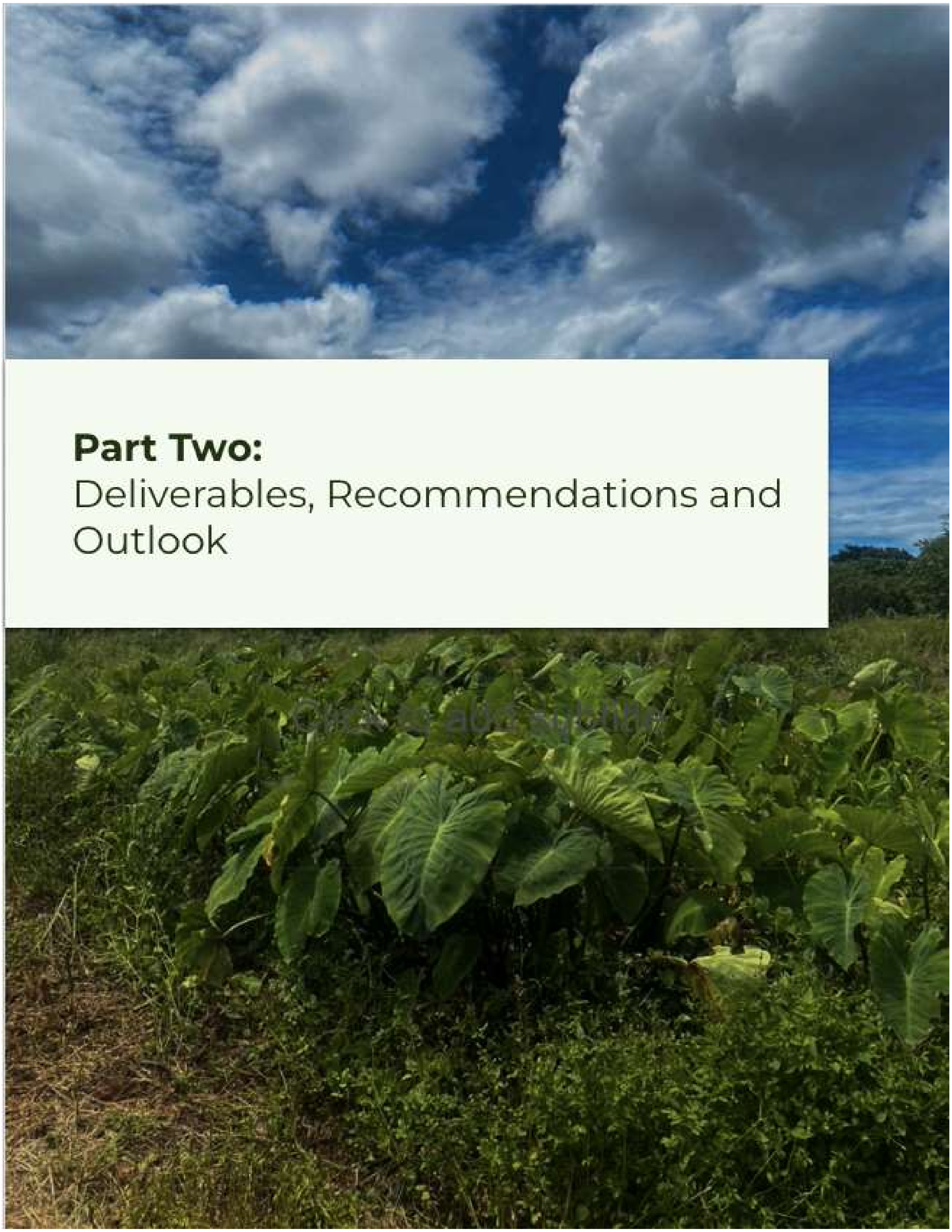
Ultimately, a centralized green building system based on these fundamental principles of native stewardship will increase the overall resilience of Molokai and enable residents to embed food, land, and energy sovereignty principles into their daily life. By creating a resilience hub that increases access to locally grown food, clean water, and renewable energy, Molokai residents can ensure the future of their island and way of living.

Chapter II. Methods Overview

Given the listening-then-acting approach and the wide set of questions covering the multiple facets of the facility design and planning, our methodologies for responding to these questions will take on a diverse approach. Our team’s work, as detailed in this report, is designed to support Sustʻāinable Molokai’s food hub and resiliency center initiative in its initial phases. This work underwrites SM’s first phase of funding to help plan, design, and implement a community resiliency center that supports the needs of Molokai’s residents. Our work involved completing precedent studies of food infrastructure, site assessments, and analysis of energy and greywater models.

Sustʻāinable Molokai has conducted an extensive survey with approximately 70 residents to gain insight into their perspectives and thoughts on what should be prioritized for the facility, which has dictated the primary deliverables for this project. The survey primarily focused on farming and business communities.

A detailed discussion of our methods for each element of the Center included in this phase of the project is included within the respective associated deliverable chapters.



Part Two: Deliverables, Recommendations and Outlook

Deliverables and Findings

The impact of our deliverables is vast and will not only assist SM in its climate action/community resiliency goals but also in providing an opportunity for research partnerships with community members. More specifically, the reports delivered to SM will allow them to make informed decisions on how to proceed with implementing sustainability, food, and renewable energy systems and designs. The resulting facility will be utilized by the residents of Molokai and will be an important gathering place for culture and learning about food sovereignty, renewable energy, climate change, and community ownership of land.

This second part contains a detailed discussion of what we created and provided to SM that can be integrated into the overall feasibility study.

Chapter III. Precedent Studies Report & Other Food Systems Precedent Studies Research

Executive Summary

The idea of the resilience center comes from an analysis of Molokai's infrastructure challenges, ranging from limited food production and aggregation resources to expensive energy and water sources. While drafting plans for the ‘Umeke ‘Ai Center, the SM team looked at the infrastructure of the surrounding islands’ food banks, produce aggregation sites, and food entrepreneurship programs. In 2022, members of the SM team visited sites on Maui, O’ahu, and Hawai’i islands and took detailed photos and notes of their tours. These models provide opportunities to imagine ways of designing and developing the food-related programming of the ‘Umeke ‘Ai Center.

The food sub-group’s primary deliverable was a precedent studies report of 22 sites on the islands of O'ahu, the Big Island, Maui and Molokai. Key details, including property size, tax class, and amenities, were included in a report alongside photos of the locations.

Methods

In order to develop a resiliency hub that fit the unique needs of Molokai, our food sub-group conducted the following research methods:

(a.) in-person precedent site visits in Molokai,
(b.) windshield surveys
(c.) compilation of precedent site visits information
(d.) online research
(e.) leveraging team members’ expertise

These research methods culminated in three deliverables: (a.) a precedent site research report, (b.) an analysis of facility costs, and (c.) for-profit model research. These research methods build on the Maui Nui Food Bank Needs Assessment and the ‘Umeke ‘Ai Resilience & Sustainability Needs Assessment that Sustʻāinable Molokai conducted from 2020 to 2023, which resulted in the

13 guiding principles for ‘Umeke ‘Ai. These principles include cultural identity, food sovereignty, renewable energy, and community health (including disaster preparedness). They also build on the University of Hawaiʻi architecture students’ architectural design concepts for the ‘Umeke ‘Ai Center.

Precedent Sites Research and In-Person Visits

As part of their community needs assessment, SM conducted precedent site visits at food hub facilities, community centers, and related facilities. Site visits provide insights on best practices for the ‘Umeke ‘Ai Center by gathering and exploring successes and lessons learned from other sites with similar functions and goals as the ‘Umeke ‘Ai Center. A precedent study can help solve problems in a design process that have previously been solved in other designs, such as design concepts, material choices, and construction methods.

In the summer of 2023, our team conducted precedent site visits of community centers and other relevant facilities, totaling nine site visits on Molokai. The SM ‘Umeke ‘Ai team selected these nine sites to determine the available resources and infrastructure on the island and how the ‘Umeke ‘Ai Center could adopt and complement the existing food hub and community center infrastructure.

Our team collected information on the facilities’ amenities, design, and programming for each site visit to understand best practices for the ‘Umeke ‘Ai Center. Our main focus was food-related infrastructure, such as kitchens, storage, and aggregation areas. By walking through the space and talking with the facilities manager for each location, we obtained information on kitchen design (including certification processes), equipment (refrigerators, stoves, counter space, windows that connect the kitchen back to the larger facility space), and ways in which kitchens were rented out and used in general. While our main focus was on food infrastructure, we also looked at the general building design and use features, such as community hall capacity, emergency center design, energy systems, bathrooms, and outdoor spaces (i.e., loading dock, parking lot, field), to name a few.

To gain further insight into the sites we visited in-person, our team also conducted an online research process. We reviewed organizations’ websites and local government GIS websites to identify critical information about the facilities visited during our Molokai site visits and the site visits conducted by SM in 2022 on neighboring islands (i.e., Maui, O’ahu, and Hawai’i Island). Through these online sources, we collected site information that would be helpful in determining a potential site and features for the ‘Umeke ‘Ai Center: profit status, property area, building size, market land value, and tax classification.

Utilizing Community Knowledge

Our work built upon previous site visits conducted by the SM staff members. From 2022 to 2023, the SM ‘Umeke ‘Ai team traveled interisland to conduct site visits at food hub facilities and other food-related facilities. During these site visits, they talked with operators and took pictures and notes of the amenities. They also evaluated the pros and cons of each site. Our team reviewed these data collections to pull out key assessment themes for each site, such as kitchen equipment, gathering spaces, and energy systems. We organized each site based on these themes to be able to analyze which amenities are most and least conducive to a successful multi-faceted center, such as the ‘Umeke ‘Ai Center. As part of this compilation and selection process, we also compiled key recommendations provided by staff from the different site visits as a way to avoid design concepts that are not compatible, as well as inspire creative thinking on how a space can seamlessly integrate multiple key functions.

Through our team members’ food systems expertise, we were able to pinpoint a crucial and unique food hub case study in Portland, Oregon called The Redd. The Redd is a food hub under the non-profit, Ecotrust, that includes many of the elements that SM is interested in incorporating into the ‘Umeke ‘Ai Center: warehouse space for aggregation, cold and dry storage, and logistics, offices, kitchen production, and event space (e.g., demo kitchen and outdoor plaza). We connected the SM ‘Umeke ‘Ai team with The Redd staff, which resulted in a site visit and a new partnership with Ecotrust that has the potential for SM to learn from Ecotrust’s expertise in the development, design and planning, and operations of infrastructure projects closely aligned to the ‘Umeke ‘Ai Center vision.

Food Bank & Resiliency Center Cost Analysis

In seeking funding support for the ‘Umeke ‘Ai Center’s design and development process, the SM ‘Umeke ‘Ai team needed to carry out a food bank and resiliency center cost analysis that captured the one-time and recurring costs for the different branches of the Center: Molokai Pantry Needs, Molokai Food Bank Facility, Resiliency Center, and Emergency Satellite Centers. Below are the ways we supported the final analysis product, which was part of the 2023 SM Feasibility Study.

Our team members have experience in the spaces of food donation and local food infrastructure. This expertise lended itself to providing information on food hub and food bank facilities’ categories and costs, such as land acquisition, large equipment and vehicles, and local produce and products.

In addition to pulling in our team’s knowledge base, we looked up relevant financial information from key organizations, such as the USDA and Maui Food Bank. We also pulled information from local vendors, such as Hawaiian Trailers and Makai Container & Equipment Solutions. Below is a screenshot of the cost analysis cost categories and cost estimates we generated for SM. Please note that these were for brainstorming purposes; they did not necessarily make into their final feasibility study numbers.

PROJECTED ANNUAL COSTS: to run at needed capacity		
*Based on 1 pantry - speak to Sust'āinable Molokai's needs is sufficient		
	Item Description	**Cost**
	Molokai FOOD Pantries: (18-20 pantries, using SM as model)	
x	Purchase more local produce/products - this cost has been determined based off of SM's current expenses 2022 ($55k), estimate higher and include 8% food increase. To have a real impact, this amt needs to be more.	$75,000
Infrastructure:		
x	Packing/Distribution Space (1yr lease @ $2500/mos) [1]	$30,000
n/a	Public education (informational seminars)	$53,791
x	Volunteer recruitment & recognition (lunches, conference, etc.)	$5,000
n/a	Website hosting & maintenance (especially for Mobile Market)	
FUTURE (2-3 yrs): PROGRAM DEVELOPMENT & RESILIENCY CENTER		
*One time costs for new programs & development of the resiliency center		
	Item Description	**Cost Each**
	What Molokai FOOD Pantries want help with; near future	
	Vehicle Insurance (yearly)	$1,300 - 5,000
	Equipment	
x	Food storage - racking	$500-$1000
x	Utility carts (for moving food around)	$500
	Miscellaneous - standing mats, scissors to open boxes, etc.	$80
x	Commercial Refrigerator - 3 door stainless steel [2]	$8,500
x	Pallet Jacks (for moving of pallets on ground)	$500
2	Chest Freezers	$1,000
	Air Conditioning (for a 1500 sq ft area)	$3,750
	Office furniture and equipment	
	Software and data management tools (inventory control, operation metrics)	
	Vehicle insurance	
	Gas for Vehicles	
	Maintenance Costs	$52,704
x	Shipping $1K per vehicle	$1,000
Development costs		
x	Permitting and approvals (fees for utility connections, County review and approvals, etc.)	
	Owner's insurance	$3,600 or $34,695?
	Marketing/advertising	$130,748
	2 Satellite Centers (East & West End)	
	Warehouse equipment (based on Maui Food Bank 2020 audit)	
x	20' containers	$4,500 – $9,000

Figure 2. *‘Umeke ‘Ai Cost Analysis Categories and Dollar Estimates.* Screenshot of a Brainstorming Version of the Cost Analysis Spreadsheet. 2023.

Precedent Research: For-Profit Models

Part of the exploration for the ‘Umeke ‘Ai Center involves looking at elements of the Center that can be for-profit and revenue streams for SM and the Center to ensure its financial viability. Our team began the process of precedent research of for-profit models in the areas of food systems, green building, and community centers. Based on the interest expressed by SM staff, we dived mostly into researching breweries, coworking spaces, maker spaces, green building, and event spaces. However, there is opportunity to further explore the areas of food hubs and incubation kitchens outside of the islands of Hawaiʻi, Hawai’i-based chefs, prototype spaces for energy, and water and composting systems, as well as further building on our research for the other areas mentioned above. Our team has a spreadsheet with each of these categories and columns of key data points to research for each model type

(Figure 3). This spreadsheet facilitates data collection for our team and future student teams.

A	B	C	D	E	F	G	H	I	J	K
Name	Location	Origin Date	Size	How Many People are on Staff	Pricing Range	Ownership Status	Unique Aspects	Lessons Learned	Link	
OLA	74-5598 Luhia Street, Kailua-Kona, HI 96740 1177 Kilauea Avenue, Hilo, HI 96720	December 2017(?)		59		1.) Ola Brew is also proudly both employee and community owned. We have over 2800 small investors and 40+ employee-owners	Has a distribution deal with Whole Foods		https://www.olabrewco.com/	
Maui Brewery									https://mauibrewingco.com/mbc_news/	
Kona Brewery	Kailua & Oahu	1994		75	$8.99/six pack	Anheuser-Busch InBev	Very broad market availability thanks to parent company			
Pau Maui (Hali'imaile Distilling Co.)	Makawao, Maui	2010		<25	$20/bottle	Tim and Neil LeVecke, of Hali'imaile Distilling Co.	Vodka made with pineapples			
Grace in Growlers	Kailua & O'ahu	2016		6-10		Holly and Tim Veling	"Motivated by Christianity", all profits go to charity such as Compassion International		http://www.oneninetynine.org/graceingrowlers	
Aloha Beer Company	Kaka'ako, Honolulu	1994			$12/growler	Steve Sombrero	Distributes to mainland			
Ocean Vodka	Kula, Maui	2004		15	$30-$40	Owned by Hawaii Sea Spirits, which is owned by Jennifer Vasquez	Sources from a Maui farm, at which their distillery is also sited			

Breweries | Coworking Space | Maker Space | Green Building | Event Space | Food Hub | Prototype Space | Bulk Materials | Incub

Figure 3. *Excerpt from the For-Profit Model Sheet featuring local breweries.* Screenshot of Precedent Research on For-Profit Models Google Sheet. 2023.

Our team reviewed organization websites and Google Maps to collect information about each type of for-profit model. Through this online research, our team was able to collect information about the for-profit model’s story and unique aspects, such as programming structure, equipment and design concepts. For example, the O’ahu Makerspace website provided information about membership costs, space size, and their available printing equipment.

Precedent Site Report

Our team compiled the data from SM’s outer island site visits, our team’s in-person site visits of Molokai, our community knowledge gathering practices and our online research analysis into a 47 page report. As mentioned in the methods section, the report information was sourced from in-person site visits and the SM staff site visit photos and notes. Below is a one-page excerpt, showcasing the Kahumana site on O’ahu. Please refer to Appendix B for the full report. Further below, we will discuss the main findings and recommendations that resulted from this report and include the full report.

Precedent Report: O’ahu Community Centers
Kahumana

KAHUMANA

Overview

Profit Status: Non-profit
Land Use Type: Agricultural
Property Area: 14.610 acres
Building Size: 12 buildings, 3,366 - 272 sq ft
Market Land Value: $1,113,600
Energy: Some solar
Capacity: n/a
Refrigeration Size: Whisper fridge, cooling fridge; 10k cooling system, 3k fridge retrofitted

Amenities

- First 4 buildings were built in the 1950s and 8 more buildings were added later
- 201 growers use the food hub aggregation service
- 31 acre certified organic farm, homes are on 12 of the acres
- 30 - 35 staff total, 100 staff for retreat center

Outdoor Kitchen and Dining
Restaurant Space
Freezer Shelves
Outdoor Receiving Area
Kitchen Juicer
Kitchen Dehydrator

27

Figure 4. *Excerpt from Precedent Site Research Report featuring Kahumana Farms (O’ahu, Hawai’i).* Screenshot from Precedent Site Research Report. 2024.

Precedent Site Report Findings & Recommendations

The following are key themes and recommendations from our analysis of the 23 sites in our precedent site report. Each of these recommendations and insights aim to further Sustʻāinable Molokai’s food sovereignty mission to “permanently align the local food supply with their community’s needs, increase the total food production on Molokai, and ensure everyone has access to affordable, local, healthy food” (Molokai Needs Assessment Report, 2023)

Cold & Dry Storage

Cold and dry storage is vital to creating a more resilient food system and food security by ensuring that food waste is minimized and available food reaches those who need it most. SM identified storage as an important element to highlight in the precedent study, particularly best practices for cold storage and maximizing dry storage space. Cold storage is particularly important for the stability of a resilience hub on Molokai because, currently, long-term supply of perishable food products are brought into the island on an inconsistent basis. The current lack of cold storage capacity on Molokai exacerbates pressure around monthly barge deliveries since there is no central storage space for perishable food and most need to be immediately delivered to various food bank affiliated pantries on the island. This stressful food storage environment puts additional strain on food pantries and recipients of food donations. SM’s community needs survey reflects community members’ awareness of these systemic shortage issues (refer to Figure 5 below). Adequate food storage not only contributes to everyday resiliency but also provides critical infrastructure for emergency resiliency. In order to alleviate these systemic pressures, the ‘Umeke ‘Ai Center should provide ample cold storage for perishable food products in addition to sufficient warehouse space for dry goods.

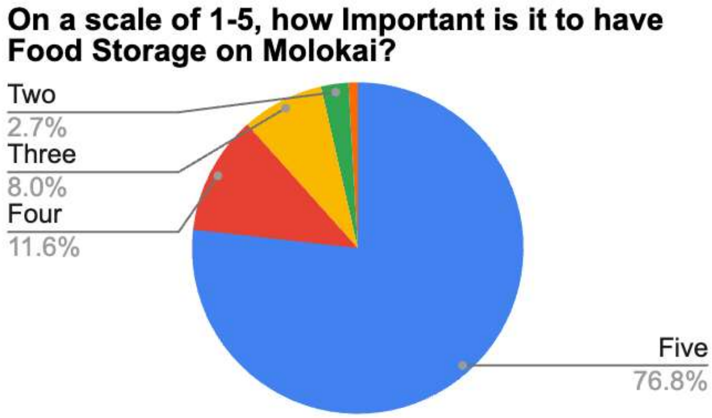


Figure 5. *SM Community Survey About Food Storage*. Sustʻāinable Molokai Community Needs Assessment Survey Results. 2022.

In analyzing the precedent sites, our team identified a range of cold storage options, including walk-in refrigeration and freezer combinations, reach-in fridges similar to those found in grocery stores, and smaller deep freezers typically used for meat preservation. Groups with larger capacity, such as the Hawai’i Food Bank on O’ahu and the Maui Food Hub on Maui, had large cold storage spaces, such as a walk-in reefer and freezer, that also offered complementary food processing infrastructure, such as meat processing and other foods that require being consistently chilled.

In terms of warehouse storage for dry goods, from shelves within a small room to a large warehouse space. Large shelves, including stationary and portable metal shelving, were broadly used. However, a key trend is that dry good storage space is in-need by a number of sites. For example, several sites, such as the Hawai’i Food Bank, are looking for a bigger food storage space, which reflects a key reminder for SM to build a larger space than anticipated to allow for growth and ensure there’s sufficient dry and cold storage space. In doing so, the ‘Umeke ‘Ai Center can serve food sovereignty efforts at the necessary scale.

In general, some spaces were more suited for storage, and had ramps, shelving, and warehouse doors to accommodate food storage. In these sites, cold storage could be built-in or brought in. Cold storage was consistently the backbone of many sites’ operations, and as such its importance to future design cannot be overstated. These are all important factors to consider when creating a highly multifunctional resiliency hub.

Certified Kitchens & Food Processing Infrastructure

Certified kitchens are inspected and registered commercial kitchens where food products intended for sale can be safely made in accordance with laws and regulations (University of Hawai’i, 2020). Many foods intended for sale can only be made in licensed kitchens. As such, licensed commercial kitchens play an essential role in helping Native Hawaiians and other Indigenous groups reclaim their local food systems by encouraging farmers to prepare their foods safely and responsibly in a commercial kitchen that is fully licensed and certified (First Nations Development Institute, 2013). In Molokai, food entrepreneurship is increasing in Molokai with the increased awareness of the nutritional benefits of traditional foods and locally produced foods. These food entrepreneurs, including farmers, depend on commercial kitchens to prepare specialty food products for consumption and distribution. The importance of certified kitchens for incubating and promoting food entrepreneurship, especially traditional foods, is shown through Figure 6 below with the majority of community survey respondents expressing they would use a certified kitchen on the island. Similar to dry and cold storage, having a sufficient scale of certified kitchens provides the ‘Umeke ‘Ai Center with critical infrastructure for resiliency when it comes to emergencies, such as disastrous tropical storms and flooding.

Figure 6. *SM Community Survey About Certified Kitchens. Sustʻāinable Molokai Community Needs Assessment Survey Results. 2022.*

In our precedent site research, we identified at least a third of the site had certified kitchens. A key theme for certified kitchens is the importance of providing a sufficient number of kitchens at low or no cost rental options. Pacific Gateway Culinary Business Incubator (PGCBI) is a prime example with 12 full-suite commercial kitchens, including full, baking and food prep kitchens. PGCBI’s suite of licensed commercial kitchens provides entrepreneurs with a facility, equipment, and resources to expand their food service-related business, especially around traditional and specialty foods, showcasing the importance of certified kitchens in building a resilient local food system. On Molokai, a prime example of the holistic set of benefits provided through a certified kitchen is the Lanikeha Community Center. This center’s certified kitchen allows beneficiaries and other commercial food business owners to prepare food, and farmers to prepare their produce and products to ship to outer islands. This center also shows the strong impact of a multi-purpose facility via complementary functions, such as the certified kitchen being located in the same facility as a gathering space for educational workshops on food systems issues, community events and meetings, and fundraisers.

Given that these certified kitchens also act as crucial food processing infrastructure, there were some key design considerations brought up in the site tours about how to set up a kitchen to effectively serve a food processing function. Food processing areas typically include space for farmers to bring their uncleaned produce and prepare it to be either be sold on-site or included in CSA boxes. Several sites also have separate areas for meat processing for safety measures.

In addition, certified kitchens provide numerous advantages over uncertified kitchens. They tend to provide better capacity for food aggregation, allowing for ease of distribution for prepared foods. Also, prepared foods can be sold for higher margins while supporting entrepreneurs, who in turn support the center’s financial viability by providing an income source for the center. While certified kitchens are ideal for generating resiliency for Molokai’s local food system, uncertified kitchens still play a beneficial role in preparing and processing food. In Molokai, four sites had uncertified kitchens, including the Kilohana Community Center and Kualapu’u Recreation Center. In some cases, people selling homemade foods use these uncertified kitchens, providing greater accessibility for different scales of food entrepreneurship, which also ends up increasing a food system’s resiliency.

Given the centralized nature of the ‘Umeke ‘Ai Center, it will be important for SM to ensure there are multiple certified kitchens to allow for a large enough scale of food entrepreneurs, farmers, and other key stakeholders to use these spaces as critical food processing, incubation and entrepreneurship activities. Another important factor to consider is ensuring these certified kitchens are available at low or no rental costs to provide the greatest amount of accessibility, especially for small-scale farmers and food entrepreneurs with limited resources. In this case, securing sufficient grant monies will ensure these kitchens are still financially viable spaces.

Traditional Agricultural Systems Sites

As mentioned in our Introduction’s ‘Legacy of Food Sovereignty in Molokai’ section, Molokai has a strong movement in connecting with historical and Native Hawaiian food practices, such as the cultivation of traditional crops like kalo. The ‘Umeke ‘Ai Center presents a significant opportunity to revive traditional agricultural systems by dedicating the necessary land and infrastructure to produce and process traditional foods.

This is further confirmed through our precedent research. The inclusion of agriculture systems, especially that which has traditional crops growing within it, was relevant. These are most common on farms like the Kohala Center Farm on the big island, where intercrops that include kalo were grown. The Ulu Co-op and Go-Farm Training Farm & Aggregation Site cooperatively grew ulu starts at the latter site, which helped tie into their ulu distribution business. It is worth noting that they also had dedicated peelers and dehydrators for the ulu; this could be important with regard to a focus on growing and distributing traditional Hawaiian crops. Agricultural sites could also serve as a setting for education and community gathering. Native plants can also be used for landscaping and cultural purposes.

SM should look to these site examples to make sure they include the necessary resources for effective design and implementation of traditional food production, processing, and distribution. This will include having farm plots dedicated to traditional crops and harvesting methods, a demo production farm to serve as an educational space for farmer trainings, and dehydrators and other similar equipment for the processing that needs to happen for the crops to be sold or donated.

For-Profit Opportunities

The multifaceted purpose of the ‘Umeke ‘Ai Center’s framework of a food hub, emergency resiliency hub, and community center lends itself to a diversity of for-profit opportunities within and outside the scope of food systems.

A primary food business model opportunity is including a storefront that sells a combination of produce grown on-site and from partner farms, promoting business partnerships while ensuring easy community access. A farm-to-table restaurant, such as Huimau’s model, is also possible at the ‘Umeke ‘Ai Center. Looking beyond the scope of food, there’s a suggestion of including an Amazon Return Center in the resilience hub to allow for customers to address their needs in one central space. Based on conversations with SM staff and for-profit model research mentioned in our Methods section above, there is also opportunity to explore breweries, rotating chefs and pop-up events, and event space rentals, to name a few.

