ASSESSING GREENHOUSE FEASIBILITY:

A Report to the Ngāti Kea Ngāti Tuara Hapū of Horohoro, New Zealand

Sponsored by:

NGĀTI KEA NGĀTI TUARA

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
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Ngāti Kea Ngāti Tuara Electricity Utilization

Assessing Greenhouse Feasibility: A Report to the Ngāti Kea Ngāti Tuara Hapū of Horohoro, New Zealand

An Interactive Qualifying Project Report submitted to the Faculty of
Worcester Polytechnic Institute in partial fulfillment of the requirements
for the Degree of Bachelor of Science in cooperation with
the School of Māori Studies at Victoria University of Wellington

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Abstract

This project produced a feasibility report for a hydroponic greenhouse to the Ngāti Kea Ngāti Tuara Hapū of Horohoro, New Zealand that aims to utilize the excess electricity produced by the Māori community's micro-hydro power system. To ascertain opinions on a greenhouse project and specific candidate crops, watercress and koura, the team interviewed and surveyed members of the hapū, restaurants, and consumers in nearby tourist hot-spot Rotorua. The report presents a series of flow charts, allowing the hapū to choose a greenhouse structure and technology. The project also addressed the micro-hydro system's intake congestion and documented its maintenance. Technical reviews and participant observation allowed the team to recommend a floating boom to decrease the congestion.

Executive Summary

Introduction

In December 2013 the Māori community of Ngāti Kea Ngāti Tuara (NKNT) in Horohoro, New Zealand installed a series of three micro-hydroelectric turbines to power their *hapū* (village). The turbines utilize the potential energy of a waterfall in the nearby Pokaitu stream to produce clean, sustainable energy. The system currently produces more electricity than the community needs and the hapū sells the surplus electricity back to the grid for an insignificant profit. Our project sponsor, Dr. Maria Bargh, is a member of the hapū and a professor at the School of Māori Studies at Victoria University of Wellington. With her guidance and assistance, the team developed a feasibility plan for a greenhouse that provides the members of the Ngāti Kea Ngāti Tuara Hapū with an effective strategy to utilize the available electricity produced by the community's micro-hydro power system. The project also investigated a solution for the turbine intake congestion problem present in the micro-hydro unit.

Background

The Ngāti Kea Ngāti Tuara Hapū is located in a rural town called Horohoro (starred in Figure 1), which is situated approximately sixteen kilometers south of Rotorua, the economic center of the Bay of Plenty region (highlighted in green in Figure 1). NKNT's micro-hydro facility powers the community's *Marae* (meeting house), church, a nearby farm, a Māori language immersion play-center and the Horohoro Primary School. The hapū's values, outlined in the community's strategic development plan, guided our methodologies and heavily influenced our decision-making. The plan emphasizes that any endeavor must satisfy certain economic, environmental, social, and cultural standards. Our greenhouse proposal fulfills these standards, often referred to as the hapū's quadruple bottom line. The actions of the community must not only yield a profit, but more importantly benefit the environment, unite the members of the hapū, and align with their guiding cultural values.

Figure 1: Map of New Zealand's North Island (Bay of Plenty, 2005)

Hapū member Kataraina George weighed the viability of a few potential crops and livestock in an initial feasibility report from 2014 – *The Feasibility of Tuna/Koura/Watercress Cultivation*. The next step in the process, and where our project began, was to determine the feasibility of a greenhouse and to recommend specific crops that would do well in this setting. Of the options presented by Ms. George and those gathered from our own research, we determined that both watercress (a leafy super-food) and koura (freshwater crayfish), displayed in Figure 2,

Figure 2: Watercress (right) and Koura (left), (Doc.govt.nz, 2016), (*Watercress*, 2016)

had the biggest potential to meet the community's needs as well as the desires of the surrounding market. We considered hydroponic (grown in nutrient-enriched water without the use of soil) and aquaponic (a symbiotic relationship between plants and fish) growing options as technology the hapū could use in the greenhouse.

