ENVIRONMENTAL AND ECONOMIC BENEFITS OF LOCALLY GROWN VERSUS IMPORTED AGRICULTURE: A CASE STUDY OF SUMIDA FARM

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I certify that I have read this thesis and that, in my opinion, it is satisfactory in scope and quality as a thesis for the degree of Bachelor of Science in Global Environmental Science.

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Abstract

The state of Hawaiʻi relies heavily on food imports in order to feed its residents. In return, the state is highly impacted by food chain issues and fuel surcharges. In order to determine the benefits of supporting local agriculture in Hawaiʻi, this study analyzes the impacts of "local" food using Sumida Farm, a local watercress farm, as a case study. In addition, this study will also characterize some of the key environmental and economic benefits of locally produced versus imported produce. These will be shown by (1) calculating the price differential between local and imported watercress, (2) calculating the greenhouse gas emissions of local and imported watercress, and (3) describing and illustrating the social reach and community impact of Sumida Farm.

We find that the cost of imported watercress for the residents of Hawaiʻi is more than double the cost of local watercress, and residents would need to pay about $3 million more per year for imported watercress. We also find that the total greenhouse gas emissions associated with imported watercress is over 50 times the emissions of local watercress. Finally, we find that although most of Sumida Farm's community presence is on the island of Oʻahu, their impact can be felt throughout most islands across the state.

Keywords: Local agriculture, Sumida Farm, watercress

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AFOLU - Agriculture, Forestry, and Other Land Uses

CFT – Cool Farm Tool

EDF – Environmental Defense Fund

GIS – Geographical Information Systems

GHG – Greenhouse Gas

NDC – Nationally Determined Contribution

1.0 Introduction

This thesis had three objectives: (1) to calculate the price differential between local and imported watercress, (2) to calculate the greenhouse gas emissions of local and imported watercress, and (3) to describe and illustrate the social reach and community impact of Sumida Farm.

1.1 The Importance of Local Agriculture

The agriculture and food industry is one of the biggest and most important industries in the world. This means that many individuals also rely on farming for economic reasons. Improving agricultural practices to be more sustainable, practical, and resilient could be an answer for world hunger and poverty, and provide more jobs, nutritional food, and economic stability in individual communities (Townsend, 2015).

While “local” food has no concrete definition and can vary between regions, companies, and consumers, food is often considered “local” if it has travelled less than 400 miles from its origin (Hand et al., 2010). In the United States, the local food market is a small yet growing subindustry. In 2007, local direct-to-consumer sales made up 0.4% of total agricultural sales, while direct-to-consumer marketing made $1.2 billion. In 1997, this number was 0.3% and $551 million respectively (Hand et al., 2010). Consumers in the U.S. who value high-quality food are also more likely to buy local produce due to perceived freshness, quality, lower environmental effects, and to support local farmers.

This sentiment is also prominent in Hawaiʻi. 83% of residents believe that it is important for Hawaiʻi to continue to practice farming and provide local produce to the community. However, local produce purchases made up only 30% of their total weekly groceries (Le, 2023). Native Hawaiians and Pacific Islanders were more likely to purchase local food compared to other ethnic groups. Local produce purchases also varied between counties. For example, Honolulu and Maui County were less likely to purchase local food, while Kauaʻi and Hawaiʻi County were more likely (Le, 2023).

1.2 The Connection Between Agriculture and Greenhouse Gas Emissions

The agriculture industry contributes to 21-37% of greenhouse gas (GHG) emissions worldwide (Lynch et al., 2021). As the human population continues to grow, the demand for food production and supply will only increase. Effects of climate change, such as increasing the frequency of wildfires, droughts, heatwaves, and storms, have already began to impact farmlands across the world (Lynch et al., 2021). These events can cause major food supply shortages and greatly disrupt the global food security system. Therefore, to mitigate the amount of greenhouse emissions produced, sustainable farming practices and reducing food waste are highly recommended.

For every ton of CO_2 that is emitted, a majority of it will remain in the atmosphere for a millennium. Therefore, it is imperative for countries around the world to start acting on reducing carbon emissions. The Paris Agreement is an international treaty signed by 195 parties in order to combat climate change. Its main goal is to keep global temperature increases to 1.5 degrees Celsius above pre-industrial levels (Eagle et al., 2022). The agreement also requires nations to establish and maintain a nationally determined contribution (NDC) on how they plan to mitigate their emissions. However, while carbon emissions make up the majority of GHG emissions, all emissions must be reduced to fight climate change, not just CO_2 (Lynch et al., 2021). These include nitrous oxides and methane, which are the leading emissions in the agricultural sector in the United States (Eagle et al., 2022). In 2018, the agricultural sector made up 10% of GHGs produced in the United States, producing 738 million metric tons. For example, 70% of agriculture related methane emissions come from livestock, totaling to 7.1 million metric tons. 97% of these emissions come from cows. Nitrogen fertilizer and manure applications make up 94% of nitrous oxide emissions, totaling 1.1 million metric tons (Eagle et al., 2022).

GHG emissions produced in the agricultural industry can be categorized into two types: transportation and production. However, the majority of emissions will occur on the production side; transportation only makes up to approximately 10% for most produce (Poore & Nemecek, 2018). The more GHG emissions a farm produces, the less transportation emissions become relevant. This is especially true for beef, where transportation emissions only make up less than 1% of the total emissions. Therefore, while eating locally may have some benefits, it is recommended that nations introduce policies that could influence dietary choices where meat consumption is reduced (Lynch et al., 2021).

In April 2021, President Joe Biden announced a NDC that would cut GHG levels down to 50% from 2005 levels by 2030 (Eagle et al., 2022). This would be done by investing in renewable energy and energy and water-efficient buildings, and reducing emissions in all industries. For the agricultural industry specifically, the United States could set an achievable yet aggressive target that could reduce annual emissions by 560 million metric tons by 2030 (Eagle et al., 2022).

In 2015, the Agriculture, Forestry, and Other Land Uses (AFOLU) sector in Hawaiʻi emitted 1.1 million metric tons of GHGs (Venezia et al., 2019). This accounted for 5% of Hawaiʻi's total emissions. However, Hawaiʻi may benefit from expanding the agriculture industry, as replacing just 10% of Hawaiʻi's food imports with local produce would generate $188 million in revenue and over 2,300 jobs (State of Hawaiʻi Office of Planning, 2012).