Given that one of the ‘Umeke ‘Ai Center’s areas of focus is supporting a local green economy, SM needs to make sure there is the necessary development in the Center that can accommodate a set of diverse and complementary for-profit models, such as the ones listed above. This will support small business owners and the financial viability of the ‘Umeke ‘Ai Center by providing sources of income.

Energy Availability

As referenced in our Background’s *Energy Landscape* section, Molokai currently has a heavy reliance on diesel generators with most energy coming from Hawaiian Electric’s Pala’au power plant. As such, thinking through resilient alternative energy systems is critical for the ‘Umeke ‘Ai Center.

In some sites, solar energy systems were found, such as the Kihei Community Center Gym on Maui, where a solar array shaded the parking lots while providing energy. In Molokai, pre-existing solar-reuse projects may allow for cheaper access to solar panels, which is important to consider due to high shipping costs.

The element of easily-repaired energy systems is critical to consider for the ‘Umeke ‘Ai Center. At the Maui Food Bank, repairability was taken into account with an “easy to repair power system” explicitly noted. Having a system that can be easily repaired is especially important considering storms increasing in occurrence and intensity with climate change. During these emergencies, it’s important to have energy systems that can function or be easily repaired to function in order to protect food that needs to be refrigerated or frozen.

Other energy-related considerations are high-energy uses and the sync between energy availability and use. Air conditioning, fans, and other forms of ventilation often use significant energy, which is another cost to consider with regard to planning the center. When considering energy availability, time must also be taken into account. With solar power, there is a discrepancy between when it is generated—during the day—and when it is used, in the evening and the early morning.

Architecture Features

As we mentioned in our methods for the precedent site report, a main purpose behind conducting this type of research is to gain a better understanding of successes and lessons learned in the design process of other sites with similar functions and goals as the ‘Umeke ‘Ai Center. Below we’ve organized our findings and recommendations around architecture features to keep in mind for ‘Umeke ‘Ai into three categories: general, food systems, and emergency resiliency.

Cross-Cutting/General
Thorough planning of architectural design, including how the different spaces and business and community partners within the Center can be best organized will be essential to designing the ‘Umeke ‘Ai Center.

Some buildings took inspiration from traditional Hawaiian architecture, such as Kulana ‘Oiwi on Molokai. This allows for integrating cultural traditions, including a space for dedicated community gathering. There needs to be consideration for the surrounding area, as seen at Kulana ‘Oiwi where a noted concern was the road next to the community gathering space causing traffic and sound pollution.

A theme mentioned under our *Dry and Cold Storage* section that is applicable to the larger framework for designing and developing ‘Umeke ‘Ai are recommendations from several sites to build a space larger than anticipated to allow for growth. This can include both indoor storage and kitchens, as well as outdoor community spaces. SM should also ensure ample parking spaces for visitors and workers to be able to easily access the space for their needs. Below we describe some food systems-specific recommendations for parking lot design.

Food Systems Considerations
Precedent site tours revealed that bays for the drop off and pickup of food would create a more efficient method of aggregation and distribution, which provides an important consideration for SM to incorporate similar bay structures for their food distribution functions. Part of this requires a parking lot design with a loading dock for trucks to easily drop off or pick up food for distribution. This could be useful when consideration efforts like the Mobile Market already hosted by SM. Additionally, the Center’s design should have central access to refrigeration and entrance to kitchens to allow these spaces to be maximimized in their functions.

Emergency Resiliency Considerations
Several sites were designed with emergency resiliency in mind, given how climate change is causing an increase in the intensities of storms. Sites such as the Kihei Community Center Gym had windows designed to be hurricane proofed. Other storm-proofing safety measures, such as ensuring that sites were not located in a flood zone and shuttering doors and windows, were also taken into account.

Generally, the recommendations hint at the need for a resilience hub that allows for aggregation, food preparation, and emergency services to be utilized simultaneously while also providing an accessible community gathering space.

Chapter IV. Site Assessments and Mapping

Executive Summary

With precedents and case studies of similar projects for ‘Umeke ‘Ai in place, our team next moved to the “development” phase for the Center. Before any buildings can be constructed, land must be procured on Molokai to build upon. One of the primary briefs in this project’s initial proposal was to perform site assessments and feasibility studies toward determining where to site the Center, based on a variety of factors that could inform its development and either free or constrain its future potential.

This chapter details thirteen considered sites for the Center and their advantages and disadvantages for the feasibility of the Center’s many functions and needs. These sites were analyzed and visualized with a variety of methods, including spatial analysis with ArcGIS Pro and ESRI Online systems, which allowed for mapping to compare sites and gathering geospatial feasibility data. Other methods of analysis, like energy use calculations and data collection on property tax information for each site, are also included in this chapter. The recommendations based on this analysis prove that there are multiple sites that could be suitable for ‘Umeke ‘Ai—although they may not be the sites that were originally at the forefront—and there should be ample resources, pending SM’s ability to procure one of the recommended sites, to design a thriving system of interworking resilient functions at the Center.

Methods

Preliminary Data Collection

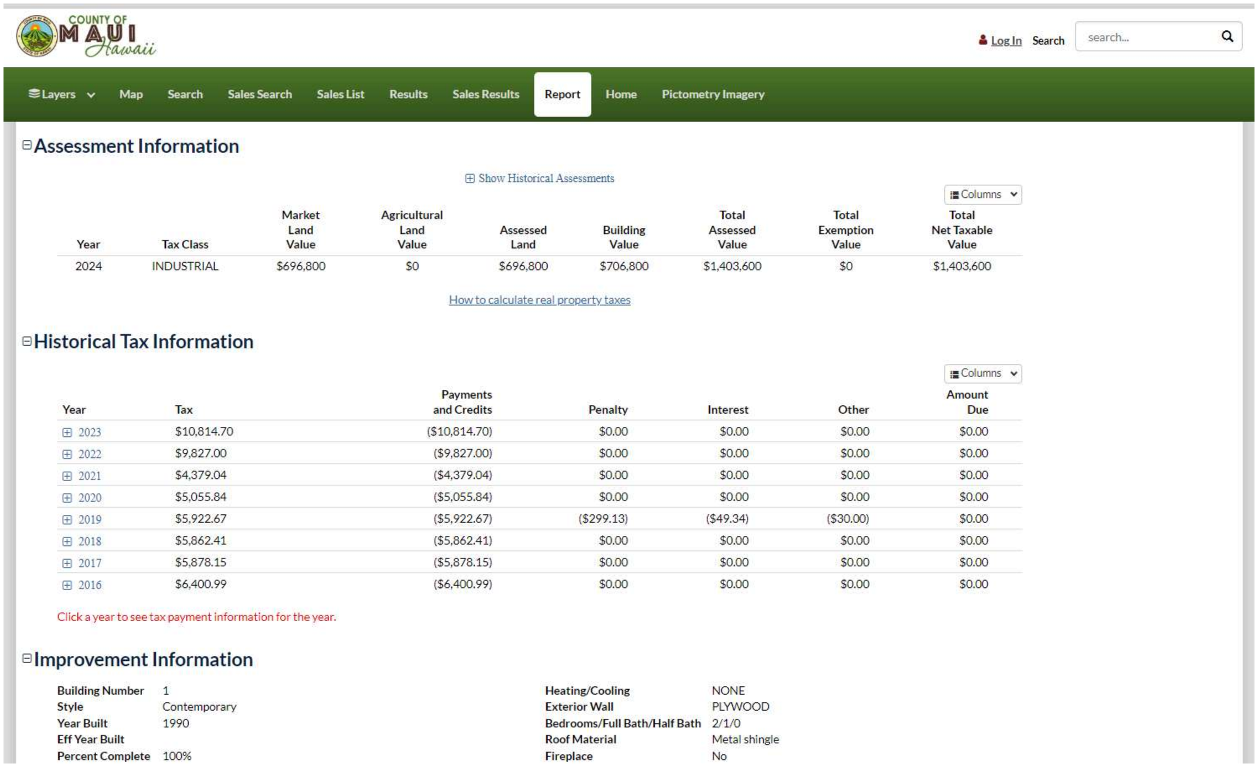
In order to eventually designate a single site for the development of ‘Umeke ‘Ai, the team performed site assessments, utilizing a variety of methodologies to form a cohesive view of the feasibility of each potential site.

The initial narrowing of potential sites was performed by SM through 2022 and early 2023, with a variety of factors in mind to eliminate sites:

- Sites must be outside of flood, passive flood, and sea level rise zones.
- Sites must be potentially available for purchase or lease, whether officially on the market or through community connections and negotiation.
- Sites must be easily accessible to a majority of the island in order to efficiently act as an emergency shelter.

The initial filter process, performed with SM’s knowledge of the island and community, narrowed the search process down to about 20 viable sites. Various feasibility studies were then performed on these sites to further narrow them down.

The next step in the filtering process to determine site viability was to determine the address, Tax Map Key/Parcel Number (TMK), Owner, Neighborhood Code, Class (i.e. industrial, agricultural, etc.), Property Size (acres and sq. ft.), Existing Building Types, Buildable area of property, Assessed Land Value, Assessed Building Value, compiled past planning permits, and finally, maps obtained from Google Earth of each site at various scales. Most of this information was obtained from the Maui County Property Tax Parcel Viewer and Maui County Real Property Tax Assessment Website, which is a county-run website combining property tax information for every land parcel in Maui County and an online GIS Web Map showing the exterior boundaries of each parcel (Maui County, 2024).



COUNTY OF MAUI Hawaii

Log In Search search...

Layers Map Search Sales Search Sales List Results Sales Results Report Home Pictometry Imagery

Assessment Information

Show Historical Assessments

Columns

Year	Tax Class	Market Land Value	Agricultural Land Value	Assessed Land	Building Value	Total Assessed Value	Total Exemption Value	Total Net Taxable Value
2024	INDUSTRIAL	$696,800	$0	$696,800	$706,800	$1,403,600	$0	$1,403,600

How to calculate real property taxes

Historical Tax Information

Columns

Year	Tax	Payments and Credits	Penalty	Interest	Other	Amount Due
2023	$10,814.70	($10,814.70)	$0.00	$0.00	$0.00	$0.00
2022	$9,827.00	($9,827.00)	$0.00	$0.00	$0.00	$0.00
2021	$4,379.04	($4,379.04)	$0.00	$0.00	$0.00	$0.00
2020	$5,055.84	($5,055.84)	$0.00	$0.00	$0.00	$0.00
2019	$5,922.67	($5,922.67)	($299.13)	($49.34)	($30.00)	$0.00
2018	$5,862.41	($5,862.41)	$0.00	$0.00	$0.00	$0.00
2017	$5,878.15	($5,878.15)	$0.00	$0.00	$0.00	$0.00
2016	$6,400.99	($6,400.99)	$0.00	$0.00	$0.00	$0.00

Click a year to see tax payment information for the year.

Improvement Information

Building Number	1	Heating/Cooling	NONE
Style	Contemporary	Exterior Wall	PLYWOOD
Year Built	1990	Bedrooms/Full Bath/Half Bath	2/1/0
Eff Year Built		Roof Material	Metal shingle
Percent Complete	100%	Fireplace	No

Figure 7. *Screenshot of Maui County Tax Viewer.* Partial screen capture from Maui County. 2024.

The site assessment information was collected into a single spreadsheet with the information for all of the sites, for ease of later analysis and internal use (see Table 3; Site Assessments Spreadsheet). Once this spreadsheet was in place, and in conjunction with the precedent study information for other relevant sites around Molokai, we prepared a GIS map detailing the advantages and disadvantages of each site and its assessment information. This visualization of the sites and attribute assignment to each site from the collated site assessment spreadsheet enabled a clearer vision of the geospatial connectivity of each site and its relevance to the ‘Umeke ‘Ai project.

Geospatial Data Creation

The GIS map was initially created and analyzed in ESRI ArcGIS Pro Desktop and was later translated to an interactive Web App on ESRI Online, in order to further its longevity and use within SM’s various projects and community communications. In order to compile the data into an ESRI-friendly format, the data was first downloaded from the team’s cost analysis, energy analysis, and site assessment spreadsheets and cleaned and combined in Excel. Only certain aspects of each original spreadsheet were retained in order to streamline the eventual attribute tables that would be attached to each layer.

Within ArcGIS Pro, a polygon feature class was created for both the Site Assessments (proposed sites) and the Precedent Studies (Molokai sites only). Using the Maui County Property Tax Parcel Viewer web map, Google Earth, and ESRI ArcGIS basemap information, the specific TMKs of interest were identified for each feature class and hand digitized into polygons matching the TMK boundaries. While there are other pre-existing online layers ostensibly available for Hawaiʻi TMKs, these did not match up with current TMKs on Molokai and were missing many of the smaller TMKs involved in the precedent studies, so hand digitization was performed to ensure full accuracy and and accurate matches with the project goals. This follows a similar pattern of geospatial data-finding for Molokai extents: given that Molokai currently lacks the infrastructure for robust data collection, especially geospatial data, many layers that might be useful for general site assessment or feasibility studies do not currently exist for the island, or if they do exist, they are often populated with sparse, inaccurate, or outdated information. The current GIS map uses what data is currently available, but could certainly be expanded upon with further data collection and hand digitization performed by other research groups on Molokai.

Once the individual TMK polygons were populated for the site assessment and precedent study feature classes, the feature classes were then modified with the “Add Field” and “Modify Field” geoprocessing tools in ArcGIS Pro to add in data from the clean Excel spreadsheets to the attribute tables for each feature class. For the site assessments layer, called “SM_considered_sites” in the map, the following fields were added (in addition to basic identifiers and geometry): SiteName, TMK, Address, Neighborhood_Code, TaxClass, Preexist_Builds, AssessedValue (using the total assessed value, of building plus land), OwnerNames, and Acreage. For the precedent studies layer, the following fields were added (in addition to basic identifiers and geometry): Island, SiteName, Type of Site, Profit Status, Use/Capacity, Land Area (sqft), Buildings Area (sqft), Market Land Value ($), Cafe Space?, Certified Kitchen?, Farm/Growing Space?, Gathering Space?, Aggregation Spot?, and Avg Energy

Use Per Month (kWh). Domains for each field were also created to streamline future data additions to the map, if they are made.

The average energy use per month for the precedent studies field of the same name was partially collected, partially calculated. Values were directly utilized from electricity meters where that information was available for certain precedent studies buildings, primarily the community centers on Molokai (Kilohana, Mitchell Pauole, Kualapu’u, and Maunaloa). Electricity costs for the year were directly translated to kWh using a standard Molokai electricity rate of 53.5 cents/kWh from Hawaiian Electric (an estimated value between the costs for residential zoning and “G” Small Power Use Businesses to match a building like the community centers) (Hawaiian Electric, 2023). The following calculation was then performed for each community center:

$$\frac{1\ kWh}{52.5\ cents} \times \frac{100\ cents}{1\ \$} \times Avg.\ Monthly\ \$\ Charged = Avg.\ kWh\ used\ per\ month$$
$$\left(\times \frac{12\ months}{1\ year}\right) = Avg.\ kWh\ used\ per\ year$$

Once kWh energy useage was determined for the four community centers, other values could then be extrapolated for the rest of the precedent study sites in order to fill in as much energy data as possible. This was done by determining different energy “intensities” of the known energy usage data points. For the four known community centers, the average kWh used per month was divided by the center’s square footage to determine a baseline intensity. These intensities were then further categorized, based on the centers’ known appliances, amenities, and overall capacity and estimated use each month.

Kilohana, Maunaloa, and Kualapu’u, having similar usages and amenities, were determined to be the “least energy intensive” baseline. The kWh/sqft for these sites, averaged, was calculated to be 0.1017 kWh/sqft for each month. Mitchell Pauole was determined to be a “high energy intensive” site, and had an energy usage of about 0.751 kWh/sqft. These four sites were the only ones with known kWh/sqft values. We then took an approximate middle value of these two for a “medium energy intensive” site that we did not have data for, like Lanikeha, which would be about 0.5 kWh/sqft with this estimate. Using these intensities as multiplication factors, the rest of the precedent study sites’ energy use in kWh were then extrapolated based on the square footage of their buildings and their estimated “intensity” (low, medium, or high) based on monthly use, location, and facilities. These values were used both in the precedent study report and the GIS mapping attribute tables.

The SM_considered_sites (site assessments) layer has no null values and the potential for expansion if more lenses for feasibility assessment are required; the precedent studies layer does have some null values where information was unavailable about certain sites. The precedent studies layer also has room for expansion. Both feature classes, and the map as a whole, are viewed as a living document that can be modified to meet future SM analysis and communication needs.

Comprehensive Map Creation: Feasibility Layers

In addition to the hand-digitized feature classes specifically reflecting the site assessment and precedent study research, further layers were then added into the GIS map to enhance its analysis capabilities and more accurately reflect the feasibility of considered sites and represent areas of consideration for overall resiliency. Most of these additional layers were accessed from the State of Hawaiʻi’s Office of Planning and Sustainable Development Hawaiʻi Statewide GIS Program website (State of Hawaiʻi, 2024). This open GIS data portal is the most comprehensive geospatial database currently available for Hawaiʻi as a whole, although the data for islands like O’ahu and Hawai’i (“the Big Island”) are more comprehensive and up-to-date than those for Molokai.

Several layers were extracted from the portal and eventually included in the final version of the map (full name included first, and then the name of the layer within the GIS map in parentheses): (1) Molokai 2020 Census Tracts (tracts20), (2) Wildfire Risk (firerisk), (3) USDA Moisture Zone Classification (moisture_zones), (4) Sea Level Rise, Flooding, and Passive Flooding Risk (Sea Level Rise / Flooding), (5) Wind Power Capacity (hi_pwr50m), and (6) Annual Solar Radiation (W/m2). Individual metadata documents for each of these layers, developed by the Hawaiʻi Statewide GIS Program, are linked in the Web App created from these layers.

For each described layer, the symbology was modified by using the “classify” method with Jenks Natural Breaks, typically with more classes than the average (5-9) to obtain more granular detail for each of the layers. More intuitive color ramps were also added (for instance, yellow-red gradients for solar data) in symbology modifications.

Although many more potential layers for analysis are available on the State of Hawaiʻi’s GIS portal, these layers were specifically included after a thorough exploration of the database’s offerings to specifically meet the project design needs for ‘Umeke ‘Ai. For instance, even though Molokai only contains three census tracts, the census tract layer was included in order for potential later analyses, like clustering analysis or Spatial-Point Pattern Assessment (SPPA), to be performed in conjunction with any later geospatial data-gathering on Molokai (for instance, the distribution of food banks). These census tracts also provide a rough estimate of population distribution across the island, which could assist with choosing a site that is accessible to the highest density of people who would be endangered by an emergency event.

The inclusion of a wildfire risk layer is self-evident; especially after the 2023 Lahaina wildfires on Maui and the yet-untold lasting damage they have caused, it is imperative that a resilience center on Molokai consider fire risk (Kerber and Alkonis, 2024). The placement of a fire risk data layer also allows for further analysis of precedent study sites within high-risk areas, which may further underline the necessity of ‘Umeke ‘Ai. Similarly to the wildfire risk layer, the complimentary (but not entirely opposite) layer of USDA moisture zones was added into the map. Moisture zones are a USDA classification relating the annual precipitation of an area to its elevation, which, when combined, provide a comprehensive view of vegetation habitat zones. Moisture zones, as opposed to a pure precipitation layer, enable a more advanced assessment of the vegetation and agricultural potential of sites. Given that one of the center’s primary goals is to develop a sustainable agriculture demonstration farm, local native food production, and landscaping with indigenous plants, precipitation levels and moisture zone classification are as imperative for site assessment goals as wildfire risk.

Other climate factors were also considered in the mapping layer inclusions. Of major concern to island states like Hawaiʻi is sea level rise (SLR) and flooding, which will only continue to increase with climate change and global warming. The Sea Level Rise / Flooding layer presents polygons for Molokai representing sea level rise exposure areas at 1.1, 2.0, and 3.2 feet, and generally reflects passive flooding zones. These SLR increments were determined by the data originators based on extensive modeling of climate impacts on SLR, specifically in Hawai’i, in different warming scenarios. The sea level rise layer overlaps with many of the precedent study sites on Molokai, all of which currently serve important functions within the community. The positionality of ‘Umeke ‘Ai outside of these flooding zones will protect it even from extreme climate change-induced SLR, and potentially allow it to fill the niches of endangered precedent study sites on the island if and when they are overtaken by the ocean.

As previously mentioned, a layer on census tracts was added to the map. The represented tracts are for 2020 and provide the exact boundaries and other data, such as population density, for each of the three tracts on Molokai. While the tracts are not as granular as they could be, with each representing a third of the island, this is the smallest spatial resolution possible for Molokai population data. This layer generally helps to visualize population spread on the eastern versus western sides of the island and could enable future population density data-gathering and/or analysis efforts for ‘Umeke ‘Ai and other SM projects.

Finally, energy feasibility layers indicating both wind and solar power potential were added to the map. Another integral aspect of ‘Umeke ‘Ai is the development of a renewable microgrid to support as much of the center’s energy needs as possible, in addition to the use of solar panels on the refrigerated mobile container used by SM for food distribution. The wind power layer provides line vector data detailing the wind power potential (in W/m^2) at 50m above ground (about the height of a traditional wind turbine). Although wind power does not currently exist on Molokai at a commercial or sizeable local scale, it conceivably could become a part of Molokai’s energy independence scheme detailed in SM’s CERAP report. Wind power could also be important for any future analysis of individual-home scale wind turbines that could be used at the resilience center for further energy generation and peak load management. The solar power layer similarly estimates, in W/m^2, the insolation potential of the island based on topography and solar hours per day. While this layer does not take into account individual shadows, slope, and other factors in solar panel placement, it provides a robust enough estimate to enable current site assessment considerations for ʻUmeke ʻAi solar power potential.

The map and all of the described layers are in the NAD83 HARN UTM Zone 4 datum and projected coordinate system, which will provide continuity with other Hawaiʻi-relevant maps currently in development. Once the GIS map was finalized, it was uploaded to ESRI Online as an interactive Web App, which can be viewed at the following link: https://umich.maps.arcgis.com/home/item.html?id=1efdac0c953f4cf3a744419ea91680b8#overview. The Web App contains all metadata information and allows for the user to toggle layers on and off for feasibility, zoom to layers, select objects for analysis, and more. The various map layers discussed here can also be viewed in the following section, except for the wind power layer, which is visualized in the sixth chapter on energy analysis. Other maps are also replicated later in this report for ease of reference across different chapters.

Site Assessments and Feasibility Analysis

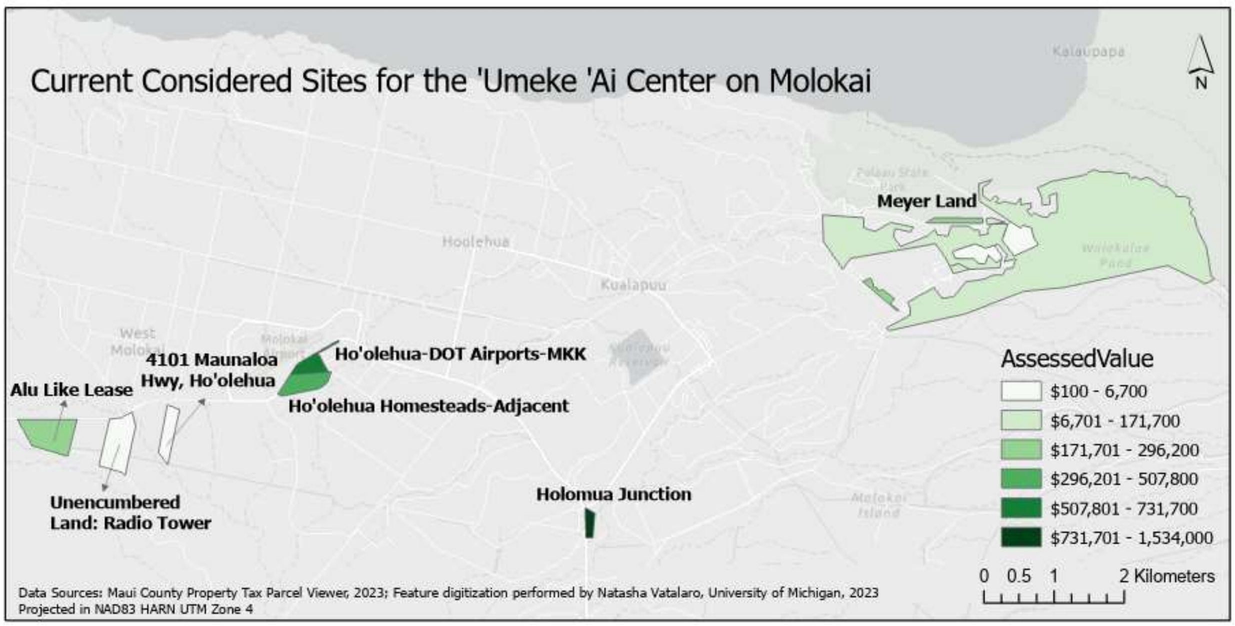
TABLE 3. Site Assessments Spreadsheet.

	A	B	C	D	E	F	G
1	**Site Assessment**	Top Priority Only Property For Sale	Top Priority				
2	Name:	**Holomua Junction**	**Hoolehua-DOT Airports-MKK**	**Hoolehua (adj. to 520040820000 & DHHL Na'iwa Homesteads)**	**4101 Maunaloa Hwy, Hoolehua**	**Alu Like Lease**	**Unincumbered Land: Radio Tower**
3	Address:	2130 Maunaloa Hwy Hoolehua, HI 96729	MAUNALOA HWY HOOLEHUA HI 96729	MAUNALOA HWY HOOLEHUA HI 96729	4101 MAUNALOA HWY HOOLEHUA HI 96729	4575 MAUNALOA HWY HOOLEHUA HI 96729	MAUNALOA HWY HOOLEHUA HI 96729
4	TMK: (Tax Map Key/Parcel Number)	520120050000	520040820000	520040460000	520010010000	520010310000 (portion of it)	**520010320000**
5	Owner:	Swenson, Diane L Trust	State of Hawaii	State of Hawaii	Department of Hawaiian Homelands	Department of Hawaiian Homelands	Department of Hawaiian Homelands
6	Neighborhood Code	5271-4	AIRPORT	5254-5	5299-5	5299-5	5299-5
7	Class:	Industrial	Agricultural	Agricultural	Agricultural	NON-OWNER-OCCUPIED/RESIDENTIAL	Agricultural
8	Legal Info	Lot 11-A Map 8 LCAPP 1861 11.414 AC					
9	Property Size:	11.414 acres	22.513 acres	42.313 acres	35 acres	portion of/not the whole thing (whole: 70 acres)	45.2
10	Existing Building Types & SF:	2 buildings: 1 shell/industrial, 1 retail	None	There are some buildings https://drive.google.com/file/d/1jetQ5WAYJIOtSMZAHxQ5vtyqLgaNpbbm/view?usp=share_link	None	Yes	
11	Buildable area of property:	95% (2 pre-existing buildings, parcel ends right before slope down into gulch)	100% (looks like pretty flat agri land)	98% (looks like pretty flat agri land with small buildings)	100% (looks like pretty flat agri land)	98% (looks like pretty flat agri land with 1 building)	100% (looks like pretty flat agri land)

+ ≡ 1 Site Assessment ▾ | Fesibility Study ▾ | Facilities Researched ▾ | Surveys ▾ | 'Umeke Center Tasks ▾ | UH ARCH 415 MKK Trip ▾ | Emergency Plan Task

Image description: Screen capture of the initial aggregated Site Assessments spreadsheet developed for the feasibility studies.

We created the spreadsheet shown in Table 3 to aggregate all basic information about the considered sites, which fulfilled an initial request from SM for this portion of the project. Included in and linked in the spreadsheet are packages of Google Maps screenshots, at various scales, of each site, along with packages of relevant permits for the sites from the County of Maui Property Tax Viewer. Altogether, this initial deliverable presented a springboard for further feasibility analysis on the suitability of the various sites.



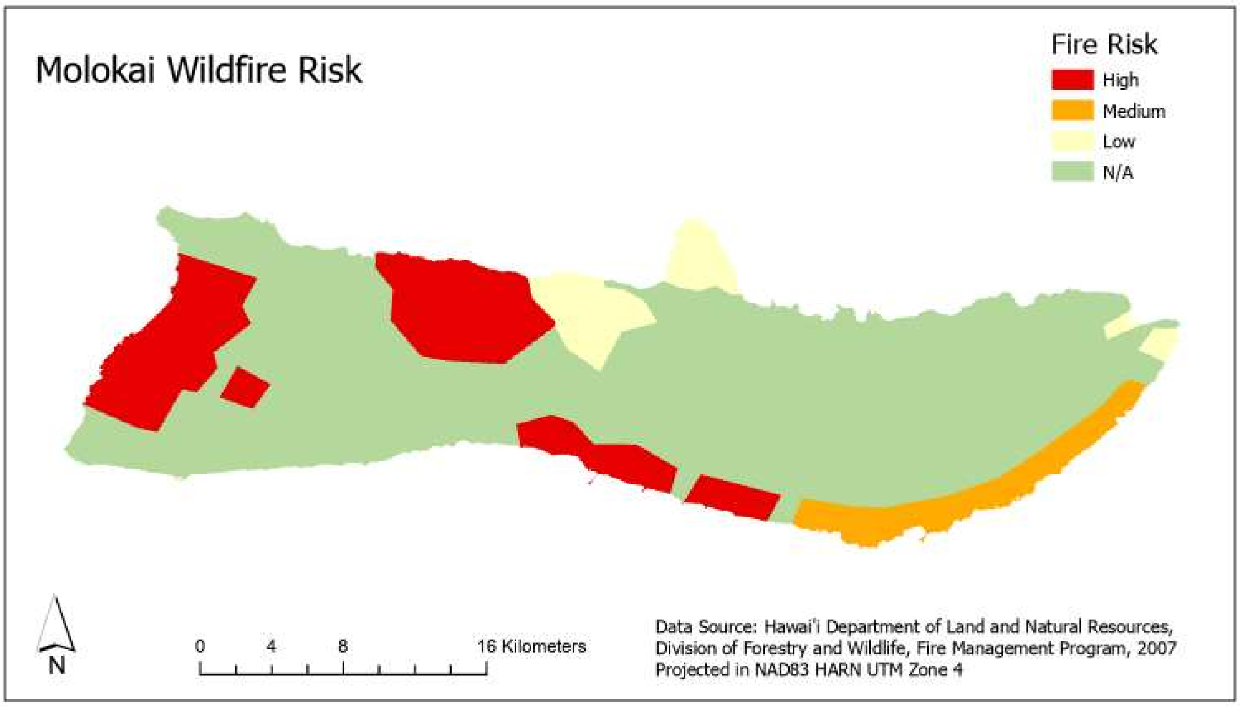
Map 1. *Current Considered Sites for the ‘Umeke ‘Ai Center on Molokai*. Pictured on the map are the 13 considered sites, visualized by assessed total value (land and buildings), and labels with the names of each site. The sites are clustered in central and northern Molokai. Parcels were hand-digitized based on the Maui County Property Tax Parcel Viewer. Map by Natasha Vatalaro, 2024.

TABLE 4. GIS Attribute Table for Map 1.

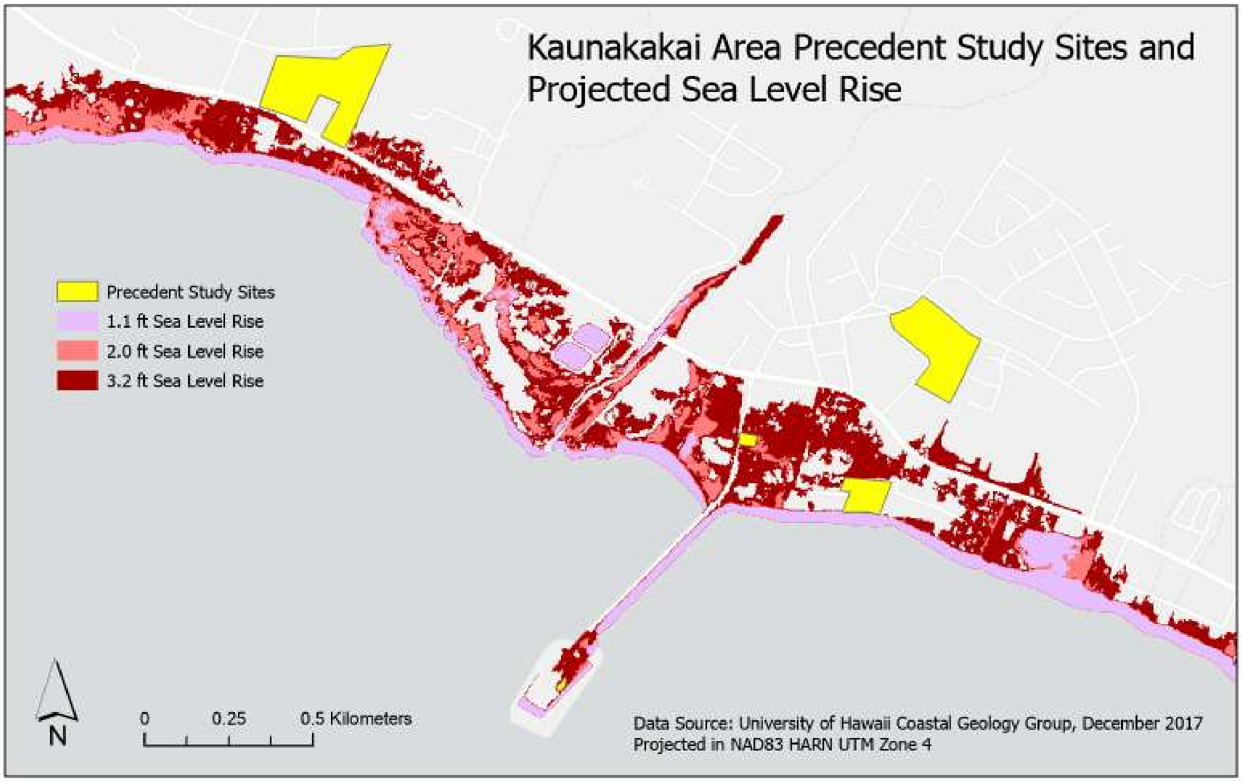
Id	Site Name	TMK	Address	Neighborhood Class	TaxClass	Pre-exist. Buildings	Assessed Value	Owners	Acres
1	Holomua Junction	520120050000	2130 MAUNALOA H	5271-4	Industrial	Yes	$1,534,000.00	Swenson, Diane L Trust	11.41399956
2	Hoolehua-DOT Airports-MKK	520040820000	MAUNALOA HWY	Airport	Agricultural	No	$731,700.00	State of Hawaii	22.51300049
3	Hoolehua Homesteads-Adjacent	520040460000	MAUNALOA HWY	5254-5	Agricultural	Yes	$507,800.00	State of Hawaii	42.31299973
4	4101 Maunaloa Hwy, Hoolehua	520010010000	4101 MAUNALOA H	5299-5	Agricultural	No	$100.00	Department of Hawaiian Homelands	35
5	Alu Like Lease	520010310000	4575 MAUNALOA H	5299-5	Non-Owner Occupied/Residential	Yes	$237,800.00	Department of Hawaiian Homelands	70
6	Unencumbered Land: Radio Tower	520010320000	MAUNALOA HWY	5299-5	Agricultural	No	$100.00	Department of Hawaiian Homelands	45.20000076
7	Meyers Land	520140020000	KALAE HWY KUAL	5754-5	Agricultural	No	$171,700.00	Miala, INC / R W Meyer LTD	1288.579956
8	Meyers Land	520140520000	AHE PL HOOLEHU	5261-8	Residential	Yes	$296,200.00	Miala, INC / R W Meyer LTD	10.97000027
9	Meyers Land	520140550000	2645 KALAE HWY	5231-5	Agricultural	Yes	$5,500.00	Miala, INC / R W Meyer LTD	34.22000122
10	Meyers Land	520140560000	KALAE HWY HOOI	5231-5	Agricultural	No	$141,500.00	Meyer, Alexander F Trust / Benjamin, Sa	8.75
11	Meyers Land	520140640000	KALAE KUALAPUL	5254-5	Agricultural	No	$6,700.00	Miala, INC / R W Meyer LTD	34.86000061
12	Meyers Land	520130190000	KALAE HWY HOOI	5254-5	Agricultural	No	$130,200.00	Miala, INC / R W Meyer LTD	3.453000069
13	Meyers Land	520130040000	2681 KALAE HWY	5241-5	Agricultural	No	$203,600.00	Miala, INC / R W Meyer LTD	11.8380003

Image description: Screen capture of the attribute table for Map 1, derived from the initial Site Assessments aggregated spreadsheet data.

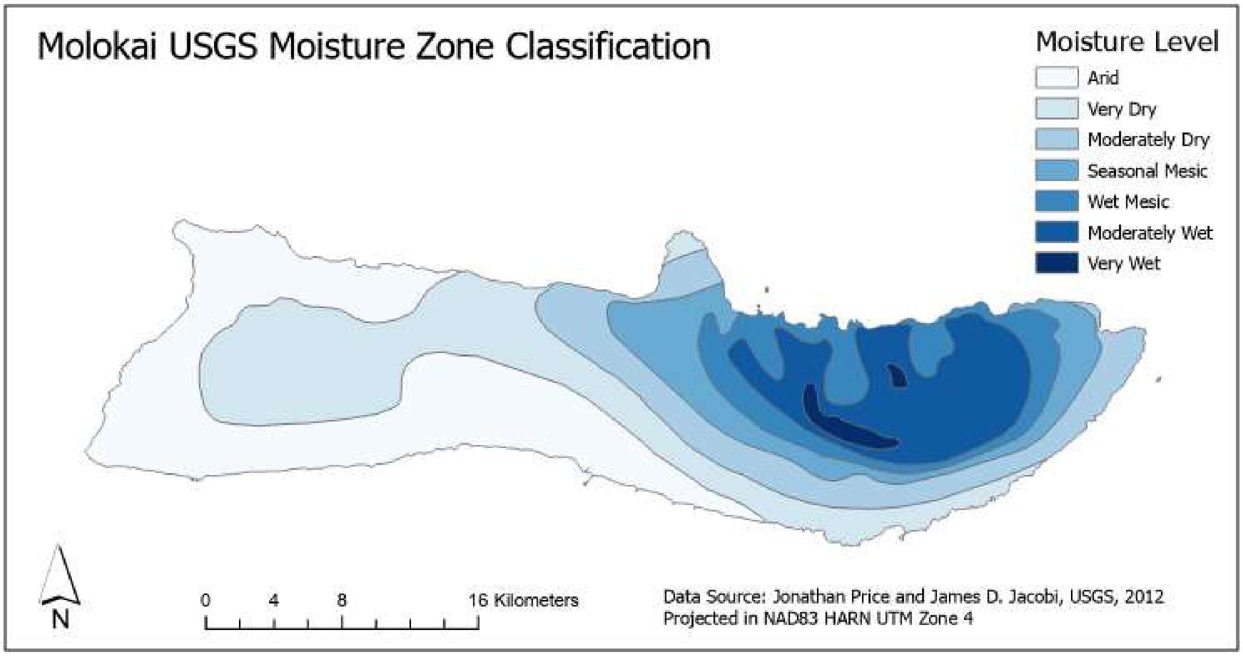
Thirteen of the primary considered sites for the center are labeled in Table 4 as they appear in the GIS map, which was derived from the initial aggregation spreadsheet (Table 3) for the site assessments. The parcels are varied, each with their own advantages and disadvantages. All of these sites and their access points are outside the reaches of sea level rise and passive flooding that might occur from climate change in order to ensure only long-term feasible sites would be considered. To further determine the feasibility of these 13 land parcels for the Center, below are the four maps showing the various “feasibility” perspectives for the various sites, including wildfire risk, projected sea level rise (with precedent study sites), moisture zones, and solar potential for the island.



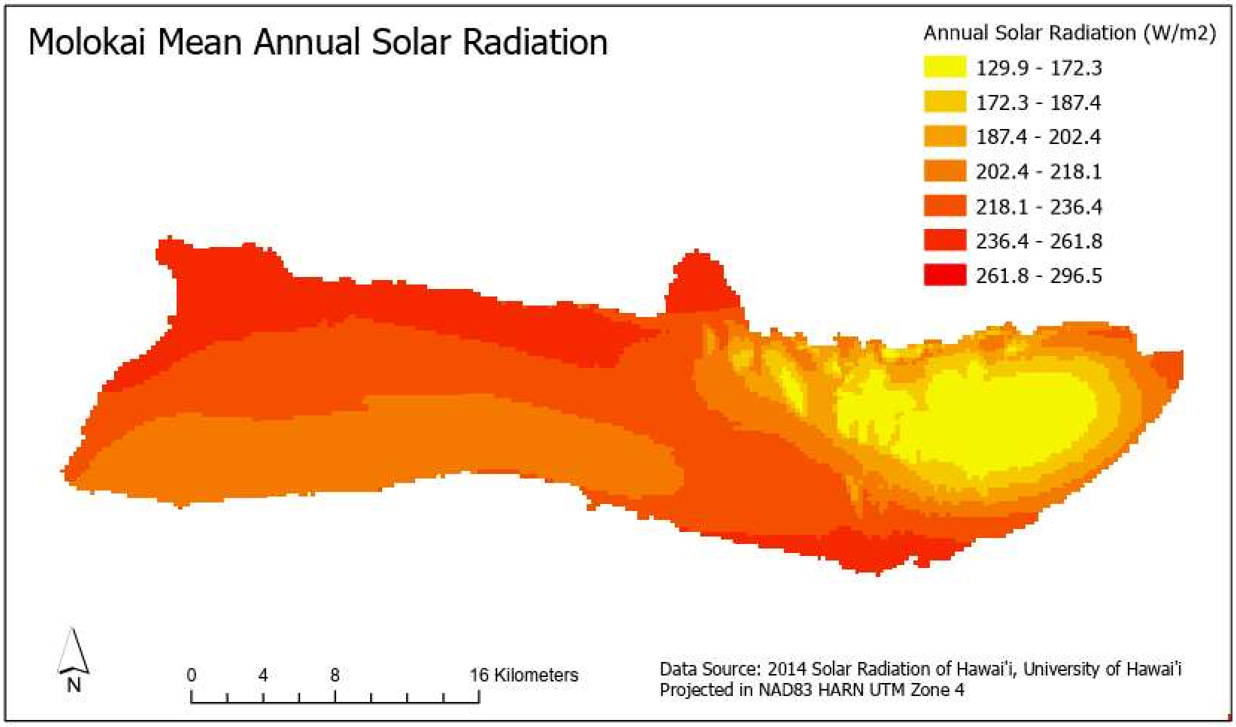
Map 2. *Molokai Wildfire Risk.* Data from the Hawai’i DLNR Fire Management Program, 2007. Map by Natasha Vatalaro, 2024.



Map 3. *Kaunakakai Area Precedent Study Sites and Projected Sea Level Rise*. Sea level rise is pictured at the town-level for a greater level of visual granularity and projected at various levels of severity based on future climate change. Precedent study sites were hand digitized, and sea level rise projection data is from the University of Hawai’i Coastal Geology Group, 2017. Map by Natasha Vatalaro, 2024.



Map 4. *Molokai USGS Moisture Zone Classification.* Moisture zones are classified by the USGS based on annual rainfall and topography, combined into a single index that allows for greater analysis of the capacity of a region to support agriculture. Data from Price and Jacobi, USGS, 2021. Map by Natasha Vatalaro, 2024.



Map 5. *Molokai Mean Annual Solar Radiation.* Solar Potential is visualized in W/m^2 for ease of energy analysis. Data from the University of Hawai’i, 2014. Map by Natasha Vatalaro, 2024.

The advantages and disadvantages of these sites will now be discussed in detail, in relation to these four maps and other feasibility considerations.

Holomua Junction

Holomua Junction was the primary site under consideration due to its active for-sale status from the onset of this project. This site, as visualized in Map 1, is ideally situated at the crossroads of Ho’olehua (the northern neighborhood of the island and the airport), the western side of the island, including Maunaloa, and the population center of Kaunakakai. It is near major roads and highways, granting it easy access to the highest number of people; it also has pre-existing buildings and industrial zoning, and it is near SM’s ideal 12-acre “minimum” parcel size. Holomua Junction is not in a fire risk zone, and it receives adequate insolation for effective solar panel use. The site also has a view of the caldera and the ocean from certain vantage points, which, while merely an aesthetic advantage, could lend the site well to any future for-profit ventures potentially implemented in the Center.

Photo 1. *View of Holomua Junction and Current Buildings On Site.* By Natasha Vatalaro, 2023.

However, Holomua Junction’s high price and historic zoning changes have made it a difficult land parcel to purchase, despite its availability. This site is by far the most expensive of any of the considered sites, and with the least acreage, as visualized in Map 1. According to internal SM analysis, water hookups are not accessible for the site, making any development of a food hub that requires water difficult. Additionally, the site is in an “arid” moisture zone, which could limit the type of plants that could be grown or increase irrigation costs. Given these difficulties, Holomua Junction has fallen from a first-priority site to an unlikely candidate for ‘Umeke ‘Ai going into the next stage of development.

Airport and Homestead Sites

The next primary sites under consideration are two sites near the Molokai Airport (IDs 2 and 3 from Table 4). Both of these sites are zoned as agricultural land, which would ease the development of a demo farm and other aspects of the food hub, and are owned by the State of Hawaiʻi. They are both assessed at roughly between $500,000—$730,000, and are 42 acres and 22 acres, respectively—significantly less expensive per acre than Holomua Junction, and with much more room for the resilience center to expand and truly capitalize on its many desired functions.

The 42 acre site does have pre-existing buildings in the form of homesteads adjacent to the land parcel. The proximity of these homesteads to the parcels could be both advantageous and disadvantageous: the homesteads primarily consist of Indigenous families living off-grid, working as subsistence farmers—exactly the members of the community that ‘Umeke ‘Ai hopes to aid with its commercial kitchens, food bank capacity, renewable microgrid, community center, and business development opportunities. However, homesteaders may not necessarily want a resilience center bringing traffic and people from all over the island into their backyards, in addition to the razing of some of the short forest that currently resides on the sites in order to make way for the development. Additionally, the site closest to the airport may face permitting issues due to Department of Transportation objections to the resilience center being so nearby, potentially blocking future development of the airport, but conversely, an emergency hub located near the airport may be the best placement for such a building, and would be the first thing those flying into the island would see. These sites are in a high fire risk zone due to their position in arid or very dry moisture zones; due to the same sun, they would be ideally placed for solar panel energy maximization. These parcels are not currently for sale and any purchase would need to be negotiated with the state.

“Unnamed” sites

Two of the “unnamed” sites are the next parcels under consideration: 4101 Maunaloa Hwy and the “Unencumbered Land: Radio Tower” parcel (IDs 4 and 6 from Table 4). These sites are both zoned as agricultural land and are owned by the Department of Hawaiian Homelands, bringing them down to only $100 per site. They are approximately 35 and 45 acres, respectively; more than enough land to develop a demo farm, microgrid, and a number of buildings, with room to grow. The sites are ideally suited in medium to high solar intensity zones and would be good candidates for solar power, and they are centrally located on Maunaloa Highway, making them easily accessible to community members. They are largely in a low risk fire zone, although they are on the edge of a high risk fire zone, which could edge toward these sites in future years as climate change continues to exacerbate precipitation changes. These parcels are in “arid” to “very dry” moisture zones, which could limit the type and amount of vegetation and produce that could be grown at the Center.

Although the DHHL’s homesteading program for Native Hawaiians could grant opportunities to help develop ‘Umeke ‘Ai, the department’s history of waitlisting and revoking homestead leases could bring uncertainty to the overall desired longevity of the ‘Umeke ‘Ai project, although the department may be seeing some progress on resolving this issue going forward (Andrade, 2022). Similar to these sites and very close to them is the Alu Like Lease site, which is also being considered and is up for a potential lease, and is more available than the DHHL sites. Alu Like is zoned as non-owner occupied and residential, which could pose problems in terms of industrial or agricultural development.

Overall, these sites are low-cost and would be well-suited for development expansion, some native plant agriculture, and solar energy generation, but less than ideal in terms of probable site retention and ownership, extensive agriculture, water access, and zoning for industry, gathering spaces, or for-profit attachments to the Center.

Meyer Family Land

The last eight considered sites are land parcels owned by various subsidiaries of the Meyer family, a large land-owning family on Molokai that has influenced much of the island’s recent history (Graham, 2018). These sites are primarily on the north end of the island between Ho’olehua and Kalaupapa. Given that Kalaupapa is inaccessible, the Meyer lands under consideration are relatively far away from most populated areas of the island, apart from Ho’olehua, and consist primarily of forested swaths of land. The parcels are zoned as agricultural and are located in “seasonal mesic” moisture zones, making them ideal for sustainable agriculture and food production. These sites also receive enough insolation for high solar power capacity and have moderate wind power capacity. The assessed land value ranges from as little as $5,500 to as much as $296,000, depending on the pre-existing buildings, road access, size, and proximity to Ho’olehua, indicating these sites could be affordable, pending the right grants and funding sources to purchase the land.

The main drawback of these sites is that due to their private ownership, there is no guarantee these sites could be made available, whether through leases or outright purchase. And if sites were leased to SM by subsidiaries of the Meyer land holdings, there is no guarantee those leases would be permanent. Additionally, much of these sites are covered in medium-growth forests and varying terrain, much of it without road or trail access; flat land immediately available for development is not guaranteed, and a significant initial investment would need to be put toward preparing these sites for the development ‘Umeke ‘Ai would require.

The below photos provide various views of the varying terrain of the Meyer land sites.

Photo 2. *Stretch of Meyer Land, with Lake*. Photo by Ben Krueger, 2023.

Photo 3. *Meyer Lands by the Cliffs of Northern Molokai.* Photo by Ben Krueger, 2023.

Photo 4. *Meyer Lands by the Cliffs of Northern Molokai, Wide View.* Photo by L’Oreal Hawkes-Williams, 2023.

Photo 5. *Example of Forested Vegetation Prevalent on Meyer Lands in Northern Molokai, Taken on the Meyer-owned Mule Ranch.* Photo by L’Oreal Hawkes-Williams, 2023.

Photo 6. *View of Kalaupapa from Meyer-owned Lands near Ho’olehua.* Photo by Ben Krueger, 2023.

Site Selection Outlook

There is no “perfect” site for ‘Umeke ‘Ai on Molokai; each suitable parcel has its own advantages and disadvantages. The current position of precedent study sites in high-risk areas underscores the need for ‘Umeke ‘Ai to be as ideally situated as possible for future climate change as well as ensured continuous community access to services. Common tradeoffs with the considered sites, such as exchanging a low price for high government involvement, high moisture availability for low solar capacity, high price for current market availability, proximity to town centers for proximity to rural homesteaders in need of community services, and overall zoning limitations could prevent ‘Umeke ‘Ai from reaching its full potential on any of these various sites if feasibility is not carefully considered. Since Holomua Junction, previously considered to be the most desirable site due to its immediate purchasing availability, is no longer considered suitable due to its lack of water and utility access, other sites from this assessment must now be equally considered.

In general, outright land purchase may simply not be possible for this project, at least initially, due to the for-sale status, or lack thereof, of each property. If leases are to be considered for this project, a strong contract would need to be negotiated between SM and the leasing party in order to ensure the longevity of the Center at that site. Based on this report’s analysis, a lease on the Alu Like, airport-adjacent, or Meyer land sites may be the current best option for ‘Umeke ‘Ai’s development and future expansion, depending on overall lease options and zoning flexibility for the various sites.

Ensuring the longevity of geospatial data demonstrating this site assessment and overall feasibility study is also important for the ‘Umeke ‘Ai project, and will assist with future community communications about the Center. The maps developed for this site assessment will be passed on to SM and groups continuing this work on Molokai for further development, community engagement work, and supporting future geospatial data development on Molokai. There is also potential for future spatial analysis to build on the Web App created here (https://umich.maps.arcgis.com/home/item.html?id=1efdac0c953f4cf3a744419ea91680b8#overview) by adding more layers to the source Web Map, or by creating a Story Map based on this overall analysis to bolster communications about the project going forward.

As of April of 2024, SM has secured federal funding of $1.3 million toward the purchase of a site for ‘Umeke ‘Ai within the next year. This funding more than covers the expected price of all of the sites analyzed here and ensures cost will not be a significant barrier toward the progression of site selection for this project, allowing overall feasibility and suitability for the project’s many needs to be the deciding factor in SM’s decision.

Chapter V. Energy Analysis

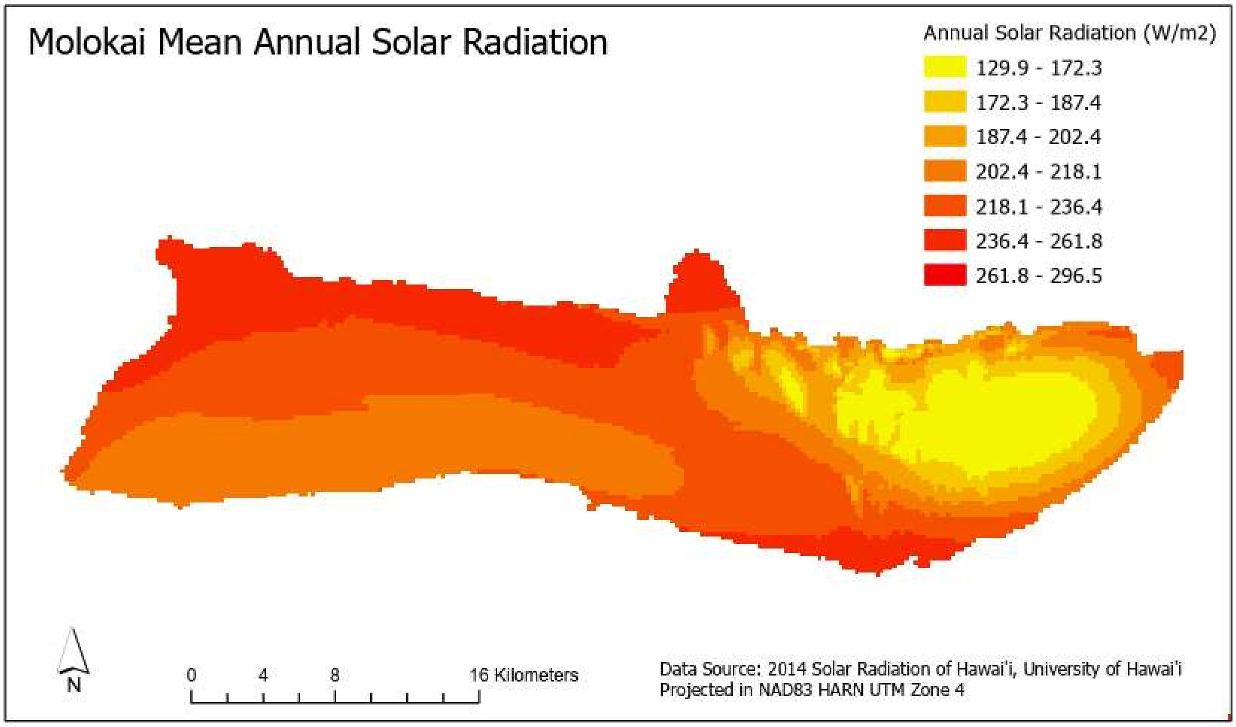
One recurring theme and aim for the ‘Umeke ‘Ai Center is its capability to be energy independent while utilizing the available renewable energy resources on island. Not only would this be a sustainable way to design the infrastructure with a low operating carbon footprint, but it would also serve as an inspiration and role model for other Hawaiian islands to follow on their respective sustainability journeys.