1.3 The Agricultural Industry in Hawai‘i

The agriculture industry in Hawai‘i took off with pineapple and sugarcane fields in the mid 1800s. The industry was at its highest point in the 1960s, and half of the produce consumed in the state were produced locally (State of Hawai‘i Office of Planning, 2012). However, for a variety of reasons, including a rapid expansion of the tourism sector in the 1970s, Hawai‘i’s biggest industry started to shift from agriculture to tourism. To accommodate the increase in demand, vegetable imports started to exceed local production by the end of the decade (State of Hawai‘i Office of Planning, 2012). Pineapple and sugarcane production started to decline, but diversified crops, such as melons, corn, and cabbage, would greatly increase during the 1990s. However, there is no denying that the farming industry overall is declining in Hawai‘i. In 2017, it was found that farmlands and croplands decreased by 42-45% since 1982 (Rehkamp et al., 2017). This may be due to rising labor costs, land availability, and other input and maintenance expenditures. These constraints make it difficult for the state to be competitive in the agricultural industry.

Today, the state of Hawai‘i imports 90% of its food into the state (State of Hawai‘i Office of Planning, 2012). Therefore, there is a concern that Hawai‘i will be susceptible to food shortages due to supply chain issues and fuel surcharges. Hawai‘i is working towards increasing production of locally grown food. For example, one of the state's sustainability goals is to double local food production to 20-30% by 2030 (Hawai‘i 2050 Sustainability Task Force, 2008). While Hawai‘i has become less food self-sufficient in the last three decades, certain crops are dominated by local agriculture, such as watercress, tomatoes, sweet corn, and certain Asian vegetables (State of Hawai‘i Office of Planning, 2012).

1.4 The History and Importance of Sumida Farm

In 1928, Sumida Farm was founded in ‘Aiea, Hawai‘i. Currently, the farm is on its fourth generation of family members. With only ten acres of land, Sumida Farm produces about 90% of the state's watercress. They produce four to five tons of watercress a week and distribute to local businesses across the state. However, the demand for watercress in Hawai‘i is much greater than the supply available. Sumida Farm sells all watercress that their farm produces, and to meet local demand, watercress from the mainland is imported as supplementation (Sumida, 2022).

Watercress holds cultural importance in Hawai‘i. One way this is shown is through local cuisines. For example, salted beef and watercress is a popular dish that originates from Hawaiian culture. Pork watercress soup is another popular way of consumption in local Asian culture. Many other ethnic groups incorporate watercress into their own dishes that cannot be replaced with other common, leafy vegetables. Not only that, in 2014, watercress was named as the number one superfood by Williams Paterson University due to its high nutrient content (Di Noia, 2014).

Sumida Farm holds many strong connections to the local community. In 1948, second – generation owner Masaru Sumida founded the Hawaiʻi Farm Bureau and the ʻAiea Boat Club. In 1992, Sumida Farm was acknowledged by The National Endowment for Soil and Water Conservation for their outstanding performance in conserving natural resources (Sumida, 2022). Finally, Sumida Farm partners with many local chefs and businesses to promote their watercress and local farming. Before the COVID-19 pandemic, the farm hosted free elementary school tours, which received about 3,000 visitors per year at its peak. Surrounded by Pearlridge Shopping Center, Pali Momi Medical Center, and Pearl Harbor, the farm prides itself as a historical landmark and a green space in a concrete jungle (Sumida, 2022).

Buying locally may be better than imported produce because it is fresher and tends to be cheaper when considering the price per pound. The quality of locally produced watercress can be attributed to less travel time, and the farm's unique location that utilizes natural spring water and long hours of sunlight (Sumida, 2022).

2.0 Methods

2.1 Collecting Economic Data

Local supply for watercress consistently falls short of demand, so a small share is imported mostly from California (Sumida Farm, 2022). One way to think about the economic benefit of Sumida farm (who provides the majority of Hawai‘i-grown watercress) is to calculate the price differential between the value of local watercress sold and the replacement cost of importing the same amount of watercress from California, where the state gets most of its imported watercress (Sumida Farm, 2022). The first objective was to calculate the price difference between local and imported watercress, as one indication of Sumida farm's economic benefit to local consumers. To do so, watercress production information, as well as the sales price of local and imported watercress in retail stores were collected. Local grocery stores on O‘ahu were visited to weigh watercress bunches and record the price per bunch. Local watercress price and weight were collected at Foodland – School Street. Imported organic watercress price and weight were collected at Whole Foods – Queen Store. Imported nonorganic watercress was collected at Safeway – Pali Highway.

2.2 Interviews

In order to have a better understanding of Sumida Farm's local impact and its operations, interviews were conducted. David Sumida, Sumida Farm's third-generation farm owner, was interviewed about Sumida Farm's history and cultural impact. Current owners Emi and Kyle Suzuki, as well as assistant operations manager Richie Morales, were interviewed about their day-to-day operations and sales. Finally, Corina Quach, Sumida Farm's social media manager, and Chris Fujimoto, the farm's chef consultant, were both interviewed about Sumida Farm's community outreach.

2.3 Estimating Transportation GHG Emissions

The second objective of this research is to find the GHG emissions produced by Sumida and a representative watercress farm in California. The calculation of GHG emissions are broken up into two categories: transportation and production.

In 2021, California was the leading state of watercress production across the country (California Department of Food and Agriculture, 2022). Therefore, a farm located in this state was used as the representative watercress farm.

There are many different calculators and methodologies available to calculate GHG emissions of transportation. For example, the European Standard is a common methodology to calculate energy consumption and emissions of all sorts of transportation modes. The U.S. Environmental Protection Agency also released a program to calculate emissions from supply chain transportation (Wild, 2021).

For this research, a calculator published by the Environmental Defense Fund (EDF) was used. This calculator uses the standard established by the Greenhouse Gas Protocol, an international multi-stakeholder partnership between business, governments, and other organizations (Wild, 2021).

Equation (1) is shown below, where the formula (Mathers et al., 2015) used to determine the monthly total emissions is:

$$Greenhouse\ Gas\ Emissions = D \times W \times EF \tag{1}$$

Where:

D = distance shipment travelled (miles)

W = weight of shipment (tons)

EF = Emissions Factor

This equation was recommended by the EDF to calculate logistics-related GHG emissions from freight travel. This equation was simple enough to utilize based on the information provided by Sumida Farm. The handbook provided by the EDF is informative and user-friendly as well. While an emission calculating software could have been used, the guide provided by the EDF allowed for flexibility and calculation for individual segments of a freight’s journey.

To simplify the process, only customers who were direct buyers of Sumida Farm’s watercress were included in this research. Third-party customers, such as those who purchase watercress from a direct vendor of Sumida Farm, were not included.

To calculate the total distance Sumida Farm's watercress travelled, the distances between Sumida Farm and distributors, local grocery stores and airports were measured using Google Maps. In this research, a carbon emissions factor of 161.8 grams of CO_2 per short-ton mile (equivalent of shipping 1 U.S. ton of product per mile) was used for semi-trucks. The emissions factors for air and ocean travel were 2050.0 and 109.2 grams of CO_2 per short-ton mile were used respectively (Mathers et al., 2015).

To calculate the transportation emissions of importing mainland watercress, a watercress aquaponics farm was used as the hypothetical farm, and Equation 1 was applied. The reason for using an aquaponics farm was because the imported nonorganic watercress found in the grocery store was likely to be sourced from this specific farm.

2.4 Estimating Production GHG Emissions

To measure the GHG emissions of the production aspect of Sumida Farm, an online GHG emissions calculator (https://app.coolfarmtool.org/) provided by Cool Farms Alliance (version 2.0.0) was utilized. While there are many different agricultural farm GHG emission calculators available, they were either too specific, analyzed specific crops unrelated to watercress, or were based on agricultural practices that were different from the U.S. The Cool Farm Tool (CFT) calculator only required key contributors of GHG emissions, such as electricity, crop residue and pesticide management, and irrigation practices. In addition, geographical location and specific vegetable type was not needed to aggregate the data.

Emissions calculated from the CFT utilized empirical models and emission factors. This tool has also been applied in over 30 publications in the last decade (Kayatz et al., 2019). Equation (2) is used to calculate carbon certificates of a farm (UNIQUE forestry and land use and Gold Standard, 2016).

$$\mathrm{CO2} - certificates_t = A_t * BE_t - PE_t - LK_t \times (1 - BUF) \qquad (2)$$

Where:

CO_2 - $certificates_t$ = CO_2 certificates in year t (tCO_2)

A_t = Area in year *t* (ha)

BE_t = Baseline emissions in year *t* (tCO_2ha)

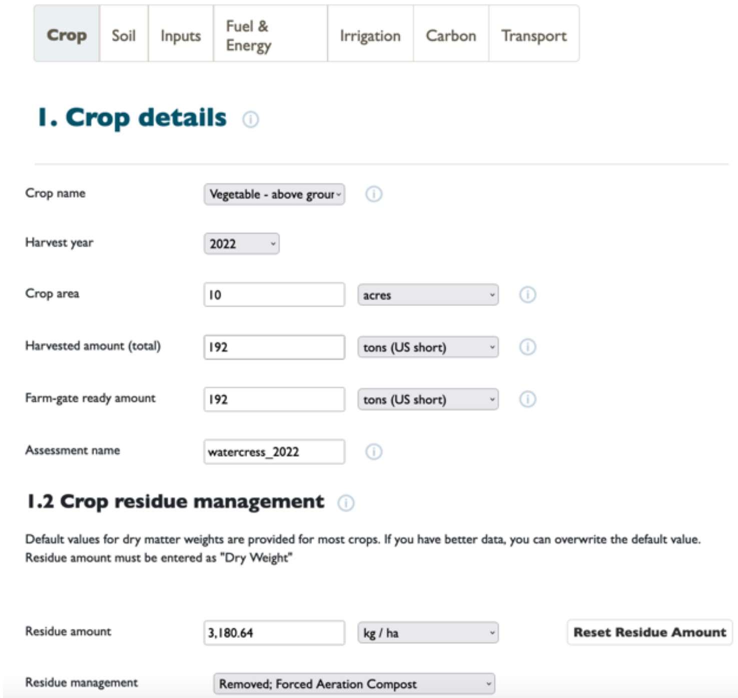
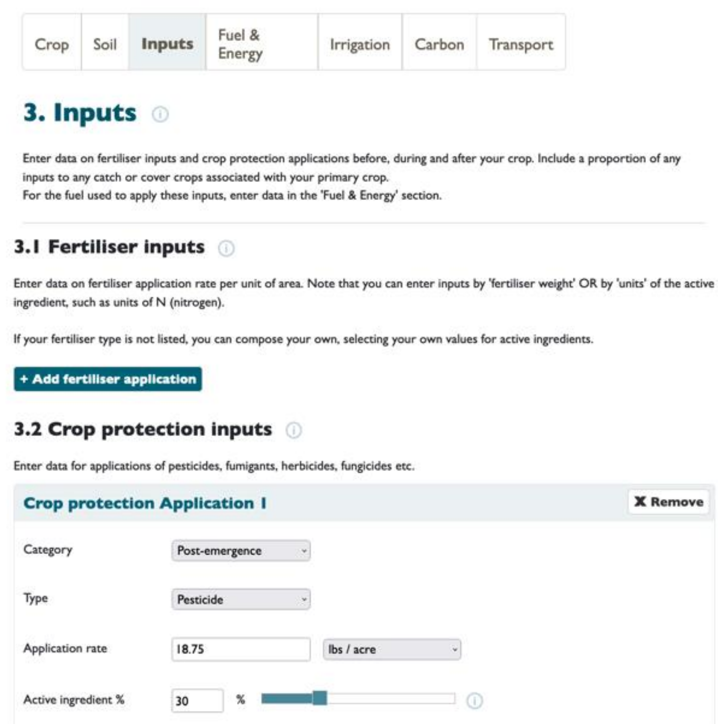
PE_t = Project emissions in year *t* (t CO_2/ha)

LK_t = Leakage emissions due to project activity in year *t* (t CO_2/ha)

BUF = Gold Standard Compliance Buffer

CO_2 certificates refer to difference between the sum of baseline emissions and the sum of project emissions.

Information provided by Sumida Farm were plugged into the CFT. Relevant inputs are shown in Table 1.

	Input information regarding crop area, output, and residue management. Crop residue refers to the parts of the plant that are not commercial sold, such as roots, stems, etc. (Cool Farm Alliance, 2023). Residue amount was defaulted to the original value provided by the calculator.
	Input information regarding fertilizers. Application rate of pesticides at Sumida Farm averaged to 18.75 pounds per acre per year, with an average active ingredient percentage of 30%.