Even though a detailed engineering design study would be necessary in the latter stages of the project, we sought to provide a high-level assessment of what is possible for such a development. Providing insight into what the potential energy demand of the facility is, as well as pairing it with an economically and environmentally sustainable energy system design, are some of the key considerations we hope SM would benefit from as they move forward with the project.

Methods

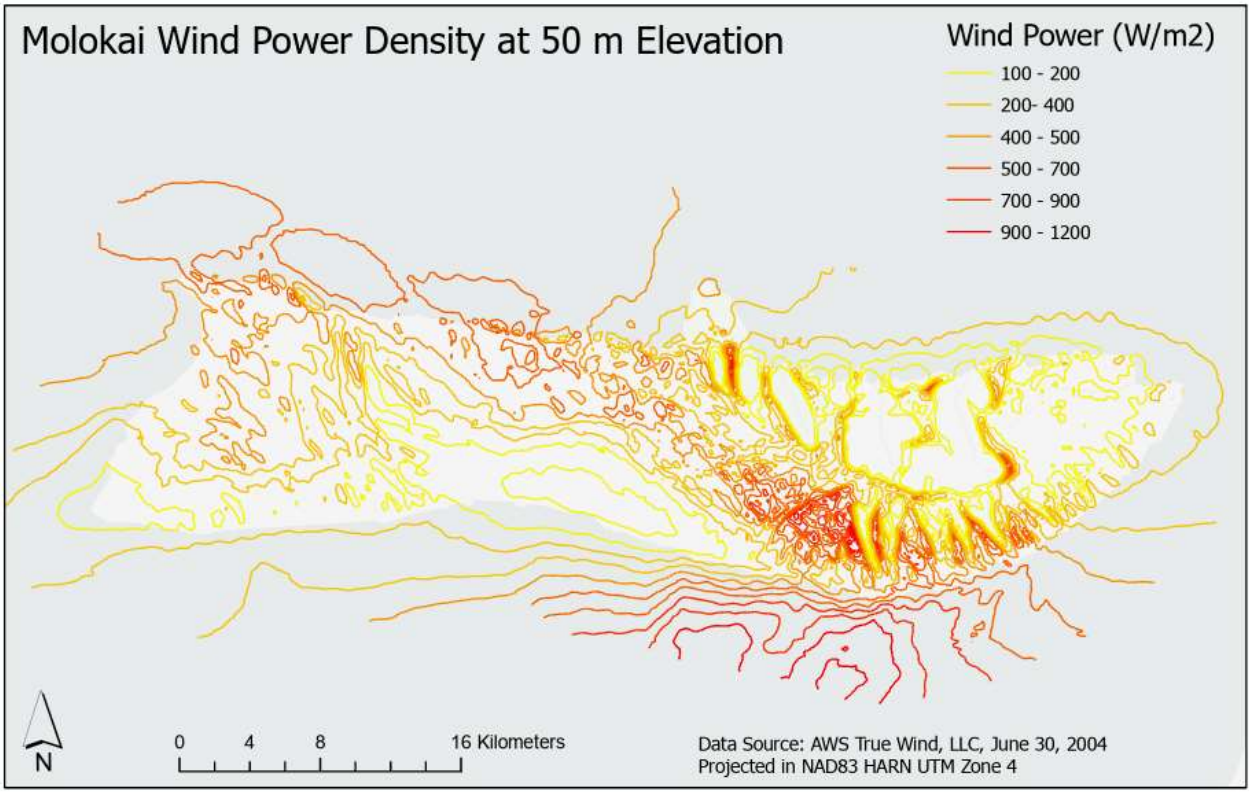
Renewable Energy Resource Study

Knowing which renewable energy technology we can incorporate into the system design of the ‘Umeke ‘Ai Center would mainly depend on the availability of renewable energy resources on the island. Without adequate solar or wind resources, it would be hard to build an economic justification for using these clean energy technologies. The map below shows the availability of annual solar radiation (W/m2) in Molokai. We can see that the majority of the island receives good annual solar radiation of over 180 W/m2. This graphic representation shows us that siting the ‘Umeke ‘Ai in Eastern Molokai may not be a good idea because, among other reasons, it receives much less solar radiation compared to other parts of the island due to its windward position.



Map 5.1. *Molokai Mean Annual Solar Radiation,* a copy of Map 5 from Chapter V: Site Assessments; Description of Deliverables. Map 5 is reposted here for ease of reference with Map 6 and relevance to the following energy analysis.

The wind map below, on the other hand, shows that wind resources are greater in the southeast side of Molokai (roughly around 500 W/m2 at the 50m height) compared to the rest of the island. Generally, however, the map shows somewhat of a poor potential for wind overall. The wind energy potential for offshore wind may be more significant, but building offshore wind energy infrastructure might prove to be challenging, at least at present, due to land rights and funding issues. Additionally, the renewable energy source will ideally be sited in the same location as ‘Umeke ‘Ai, and based on the potential sites being considered, the available wind resource there may be insufficient to support the Center’s energy needs.



Map 6. *Molokai Wind Power Density at 50m Elevation. Wind power visualized in W/m^2 for future energy analysis. Data from AWS TrueWind, LLC, 2004. Map by Natasha Vatalaro, 2024.*

While there are other renewable energy resources worth looking into such as hydropower, geothermal, tidal, or other ocean-related resources, we decided to focus on those that are more easily accessible and less complex to explore and implement for a facility such as ‘Umeke ‘Ai. For geothermal alone, it would take a tremendous amount of money and engineering efforts to explore its feasibility. We believe that this holistic renewable energy planning is better suited to the efforts being done by the Clean Energy Hui for the whole of Molokai, as compared to the standalone project of the ‘Umeke ‘Ai Center.

After determining that solar is the most likely feasible renewable energy resource for the ‘Umeke ‘Ai given its high resource concentration in the areas SM is considering, we transitioned into modeling what the solar PV system might look like to support most (if not all) of the facility’s estimated energy demand.

Energy Demand Modeling

The first step was to model the energy demand profile of the ‘Umeke ‘Ai Center. We did this by utilizing the project brief provided by Sust’āinable Molokai, as well as prior work done by architecture students from the University of Hawaiʻi. Although there are several options of where to site the ‘Umeke ‘Ai Center, the program brief was designed based on a parcel with a more complex site layout, which is a small land parcel adjacent to the Molokai Airport (and is not currently under consideration in the shortlist of considered sites). Some of the design concepts that we took inspiration from are the works of then students Airon Castaneda, Desiree Joy Malabed, and Thanh Nguyen, which have been archived and retained for planning purposes by SM.

Figure 8. *Food Hub Avenue Poster.* Designed by Airon Castaneda from University of Hawaiʻi. 2022.

Figure 9. ‘*Umeke ‘Ai Center Poster*. Designed by Desiree Joy Malabed from University of Hawaiʻi. 2022.

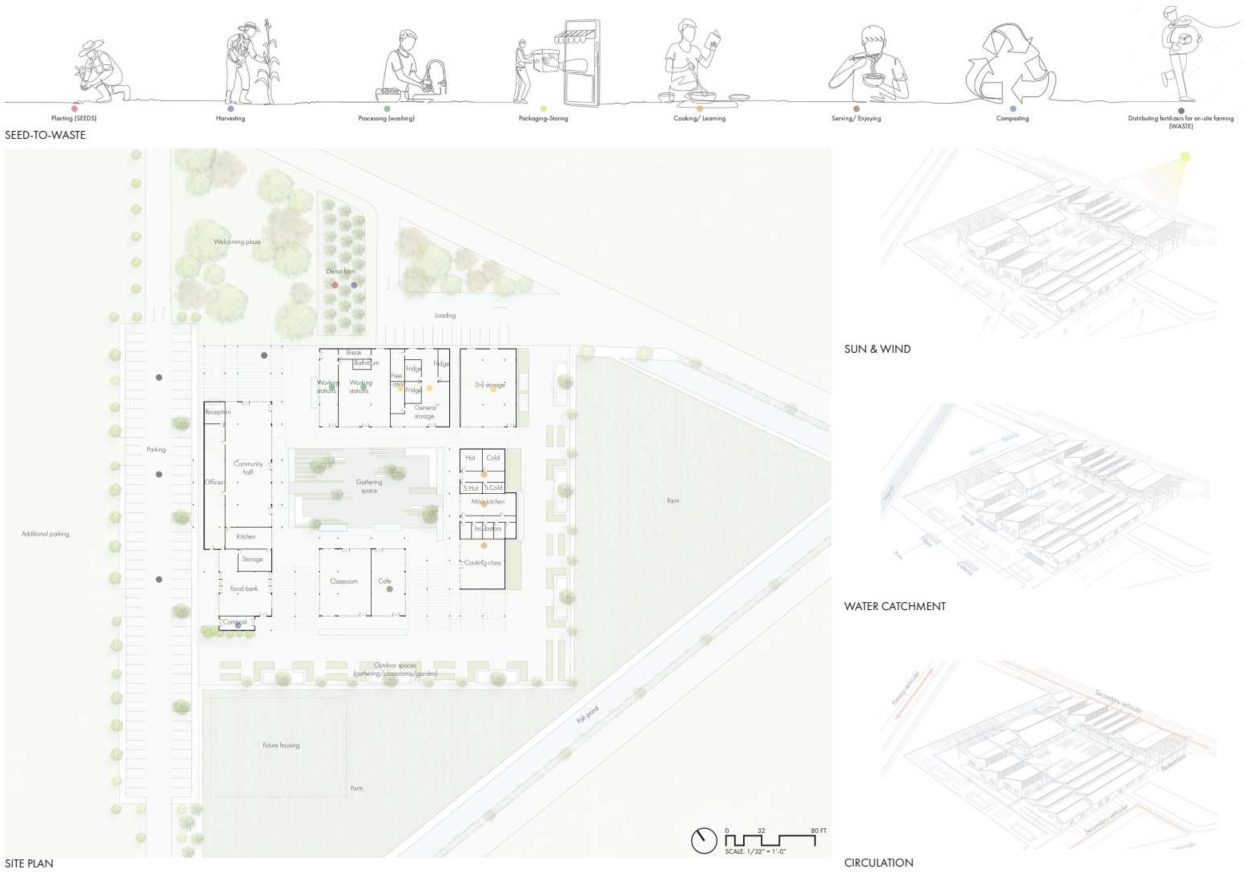


Figure 10. *Seed-to-Waste Center Poster.* Designed by Thanh Nguyen from University of Hawaiʻi. 2022.

The program brief for the studio design class involved incorporating several different functional spaces detailed in the table below and green design principles SM wanted the site to have. These include water catchment systems, solar PV systems, demo farms, community gardens, green spaces, and open working spaces.

TABLE 5. ʻUmeke ʻAi Center Sections and Land Areas

Section	**Size** (sq ft)
Food Hub	10,000
Community Center	8,000
Food Bank	3,000
Certified Kitchen	2,000

Offices	3,000
Cafe / Storefront	1,000
Molokai Arts Center	2,000
TOTAL	**29,000**

For each of these individual spaces, electricity consumption for air conditioning, lighting, and hot water heating were modeled by our team using a set of basic fixed assumptions. For air conditioning, a centralized air cooling technology was used, which has a power rating of 3.5kW for a 2,000 sq ft space (IT Landes Home Service, 2021). For lighting and hot water heating, the Department of Energy estimates an annual energy consumption of 7 kWh and 0.5 kWh per square foot per year, respectively (Twinview, 2021). Additional electricity consumption modeled specific to each of the spaces include different equipment like refrigerators and freezers, pantry and kitchen appliances, and office and multimedia equipment. The full list, specifications, and assumptions are all detailed in the Appendix, but below is a snippet showing how the spreadsheet is laid out.

TABLE 6. Projected Energy Load Analysis

	Specs	Capacity (W)	Hours/Day	Qty	Energy/Yr (kWh)
		149,879			**671,571**
Food Hub	**10,000 sqft**				
Space					
Airconditioning	3.5kW / 2,000sqft	17,500	*10*	*1*	63,875
Lighting	7kWh / sqft / year	15,982	*12*	*1*	70,000
Hot Water	0.5kWh / sqft / year	1,370	*10*	*1*	5,000
Equipment					
Freezer Refrigerator	25.5 cuft; 562kWh/yr	128	*24*	*2*	1,124
Commercial Freezer	1.5 HP or 1105 W	1,105	*24*	*1*	9,680
Reefer Storage	3kW / 18ft x 20ft	9,000	*24*	*3*	78,840
Outside Reefer (Mobile)	110V * 15A = 1.65 kW / 6'x16' mobile / 37.5sqft	1,650	*24*	*1*	14,454
Subtotal		**46,735**			**242,973**
Food Bank	**3,000 sqft**				
Space					
Airconditioning	3.5kW / 2,000sqft	5,250	*10*	*1*	19,163
Lighting	7kWh / sqft / year	4,795	*12*	*1*	21,000
Hot Water	0.5kWh / sqft / year	411	*10*	*1*	1,500
Equipment					0
Commercial Refrigerator	0.5 HP or 368 W	736	*24*	*2*	6,447
Commercial Freezer	1.5 HP or 1105 W	1,105	*24*	*1*	9,680
Walk-In Wholesale Reefer	$15-20 K installed	3,000	*24*	*1*	26,280
Subtotal		**15,296**			**84,070**

Image description: Screen capture of the energy load analysis spreadsheet done for the different sections of the ‘Umeke ‘Ai Center.

Knowing the capacity for each of these, we calculated the annual energy consumption using the energy formula below:

$$Annual\ Energy\ Consumption\ (kWh) = Power\ Rating\ (kW) * Time\ Used\ per\ year\ (hrs)$$

With this information, we used the National Renewable Energy Laboratory’s (NREL) REopt web tool to simulate how we can utilize renewable energy to supply the ‘Umeke ‘Ai’s electricity needs. REopt is a simple yet comprehensive tool to evaluate the economic viability of several energy technologies (distributed PV, battery, wind, CHP, etc.) and identify system sizing to minimize energy costs.

Renewable Energy Simulation

We can model the ‘Umeke ‘Ai Center in two ways: 1) as a single site and 2) as a portfolio of different sites. A single site analysis would be more comprehensive and can include a resiliency evaluation, taking electricity outages and critical loads into account. This is in line with the desire for the facility to still be able to perform critical functions related to food preservation during recurrent grid outages. Meanwhile, a portfolio analysis would reflect a more accurate load profile for each of the different functioning sections of the ‘Umeke ‘Ai, as we know that each section’s load profile behaves differently. For example, the food bank portion might have a load profile similar to that of a retail store running closer to 24/7 in operation, while the office space and conference rooms reflects an 8am to 5pm weekday load profile.

For the purpose of providing a more high-level insight and a bigger picture to SM, we decided to perform a single site analysis. Table 7 shows the input parameters we used to run the model using available information and assumptions from the conversations with and inputs from Sust’āinable Molokai. The rest of the parameters not shown in the table were supplied with NREL’s default values.

TABLE 7.1. REopt Input Parameters

Energy Goals	
Cost-Savings $	Resilience	Clean Energy

Technologies Selected		
PV	Battery	Generator

Site and Utility	
Site name	'Umeke 'Ai Center
Site Location	Kaunakakai, HI, USA (21.0909869, -157.0186282)
PV & wind space available	Land & roofspace
Land available (acres)	0
Roofspace available (sq ft)	29,000
URDB rate	Maui Electric Co Ltd - Molokai-SCHEDULE "J" General Service Demand-Single Phase

Load Profile	
Typical electric load profile type	simulated building
Type of building	Office - Medium
Annual electric energy consumption (kWh)	672,000

Image description: Screen capture of the custom input parameters for the simulated REopt model (part 1 of 2).

TABLE 7.2. REopt Input Parameters (cont.)

Clean Energy Goals	
Clean energy target	renewable electricity
PV	
System capital cost ($/kW-DC)	2400.0
Array type	Rooftop, Fixed
MACRS bonus depreciation	80%
Battery	
Allow grid to charge battery	No
MACRS bonus depreciation	80%
Emergency Generator	
Diesel cost ($/gal)	$5.70
Resilience	
Number of Outages	4
Custom Multiple Outage Dates	true
Outage start date	Aug 21
Outage start time	3 pm
Outage duration (hours)	3
Outage Start Hours	August 16 (12 pm), October 16 (12 pm), December 16 (12 pm), and February 15 (12 pm)
Critical load profile type	Percent
Critical load factor	30.0%

Image description: Screen capture of the custom input parameters for the simulated REopt model (part 2 of 2).

The system limitation we included is based on the total square footage area of the different sections of the ‘Umeke ‘Ai Center. We ran the analysis considering only rooftop PV to see whether that would be enough to supply the facility’s energy demand. Otherwise, we would run another analysis and allocate some portion of land for ground-mounted PV. Another key assumption here is the electricity rate to be used, which is Maui Electric Co Ltd: Molokai-SCHEDULE “J” General Service Demand-Single Phase. This is based on Hawaiian Electric’s rates schedule for facilities with electricity demand exceeding 5,000 kWh per month (Maui Electric Company, Limited, 2019). We also used feedback from Sust’āinable Molokai staff to determine common outage periods, which are during the rainy season from August to

February around midday lasting for 3 hours usually. Another major assumption is the system capital cost for PV, which we took as $2.4/W-DC ($3.39/W-DC less the 30% federal tax credit incentive) (Neumeister, 2024). For the generator and battery capital and system costs, we used NREL’s default values. For the emergency generator’s diesel cost, however, we assumed a price of $5.7/gal (Pactol, 2022). The capital costs will ultimately vary depending on the RFPs Sust’āinable Molokai receives during the more advanced stages of the project.

Optimized System Sizing

Running NREL’s REopt model, we have determined the optimized sizing of the PV + battery system to include a 290 kWdc set of PV modules and a 65 kW-power battery system with 361 kWh energy capacity. The PV size is recommended to minimize the life cycle cost of energy at the site, while the battery size is optimized for economic performance. It’s worth noting that these optimized system sizes may not be commercially available and it’s recommended that Sust’āinable Molokai find a commercial product that is close to these optimized sizes.

TABLE 8. REopt Optimized Case System Sizing

Distributed Energy Resources	Total nameplate capacity (Optimized)	Number of units	Nameplate capacity per unit	Total nameplate capacity
Emergency Generator (kW)	0 kW	1	0 kW	0 kW
Battery Power (kW)	65 kW	1	65 kW	65 kW
Battery Energy (kWh)	361 kWh	1	361 kWh	361 kWh
PV (kW DC)	290 kW DC	1	290 kW DC	290 kW DC

Image description: Screen capture of the system sizing summary of the optimized case generated using REopt.

Another item of note is that even though we included an emergency generator in the analysis parameters, the optimized size is 0 kW because the model deemed that there was no need for it. During the indicated outage periods and frequency of 3 hours midday during the rainy months, the model simulated that the solar + battery system is able to power the critical load, assumed at 30% of the capacity, which represents the refrigerators, freezers, and other equipment that need to be run with no interruptions. This can further be visualized in the one-week load profile of the system. However, an emergency generator could still be beneficial for SM to consider for the Center in case of longer outages (for instance, in the case of an extreme storm).

The load profile below is that of a typical week in the summer in Kaunakakai, Molokai. Figure 11 demonstrates the electric load changes between days of the week (weekend/weekday) depending on the activity level in the facility. For the system’s typical diurnal behavior: in the early morning, where the sun has not risen yet, the grid is powering the facility. Even though the battery is not yet fully depleted, it makes economic sense to obtain electricity from the grid during those off-peak periods, potentially because of cheaper rates. When the PV system starts generating electricity around 6 in the morning, the battery and the PVs start to power the facility. Around 9am to 3pm, where there is excess solar energy, the system uses this excess energy to charge the battery (orange). In the afternoon, when the sun has set, the battery starts to kick in until such time when it’s more economical to get electricity from the grid. During the weekends, on the other hand, when electricity load is quite low because of minimal projected activity in most areas of the ‘Umeke ‘Ai, we curtail some of the excess solar energy, as represented by the yellow area.

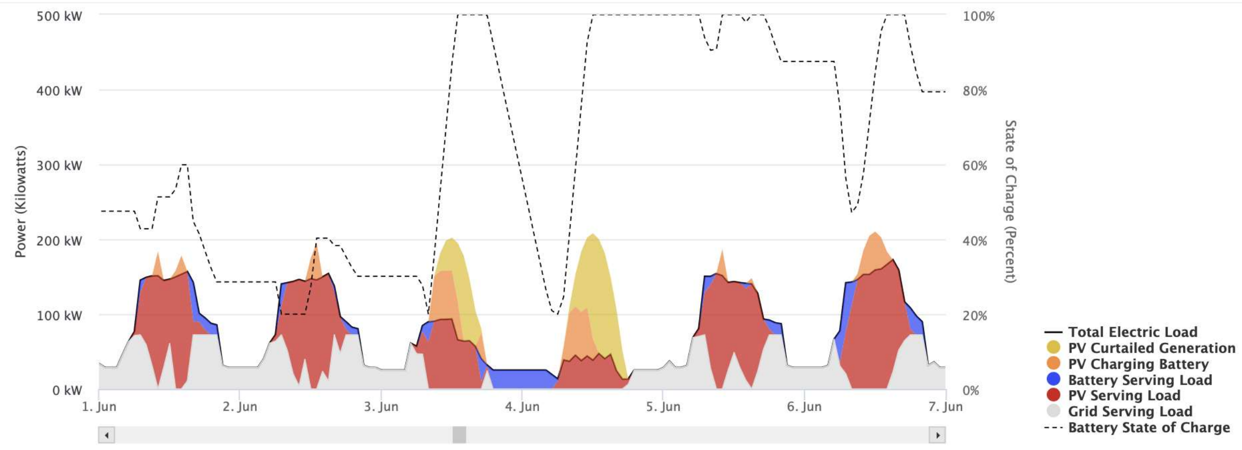


Figure 11. *Simulated Optimized Case Energy Load Profile.* NREL REopt. 2024.

Unlike the load curve, where the load is shown chronologically, the net load duration curve below in Figure 12 shows the duration of a certain load at the site. In the BAU case (gray), we can see that for a short period of time (a few hours), the peak load of the site is at around 190 kW. However, the majority of the time (shown as the flatter tail portion of the graph), the load is between 30-40 kW. Generally, the steeper the curve, the “peakier” the load is. The optimized case (blue), on the other hand, seems to represent a smaller and flatter curve, which means that it has less peak demand throughout the year, as well as lower peak load overall. This scenario would put much less strain on the current grid infrastructure in Molokai, eliminating the need to dispatch more costly peak plants for short periods of time.

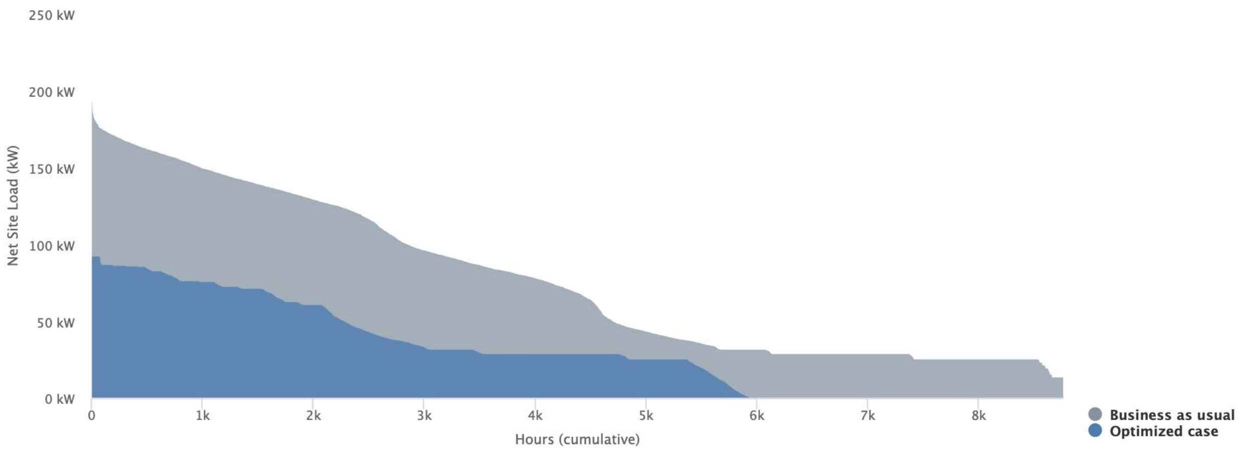


Figure 12. *Simulated Optimized Case Net Load Duration Curve*. NREL REopt. 2024.

Incorporating solar PV and battery storage in the ‘Umeke ‘Ai center provides not only some level of energy security for the facility, but it also generates environmental, health, and economic benefits. Table 9 summarizes a comparison on key performance metrics between the business as usual case, where the facility’s energy demand would be sourced solely from the grid, and the optimized case using the PV and battery solution. Annual energy consumption from the grid decreased by 59.8% with PV and storage, with the same proportional decrease in CO2, NOx, and SO2 emissions. With an upfront capital cost of $919,174 (before tax credit incentives) and $643,422 (after 30% tax credit incentives), the PV + battery solution expects a 23% IRR (return on investment), 3.63 years payback, and a Net Present Value of $1,207,975 for the whole 25 year modeled lifetime of the project.

TABLE 9. Simulated Optimized Case Performance Metrics

Parameter	BAU Case	Optimized Case

Average Annual PV Energy Production	0 kWh	456,883 kWh
Average Annual Energy Supplied from Grid	672,000 kWh	270,239 kWh
CO_2 Emissions throughout Analysis Period	10,115 tonnes	4,068 tonnes
NO_x Emissions throughout Analysis Period	68.56 tonnes	27.57 tonnes
SO_2 Emissions throughout Analysis Period	25.55 tonnes	10.28 tonnes
Cost of Climate Emissions throughout Analysis Period	$408,593	$164,312
Total Upfront Capital Cost, Before Incentives	$0	$919,174
Year 1 O&M Cost, Before Tax	$0	$5,220
Total Lifecycle Cost	$3,050,242	$1,842,268
Net Present Value (NPV)	$0	$1,202,975
Payback Period	0 years	3.63 years
Internal Rate of Return (IRR)	0%	23%

Outlook and Recommendations

Even though this model represents a very high-level overview of what the facility might look like in terms of energy demand and cost using either just the current grid or renewable energy (and its required capital cost), it is definitely promising. The high IRR and short payback period can be attributed to the tax credit incentives. If fully maximized, this solution reduces capital costs significantly for the Center's energy needs. However, further research is needed to ensure these tax credit incentives can be maximized, especially as national climate policy continues to shift. Another economic benefit is the large savings from the high electricity rates in Hawaiʻi, and especially Molokai, that can be displaced with the introduction of renewable energy technologies.

As a potential follow-up to this study, a portfolio analysis could be performed using similar assumptions as those in this REopt model but with the different areas of the ‘Umeke ‘Ai center treated as separate sites and selecting a different building type for each, reflecting more of their specific expected load profiles. More information about the expected usage for each of the sections of ‘Umeke ‘Ai will be necessary to perform this analysis. Moreover, performing other forms of analyses such as the feasibility of going fully renewable or incorporating small to medium scale wind might be worth looking into.

Chapter VI. Integrated Greywater and Rainwater Catchment Potential

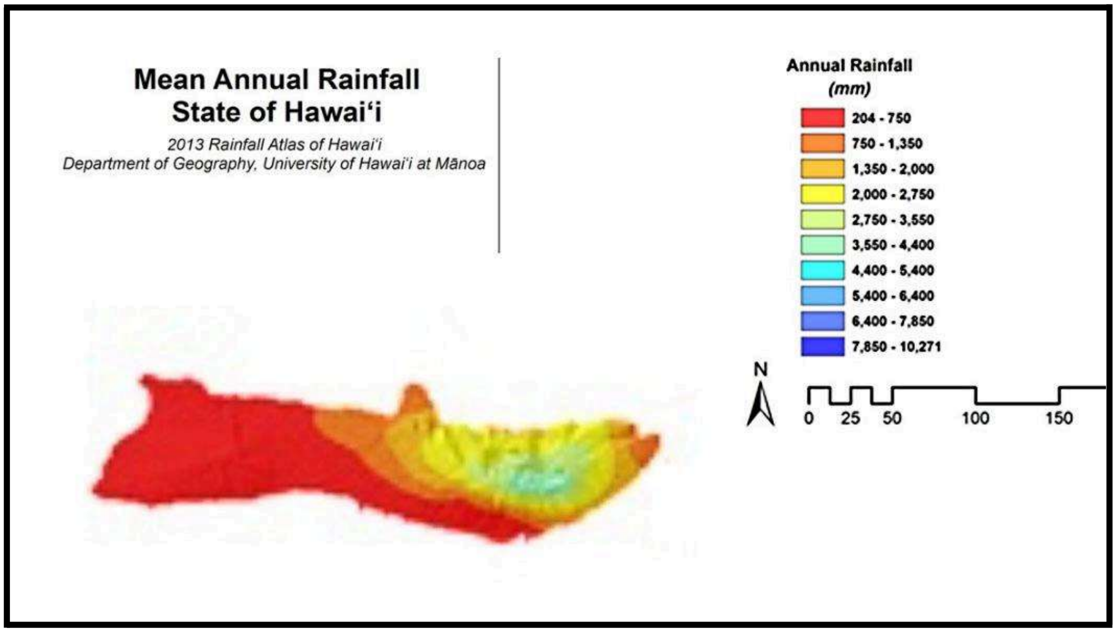
Historically, Native Hawaiians practiced a complex land use system that ensured access to natural resources was available for all peoples regardless of their social status. To honor this history, our team carefully evaluated opportunities to preserve and protect environmental resources. Water use is a major concern for the future resiliency hub because much is needed to run the facility as well as irrigate any potential crops and landscaping on the site. Access to clean potable water is vital to any community and with climate change bringing more intense storms with the potential for flooding and droughts, it is important to consider innovative solutions while in the design process. Natural resource conservation is one of SM’s priorities, particularly with concern to climate adaptation practices, and has begun testing various means of fresh water procurement. One of these includes an air-to-water generator (AWG) which draws water vapor from the air (Cattani et al., 2021). AWG technology is currently being used in SM’s mobile market trailer and generates a consistent source of water to be used in the trailer’s water cold storage for locally grown foods. SM hopes that this model will serve as a prototype to inspire residents to implement AWG technology in their own spaces to advance their everyday and emergency resiliency.

Methods

In the initial stage of developing ‘Umeke ‘Ai, SM created a needs assessment report that included their desired features for the eventual resiliency hub. The need for a green building, including LEED certified or living buildings, ranked quite high in the assessment, which also included a need for a water reuse system. To fulfill this requirement, our team analyzed greywater systems to determine whether it would be a good fit for the final ‘Umeke ‘Ai Center. This process included an evaluation of the water catchment potential of greywater and rain harvesting systems and the impact on decreased dependence on traditional water sources would have on the surrounding environment. Specifically, we researched calculations for rainwater harvesting and greywater discharge, storage, system requirements, costs analysis, tolerant vegetation, and an analysis of model water conservation systems.

For our rain harvesting assessment, we started by looking at moisture zones (Map 4) and annual rainfall totals (Table 14) to estimate water availability at the proposed site locations. We utilized data from ESRI ArcGIS data for moisture data on the island, the Rainfall Atlas of Hawaiʻi, and GIS moisture maps created by team member Natasha Vatalaro to create a table that incorporated the site location, annual mean rainfall, and zone. Based on the site assessments, there is a wide variation in moisture levels from the east side of the island to the west side. Of the 20 locations that were chosen for potential sites for the ‘Umeke ‘Ai Center, most were on the island’s drier west side and vary from being seasonally mesic, moderately dry, very dry, and arid. The moisture maps (Map 4) illustrate the amount of moisture that can be measured in the soil and therefore what plants can be supported in the area for crop production and landscaping.

Rainfall data was collected from the Rainfall Atlas of Hawaiʻi to estimate the potential water harvesting capabilities of the proposed sites (Map 7).



Map 7. *Mean Annual Rainfall 2013 Rainfall Atlas of Hawai‘i. Frazier, A. G., Giambelluca, T. W., Diaz, H. F. and Needham, H. L. (2016), Comparison of geostatistical approaches to spatially interpolate month-year rainfall for the Hawaiian Islands. Int. J. Climatol., 36(3), 1459-1470. doi: 10.1002/joc.4437*

The more rainfall that occurs means more opportunities for capture and water storage. The type of rooftop surfaces should be considered for debris collection mitigation. The square footage calculations will remain whether a roof is pitched or flat. Calculations for rainwater discharge are:

Roof Area (sqft) * Precipitation Amount (in) * 0.623 = Amount Collected (gallons).

For example, 1 inch of rain on a 1,000 sf roof will yield 623 gallons of water. Meaning, you can capture about .62 gallons per sq ft. To figure out the square footage of a roof, multiply the width x length. Utilizing the roof discharge formulas for rectangular roofs we see the following discharge data for the proposed buildings. 750 mm was used as a baseline scenario for Table 10 because that is the lowest potential annual rainfall where ‘Umeke ‘Ai might be placed, based on current considerations, according to Map 7. We also made a composite map (Map 8) that combined sites and moisture levels in the next section, Water Systems Background and Molokai Feasibility, to illustrate where each considered site will be located for overall water system feasibility.

TABLE 10. Rainfall Capture Equations for Sections in the Resilience Center

Building/ Size (sq ft)	**Discharge Formula catchment area (ft^2) * 29.5 *.62**	**Discharge for 750mm Annual Rainfall (gal)**
Food Hub 10,000 sq ft	10,000* 29.5 *.62	182,900 gallons
Community Center 8,000 sq ft	8,000 *29.5 *.62	146,320 gallons
Food Bank Facility 3000 sq ft	3,000*29.5 *.62	54,870 gallons
Offices 3,000 sq ft	3,000*29.5 *.62	54,870 gallons
KItchen 2,000 sq ft	2,000*29.5 *.62	36,580 gallons
Cafe/ Storefront 1,000 sq ft	1,000*29.5 *.62	18,290 gallons
Carports 1200 sq ft	1200*29.5 *.62	21,948 gallons

Source: L’Oreal Hawkes-Williams created the equations based on formulas developed by Brad Lancaster’s article “Rainwater Harvesting for Drylands and Beyond.”

To provide an even more detailed analysis, we utilized the hypothetical site that incorporated architectural renderings from University of Hawaiʻi landscape architect students, as guided by SM, to help visualize where the opportunities to capture rainfall would be possible. The process of calculating rainfall catchment on rooftops is as follows.

TABLE 11. Rainfall Catchment Equations and Examples

Shape of Roof	**Catchment Area Equation**	**Example**	**Gallons of Water Collected Equation**	**Example**
Rectangular Surface (At the drip line)	Length (ft) * Width (ft) =	20 ft * 60 ft = 1200 ft^2	Catchment area (ft^2) * 1in *.62	1200 * 1* .62= 744 gallons

	catchment area (ft²)			per inch of rainfall
Triangular Surface (right triangle)	(Short triangular Length (ft) ÷ 2) * Width (ft) = catchment area (ft²)	20 ft * 60 ft = 1200 ft²	Catchment area (ft²) * 1in *.62	1200 * 1* .62= 744 gallons per inch of rainfall

Source: L’Oreal Hawkes-Williams created the equations based on formulas developed by Brad Lancaster’s article “Rainwater Harvesting for Drylands and Beyond.”

The research regarding the greywater system involved researching laws and ordinances for water reuse in Hawaiʻi by analyzing publicly available data from the Hawaiʻi government websites and material developed by the Hawaiʻi State Health Department discussing best practices used in greywater system designs. For guidance on greywater system design, operation and applications for commercial buildings we referred to the *Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management*, prepared by the Pacific Institute and the application guide, *Wastewater For Commercial Buildings* prepared by Grundfos Commercial Building Services. Throughout an extensive literature review, we reviewed a number of papers to learn more about greywater systems and conducted an analysis of existing model greywater systems from which we can pull concepts. For the costs analysis we collected data from our model system analysis as well as contractor insights from the literature review.

Water Systems Background and Molokai Feasibility

Rainfall Harvesting Potential and Catchment Systems

Opportunities for capturing rain water to store and reuse depend on rainfall and the number of surfaces to catch the rainfall on. A carefully thought out filtration system, storage, and reuse system are required for a rainfall catchment system to be as effective and safe as possible.

A filtration system must be in place before the water reaches the storage tanks. A tiered level filtration system with a sediment filter with at least a

5-micron rating will remove particles and debris of various sizes that could contaminate and/or clog pipes and pump with buildup (Woodard, 2022). Ensuring the safest water for consumption should be of the highest priority if the end result is for human consumption. Methods like UV light disinfection can be used after the physical filtration to kill off bacteria that may be present. The next feature essential for the use of rainwater catchment systems is storage, including underground storage in cisterns. This method can increase the resilience of the buildings utilizing this method while saving fresh water use.

One 29' 8" x 8' 5" width x 8' 11" height cistern can store 10,000 gallons of rainwater (Norwesco, 2024). Tanks for different uses should be separated due to different treating methods. Water being piped away to fields would be stored and treated differently than greywater system support storage tanks, just as water being stored for drinking would have the highest treatment standards. Lastly, stored rainwater can be reused to water crops and be cycled inside the buildings to flush toilets. Rainwater that is unable to be stored immediately will need to be diverted away from the buildings and towards outer lying fields like orchards or designated water retention ponds. If considering reusing the harvested rainwater for emergency drinking water then an extensive water treatment system will have to be implemented to ensure safe, clean water for consumption. Other innovative ways to use the captured water can be for aesthetic purposes like fountains.

Greywater Potential

Greywater systems are used to recycle wastewater for a second or even third use. It is a sustainable method to increase water use efficiency and be more responsible with water usage. Not to be confused with *Blackwater* (wastewater from toilets/septic), greywater is water that comes from hand washing sinks, showers, and laundry that has not come in contact with sewage. Greywater is more useful than blackwater because it has less harmful contaminants and requires less processing for use afterwards (Hawaiʻi State Department Wastewater Branch of Health, 2009). *Dark Greywater* is water that comes from kitchen sinks and has the potential to become septic through improper maintenance. When dark greywater is not cleaned properly there is a potential for pathogenic bacteria, such as Salmonella and

Campylobacter, to spread through the areas greywater is used (Oteng-Peprah et al., 2018). Through a careful sanitization process, greywater quality can match the water amount needed and replace the use of potable water in processes that do not result in human or animal consumption (Allen, 2010). Non-consumption processes include the utilization of a pressurized subsurface drip system to aid in landscape irrigation (Hawaiʻi State Department Wastewater Branch of Health, 2009). Most greywater systems are for residential spaces with a limited number of people utilizing the dwelling. For commercial operations, it would be extremely beneficial to the operation of the greywater system to have ample signage and education about the system so when people come to the facility they can understand how its working as well as prepare them for using the system correctly. For example, people would need to know that only specific types of soaps could be used. Greywater usage can decrease depletion of freshwater sources and aid in saving water costs. The main goal will be to capture, store, filter, and reuse the greywater.

Table 12. Greywater Usage Considerations

Consideration	**Description**
Capture	Bathroom sinks, handwashing stations, produce washing stations and clothes washing machines would be the best source for greywater capture. With the Umeke ʻAi center being a large hub with several buildings, the rooftop space should be enough of a greywater source to irrigate adjacent crop fields. The estimated gray water flows of each occupant shall be calculated as follows: Showers, bathtubs, and lavatories = 25 gallons (95 L) per day/occupant
Filter	Proper filtration has to be implemented to ensure safe potable water as well as a smoothly working system. Fine particles like sand and debris can clog intake/backflow valves and lead to flooding or system breakdown. Redundancy in this area should be considered.

Storage	Storage tanks for greywater are to be used underground and water from the system should never come into contact with people. When tanks are filled the greywater should not be held in holding tanks for more than 24 hours. After that harmful bacteria consuming organic matter creates unpleasant odors.
Maintenance	Scheduled cycling of greywater is necessary for a healthy system that produces a viable resource. Regular maintenance of the system and water testing should be done by trained persons. Proper cycling of water and maintaining cleanliness of the system can extend the longevity of the system and reduce malfunctions.
Reuse	Sometimes a build up can happen; therefore cycles of fresh water should be planned in advance. Salinity and alkalinity toleration should be considered when choosing the plants to be irrigated by greywater. Additionally, crops that are meant to be eaten raw should not be irrigated with greywater and they should be established plants, not seedlings. Any plants being irrigated with greywater should be done by releasing the reused water underneath the soil. All greywater must be distributed underground to prevent exposure and odor.

Source: Descriptions were developed by L’Oreal Hawkes-Williams utilizing Michael Oteng-Peprah et al.’s paper, “Greywater Characteristics, Treatment Systems, Reuse Strategies and User Perception - a Review,” (2018).

Once greywater has been properly stored, it can be used to irrigate appropriate crops and native plants.

TABLE 13. Local Crops That Can Tolerate Greywater

Crops	**Native Hawaiian Plants**
Banana	Akia
Coconut	Akulikuli
Guava	Beach Naupaka

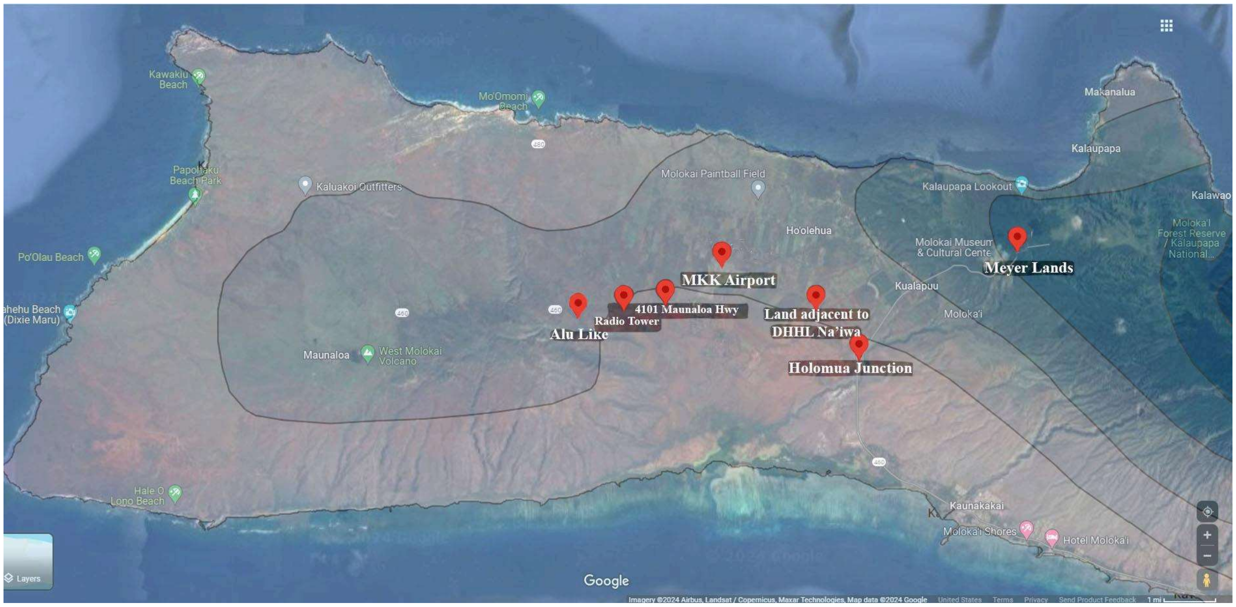
Papaya*	Pohinahina
Sugarcane	Pohuehue (beach morning glory)
Moringa oleifera	
Rosemary	
Ornamentals	**Grasses**
Ginger	Bermuda grass
Heliconia	Seashore paspalum
Ti leaf	
Wedelia	
Rose	

*Not tolerant to overwatering or high pH

Source: Chart created by L’Oreal Hawkes-Williams with information from “GUIDELINES FOR THE REUSE OF GRAY WATER.” 2009.

‘Umeke ‘Ai Site Locations and Associated Rainfall

The following map shows the moisture levels at the potential sites which will dictate which plants should be considered for the demo farm, landscaping, and bio-retention ponds. The table below indicates native and canoe plants that can tolerate greywater.



Map 8. *Composite Moisture Map of Western Molokai.* This map contains the moisture zones layer from Map 4 (map and sources can be viewed in Chapter V: Site Assessments) and the potential ‘Umeke ‘Ai sites to illustrate their positionality within moisture zones. The sites and baselayer are visualized in Google Maps. Composite map created by L’Oreal Hawkes-Williams, 2024.

Based on the considered sites for assessment and their locations in respective moisture zones (Map 8), the following temperature zones and estimated annual rainfall were determined.

TABLE 14. Location, Temperature Zone and Associated Annual Rainfall

Site	**Zone**	**Mean Annual Rainfall**
Holomua Junction	Arid	572.5 mm
Hoolehua (near Na’ iwa Homesteads)	Very Dry	597mm - 718.6 mm
Hoolehua - Dot Airport MKK	Very Dry	577.2 mm
Alu Like Lease	Very Dry	582.7 mm
Radio Tower	Arid	534.6 mm
4101 Maunaloa Highway	Arid	579 mm

Meyer land - Old Mule Ranch	Moderately Dry	801.8 mm
Meyer land - Cliffs	Moderately Dry/Seasonal Mesic	1023.5 mm

Source: Sites were provided by Sustʻāinable Molokai, L’Oreal Hawkes-Williams calculated the mean annual rainfall using rainfall data from Rainfall Atlas of Hawai’i (2013).

Model Case Studies

As part of our research into integrated water conservation for the proposed site we used model greywater systems in Hawaiʻi and Virginia Beach, VA as comparable case studies. For these sites, we focused on location, system size, costs, design, and capacity.

Model System #1: Administrative and Allied Health Building- University of Hawaiʻi, West Oʻahu.

We looked at this system first because it is in Hawaiʻi and would have the same standards and regulations as would be needed in Molokai. The system was designed by Roth Ecological Design to find innovative ways to capture water. For instance collecting water condensate from the air conditioning system is something that is not usually considered. Condensate that is collected goes directly into an underground to await filtration. The system also utilizes rainwater harvesting and that water goes through its own filtration system before it is released into swales and rain gardens for bioretention and ground water recharge. This also helps with flood mitigation. The rainwater storage tank holds 2,000 gallons of water and by their estimate should be able to provide over 30,000 gallons of water annually. Treatment of their blackwater from toilets is also done onsite and has it’s own processes and storage. Costs for the system was 32 million dollars (Wiles) and was completed in 2018.

Photo 7. *University of Hawaiʻi at West O'ahu Facilities Building. Source:* KYA Design Studio. (2017). Administration and Allied Health Facilities University of Hawaiʻi at West O'ahu | KYA Design Group. Retrieved March 26, 2024, from http://kya.design/pages/uh-administration-and-allied-health

Photo 8. *Condensate Drain Pipe*. *Source:* Condensate Drain. University of Hawaiʻi Sea Grant. (2019). *Water Reuse – Hawaiʻi Sea Grant*. Hawaiʻi Sea Grant. Retrieved March 26, 2024, from https://seagrant.soest.hawaii.edu/water-reuse/

Photo 9. *Storage Tank Access. Source:* Storage Tank Access. University of Hawaiʻi Sea Grant. (2019). *Water Reuse – Hawaiʻi Sea Grant*. Hawaiʻi Sea Grant. Retrieved March 26, 2024, from https://seagrant.soest.hawaii.edu/water-reuse/

Photo 10. *Pump and Timing Valves. Source:* Pump and Timing valves. University of Hawaiʻi Sea Grant. (2019). *Water Reuse – Hawaiʻi Sea Grant*. Hawaiʻi Sea Grant. Retrieved March 26, 2024, from https://seagrant.soest.hawaii.edu/water-reuse/

Model System #2: Brock Environmental Center in Virginia Beach, VA

This facility boasts a system that is comparable in size to the proposed 10,000 square foot Food Hub. Roughly 10,500 square feet, the BEC has implemented five systems to save water and mitigate pollution of the Chesapeake Bay and other waterways. These systems are rainwater harvesting for potable and non-potable water, greywater reuse, composting toilets, greywater treatment, and blackwater treatment. Harvested rainwater can supply the facility's potable and non-potable water needs. With a filtration and disinfectant treatment system that meets the standards of the "Virginia Waterworks Regulations, the EPA Federal Safe Drinking Water Act, which includes the Surface Water Treatment Rule, the Interim Enhanced Surface Water Treatment Rule, the Long Term 1 Enhanced Surface Water Treatment Rule, and the Long Term 2 Enhanced Surface Water Treatment Rule" (Living Futures) , the facility is able to treat their rainwater and never have to use municipal water. However, the facility is hooked up to municipal water lines for fire suppression precautions. Waterless composting toilets are used for their blackwater treatment BEC is saving on water usage and producing fertilizer from the leachate that is produced in the compost bin. The greywater system strictly serves the gardens that have native plants that are used to filter the water before it returns to the underground water table. BEC invested 170,000 collectively for their water system that includes cisterns, pressure tanks, blackwater compost bins, and pumps. Ongoing costs include utilities (sewage and water lined connectivity) and maintenance of the systems. A full analysis of the system and costs can be read in the Living Futures *Water Systems Financial Case Studies* report (Living Futures).

Photo 11. *Brock Environmental Center Green Facility. Source:* Chesapeake Bay Foundation. (2015). Brock Environmental Center Storyboard - Green Features. Retrieved March 19, 2024, from https://buildingos.com/s/cbf/storyboard2143/?chapterId=14263

Water System Recommendations for ‘Umeke ‘Ai

Creating built-in water conservation systems into design plans increases a community’s resiliency level and would be a resource with benefits to the environment and the community for years to come.

One of the proposed 'Umeke 'Ai site designs seeks to have a base of seven buildings that include a Food Hub that will be 10,000 sq ft, a, 8,000 sq ft community center, 3,000 sq ft food bank facility, 3,000 sq ft office building, 2,000 sq ft commercial kitchen, 1,000 sq ft cafe and storefront, and a 2,000 sq ft art center. There will also be carports in the parking lot that could be a potential location for rainwater harvesting. The T-frame carport design, also known as double cantilever or T-cantilever (beams that extend from one side of the structure), features full cantilevered roof coverage extending in two directions and can provide a roof surface of at least 1200 sq ft on a 20’ x 60’ carport. Utilizing the design from Elijah Davidson, we were able to show where buildings' water tanks and cisterns could be held. In the below composite site plan there are (6) 10,000 gallon cisterns for a total of 60,0000 storable gallons with options for more.

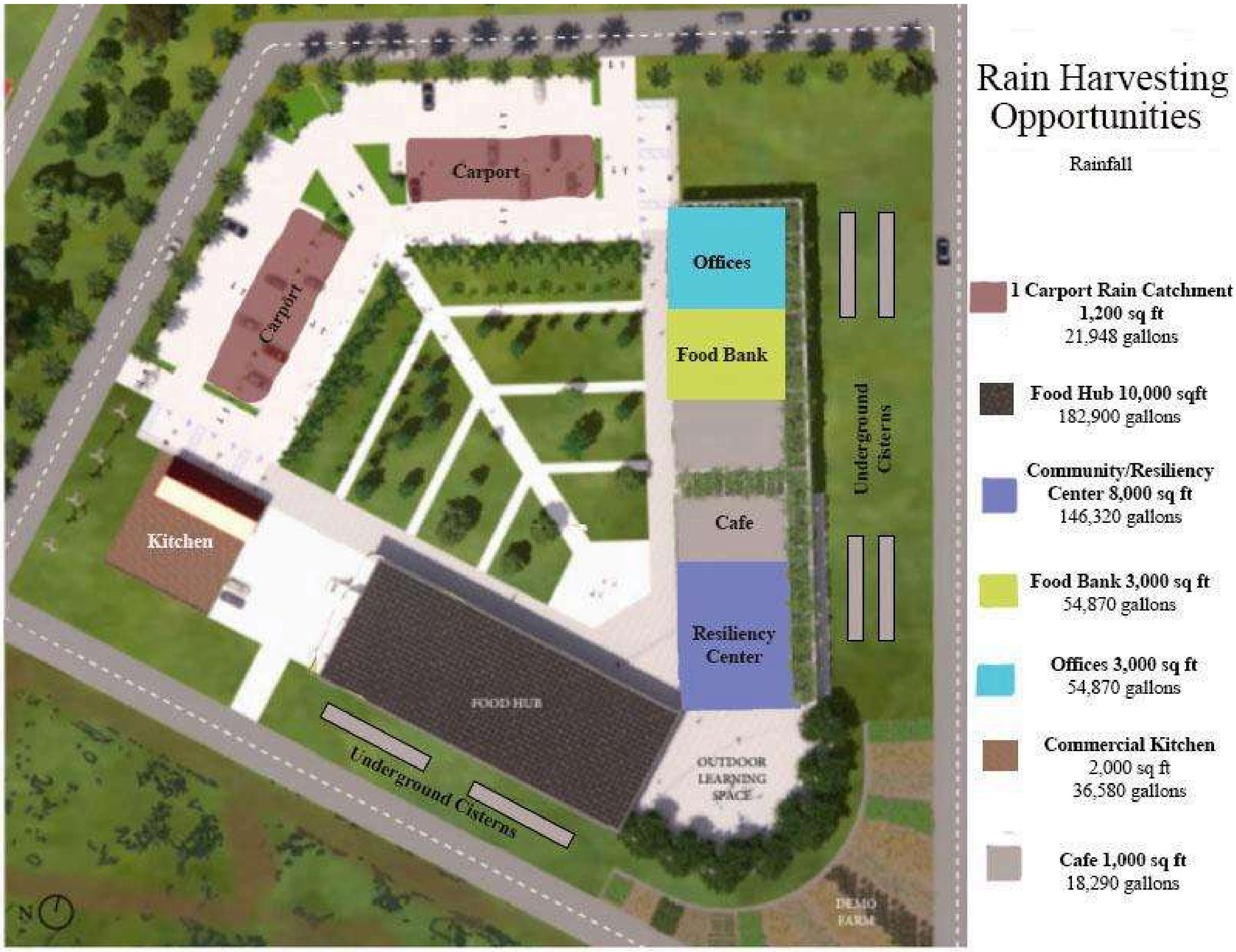


Figure 13. *Composite of Site Design from Elijah Davidson (University of Hawai'i) and Proposed Rain Harvesting Opportunities.* 2022.