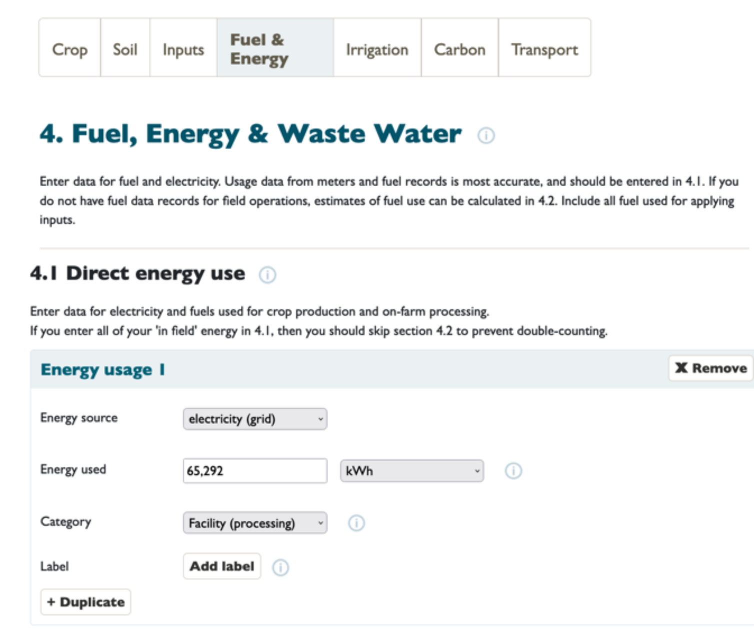
	Input information regarding energy usage. Sumida Farm currently utilizes all electricity from the central Hawaiian Electric grid.

Table 1. Screenshot of relevant inputs of Cool Farms Alliance calculator.

The CFT was also utilized for the representative California watercress farm. To calculate the amount of energy that this farm might use, a paper using a Baltimore, Maryland aquaponics farm as a case study was utilized. The average found in this research was 56 kilo-Watt hours (kWh) per 1 kilogram of crops per month (Love et al., 2015). However, due to the temperature difference between Maryland and California, only inputs of certain months were used. This depended on if the temperature difference between the two locations was less than 5 degrees Fahrenheit. To factor the differences in climates, the hypothetical average kWh used for this thesis will be 27.5 kWh per 1 kilogram of crops per month. This was calculated by taking the average of the four months.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
San Jose, California (Fahrenheit)	51	54.5	57	59.5	64	68.5	71	71	69.5	64.5	56.5	51.5
Baltimore, Maryland (Fahrenheit)	35.5	38.5	46.5	56.5	66	76	81	79	72	60	50.5	39.5
Energy Usage in Maryland Case Study (kWh)	504	131	66	34	13	10	11	11	15	48	57	135

Table 2. Average temperatures of San Jose, California and Baltimore, Maryland, and energy usage of the aquaponics farm. Highlighted months indicate which months were used to calculate the average hypothetical energy consumption of the aquaponics farm.

Using the energy consumption results obtained from Table 2, inputs were entered into the CFT. To note, another reason why an aquaponics farm was used as the mainland hypothetical farm is because there is little to no information on the energy consumption of a traditional watercress farm, or for a vegetable that grows similarly to watercress.

2.5 Creating a Community Impact Map

The third objective was to describe and illustrate the social outreach and community impact of Sumida Farm. To complete this, a map of all of Sumida Farm's connections across the state was created.

Participatory mapping is the act of assigning spatial points on a map to an idea or event that would normally not be recognized on a traditional map (Figueiredo et al., 2020). There are many different methodologies for participatoring mapping, which includes inputs and data from the public through individuals, social media, and the community. Community mapping is a form of participatory mapping, where the community is involved in its mapping and is created for the residents' benefits. It often features local entities and knowledge (Figueiredo et al., 2020).

Geographical Information Systems (GIS) can be useful in spatially identifying key figures in a community map. A study published by the University of Alberta used GIS software to create a map that documented the changes of the Athabasca River. This map was created by and for the indigenous tribes that live along the river, who are impacted by the river's change in water levels due to the development of land around the area (Figueiredo et al., 2020).

GIS software can also be used to identify food assets in a community. In Vancouver, Canada, this software was used to create a community map that highlighted where Vancouverites believed a food asset was located and what it means to them (Soma et al., 2021). GIS software was also used to map secondary health impacts, such as housing insecurity and education disruption, of the COVID-19 pandemic (Crooks et al., 2021).

Local agriculture may not only provide environmental and economic value, but social value as well. To document the social benefits of Sumida Farm, a community map was created. Sumida Farm's key partnerships were identified by the farm's owners. Then, using ArcGIS Online (version 11.1), locations of all community partners, grocery stores, and distributors were mapped, and Inkscape (version 1.2) was used to edit and create a legend. The use of GIS was due to the geographical location of each entity being important. Sumida Farm is a small farm on a chain of islands, and therefore showing the relationships between the farm and their partners spatially was deemed the best option.

3.0 Results

3.1 Economic Impact of Sumida Farm

The weight of each representative watercress bunch was divided by the price to get the price/pound. Sumida Farm provided the amount of watercress sold per month in 2022, which averaged about 32,000 pounds per month. The amount of watercress available for sale varies seasonally. For example, at peak season, about 40,000 pounds of watercress is sold per month, but at low season, that number is about 16,000 (Sumida, 2022). Each price per pound was multiplied by the average watercress pounds per month to obtain the total value per month, and then for the total value per year. These numbers are recorded in Table 3.

The total prices reflect the amount that Hawaiʻi residents pay for watercress. The yearly difference between the value (retail price times pounds sold) of Sumida watercress and imported watercress is about $3,046,872.09. This means that if the state of Hawaiʻi were to import the same amount of watercress that Sumida Farm produces, then consumers would need to pay over double the amount compared to locally grown watercress.

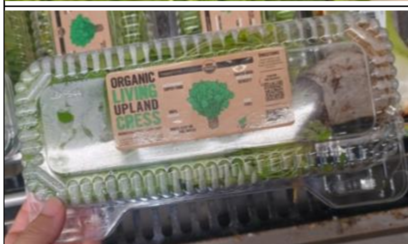
	Watercress Type	Price/Pound	Total Value Per Month	Total Value Per Year
	Local	$5.55	$177,607.11	$2,131,285.33
	Imported Organic	$13.28	$424,946.24	$5,099,354.84
	Imported nonorganic	$13.69	$438,080.00	$5,256,960.00

Table 3. Types of watercress versus costs.

3.2 Environmental Impact of Sumida Farm

The total ton-miles of each mode of transportation was recorded. Using Equation 1, the total emissions per month was recorded in Table 4.

Location	Vehicle Type	Total Ton-Miles	Carbon Emissions Factor (grams of CO_2/ton-mile)	Total Emissions per year (tons of CO_2)
Oahu	Semi-truck	147.59	161.80	0.29
Outer Islands	Airplane	519.32	2,050.00	12.78
	Semi-truck	170.10	161.80	0.33
Imports	Semi-truck	5,864.00	161.80	11.39
	Freight Boat	2,555.00	109.20	3.35

Table 4. GHG emissions of various modes of transportation.