Based on this design plan and a base level of 750 mm of annual rainfall, over 460,000 gallons of rainwater can be harvested annually with catchment to the seven buildings listed. With the greywater systems integrated into this rainwater harvesting, the ‘Umeke ‘Ai Center would also have the potential divert 25 gallons of wastewater (95 L) per day/occupant from sinks, showers, and clothes washers.

Combining rainwater harvesting with greywater is a great way to conserve water and increase water retention of soil. Incorporating water reuse into the design of the ‘Umeke ‘Ai center will be an investment that serves the community for years to come. Being a model for future thinking and living, the integration of rain harvesting and greywater to meet the needs of the 'Umeke 'Ai campus would decrease pressure on the municipal system, increase resiliency, and present an opportunity for community skill building by providing training programs to ensure skilled maintenance workers. Even though the initial investment can be costly in monetary terms, it is important to consider the long term environmental benefits and the community’s ability to be resilient during emergencies or times of sustained difficulties. Our deliverables for the integrated water conservation system research is a costs analysis, rainwater harvesting calculations, and analysis of model water systems. Our recommendations fall into three categories: system costs, design/operations, and vegetation.

System Costs

Costs for an integrated rain harvesting and greywater system will include the initial investment as well as the fees associated with maintenance and municipal utility connection. Systems may vary by size and cost which we see in the two model systems highlighted earlier in the report which range from $160,000 to 32 million investments. Each building’s estimated costs were gathered from comparable sized water conservation systems around the U.S. Below is a screen capture of the cost analysis that was made in Google sheets. In the analysis we looked at the the square footage of the site, whether it had rainwater harvesting, greywater, or blackwater treatment; rough estimate of costs; and links to model water conservation systems of comparable size.

TABLE 15. ‘Umeke ‘Ai Center Integrated Water Conservation Costs Analysis.

	A	B	C	D	E	F	G	H
1	**Umeke Ai Integrated Water Conservation Costs Analysis**							
2	The costs listed here are rough estimates from Model systems and should not be used as firm numbers							
3	Each building has numbers based on comparable sized existing systems listed in the ON-SITE WATER SYSTEMS: FINANCIAL CASE STUDIES report							
4	Item	System	Description	Price	Quantity	Total	Comments, Links, etc	Model System
5	FOOD HUB 10,000SQFT							
6	Rain Harvesting System	Rain Harv...	Directing flow of rainwater into cisterns	$10,000.00	1	$10,000.00		Brock Environmental Center
7	Water filtration skid	Rain Harv...	Filtration system for removing debris, sand and gravel	$48,000.00		$48,000.00		
8	Pipe/Plumbing	Rain Harv...	Used to get water from cisterns to desinated location			$0.00		
9	Water disinfection system	Rain Harv...	On-site system to remove bacteria in rainwater for potable use			$0.00		
10	Greywater System	Greywater	24 hr holding tank, Filtration system, Pumps and Valves	$25,000.00		$25,000.00		
11	Dripline	Greywater	Method of irrgation for greywater system	$3,000.00		$3,000.00		
12		Greywater				$0.00		
13	Gravity-fed composting bins	Blackwater	Compost bins that are underneath composting toilets to catch waste	$64,000.00		$64,000.00		
14	Composting toilets & underground leachate vault	Blackwater		$150,000.00		$150,000.00		
15		Blackwater				$0.00		
16		Blackwater				$0.00		
17	COMMUNITY CENTER 8,000 SQFT							Arch Nexus SAC
18	Greywater system	Greywater	Pipes, fitration, pumps, valves, dripline	$100,000.00	1	$100,000.00		
19	Rain Harvesting System	Rain Harv...	Directing flow of rainwater into cisterns	$60,000.00		$60,000.00		
20	Pipe/Plumbing	Rain Harv...	Used to get water from cisterns to desinated location			$60,000.00		
21	Water disinfection system	Rain Harv...	On-site system to remove bacteria in rainwater for potable use			$0.00		
22	Greywater System	Greywater	24 hr holding tank, Filtration system, Pumps and Valves	$25,000.00		$25,000.00		
23	Dripline	Greywater	Method of irrgation for greywater system	$3,000.00		$3,000.00		
24		Greywater				$0.00		
25	Gravity-fed composting bins	Blackwater	Compost bins that are underneath composting toilets to catch waste	$64,000.00		$64,000.00		
26	Composting toilets & underground leachate vault	Blackwater		$150,000.00		$150,000.00		
27	FOOD BANK FACILITY 3000 SQFT							Desert Rain
28	Greywater system	Greywater	Pipes, fitration, pumps, valves, dripline	$35,000.00		$35,000.00		
29	Water filtration to become potable	Rain Harv...	Filtration system for removing debris, sand and gravel	$15,000.00		$15,000.00		
30	24 hr holding tank	Greywater	Holding tank before being pumped to fields	$25,000.00		$25,000.00	Can be piped to one of two greywater 24 hr storage tanks	
31	Irrigation	Greywater	Underground piping sytem that leads to crops/lanscping,etc.	$25,000.00		$25,000.00		
32	Composting toilet system	Blackwater	Gravity-fed composting bins, toilets	$80,000.00		$80,000.00		
33		Blackwater				$0.00		
34	OFFICES 3000 SQFT							Tyson Living Center
35	Rain harvesting system	Rain Harv...	Gutters, filtration, pumps, pipes	$60,000.00		$60,000.00		

Image description: Screen capture of Cost Analysis for the Integrated Water Conservation for the ‘Umeke ‘Ai Center.

Design/Operations

System design must first start with identifying all of the points on the site where water use will take place, how it is used and the methods you wish to employ to capture, filter, store, and reuse. A combination of rainwater harvesting, greywater reuse, and blackwater treating will provide more than enough water for the site as well as relieve pressure on the municipal sewer system. A design firm should be contracted in conjunction with a commercial builder that can help with permits and planning. We are recommending the integrated system that SM utilizes have the following features:

- Rain catchment on every building on the ‘Umeke ‘Ai campus
- Multiple cisterns no less than 10,000 gallon holding capacity
- Designation of some vegetated areas for greywater and for rainwater
- Redundancy in filtration system to maximize safeness of water
- Greywater system in main food hub where majority of people will work
- Composting toilets in other buildings to minimize water consumption
- Switch to trained operational staff in house, once outside contractors get the system up and running

- Conversations with engineers/designers of the Brock Environmental Center and UH Allied Health Building for more insight about the pros and cons of their water treatment and conservation systems.

Vegetation

Since greywater tends to be more alkaline, a flush of freshwater should be cycled into watering rotations to prevent soil from becoming too alkaline as well as flush away accumulated salinity. Local Hawaiian crops that can tolerate greywater include banana, akia, coconut, akulikuli, guava, Beach Naupaka, papaya*, Pohinahina, sugarcane, Pohuehue (beach morning glory, moringa oleifera, and rosemary. Ornamentals and landscaping plants that tolerate greywater are grasses, ginger, Bermuda grass, heliconia, Seashore paspalum, Ti leaf, Wedelia and rose. A combination of any of these plants would provide the site with crops and aesthetically pleasing landscaping. Careful planning of water retention gardens with native plants can help to filter water and recharging of ground water.

TABLE 16. Plant Names and Optimal Location for Growth

Plant	Demo Farm	Landscaping	Bioretention Pond
Banana	✓		
Coconut			
guava	✓		
papaya*	✓		
sugarcane	✓		
Moringa oleifera	✓		
rosemary	✓		
Ginger		✓	
heliconia		✓	

Ti leaf		✓	
Wedelia		✓	
Rose		✓	
Bermuda grass			✓
Seashore paspalum			✓
akia		✓	
akulikuli*		✓	
Beach Naupaka		✓	
Pohinahina		✓	
Pohuehue (beach morning glory		✓	

Source: L’Oreal Hawkes-Williams created chart of crops found in the “Guidelines For The Reuse Of Gray Water.” 2009, and the optimal location for them on the proposed site.

Challenges and Opportunities

Implementation of an integrated water conservation system can have a few challenges. Costs, design, maintenance, and supply of water for the system are the main areas that can pose obstacles to creating a sustainable water conservation system that works as intended. Greywater systems are expensive up front, but one has to consider the more pressing matters of relieving strain on environmental resources and being able to serve the community in the event of emergencies. Such intricate systems need to be maintained closely and the workforce needed to do so is nearly nonexistent due to this being a new industry. Designing the system could pose some challenges depending on site location. Making sure to pick a site that is well suited for the system by meeting certain requirements like accessibility and space to place underground tanks. Lastly, since we are unable to control how much rainfall occurs we are left to the mercy of nature but picking a site that is less dry can ensure enough water for the plants in the system .

Though several challenges present themselves when considering integrating a greywater system, it is important to see the opportunities that arise as well. With an innovative system like the one we are considering there will need to be people to maintain it. Trained workers may not be readily available, but with a water system training program specific to their integrated water system, SM can train the service people needed to maintain it. A training program would benefit the community as well because people will be able to implement and service their own small water systems.

Chapter VII. Gala Page

Learngala.com is an educational website designed for academics, researchers, and other users to publish case studies covering a wide array of topics. While these topics vary in subject matter, they are all readily accessible once published. The platform allows users to create groups for commenting on case studies, with authors expected to update their materials periodically.

Methods

The Gala Page deliverable stemmed from several factors. Firstly, a team member attended a class where the final project involved creating a page on Gala. Secondly, the team faced challenges in effectively communicating the broad goals and contexts of the ‘Umeke ‘Ai project, particularly in a manner easily accessible through the internet or other mediums. This potential obstacle could hinder future communication efforts regarding the project. Consequently, the team member mentioned above took the initiative to develop a page aimed at facilitating the communication of ideas surrounding the project in an easily accessible manner. It is crucial to recognize that access to the webpage requires internet connectivity, highlighting a limitation in this mode of communication.

The creation of the finalized Gala page on the project was a result of several steps. Initially, individuals engaged in brainstorming sessions with peers to explore project ideas, culminating in a central "pitch." This pitch took the form of a presentation delivered in front of peers and the course professor. Following feedback from this audience, the student proceeded to draft materials for the Gala page they were tasked with creating. This drafting process involved various approaches, such as taking notes, gathering information and sources, and delving deeper into the contextual background of the discussed issue.

For the Gala page on this project, information was gathered from various sources, including Sust’āinable Molokai’s website and project proposal, as well as input from the Molokai Hunting Club, ‘Āina Momona, Maui County, and several food hubs. The page underwent several iterations, which involved peer review and editing processes. The scope was kept concise, bringing in topics like colonialism, landback, food sovereignty, and activism. Additionally, island-centric issues such as the legacies of old agriculture and Axis deer were included to provide readers a better understanding of the unique challenges faced by Molokai and her people.

An important factor to consider was the audience. The open accessibility of Gala proved beneficial, as it allowed anyone with the link to access and learn about the project. With this in mind, the page was created with the Molokai community as the primary audience, while also catering to future project workers and other interested parties seeking information about the project.

The page was finalized after extensive peer review and feedback processes. Recognizing the long-term nature of the ‘Umeke ‘Ai project and the involvement of future SEAS teams, the page is designed to be continually updated and refined as subsequent teams pursue deliverables. This ongoing process aims to uphold transparency and contribute to the evolving narrative of the ‘Umeke ‘Ai center. Therefore, it is important to note that this version of the page is not considered final, but rather a dynamic representation that will evolve over time.

Benefits of a Virtual Toolkit and Page

The Gala page offers a multitude of inherent and derived benefits for the project. One of the most prominent is the ability to efficiently disseminate project details, a crucial aspect given the complex and evolving nature of SEAS projects and their intersection with local communities. As these projects evolve over time with shifting goals and compositions, effectively communicating the precise nature of the project can be challenging. This page is able to neatly organize different facets of the project, fostering a more coherent and concise narrative that sets a precedent for addressing specific project aspects.

Moreover, the page serves as a valuable resource for future teams and Sust’āinable Molokai alike. Its dynamic nature allows for continual editing and updating, ensuring that it remains relevant and informative. By integrating the page with existing resources on the ‘Umeke ‘Ai center, it can enhance communication with incoming project workers, facilitating smoother onboarding processes.

Additionally, the Gala page can be a resource for those interested in similar projects, either for research or for working on a similar project. Together with the information presented in this paper, it could be a valuable resource for those looking to do similar work. Furthermore, the page serves as a platform for highlighting decolonial values, leveraging its open accessibility to communicate the principles underlying the project’s work. This enhanced visibility and articulation of project values could foster increased interest and investment in this and similar initiatives, ultimately benefiting food sovereignty efforts on Molokai.

Description of Deliverable

The Gala page comprised of the following main sections:

1. Overview
2. Background
3. Non-profit information
4. Issues faced in Molokai’s food system

5. Food hub information and benefits
6. Ties to landback
7. Future project work

The overview page contains an introduction to the ‘Umeke ‘Ai project, as well as an author background and disclaimer. The learning objectives for the module are followed by a map showing the specific location of the project in the Hawaiian island chain. Additionally, the background information provides geographical and topological details, along with a brief history on colonization and activism on the island. This section also delves into UM SEAS involvement, offering insights into the project’s development and context. This background information helps create an understanding of the origins and evolution of SM and its initiatives.

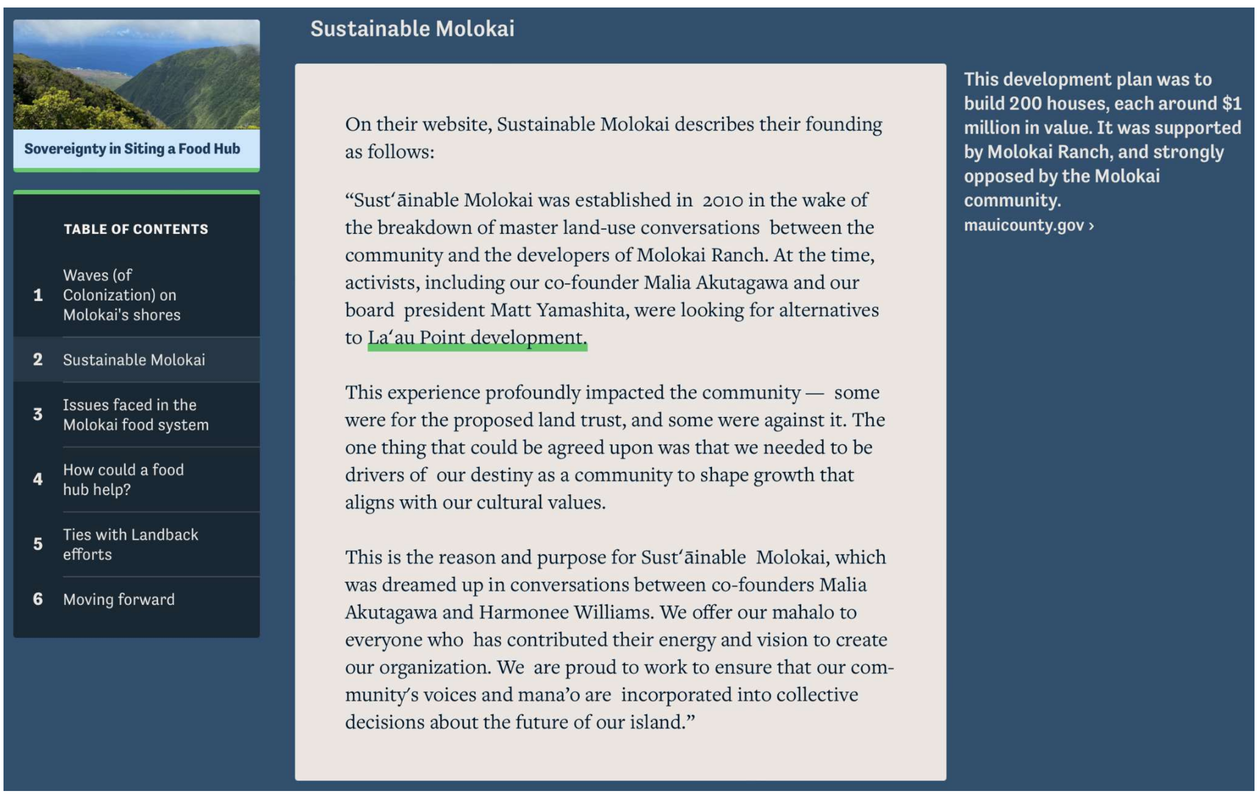


Figure 14. *Screenshot of the Gala Website Homepage*. 2024.

The non-profit information section features a quote about SM’s founding and their efforts towards promoting food sovereignty on the island. Additionally, it highlights existing programs such as the PEEPS program and the mobile market, shedding light on ongoing initiatives aimed at addressing food-related challenges. Subsequently, attention is directed towards the issues surrounding Molokai’s food system, such as the overwhelming presence of axis deer, commodification, and legacies of colonialism. These two sections serve to contextualize the challenges the ‘Umeke ‘Ai center aims to address.

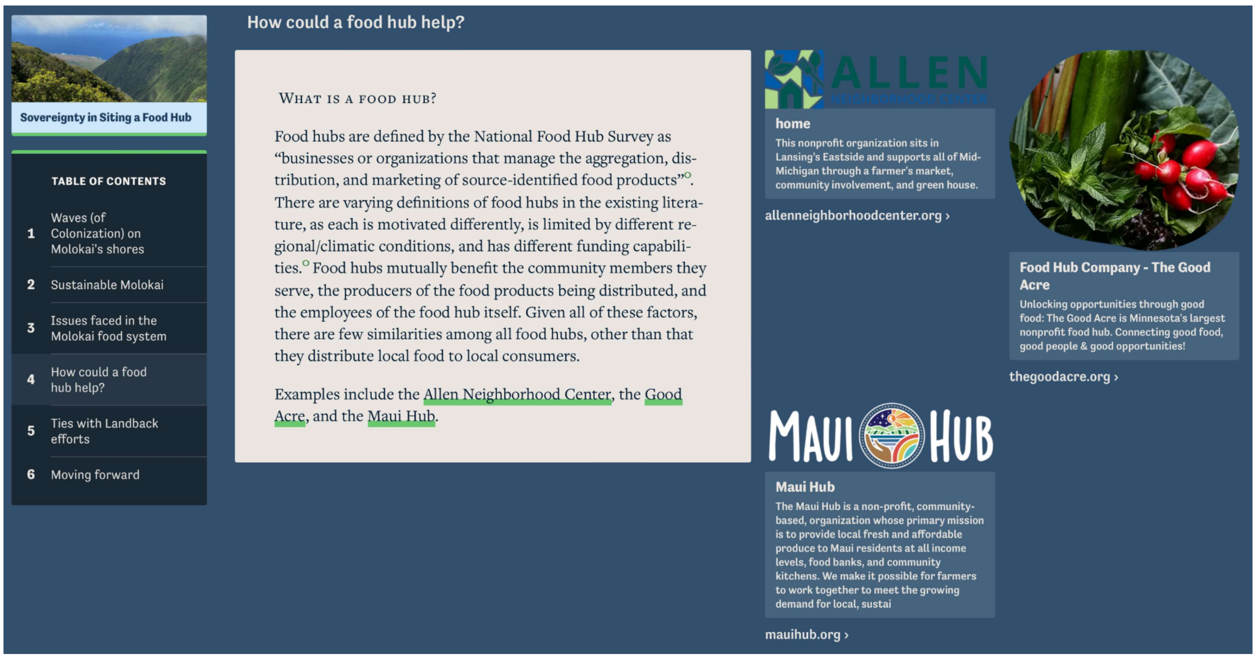


Figure 15. *Screenshot of the Food Hub Infrastructure Analysis Page*. 2024.

The exploration of the food hub’s benefits begins drawing parallels with mainland examples, such as the Allen Neighborhood Center of Lansing. This is followed by an examination of food sovereignty and its importance in Molokai, considering its implications for economic and health outcomes. In doing this, the groundwork is laid out for future work, as to be spearheaded by SM and subsequent SEAS teams, in collaboration with other community entities on Molokai.

Despite its merits, the module still has certain issues. One such issue is the requirement of internet access, which may be especially challenging for those with service or electricity challenges. Additionally, the module’s broad scope provides only a “birds-eye-view” of the project, which could benefit from more specific information to enhance clarity. Furthermore, the module’s authorship and perspective, being the creation of a single individual, may limit its comprehensiveness and scope. For instance, there is limited information about the sister SEAS project concerning Molokai Ranch. However, through continued iteration and refinement, these issues may be addressed, allowing the module to better serve its intended purpose.

The full Gala page can be accessed by following this link.

Chapter VIII. Recommendations and Outlook

Environmental catastrophes will become increasingly common in the Hawaiian archipelago, requiring a radical shift in how food is grown, prepared, and sold on the islands. The creation of the ‘Umeke ‘Ai Center will enable Molokai to simultaneously increase everyday resiliency needs, such as community gathering and education spaces, and emergency resiliency needs, such as a food bank and long-term storage. In doing so, Molokai can move beyond reacting to emergencies to building its resilience protocol to ensure long-term food and energy stability.

Lessons Learned Per Project Deliverable

Below, we provide a summary of lessons learned, including challenges and opportunities, for each of our project deliverables. Please refer to the project deliverable’s dedicated chapter for more details.

Precedent Site Report

The precedent site report revealed key findings and recommendations across six categories: cold and dry storage, certified kitchens/food processing infrastructure, traditional agricultural systems sites, for-profit opportunities, energy availability, and architecture features. It’s important for SM to consider how these six key themes can come together to maximize the design and functions of the facility and overall campus. An important overarching takeaway is the need to build a space that is larger than anticipated, as many precedent sites ran into the issue of not having enough space for their multiple resiliency needs, especially cold storage. Also, having multiple certified kitchens at low or no rental cost options will provide Molokai with the necessary incubation for local food entrepreneurs and fulfill food processing for safety measures. The full description of findings can be found under Precedent Site Report Findings in Chapter 5. Overall, the precedent sites revealed some general trends and insights around critical elements to incorporate into ‘Umeke ‘Ai as SM begins its architectural designs.

Moving forward, the current precedent site report will be transferred to SM and upcoming research groups to continue expanding and filling in the gaps where necessary, such as specific numbers on energy availability at each site and more details about refrigeration size for each site. Opportunities for future research include carrying out a more detailed analysis of the different scales of refrigeration and certified kitchens, including average building square footage and more specifics on quantities of equipment.

Site Assessments

In evaluating the sites currently considered for ‘Umeke ‘Ai, multiple tradeoffs were revealed, such as exchanging a low price for high government involvement and high moisture availability for low solar capacity. Given that Holomua Junction is no longer in consideration due to a lack of water and utility access, other sites from this assessment must now be equally considered. A review of the potential sites revealed that outright land purchase may not be possible for this project initially because of the lack of for-sale status for many properties. As such, SM may want to consider a lease that ensures the longevity of the Center at the site through a strong contract. For example, a lease on Alu Like, airport-adjacent, or Meyer land sites may be the current best option for the ‘Umeke ‘Ai’s development and future expansion, depending on lease options and zoning flexibility for various sites. The recently secured federal funding toward the purchase of a site for ‘Umeke ‘Ai Center covers the expected price of all the sites analyzed here and ensures cost will not be a significant barrier toward site selection, allowing feasibility and suitability for the project’s multiple facets to be a deciding factor in SM’s site decision.

In terms of next steps, maps developed for the site assessment will be passed on to SM and groups continuing this work on Molokai for future geospatial data development and analysis. There is potential to build on the Web App created by adding more layers to the source Web Map or creating a Story Map based on this overall analysis, which will bolster project communications. There is also a strong opportunity for future geospatial work on the island: robust, current, and detailed datasets are currently lacking for Molokai, and research groups that can build these datasets with remote sensing and field work to establish new layers would be extremely valuable. The layers could include homestead locations and detailed population density, crop coverage across farms, groundwater aquifers, off-grid solar panel locations, water and energy utility hookup locations, and more that could facilitate future resiliency spatial analysis on the island.

Energy Analysis

Through three research stages, a photovoltaic (PV) and battery hybrid energy system was identified as a potential microgrid option for the ‘Umeke ‘Ai Center. Solar is the most feasible renewable energy source given its high concentration in the areas that SM is considering. Energy demand modeling revealed that an optimized system sizing for this PV and battery system is 290 kWdc set of PV modules and a 65 kW-power battery system, with 361 kWh of total energy capacity. While an emergency generator is not necessary for shorter shortages (about 3 hours around midday), an emergency generator may be beneficial for longer outages, such as during an intense storm.

A solar and battery system requires a high upfront cost. However, this system provides significant environmental and climate benefits, including a decrease in annual energy consumption from the grid by almost 60% and about the same proportional decrease in $CO2$, NOx, and $SO2$ emissions. Additionally, the economic benefits in the long-term are numerous, including the large savings from high electricity rates on Molokai, a 23% return on investment with 3.63 years payback, and a net present value of $1,207,975 for the 25-year modeled lifetime of the project. The independence of this microgrid would also provide resiliency in the case of grid outages during natural disasters, such as hurricanes. Potential next steps for the energy analysis include modeling the ‘Umeke ‘Ai Center’s components as separate sites to provide a more accurate load profile for each of the different functioning sections of the

Center. There is also an opportunity to determine the feasibility of going 100% renewable or incorporating small to medium-scale wind in future analyses.

Integrated Greywater System

To achieve an effective integrated greywater reuse systems, SM should consider implementing a set of features, including having a rain catchment on every building on the ‘Umeke ‘Ai campus and multiple cisterns with a holding capacity of at least 10,000 gallons each. When it comes to vegetation, a combination of local Hawaiian crops that can tolerate greywater, such as bananas, and ornamental and landscaping plants, such as grasses and ginger, create an aesthetically pleasing landscape.

An integrated greywater system is an innovative mode that requires a significant upfront investment and is an area where there’s nearly no existing workforce on the island, which can discourage organizations and individuals from pursuing this model. However, numerous benefits outreach the costs in the long-term, such as relieving the strain on limited environmental resources and resiliently serving communities during emergencies. SM also has a great opportunity to build a trained workforce on Molokai to monitor and implement these water systems through a water system training program specific to their integrated water system.

Challenges and Limitations

Accessing data
A main limitation across our project deliverables was the lack of available, accessible, and updated data. A particular issue is the lack of updated spatial data for all of Hawai’i, Molokai in particular. As a result, we were only able to start streamlining all research on food hubs, aggregation sites, and food banks in the surrounding Hawaiian Islands. The next steps under deliverables explain how future research groups can carry on this work.

Merging Multi-Disciplinary Work
The multi-disciplinary nature of our project is both a strength and a challenge. While it provides a robust and well-rounded approach to addressing ‘Umeke ‘Ai’s development and design goals, our team had to

navigate how to merge our work to be as cohesive as possible. Through conversations with each other and with our client and advisor, we were able to streamline and cross-reference our work in a clear and cohesive way, as shown through this report.