Using the CFT, a breakdown of GHG emissions from the production side of Sumida Farm and the mainland farm was recorded in Table 5. The CFT found that the crop residue for the mainland farm was negligible due to the fact that farm acreage is very small. Pesticides were entered as "zero" into the CFT since aquaponic farms can produce crops using no synthetic chemicals (Love et al., 2015).

Type:	Sumida Farm Emissions (kg CO_2e/year)	Mainland Farm Emissions (kg CO_2e/year)
Crop Residue	2348	n/a
Pesticides	160	n/a
Electricity	26,208	2,128,581

Table 5. Breakdown of Sumida and mainland farm's GHG production emissions.

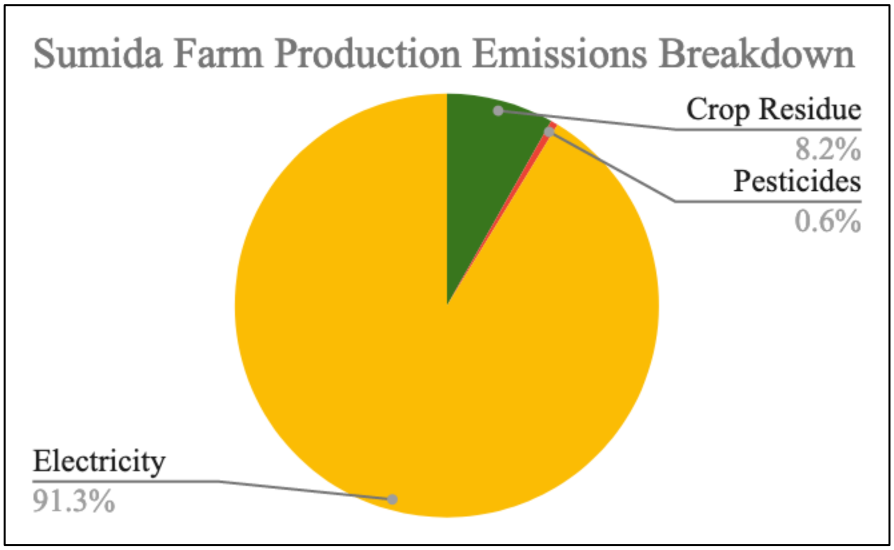


Figure 1. Distribution of Sumida Farm's production GHG emissions.

To calculate the total GHG emissions produced per year for both Sumida Farm and the mainland farm, Equation (3) was used. The findings were then recorded in Table 6.

Total GHG Emissions = Total Transportation Emissions + Total Production Emissions (3)

Farm	Total Transportation Emissions (kg CO_2e)	Total Production Emissions (kg CO_2e)	Total per year (kg CO_2e)
Sumida	12,165.35	28,716	40,881.35
Mainland	25,410.25	2,128,581	2,153,991.25

Table 6. Comparison of Sumida vs. Mainland total GHG emissions.

The high production emissions produced by the hypothetical farm could be attributed to the energy usage of the aquaponics farm. An aquaponics system must maintain a certain water temperature 24 hours a day, 7 days a week, and depending on the season, this could cause an increased use in energy. It also requires electricity to pump and aerate the water. However, it is possible to decrease energy usage from the grid by implementing renewable energy practices.

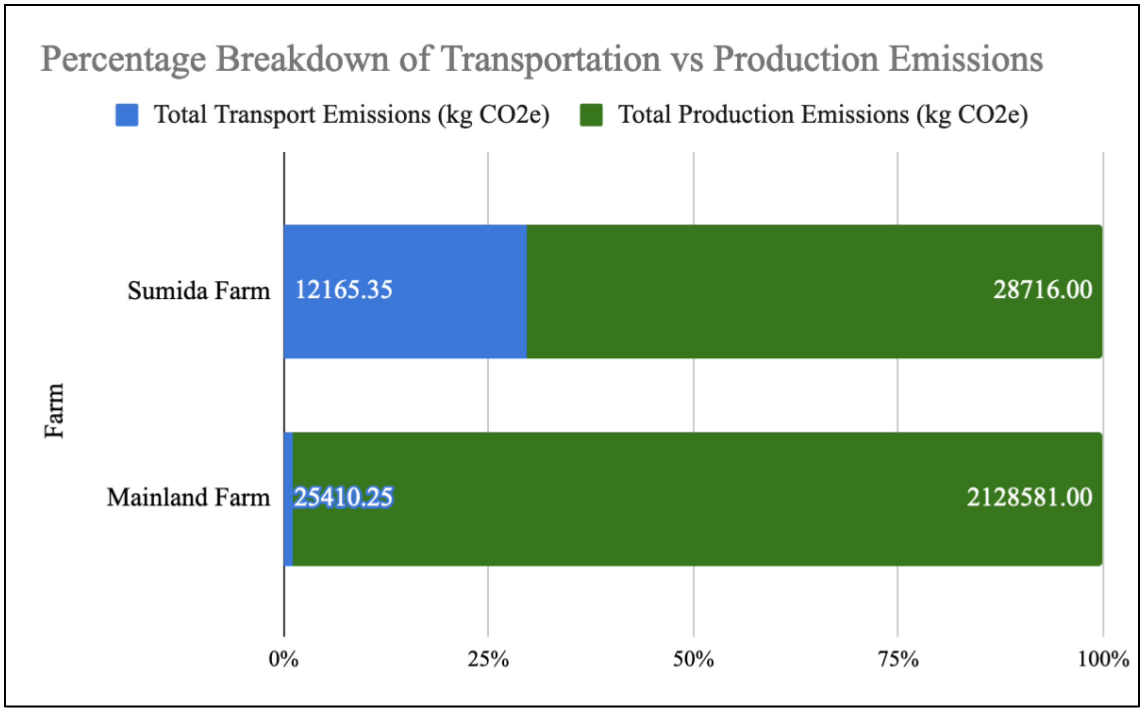


Figure 2. Percentage breakdown of local versus imported GHG emissions.

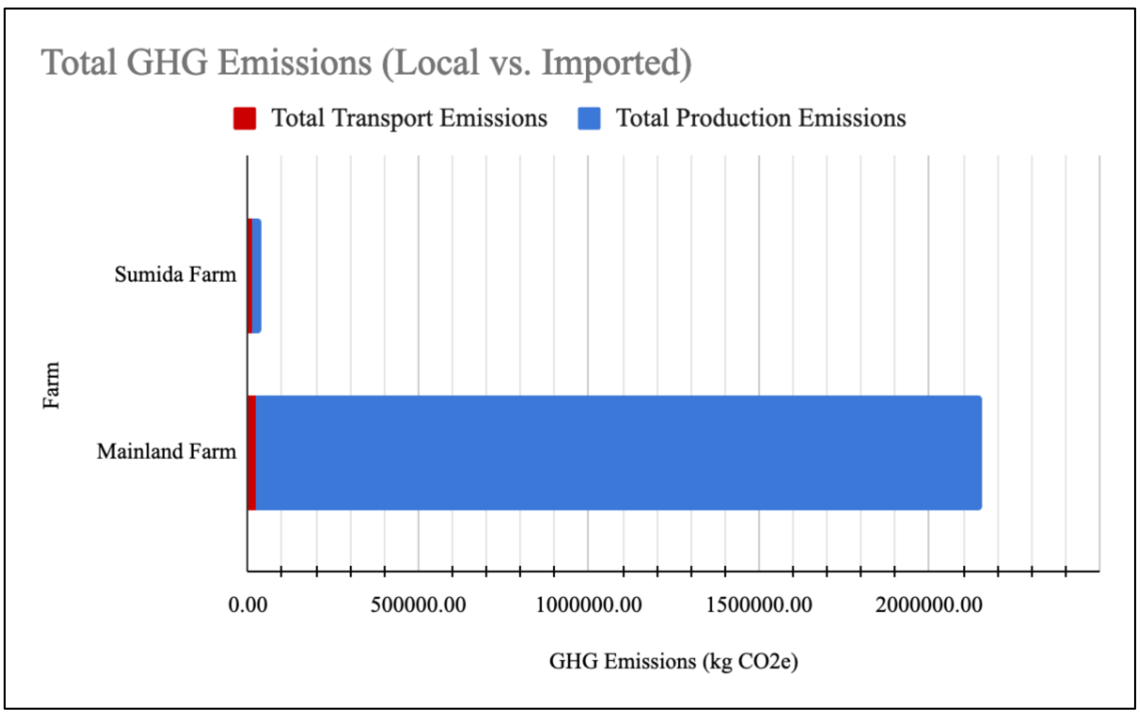


Figure 3. Total GHG emissions produced by Sumida Farm and Mainland Farm.

The difference of GHG emission production between the two farms is 2,113,236.66 kilograms of CO_2e per year. This means that the representative mainland aquaponics farm produces over 50 times the amount of GHG emissions in a year compared to Sumida Farm.

3.3 Sumida Farm's Community Impact

Sumida Farm currently directly sells their watercress to twelve different distributing companies throughout the state of Hawaiʻi. Their watercress can be found in five different grocery stores and chains, including major stores such as Foodland Supermarket and Times Supermarket. Sumida Farm also holds importance in the community through local partnerships with chefs and restaurants and supports the growing trend of the farm-to-table movement. The farm is a host research site in partnership with the University of Hawaiʻi for water, wildlife, and microbial studies as well as for photography and farm life investigations. For example, Sumida Farm was used as a case study for environmental challenges that local farms might face in the future (Engels et al., 2020).

Third-generation owner David Sumida strongly believes in staying connected to the community. "We want to do what we do best – grow beautiful watercress for the people, provide a living classroom for Hawaiʻi's children, and establish a place where people can experience old Hawaiʻi. We believe we are an important asset to our community, and it would be such an irreversible loss if our land were lost" (Sumida, 2022).

Sumida also believes that their farm could be a good model for other small local farms. He stated, “We only lease ten acres of land, but that’s actually not much compared to some of the bigger farms here in Hawai‘i. Even so, we produce just as much as these farms. I think we’re a really good example of what could be possible” (Sumida, 2022).

Sumida Farm has made many contributions to the community, especially in recent years. Examples of key events that the farm has participated in are listed in Table 7.

Key Community Outreach Events	Description
Farm Tours and Workdays	Sumida Farm provides tours on their farm to children and senior citizens to teach the community about farm life and the cultural and historical value of the farm. They also host volunteer workdays, which allows locals to experience what it is like to work on the farm.
Restaurant and Chef Collaborations	Sumida Farm partners with local businesses to promote or innovate new watercress dishes. A notable partnership includes a collaboration with BeerLab HI to create a farm-inspired beer.
Local events	Sumida Farm collaborated with Chef Jon Matsubara to promote salt watercress beef soup at the Leeward Culinary Arts Gala in May 2023.
College Partnerships	Sumida Farm hosts research partnerships with the University of Hawaiʻi. The farm is used as case studies for water, microbial, pharmaceutical, and wildlife research. In addition, the farm partners with the Kapiʻolani Community College as host judges, as well as donating watercress for their students to use.

Table 7. In-depth description of key collaborations with the community.

Representatives of Sumida Farm present at the 2023 Leeward Culinary Arts Gala were interviewed. When asked about why community outreach is important for farms to do, Chris Fujimoto, the farm's chef consultant, replied, "Local farms and the community really work well together; that's how we feed our communities – through our produce and through our food. Having that relationship, not only with them but also with chefs, is important in understanding what our community and what our customers want" (Fujimoto, 2023).

Corina Quach, the farm's social media manager, said, "People know about the grass shack in the watercress farm in the middle of Pearlridge, but not necessarily know who Sumida Farm is. It's important to do outreach because if we didn't go and market ourselves, they would have never known that correlation. We engage with the community so that people will remember our name, know our story, and support our farm" (Quach, 2023).

Since most of Sumida Farm‘s key partnerships are located on the island of O‘ahu, one community map focuses specifically on highlighting those collaborations, as shown in Figure 4. To illustrate Sumida Farm's statewide impact, Figure 7 focuses on those connections.