Next Steps

We are excited to share our report with the members of SM, the Molokai community at large, and the two new groups of UM SEAS capstone students who will continue to collaborate with SM to research the sustainability components for a resiliency center on Molokai. It is our hope that future UM capstone teams can continue this work with SM and advance our school’s ongoing partnership with the non-profit community development organization. Exciting future research opportunities await, such as the upcoming partnership with Ho’āhu Energy Cooperative, a community-owned and led organization working to ensure the local community has authority over their energy sources. It is our belief that energy sovereignty is interconnected with land and food sovereignty. Future work could also evolve into the research of best practices for mobile farmers markets and for-profit options for the resiliency center that will advance the organization’s ability to provide new financial and material opportunities to Molokai residents.

Ultimately, this project is meant to bolster the ongoing efforts in Hawai’i and Molokai specifically. There is a growing awareness that the current system, in which Hawai’i imports 85% of all food consumed on the islands, is unsustainable and vulnerable to climate and health emergencies (Terrell, 2021). As a team of researchers, only one of whom is from Hawai’i, we endeavored to follow the lead of those on the ground working directly with communities who are currently facing the impact of an unstable support system. This has shaped our work and deliverables, which are largely recommendations based on our research and the best practices in the fields of environmental justice, sustainable development, and architectural design.

References

Akutagawa, M. K. H., W., W. (n.d.). *A framework for theʻ aha moku system and collaborative governance (ʻAha Kiole o Molokaʻi Handout). ʻAha Kiole o Molokaʻi.* Retrieved July 8, 2023, from http://mauicounty.us/wp-content/uploads/2018/12/Framework-for-the-Aha-Moku-System-and-Collaborative-Governance-MICP-b.pdf
Akutagawa, M., Williams, H., & Kamakaʻala, S. (2016). *Traditional & Customary Practices Report for Manaʻe, Molokaʻi*. http://hdl.handle.net/10125/46017
Allen, L., Christian-Smith, J., & Palaniappan, M. (2010). *Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management* (pp. 1–41). Pacific Institute. https://drive.google.com/drive/folders/1VHPc6gb9izCSD-y-w7I27BL3uUuu9Nui
Anderson, B. P. (2019, March 1). The Past is Present: Kalo Farming on Hawaiʻi Island. *Ke Ola Magazine*. https://keolamagazine.com/agriculture/kalo-farming-on-hawaii-island/
Andrade, T. J. H. (2022). Belated Justice: The Failures and Promise of the Hawaiian Homes Commission Act. *American Indian Law Review*, *46*(1). https://digitalcommons.law.ou.edu/ailr/vol46/iss1/2/
Baja, K. (2018). *Resilience Hubs: Shifting Power to Communities and Increasing Community Capacity* (pp. 1–10). Urban Sustainability Directors Network. https://www.usdn.org/uploads/cms/documents/usdn_resiliencehubs_2018.pdf
Barile, J., Bird, O., Nakamura, B., Pruitt, A., Wu, Y., & Zhang, W. (2021). *Addressing Hunger & Food Insecurity among Hawaiʻi's Families* (Health Policy Initiative 2; UH Mānoa and First Insurance Company of Hawaiʻi, pp. 1–22). College of Social Sciences, UH Mānoa. https://drive.google.com/file/d/1e3MkhACuaFYxULdsfwx56Jp1psCMAm4t/view?usp=sharing&usp=embed_facebook
Berning, E. H., Andersen, C. V. H., Mertz, O., Dickinson, N., Opgenorth, M., Lincoln, N. K., Rashford, J. H., & Rønsted, N. (2022). Resilience of breadfruit agro-ecosystems in Hawaiʻi during the COVID-19 pandemic. *CABI Agriculture and Bioscience*, *3*(1), 56. https://doi.org/10.1186/s43170-022-00125-3
Big Island Now. (2013, October 1). Hawai`i No. 2 in Nation for Foreign-Owned Ag Lands. *Big Island Now*. https://bigislandnow.com/2013/10/01/blog-hawaii-no-2-in-nation-for-foreign-owned-ag-lands/
Blue Bird Jernigan, V. (2021). Food Sovereignty Indicators for Indigenous Community Capacity Building and Health. *Frontiers*.

https://www.frontiersin.org/articles/10.3389/fsufs.2021.704750/full
Castaneda, A. (2022). *Food Hub Avenue Poster*. University of Hawai’i.
Cattani, L., Cattani, P., & Magrini, A. (2021). Air to Water Generator Integrated Systems: The Proposal of a Global Evaluation Index—GEI Formulation and Application Examples. *Energies*, *14*(24), 8528. https://doi.org/10.3390/en14248528
Chesapeake Bay Foundation. (2015). *Brock Environmental Center Storyboard—Green Features*. Atrius. https://buildingos.com/s/cbf/storyboard2143/?chapterId=14263
Davidson, E. (2022). *Proposed Rain Harvesting Opportunities*. University of Hawai’i.
Edelman, M. (2014). Food Sovereignty: Forgotten Genealogies and Future Regulatory Challenges. In *The Journal of Peasant Studies*. https://academicworks.cuny.edu/cgi/viewcontent.cgi?article=1104&context=gc_pubs
Fire Safety Research Institute, Kerber, S., & Alkonis, D. (2024). *Lahaina Fire Comprehensive Timeline Report*. UL Research Institutes. https://doi.org/10.54206/102376/VQKQ5427
First Nations Development Institute. (2004). *For-Profit Feasibility Planning for Nonprofit Organizations* (Nonprofit Capacity Building Booklets Supported Byf the Carnegie Corporation of New York). First Nations Development Institute. https://www.firstnations.org/wp-content/uploads/publication-attachments/2004_For-Profit_Feasibility_Planning_for_Nonprofits.pdf
First Nations Development Institute. (2013). *Reclaiming Native Food Systems: Part I* (pp. 1–26). First Nations Development Institute. https://www.firstnations.org/wp-content/uploads/publication-attachments/2013_Reclaiming_Native_Food_Systems_Part_I.pdf
Franzese, J. (2021). *Greywater Reclamation in Commercial Office Buildings* (Feature) [Feature]. https://www.phcppros.com/articles/14023-greywater-reclamation-in-commercial-office-buildings
Giambelluca, T. W., Chen, Q., Frazier, A. G., Price, J. P., Chen, Y.-L., Chu, P.-S., Eischeid, J. K., & Delparte, D. M. (2013). Online Rainfall Atlas of Hawai‘i. *Bulletin of the American Meteorological Society*, *94*(3), 313–316. https://doi.org/10.1175/BAMS-D-11-00228.1
Goodrich, K. A., Sjostrom, K. D., Vaughan, C., Nichols, L., Bednarek, A., & Lemos, M. C. (2020). Who are boundary spanners and how can we support them in making knowledge more actionable in sustainability fields? *Current Opinion in Environmental Sustainability*, *42*, 45–51. https://doi.org/10.1016/j.cosust.2020.01.001
Graham, W. (2018). The Bonanza Horizon: Molokai in the Sugar Era, 1870–1893. In W. Graham, *Braided Waters* (pp. 99–125). University of California Press.

https://doi.org/10.1525/california/9780520298590.003.0005
Great Lakes Stewardship Initiative. (2016). *Guiding Principles for Exemplary Place-Based Stewardship Education* (pp. 1–10) [Regional service organizations report]. https://greatlakesstewardship.org/
Grundfos. (n.d.). *Wasterwater in Commercial Buildings: Application Guide*. https://drive.google.com/drive/folders/1VHPc6gb9izCSD-y-w7I27BL3uUuu9Nui
Hawaii Sea Grant. (2018). Water Reuse. *Sea Grant: University of Hawai'i*. https://seagrant.soest.hawaii.edu/water-reuse/
Hawaii State Department Wastewater Branch of Health. (2009). *Guidelines for the Reuse of Gray Water*. Hawaii State Department of Health. https://health.hawaii.gov/wastewater/files/2016/03/14_Gray_Water_GL.pdf
Hawaiian Electric. (2023). *Rates and Regulations, Average Price of Electricity*. Hawaiian Electric. https://www.hawaiianelectric.com/billing-and-payment/rates-and-regulations/average-price-of-electricity
IT Landes Home Service. (2021, May 16). *How Many Watts Does an Air Conditioner Use?* https://itlandes.com/how-many-watts-does-an-air-conditioner-use/
Kapāʻanaokalāokeola Nākoa Oliveira, K.-A. R. (2014). *Ancestral Places: Understanding Kanaka Geographies*. Oregon State Press. https://osupress.oregonstate.edu/book/ancestral-places
K.Denzin, N., S.Lincoln, Y., & TuhiwaiSmith, L. (2008). *Handbook of Critical and Indigenous Methodologies*. SAGE Publications, Inc. https://doi.org/10.4135/9781483385686
KYA Design Studio. (2017). *Administration and Allied Health Facilities University of Hawaii at West Oahu | KYA Inc.* http://kya.design/pages/uh-administration-and-allied-health
Look, M., Soong, S., & Kaholokula, J. (2020). *Assessment and Priorities for Health and Well-Being in Native Hawaiians and Pacific Islanders*. Department of Native Hawaiian Health. https://doi.org/10.13140/RG.2.2.22162.89286
LRIRE. (2020, March 27). *Kānāwai: Using Ancient Hawaiian Law to Prepare for the Future*. UCLA Law Review. https://www.uclalawreview.org/kanawai-using-ancient-hawaiian-law-to-prepare-for-the-future/
Malabed, D. J. (2022). *ʻUmeke ʻAi Center Poster*. University of Hawai'i.
Maui County. (2023). *County of Maui Tax Parcel Viewer* [Web App]. ESRI ArcGIS. https://mauicounty.maps.arcgis.com/apps/webappviewer/index.html?id=15c5b7a8113f44f1969e3361be2a5266
Maui County. (2024). *County of Maui's Real Property Tax Assessment Website*. Maui Real Property Tax. https://qpublic.net/hi/maui/

Maui Electric Company, Limited. (2019, July 15). *Maui Division: Schedule “J” General Service Demand* [Schedule]. https://www.google.com/url?q=https://www.hawaiianelectric.com/documents/billing_and_payment/rates/maui_electric_rates_maui/maui_rates_sch_j.pdf&sa=D&source=docs&ust=1711316700062553&usg=AOvVaw1eqZFDDquIjCFpFovv4-Iy

Maui Food Bank. (n.d.). *Food Distribution*. Maui Food Bank. Retrieved April 21, 2024, from https://mauifoodbank.org/food-distribution/

McGregor, L. W. (n.d.). *How Food Secure Are We if Natural Disaster Strikes?* Hawaii Sea Grant. Retrieved February 16, 2023, from https://seagrant.soest.hawaii.edu/how-food-secure-are-we-if-natural-disaster-strikes/

Molokai Clean Energy Hui. (2023). *Molokai Community Energy Resilience Action Plan* (1). https://indd.adobe.com/view/0be0442d-e9c3-4523-903a-5d577ec5fdc0

Molokai Community Health Center. (2024). *Population Served* (OVERVIEW OF THE COMMUNITY NEED/POPULATION SERVED). Molokai Community Health Center. https://molokaichc.org/population-served/

Molokai Needs Assessment Report. (2023). Sustʻāinable Molokai. https://drive.google.com/file/d/1Nm2KreZSrLcwAYZNE3H9N8YZso-hqvNr/view?usp=sharing&usp=embed_facebook

Neumeister, K. (2024, January 8). *How Much Do Solar Panels Cost in Hawaii?* EcoWatch. https://www.ecowatch.com/solar/panel-cost/hi

Nguyen, T. (2022). *Seed-to-Waste Center Poster*. University of Hawaiʻi.

Norwesco. (2024). *Norwesco 10,000 Gallon & Larger*. Norwesco. https://www.norwesco.com/products/waste-water-tanks/10000-gallon-larger-cistern-septic-holiding-tanks

Oteng-Peprah, M., Acheampong, M. A., & deVries, N. K. (2018). Greywater Characteristics, Treatment Systems, Reuse Strategies and User Perception—A Review. *Water, Air, and Soil Pollution*, *229*(8), 255. https://doi.org/10.1007/s11270-018-3909-8

Pactol, C. C. (2022a, March 19). Molokai Hit Hard with Rising Cost of Fuel. *The Molokai Dispatch*. https://themolokaidispatch.com/molokai-hit-hard-with-rising-cost-of-fuel/

Pactol, C. C. (2022b, September 15). Molokai Decides Its Own Energy Future. *The Molokai Dispatch*. https://themolokaidispatch.com/molokai-decides-its-own-energy-future/

Pactol, C. C. (2023, November 15). Molokai’s Renewable Energy Future Looks Bright | The Molokai Dispatch. *The Molokai Dispatch*. https://themolokaidispatch.com/molokais-renewable-energy-future-looks-bright/

Sampson, D. (2021). Food Sovereignty and Rights-Based Approaches Strengthen Food Security and Nutrition Across the Globe: A Systematic Review. *Frontiers*. https://www.frontiersin.org/articles/10.3389/fsufs.2021.686492/full

Searchinger, T., Waite, R., Ranganathan, J., & Hanson, C. (2019). *Creating a Sustainable Food Future: A menu of Solutions to feed Nearly 10 Billion People by 2050* (p. 564) [World Resources Report]. The World Bank, UN Environment, UNDP, Cirad, INRA. https://research.wri.org/sites/default/files/2019-07/WRR_Food_Full_Report_0.pdf

Seiler, M. (1979, March 31). Molokai Meanderings: Will Tourism Spoil the Aloha Spirit of Sleepy Molokai? Will Tourism Prove an Economic Salvation for This Sleepy Island, or Will It Spoil the Aloha Spirit? *Washington Post*. https://www.washingtonpost.com/archive/lifestyle/1979/04/01/molokai-meanderings/087de50a-559b-476d-a540-a74aca18b267/

Smith, L. T. (2008). *Decolonizing Methods: Research and Indigenous Peoples* (12th ed.). University of Otago Press.

State of Hawaii. (2023). *Hawaii Statewide GIS Program*. State of Hawaii Office of Planning and Sustainable Development. https://planning.hawaii.gov/gis/download-gis-data-expanded/

State of Hawaii Department of Business, Economic Development & Tourism Research and Economic Analysis Division. (2011). *Island Population and Housing Units, State of Hawaii: 2010* (pp. 1–26). Hawaii State Data Center. https://files.hawaii.gov/dbedt/census/Census_2010/PL94-171/Island_Report_Final.pdf

State of Hawaii, Department of Business, Economic Development & Tourism, & Research and Economic Analysis Division. (2011). *Island Population and Housing Units, State of Hawaii: 2010* (pp. 1–26) [Census]. Hawaii State Data Center. https://files.hawaii.gov/dbedt/census/Census_2010/PL94-171/Island_Report_Final.pdf

Taylor, D. E. (2007). Diversity and the environment: Myth-making and the status of minorities in the field. In R. C. Wilkinson & W. R. Freudenburg (Eds.), *Equity and the Environment* (Vol. 15, pp. 89–147). Emerald Group Publishing Limited. https://doi.org/10.1016/S0196-1152(07)15003-1

Terrell, J. (2021, January 27). *Hawaii’s Food System Is Broken. Now Is The Time To Fix It*. Honolulu Civil Beat. https://www.civilbeat.org/2021/01/hawaiis-food-system-is-broken-now-is-the-time-to-fix-it/

Teves, G. I. (2015). *Know Your History, Know Your Water* (Molokai Native Hawaiian Beginning Farmer Newsletter, pp. 1–13). University of Hawaii College of Tropical Agriculture and Human Resources, Cooperative

Extension Service — Molokai. https://gms.ctahr.hawaii.edu/gs/handler/getmedia.ashx?moid=2927&dt=3&g=12

Twinview. (2021). *Benchmarking commercial energy use per square foot*. https://www.twinview.com/insights/benchmarking-commercial-energy-use-per-square-foot#:~:text=Here%20is%20the%20breakdown%20of,foot%20are%20consumed%20by%20lighting

United States Census Bureau. (2022). *East Molokai CCD Census Bureau Profile*. United States Census Bureau. https://data.census.gov/profile/East_Molokai_CCD,_Maui_County,_Hawaii?g=060XX00US1500990090

Weiler, A. M., Hergesheimer, C., Brisbois, B., Wittman, H., Yassi, A., & Spiegel, J. M. (2015). Food sovereignty, food security and health equity: A meta-narrative mapping exercise. *Health Policy and Planning*, *30*(8), 1078–1092. https://doi.org/10.1093/heapol/czu109

Appendices

Appendix A: *Energy Analysis Spreadsheet*

	Specs	Capacity (W)	Hours/Day	Qty	Energy/Yr (kWh)
		149,879			**671,571**
Food Hub	**10,000 sqft**				
Space					
Airconditioning	3.5kW / 2,000sqft	17,500	*10*	*1*	63,875
Lighting	7kWh / sqft / year	15,982	*12*	*1*	70,000
Hot Water	0.5kWh / sqft / year	1,370	*10*	*1*	5,000
Equipment					
Freezer Refrigerator	25.5 cuft; 562kWh/yr	128	*24*	*2*	1,124
Commercial Freezer	1.5 HP or 1105 W	1,105	*24*	*1*	9,680
Reefer Storage	3kW / 18ft x 20ft	9,000	*24*	*3*	78,840
Outside Reefer (Mobile)	110V * 15A = 1.65 kW / 6'x16' mobile / 37.5sqft	1,650	*24*	*1*	14,454
Subtotal		**46,735**			**242,973**
Food Bank	**3,000 sqft**				
Space					
Airconditioning	3.5kW / 2,000sqft	5,250	*10*	*1*	19,163
Lighting	7kWh / sqft / year	4,795	*12*	*1*	21,000
Hot Water	0.5kWh / sqft / year	411	*10*	*1*	1,500
Equipment					0
Commercial Refrigerator	0.5 HP or 368 W	736	*24*	*2*	6,447
Commercial Freezer	1.5 HP or 1105 W	1,105	*24*	*1*	9,680
Walk-In Wholesale Reefer	$15-20 K installed	3,000	*24*	*1*	26,280
Subtotal		**15,296**			**84,070**
Certified Kitchen	**2,000 sqft**				
Space					
Airconditioning	3.5kW / 2,000sqft	3,500	*10*	*1*	12,775
Lighting	7kWh / sqft / year	3,196	*12*	*1*	14,000
Hot Water	0.5kWh / sqft / year	274	*10*	*1*	1,000
Equipment					0
Reefer Storage (Double Stand Alone)	3kW / 18ft x 20ft	3,000	*24*	*1*	26,280
Stand Alone Refrigerator (Hot Prep Area)	0.5 HP or 368 W	368	*24*	*1*	6,447
Stand Alone Refrigerator (Cold Prep Area)	0.5 HP or 368 W	368	*24*	*1*	6,447
Egg Processing Station (600 of the 2,000 sqft)	2.6kW /	2,600	*8*	*1*	7,592
Subtotal		**13,306**			**74,542**

Cafe / Storefront	**1,000 sqft**				
Space					
Airconditioning	3.5kW / 2,000sqft	1,750	*10*	*1*	6,388
Lighting	7kWh / sqft / year	1,598	*12*	*1*	7,000
Hot Water	0.5kWh / sqft / year	137	*10*	*1*	500
Equipment					
Refrigerator	25.5 cuft; 562kWh/yr	64	*24*	*1*	562
Subtotal		**3,549**			**14,450**

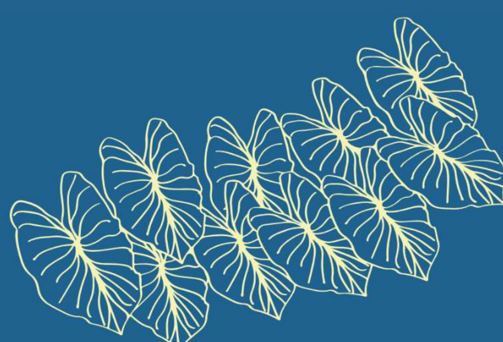
Community Center	**8,000 sqft**				
Space					
Airconditioning	3.5kW / 2,000sqft	14,000	*10*	*1*	51,100
Lighting	7kWh / sqft / year	12,785	*12*	*1*	56,000
Hot Water	0.5kWh / sqft / year	1,096	*10*	*1*	4,000
Subtotal		**27,881**			**111,100**

Offices / Conference Rooms	**3,000 sqft**				
Space					
Airconditioning	3.5kW / 2,000sqft	5,250	*10*	*1*	19,163
Lighting	7kWh / sqft / year	4,795	*12*	*1*	21,000
Hot Water	0.5kWh / sqft / year	411	*10*	*1*	1,500
Equipment					
Office Equipment	15kWh / sqft / year	15,411	*8*	*1*	45,000
Subtotal		**25,866**			**86,663**

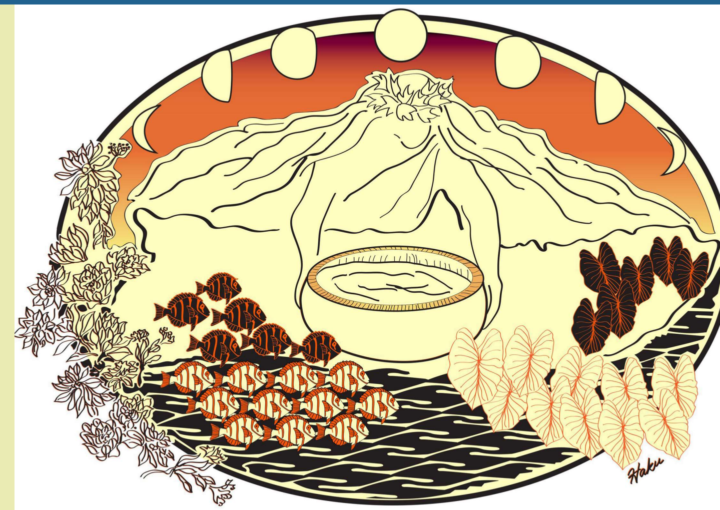
Molokai Arts Center	**2,000 sqft**				
Space					
Airconditioning	3.5kW / 2,000sqft	3,500	*10*	*1*	12,775
Lighting	7kWh / sqft / year	3,196	*12*	*1*	14,000
Hot Water	0.5kWh / sqft / year	274	*10*	*1*	1,000
Equipment					
Other Equipment	15kWh / sqft / year	10,274	*8*	*1*	30,000
Subtotal		**17,244**			**57,775**

Appendix B: *Precedent Study Report*

2022-2024 Sust‘āinable Molokai: Precedent Study



Food Infrastructure Precedent Report



Developed for Sust‘āinable Molokai

In partnership with the University of Michigan School for the Environment and Sustainability

SCHOOL FOR ENVIRONMENT AND SUSTAINABILITY
UNIVERSITY OF MICHIGAN

TABLE OF CONTENTS

MOLOKAI ICE HOUSE, INC.

Overview

Profit Status: Incorporated, non-profit
Property Area: 0.0967 acres
Building Size: 2045 sqft (estimate)
Market Land Value: $9,200
Energy Demand: 1,535.8 kWh/month (estimated)
Capacity: 170 people
Refrigeration Size: 1 fridge (not walk-in), 1 walk in reefer inside, 1 walk-in reefer outside

Amenities

- Commercial kitchen
- Gathering / community space
- Pull up window for cars and boats
- Stainless steel table
- Door to parking lot
- Power lines run the length of the wharf
- Some cabinet space


Road to the Pier


Boats Near Ice House


Aggregation/Raw-Prep Room


Preparation Area


Indoor Reefer


Outside Reefer

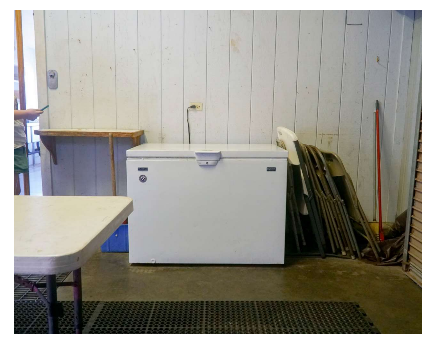

Kitchen/Service Area


Stainless Steel Double Sink


Roll-Up Door Reefer/ Chest Freezer


Two Restrooms


Refrigeration


Second Reach-in Fridge

MAUNALOA COMMUNITY CENTER

Overview

Profit Status: Government-owned
Property Area: 51,430 sqft
Building Size: 3,700 sqft
Market Land Value: $240,700
Energy Demand: 221.18 kWh/month
Capacity: 170 people
Refrigeration Size: 1 standard-size fridge (not walk-in)

Amenities

- Uncertified small kitchen
- Gathering/community space
- Big windows into community space
- Small covered walkway outside
- Large outdoor space
- Door to parking lot
- Some cabinet space
- 110 volt outlets available inside the Center


Stage


Small Kitchen


Covered Walkway


Stainless Steel Triple Sink


Indoor/Outdoor Capability


Kitchen Service Window


Stage in Community Space


Noncommercial Kitchen with Indoor Window


Covered Outdoor Walkway


Stainless Steel Counters and Triple Sink


Indoor/Outdoor with Large Lawn and Sliding Doors


Indoor Gathering Space with Three Exits

MITCHELL PAUOLE CENTER

Overview

Profit Status: Government-owned
Property Area: 6.4 acres
Building Area: 8 buildings on property, largest is 9,284 sqft
Market Land Value: $1,362,800
Energy Demand: 17,207.12 kWh/month
Capacity: 246 people
Refrigeration Size: 1 standard size fridge, not walk-in

Amenities

- Uncertified large kitchen with stainless steel counters, sinks, and grease trap with indoor window to community hall and a outdoor-facing window
- Stage, tables, and table storage
- Covered and uncovered outdoor picnic tables
- Sports complex: gymnasium, tennis courts, and skateboard park
- Large gathering space with fans
- Cleaning sink in attached closet
- Historic building and emergency shelter status
- 110 volt hookup inside and outside

Large Kitchen

Stage and Tables

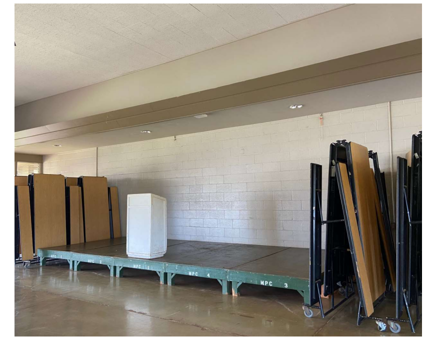
Covered Outdoors

Basketball Court

Gathering Space

Kitchen Indoor Window

Large Kitchen (stainless steel, grease trap)

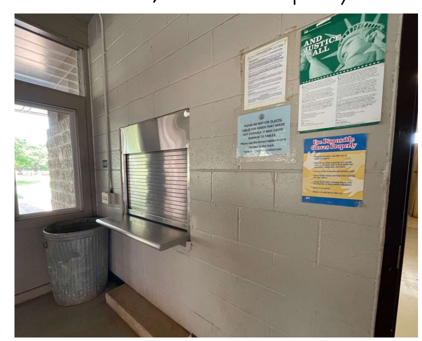


Stage, Tables, and Additional Storage

Covered Outdoor Space and Picnic Tables

Sports Complex (gymnasium, sports courts, skateboard park)

Large Indoor Gathering Space



Kitchen Indoor Window to Community Hall

KULANA 'OIWI

Overview

Profit Status: Both non- and for-profit
Property Area: 10.752 Acres
Building Area: 25,700 sqft (estimate)
Market Land Value: $100
Energy: 19,300.7 kWh/month (estimate)
Capacity: 100 people in main community space
Refrigeration Size: 3 fridges

Amenities

- Multi-building complex
- AC inside buildings
- Native trees/plants in landscape
- Culturally-significant architecture design
- Each building has its own private patio & garden
- Covered walkways
- Rainwater for irrigation
- Some buildings have solar panels on roof