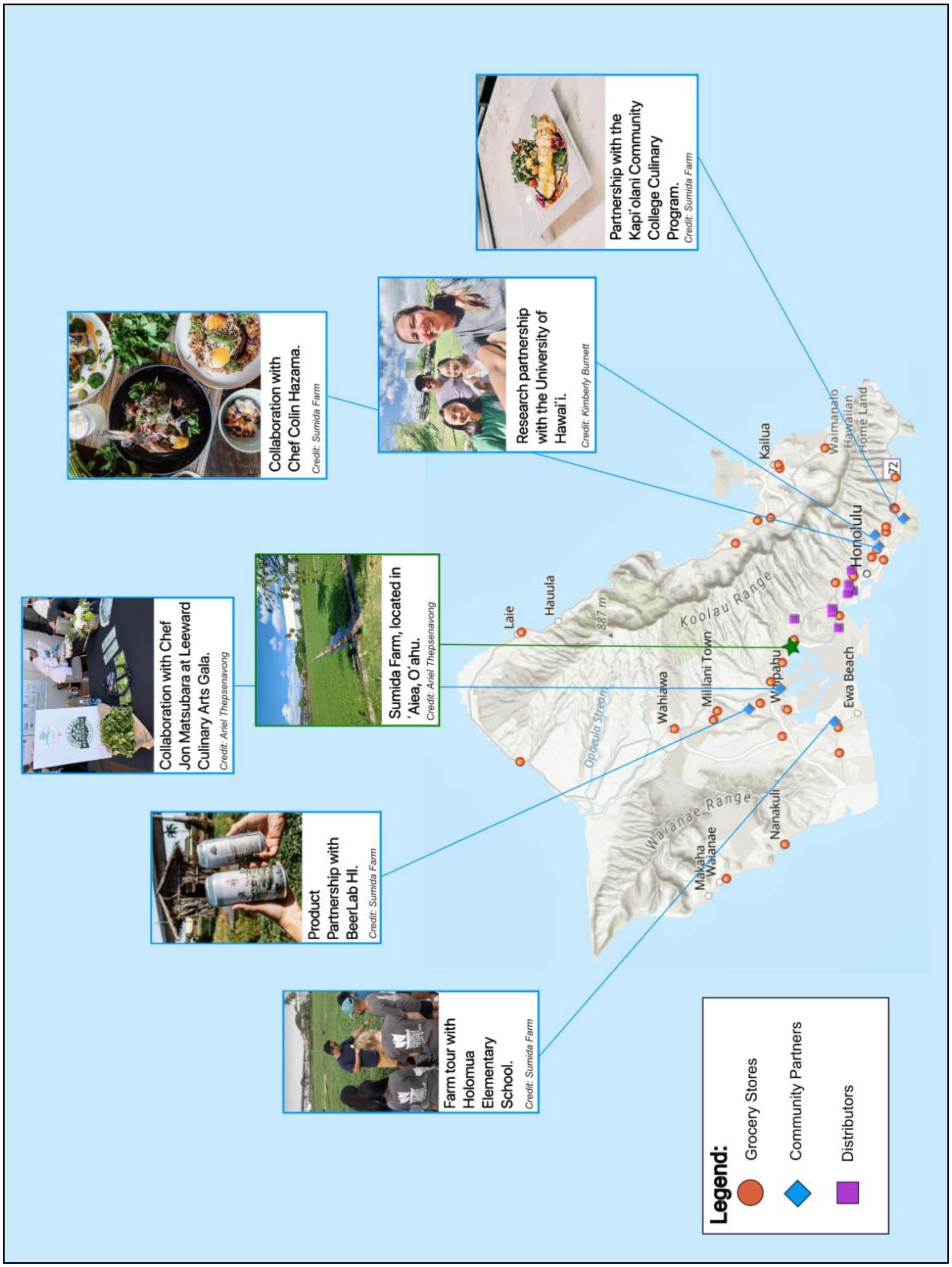


Figure 4. Map of Sumida Farm's key community partners located on O'ahu.

Figure 5. Group photo taken at Sumida Farm to signify the start of this research collaboration. From left-to-right: Emi Suzuki, Kyle Suzuki, Ariel Thepsenavong, and Dr. Kimberly Burnett.

Figure 6. Sumida Farm booth at the 2023 L‘ulu Culinary Arts Gala located at Leeward Community College.

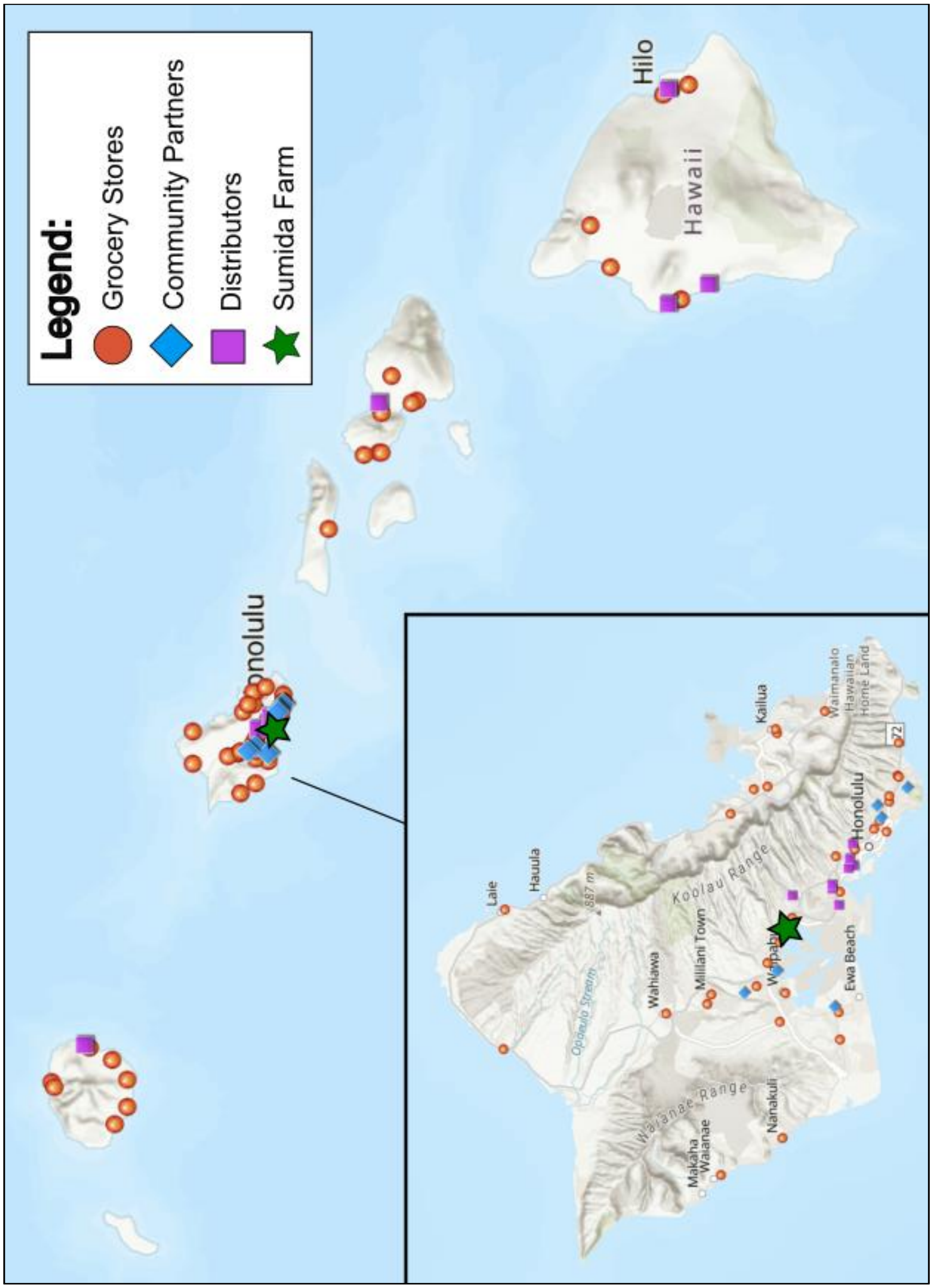


Figure 7. Statewide map of Sumida Farm's community reach and impact.