Culturally Significant Architecture

Private Outdoor Space

Covered Walkways

Native Plants

Solar Panels

Rainwater for Irrigation

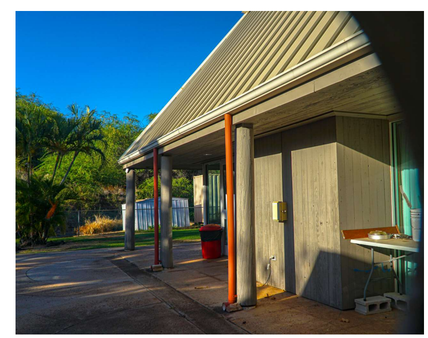
Solar Panels

Serving Window

Vaulted Ceiling Pavilion

Covered Outdoor Pavilion

Courtyard with Seating



Water Capture and Diversion

KUALAPU'U RECREATION CENTER

Overview

Profit Status: Government-owned
Property Area: 6.773 acres
Building Size: 2,824 sqft
Market Land Value: $78,800
Energy Demand: 298.03 kWh/month
Capacity: 150 people
Refrigeration Size: 1 standard-size fridge (not walk-in)

Amenities

- Uncertified small kitchen with laminated counters, stainless steel sinks, and grease trap with large indoor kitchen window facing community hall
- Field and large parking lot size
- Lanai space
- Three storage spaces
- Office space
- Six exits (2 ADA accesible)
- 110 volt outlets inside and outside

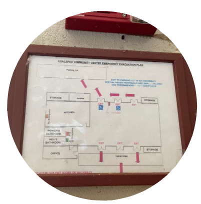
Indoor Gathering Space

Large Kitchen Indoor Window

Small Indoor Kitchen

Covered Outdoor Section

Back Door and Parking Lot Area



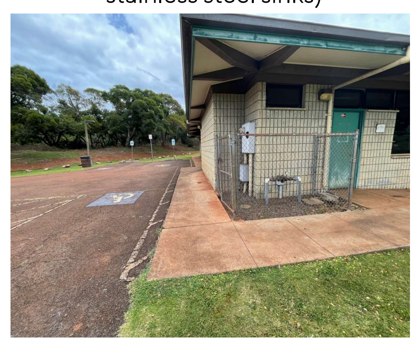
Community Center Layout

Indoor Gathering Space

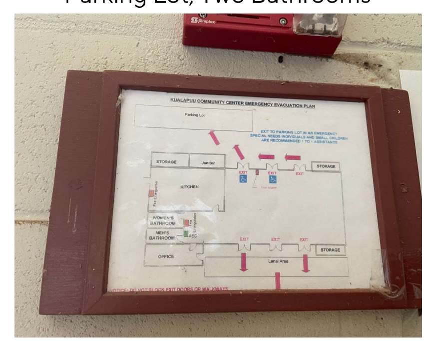
Large Indoor Kitchen Window to Gathering Space

Small Kitchen (laminated counters, stainless steel sinks)

Small Covered Outdoor Space by Parking Lot, Two Bathrooms



Back Door Entrance by Parking Lot



Community Center Layout

MOLOKAI COMMUNITY HEALTH CENTER

Overview

Profit Status: Non-profit
Property Area: 3.4379 acres
Building Size: 7 buildings on property, ranging from 600 to 4,512 sqft
Market Land Value: $1,110,500
Energy Demand: 13,300.21 kWh/month (estimate)
Capacity: n/a
Refrigeration Size: 1 walk-in-freezer and fridge, 1 reach-in-freezer and fridge, and 1 fridge in prep area

Amenities

- Certified kitchen with stainless steel tables, two walk-in fridge and freezers, 1 large reach-in fridge, 1 ice machine, and dry storage space
- Community Farm Fresh food pantry operates here, serving around 200 people every month
- AC in kitchen


Layout of Property


Outdoor Pathway


Mana Medical Mobile Clinic

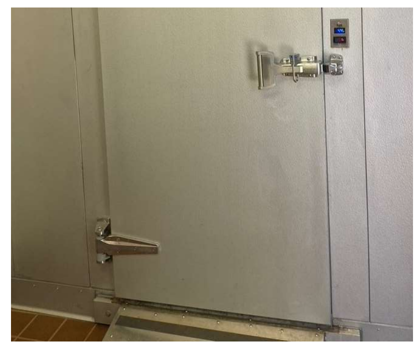

Food Prep Space


Ice Machine


Large Fridge

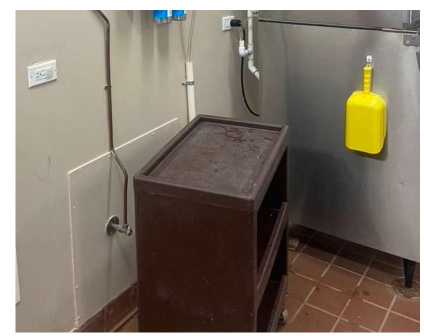
Mana Medical Mobile Clinic offering Telehealth Services


Laminated Counter and Stainless Steel Sink


Walk-In-Freezer and Fridge


Stainless Steel Counters and Sink


Wok Burners and Range Stovetop


Indoor Ice Maker

KILOHANA COMMUNITY CENTER

Overview

Profit Status: Government-owned
Property Area: 5.07 acres
Building Size: 4,764 sqft
Market Land Value: $134,500
Energy Demand: On-grid, 453.6 kWh per month
Capacity: n/a
Refrigeration Size: 1 fridge, not walk-in

Amenities

- Uncertified Kitchen with 1 reach-in fridge, laminated tables, sink for handwashing, oven, and limited storage space
- Large windows
- Outside deck
- Hood above range in kitchen
- Service space for outdoor visitors
- Event space


Back of Building


View from Inside

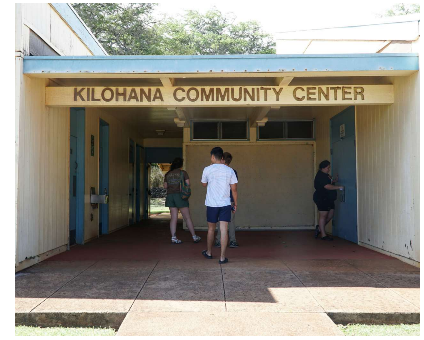

Kitchen


Outer Serving Widow


Women's Bathroom


Men's Bathroom

View from Inside



Front of Building


Kitchen


Outer Serving Widow


Women's Bathroom


Men's Bathroom

MOLOKAI CARING FOR VETERANS CENTER

Overview

Profit Status: Government-owned
Property Area: 0.37 acres
Building Size: 1,890 sqft
Market Land Value: $132,000
Energy Demand: 202.23 kWh/month (estimate)
Capacity: n/a
Refrigeration Size: 1 reach-in fridge and freezer

Amenities

- Certified kitchen with 1 reach-in fridge, stainless steel counter tops, grease trap, stove, flat top, deep fryer, and large rice cooker
- Pull up window from kitchen to indoor meeting space
- Shelves for dry storage in kitchen
- AC community area
- Door from kitchen to parking lot


Layout of the space


Parking Lot


Outside Space


Stainless Steel Counter


Rice Cooker and Stovetop


Flat Top and Deep Fryer

Precedent Report: Molokai Community Centers
Molokai Caring for Veterans Center


Gravel Parking Lot


Layout of Building


Covered Outdoor Space and Two Bathrooms


Stovetop, Flat Top, Deep Fryer


Large Rice Cooker, Wok Burner, Stovetop


Stainless Steel Counter, Small Rice Cooker and Sink

LANIKEHA COMMUNITY CENTER

Overview

Profit Status: Government-owned
Property Area: 5.638 acres
Building Size: Two buildings on this property, the first is 12,098 sqft and the second is 11,666 sqft
Market Land Value: $100
Energy: 11,822 kWh/month (estimate)
Capacity: n/a
Refrigeration Size: 1 walk-in freezer, 1 reach-in fridge, 1 smaller meat freezer

Amenities

- Certified kitchen with stainless steel counters, hand and produce washing sinks, 1 walk-in freezer, 1 reach-in fridge, and 1 small freezer used for meat storage
- Frequently used community space
- The building value is $5,714,500
- Large field behind building that can be used for events or outdoor activities

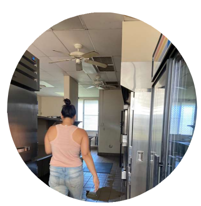
Community Hall

Parking Lot

Small Freezer

Stainless Steel Sink

Walk-In-Freezer



Second Fridge

Community Hall

Wide View of Community Hall

Parking Lot Near Kitchen

Second Freezer and Kitchen Space

Stainless Steel Sink and Hallway View

Walk-In Freezer

MAUI FOOD BANK

Overview

Profit Status: Non-profit
Land Use Type: Industrial
Property Area: 0.565 acres
Building Size: 9,500 sq ft
Market Land Value: $935,200
Energy: Fully solar powered
Capacity: n/a
Refrigeration Size: 1 large walk-in freezer, 5 rows of integrated refrigeration, several rows of dry storage racks

Amenities

- Provides an electric forklift for storage organization
- Rolling rack dry storage system
- Integrated office next to storage areas
- Government grants account for 25% of their budget


Storage Entrance


Side Entrance


Dry Storage Shelves


Storage Space


Office Space

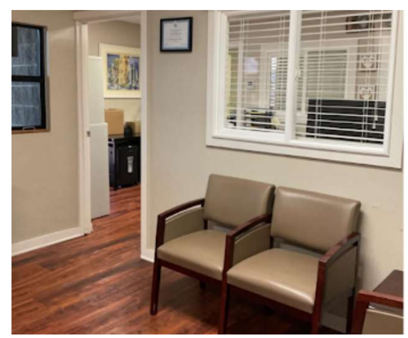

Walk-In Freezer and Refrigeration Shelves


Roll Up Doors


Dry Storage and Automatic Doors


Dry Storage Large Shelves


Walk-in Freezer and Integrated Refrigeration Shelves


Office and Meeting Space


Easy to Repair Power System

MAUI FOOD HUB

Overview

Profit Status: Non-profit
Property Area: Unknown
Building Size: 4,320 sqft
Market Land Value: $10,379,400
Energy: n/a
Capacity: n/a
Refrigeration Size: 1 walk-in freezer, 1 reach-in fridge, 1 smaller meat freezer

Amenities

- Warehouse allows for storage and distribution of goods, for no membership cost
- Markets, aggregates, and sells goods for farmers and other producers
- The building value is $6,286,100
- Some office and retail space, as well as cold storage space, parking lot and loading area

Parking Lot

Office

Cold Storage

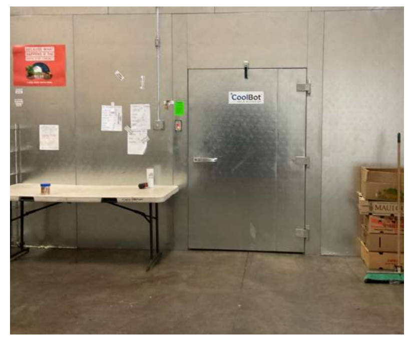
Chilled Processing Area

Internal Space

Loading Dock

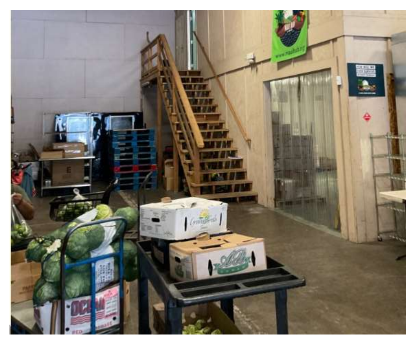
Parking Lot and retail front

Office



Cold Storage (20'x18')

Chilled Processing Area



Internal Space

Loading Dock and Forklift

KIHEI COMMUNITY CENTER GYM

Overview

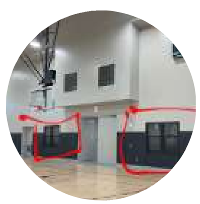
Profit Status: Government-owned
Property Area: 7 acres
Building Size: 14,956 sqft (building #1), 3,871 sq ft (building #2)
Market Land Value: $2,940,300
Energy: n/a
Capacity: 500 people
Refrigeration Size: n/a

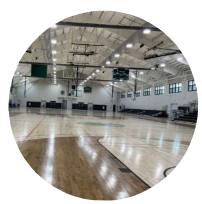
Amenities

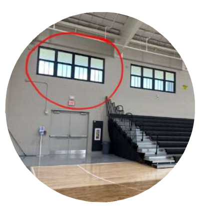
- Solar-covered parking lot
- 42'6" high gym with 3' thick beams
- Hurricane-rated windows in gym
- Concession stand with connection to a small kitchen and a pull-up window


Solar-Covered Parking Lot


Kitchen/Pull-Up Window


Office Spaces


Indoor Gym


Hurricane-Rated Windows


Small Room by Concession Stand


Outdoor Covered Playground


Meeting Room


Gym (can be four courts)

South Entrance (litter issue)


Kitchen & Pull-Up Window


Solar Panels in Parking Lot

PACIFIC GATEWAY CULINARY BUSINESS INCUBATOR

Overview

Profit Status: For-profit
Property Area: 0.48 acres (20,968 sqft)
Building Size: 6,656 sqft
Market Land Value: $2,597,900
Energy: Solar, including solar water heaters. $600/month for electrical.
Capacity: n/a. Serves 80-90 entrepreneurs per month.
Refrigeration Size: 2 walk-in reefers, multiple commercial fridges

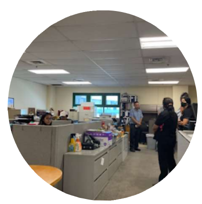
Amenities

- 12 commercial kitchens, including food prep and baking
- Kitchens are 400-1000 sqft each
- Incubator farm has "6 containers of commercial kitchens", including 1 having a full hood
- Monthly membership includes dry storage, refer, freezer, and house use


Conference Space


Dry Storage Area


Dry Storage Shelving


Office Space


Walk-In Reefer


Kitchen Cooking Area

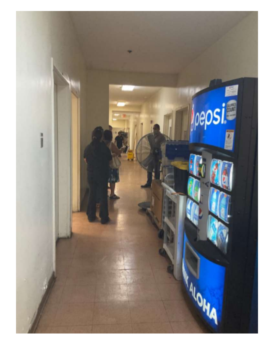

2 Walk-In Reefers


Washing & Food Prep Areas


Washing Area & Commercial Fridge


Dry Storage with Bins


Baking Equipment



Intermediary Space

KAHUMANA

Overview

Profit Status: Non-profit
Land Use Type: Agricultural
Property Area: 14.610 acres
Building Size: 12 buildings, 3,366 - 272 sq ft
Market Land Value: $1,113,600
Energy: Some solar
Capacity: n/a
Refrigeration Size: Whisper fridge, cooling fridge; 10k cooling system, 3k fridge retrofitted

Amenities

- First 4 buildings were built in the 1950s and 8 more buildings were added later
- 201 growers use the food hub aggregation service
- 31 acre certified organic farm, homes are on 12 of the acres
- 30 - 35 staff total, 100 staff for retreat center

Outdoor Kitchen and Dining

Restaurant Space

Freezer Shelves

Outdoor Receiving Area

Kitchen Juicer

Kitchen Dehydrator

Meeting Space

Outdoor Aggregation Site

Kitchen and Preparation Area

Dry Storage

Range Stove Top

Outdoor Freezer Trailer

HAWAI'I FOOD BANK

Overview

Profit Status: Non-profit
Property Area: 1.03 acres
Building Size: 23,696 sq ft
Market Land Value: $6,077,100
Energy: 300 kw solar energy system & non-renewable
Capacity: 120,000 people served per month (110,000 people in O'ahu, 10,000 people on Kaua'i)
Refrigeration Size: n/a

Amenities

- Retailer donations are a main food source (8 retailer/wholesaler trucks)
- 60 staff: 30 office staff, 30 warehouse staff
- Local farm procurement, including Ka'ahumanu Farms
- Centrally located, but in a flood zone
- Huge demand for cold storage


Loading Dock


Dock Driveway


Conference Room


Dry Storage Area

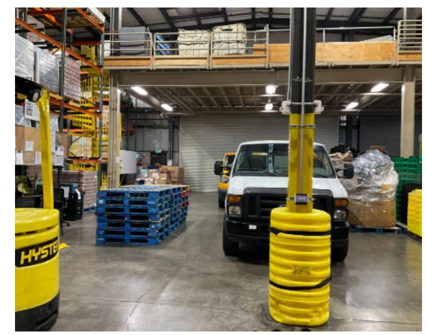

Sales Floor

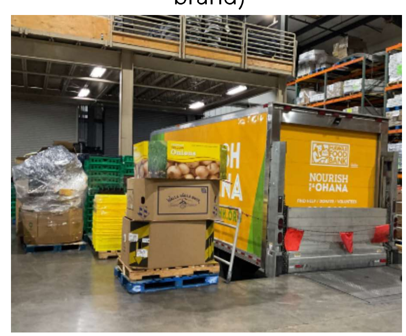

Walk-In Reefer


Food Sorting Area

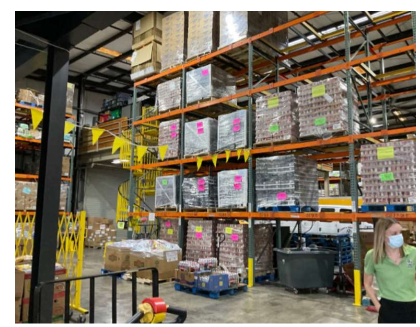

Cold Storage Space


Walk-In Reefer (door is Jamison brand)


Two Pull-In Forklifts



One Bay Truck Dock


Sales Floor

O'AHU FRESH/O'AHU FOOD HUB

Overview

Profit Status: Both non/for-profit
Property Area: 0.2897 acres
Building Size: 12,621 sq ft
Market Land Value: $2,991,400
Energy: n/a
Capacity: n/a
Refrigeration Size: n/a

Amenities

- A number of reefers (looking to centralize this aspect)
- Food hub model provides flexibility for producers and consumers
- Ulu chip business/truck
- Rental space for farmers and cooks for a variety of purposes

Kitchen

Equipment Storage

Ulu Truck

Dry Storage

Prep/Bake Kitchen

Reefer

Kitchen

Equipment Storage

Ulu Truck

Dry Storage

Prep/Bake Kitchen

Reefer

KOKUA KAHLIHI VALLEY

Overview

Profit Status: Non-profit
Land Use Type: Residential
Property Area: 21.1860 acres
Building Size: 2 buildings (2,264 sq ft, 862 sq ft)
Market Land Value: $3,726,300
Energy: n/a
Capacity: n/a
Refrigeration Size: n/a

Amenities

- 100 acres is Ho'olua 'Aina, a nature preserve
- Roots Food Hub is one part of the Kokua Kahlihi Valley community health program
- Roots Café & Market sold 15,000 lbs of ulu during the season
- Rain water catchment system waters garden plots


Roots Café & Market


Garden Plot


Café Kitchen


Indoor Dining


Invasive Forest


Hau Tree

Roots Café & Market


Garden in Ho'olua 'Aina


Water Catchment System


Kitchen Prep Area


Roots Café Lunch


Café Kitchen Entrance

HUIMAU

Overview

Profit Status: Non-Profit
Land Use Type: Agricultural
Property Area: 1,000 acres
Building Size: n/a
Market Land Value: n/a
Energy: n/a
Capacity: 285 lessees
Refrigeration Size: n/a

Amenities

- 80 acres converted from former sugar plantation land to ulu
- Farm to table
- Agroecology methods, including Pakukui farm method, covered imu area, companion planting (banana on eucalyptus)
- 10 acres of reforested native plants


Farm to Table


Covered Imu Area


Companion Planting


Native Plant Reforestation


Portable Insulated Trailer


Pakukui Farming


Native Plant Reforestation


Storage Shed

Imu Area


Native Plant Reforestation


Commercial Vehicle


Portable Insulated Trailer

KOHALA CENTER FARM

Overview

Profit Status: Non-profit
Property Area: 12 acres
Building Size: 10,137 sqft
Market Land Value: $1,054,400
Energy: n/a
Capacity: n/a
Refrigeration Size: n/a

Amenities

- Focused on research
- Giving 90% of produced food away for free
- Helping newer farmers get started with a better understanding of agriculture; helping with grant access; farmers pay for this experience/training
- Seed-saving, especially of rare varieties of traditionally cultivated plants


Permaculture Setup


Training Orchard


Greenhouse


Equipment Shed


Kalo Field


Terraces


Permaculture Setup


Training Orchard


Greenhouse


Equipment Shed


Kalo Field


Terraces

ULU CO-OP

Overview

Profit Status: Cooperative
Property Area: 1.91 acres (Kailua-Kona facility), 50.89 acres (Hilo facility)
Building Size: 4,800 sq ft (Kailua-Kona facility), 1,476,031 sq ft (Hilo facility)
Market Land Value: $335,600 (Kailua-Kona facility), $688,800 (Hilo facility)
Energy: 18 solar panels provides some of the needed electricity (Kailua-Kona facility)
Capacity: n/a
Refrigeration Size: Freezer with 8 pallet size capacity (Kailua-Kona facility)

Amenities

- 140 farms across the islands are members of the co-op
- Two processing locations in Kailua-Kona (Honalo Marshaling Yard) and Hilo ('Alae Postharvest Facility)
- Portable dehydrator and commercial peeler available at Honalo Marshaling Yard

Aggregation Area

Storage Space

Ulu Nursery

Ulu Peeler

Dehydrator

Ulu Washer

Roof Solar Panels

Pull Up Entrance to Storage

Portable Metal Shelves

Walk-in Freezer

Ulu Nursery

Locally Grown Kalo

HAWAI'I FOOD BASKET FOOD BANK

Overview

Profit Status: Non-Profit
Property Area: 0.3444 acres
Building Size: Distribution warehouse (3,280 sq ft) and Storage Warehouse (5,186 sq ft)
Market Land Value: $271,800
Energy: n/a
Capacity: n/a
Refrigeration Size: 6 reach-in fridges, 3 reach-in freezers

Amenities

- Warehouse on east and west side of island with dedicated outreach staff
- Part of Hawaii Good Food Alliance
- Provides food to families and soup kitchens via direct delivery

Kupuna Pantry

Community Collabs

Food Pantry

Food Basket Event

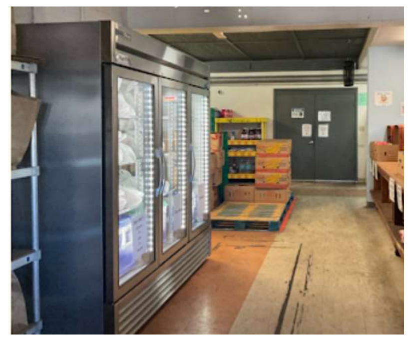
Hilo Food Center Concept

Distribution Event

Precedent Report: Hawai'i Island Community Centers
Hawai'i Food Basket Food Bank

Entrance to Storage

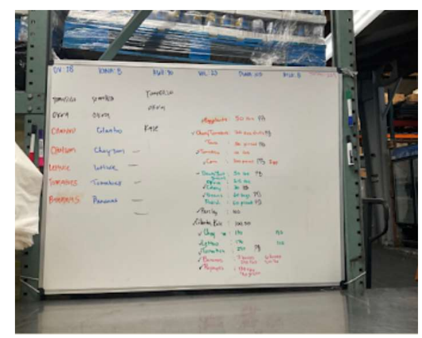
Reach-in Freezer and Fridge



Reach-in Fridge

Handwashing Station

Dakine Mystery Boxes



Whiteboard Schedule

GO-FARM TRAINING FARM & AGGREGATION SITE

Overview

Profit Status: University of Hawai'i affiliate
Land Use Type: Agriculture
Property Area: Multiple sites
Building Size: Site-dependent
Market Land Value: Site-dependent
Energy: n/a
Capacity: n/a
Refrigeration Size: n/a

Amenities

- Farmer training programs; differing levels of training
- Workshops offered on O'ahu, Kaua'i, Maui, and Hawai'i Island
- Canoe-crop program and info that prioritizes Indigenous forms of knowledge
- Meat and ulu processing spaces

Swale and Greenhouse

Meat/Ulu Processing

Kalo Intercrop

Processing Warehouse

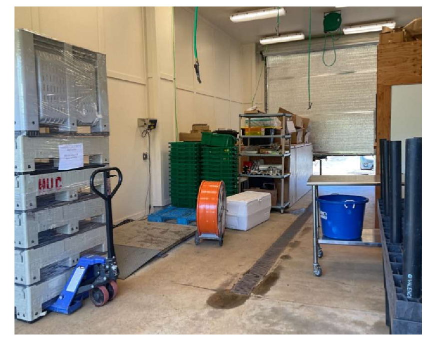
Irrigation

Ulu Co-op Agg. Site

Swale and Greenhouse

Meat/Ulu Processing

Kalo Intercrop



Processing Warehouse

Irrigation

Ulu Co-op Agg. Site

Photo Citations

Molokai Island

Molokai Ice House
Photographed by Flickr User kalihikahuna74. (2009). https://www.flickr.com/photos/35532641@N04/3678054272/in/photostream/

Kulana ʻOiwi
Salbosa, Augie. "Society of Architectural Historians Archipedia." (2001). https://sah-archipedia.org/buildings/HI-01-ML5

Molokai Community Health Center
"Molokai Community Health Center." https://molokaichc.org/

Photo Citations

Maui Island

Maui Food Bank
"Maui Health Donates Over 4,600 Pounds of Turkey and Rice to Maui Food Bank." (2023). https://www.mauihealth.org/news/releases/maui-health-donates-over-4-600-pounds-of-turkey-and-rice-to-maui-food-bank/

Go-Farm Training Farm & Aggregation Site
"Hawaiʻi Agribusiness Guidebook 2020 Edition." https://gofarmhawaii.org/agbusiness-guidebook/

The Kohala Center
"Ōhāhā Mahi ʻAi Agricultural Training and Education Program." https://kohalacenter.org/ohaha-mahiai

Lanikeha Community Center
"Hoolehua Community Center." https://usharch.com/portfolio/hoolehua-community-center/

Maui Food Hub
"Maui Hub expands, bringing local food to more neighborhood." (2022). https://mauinow.com/2022/03/18/maui-hub-expands-bringing-local-food-to-more-neighborhoods/

Photo Citations

Oahu Island

Pacific Gateway Culinary Business Center

"Pacific Gateway Center." https://www.pacificgatewaycenter.org/our-story

Photo Citations

Hawai'i Island

Hawaii Food Basket

Ruminski, Laura. (2017). Hawaii Tribune Herald. https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.hawaiitribune-herald.com%2F2017%2F12%2F15%2Fhawaii-news%2Fthe-food-basket-seeks-volunteers-to-help-sort-donations

Hawaii Food Basket. https://www.hawaiifoodbasket.org/

Google (2024). https://www.google.com/maps/

Croxford, David. (2020). https://www.honolulumagazine.com/hawaii-foodbank-has-distributed-more-than-3-7-million-pounds-of-food-on-oahu-in-less-than-2-months/

HuiMAU

HuiMAU. https://www.alaulili.com/

Go-Farm Training Farm & Aggregation Site

"Hawai'i Agribusiness Guidebook 2020 Edition." https://gofarmhawaii.org/agbusiness-guidebook/

The Kohala Center

"Ōhāhā Mahi 'Ai Agricultural Training and Education Program." (2022) https://kohalacenter.org/ohaha-mahiai