Grocery Stores	Island
Foodland - Dillingham	O‘ahu
Foodland - Ewa Beach	O‘ahu
Foodland - ‘Āina Haina	O‘ahu
Foodland - Ala Moana	O‘ahu
Foodland - Ka Makana Ali‘i (Kapolei)	O‘ahu
Foodland - Pearl City	O‘ahu
Foodland – Lā‘ie	O‘ahu
Foodland - Kailua	O‘ahu
Foodland - Kāne‘ohe	O‘ahu
Foodland - Market City	O‘ahu
Foodland - Mililani	O‘ahu
Foodland - Pūpūkea	O‘ahu
Foodland - School Street	O‘ahu
Foodland - Wahiawā	O‘ahu
Foodland - Waipi‘o	O‘ahu
Foodland - Kāhala	O‘ahu
Foodland - Nānākuli	O‘ahu
Times - ‘Aiea	O‘ahu
Times - Beretania	O‘ahu
Times - Kāhala	O‘ahu
Times - Kailua	O‘ahu
Times - Kaimukī	O‘ahu
Times - Kamehameha Shopping Center	O‘ahu
Times - Kāne‘ohe	O‘ahu
Times - Ko‘olau	O‘ahu
Times - Liliha	O‘ahu
Times - McCully	O‘ahu
Times - Mililani	O‘ahu
Times - Royal Kunia	O‘ahu
Times - Waimalu	O‘ahu
Times - Waipahu	O‘ahu
Times - Shima's Supermarket	O‘ahu
Wai‘anae Store	O‘ahu
Foodland - Ka‘ahumanu	Maui
Foodland - Kehalani	Maui
Foodland - Lāhainā	Maui
Foodland - Lahaina (Foodland Farms)	Maui
Foodland - Kīhei	Maui
Foodland - Pukalani	Maui
Times - Honokowai	Maui
Times - Kīhei	Maui
Foodland - Mauna Lani	Big Island
Foodland – Kea‘au	Big Island
Foodland - Waimea	Big Island
Foodland - Hilo	Big Island
Foodland - Kona	Big Island
Foodland - Pū‘ainakō	Big Island
Foodland - Princeville	Kaua‘i
Times - Līhu‘e	Kaua‘i
‘Ele‘ele Big Save	Kaua‘i
Hanalei Big Save	Kaua‘i
Kapa‘a Big Save	Kaua‘i
Kōloa Big Save	Kaua‘i
Waimea Big Save	Kaua‘i
Friendly Market	Moloka‘i

Table 8. Direct grocery store purchasers of Sumida Farm’s watercress.

Collaborative Partners	Island
Holomua Elementary	O‘ahu
BeerLab HI	O‘ahu
Leeward Community College	O‘ahu
Collaboration with Chef Hazama	O‘ahu
University of Hawai‘i at Mānoa	O‘ahu
Kapi‘olani Community College	O‘ahu

Table 9. Example partners of Sumida Farm.

Sumida Farm’s watercress can be found on five of the major islands in Hawai‘i, with the majority on O‘ahu. Agricultural community collaborations allow farms and businesses to spread knowledge, create innovative products, and become a hub for research and career development. Additionally, the magnitude of the farm’s community impact could be quantified in further studies. This could be done by surveying how many people interacted with Sumida’s watercress at local restaurants, events, and collaborations.

4.0 Conclusion

The three objectives of this thesis were (1) to compare the price differential and (2) GHG emissions differential between local and imported watercress, and (3) to document and illustrate the community impact of Sumida Farm. This was done through calculating the price per pound of watercress and using this to estimate the benefit of local watercress production to consumers over imported watercress, utilizing software to calculate transportation and production GHG emissions to estimate the GHG savings from local watercress production, and creating a community impact map of Sumida Farm.

Although watercress is a small industry in Hawai‘i, it would still be very expensive, both environmentally and economically, to import the same amount as currently locally produced watercress if Sumida Farm did not exist. If the state of Hawai‘i had to import the same amount of watercress that Sumida Farm produces, consumers would need to pay a total of about $3 million more per year for imported watercress. The representative mainland aquaponics farm also produced over 50 times the amount of GHG production emissions per year compared to Sumida Farm. Finally, Sumida Farm is an important entity in local business partnerships. Without the farm, many residents would lose the opportunity to learn about local farming and experience Sumida’s watercress.

This study also corroborates with the fact that most of Sumida Farm’s biggest emission contribution is associated with production. It was found that transportation made up about 30% of Sumida Farm’s total emissions. Furthermore, GHG emissions produced by the farm can be lowered through implementation of renewable energy. Currently, Sumida Farm is looking into hydroelectric energy to lower emissions (Sumida, 2023).

A common misconception is that local crops are often more expensive to purchase. However, considering the price per pound, quality, and socioeconomic benefits, it may be more advantageous to purchase locally grown produce in Hawaiʻi.

Importing watercress from the mainland U.S. to Hawaiʻi will continue to be more difficult. According to the California Department of Food and Agriculture (2022), in 2021, California was the leading state of watercress production in the country. This consisted of a handful of watercress farms that are located in Southern California (Bosch, 1992). However, as of 2023, it was found that major watercress producers in California have since closed. For example, the biggest watercress farm on the west coast, which consisted of 65 acres of farmland, shut down its operations in the beginning of 2023 (California Secretary of State, 2023). Therefore, the aquaponics farm used in this study could be one of the last watercress producers in California. Without Sumida Farm in the state, Hawaiʻi would have major difficulty meeting local resident's demand relying solely on watercress imports.

This case study can be applied to other types of local produce, such as lettuce, kale, and other leafy greens to further investigate the price and GHG differentials between local and imported agricultural products. The study itself also further solidifies the importance of food security, and the importance of reducing produce imports into the state.

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