The local market, particularly in Rotorua, presents the opportunity for the hapū to commercially sell the crops and livestock they produce to a number of upscale restaurants in a section of town playfully named "Eat Streat", as well as a nearby luxury resort, Treetops Lodge, located just down the road from the hapū in Horohoro. While turning the greenhouse into a commercial venture is not the community's number one goal, it is important to the hapū that the project be economically sustainable.

Currently the micro-hydro system suffers from intake congestion caused by pine needles and other debris. A worker must manually clear the debris that accumulates on a daily basis to ensure the turbines are operating to their fullest potential. Since the greenhouse would need to utilize electricity from this system, it is important that the turbines be running smoothly. With this information in mind, the team developed five objectives that we have completed throughout this project.

Objectives and Methods

The objectives for the project were as follows:

1. Assess the opinions of relevant stakeholders.
2. Research and recommend crops to grow in the greenhouse.
3. Propose a growing system and physical parameters for a greenhouse.
4. Document care and maintenance methods for NKNT's hydroelectric turbines.
5. Suggest a strategy to alleviate turbine intake congestion.

The team was able to collect a combination of qualitative and quantitative data through interviews, surveys, participant observation, and literature reviews. Our first and second objectives used similar methodologies and are closely related, as the second objective depends on the results we gathered form our first goal. We defined our stakeholders and chose potential crops of interest through our initial research conducted prior to our departure while in Worcester, Massachusetts. Shortly after arriving in New Zealand, the team took a trip up to Rotorua, where we conducted semi-structured interviews with hapū members and Eat Streat restaurants, as seen in Figure 3. The team took only one trip to Horohoro to gather most of this information, thus the success of this project depended on careful preparation and planning in the weeks leading up to the trip. While on site, two team members conducted each interview and recorded conversations both digitally and through written notes. The team then transcribed these conversations for later reference when developing recommendations and making decisions. The team also conducted 42 short, three-minute surveys with those walking through the Eat Streat area. These surveys provided not only demographic information, but also opinions on watercress and koura and knowledge of Māori cuisine. This data provided a quantitative view of local consumer perspectives. Since the team was only able to conduct two formal interviews with hapū members, we created a survey on

Figure 3: Eat Streat (Eat Streat, 2014)

Google Forms. Dr. Bargh posted this supplementary survey on the hapū's Facebook group to gather opinions from a greater pool of hapū members.

We accomplished our third objective, actually considering the physical parameters and technologies surrounding a greenhouse, through an interview with PlentyFlora, a glasshouse specializing in flower horticulture, and through reviews of technical literature. Our initial plan to grow watercress and koura meant thorough research into many broad design parameters: water supply, irrigation, nutrients and nutrient distribution, and growing apparatuses. The hapū will ultimately decide the structure of the greenhouse based on information we have provided in a flow chart. Our recommendations section further expands on this idea.

We developed our fourth and fifth objectives to provide the hapū with documentation of regular maintenance of the micro-hydro system and investigate solutions to the turbine intake congestion problem. Dr. Bargh encouraged us to create a maintenance manual for the turbines in the case that Mr. Riki Oneroa, who currently maintains the system himself, is unavailable to care for the unit. The team accomplished both of these objectives through research of other turbines with debris problems and through participant observation with Mr. Oneroa (Figure 4), who gave our team a thorough tour of the micro-hydro unit. During this tour we recorded our conversation with Mr. Oneroa as he answered our questions regarding congestion and maintenance. We also took pictures of the turbines and surrounding area to reference in the manual and our report.

Figure 4: Team Consulting with Mr. Oneroa

Results

The hapū survey received 16 responses. The answers displayed general widespread approval of both the greenhouse as well as the candidate crops. Of the 15 respondents, 14 felt a greenhouse would benefit the community. When asked exactly how a greenhouse might benefit the community, the most popular answers included job creation, a source of food, and increasing the hapū's commitment to sustainability. Each choice received 13 votes. The responses also included short recommendations and reactions, such as from one hapū member who thought that it "would be great to see the hapū getting involved with sustainability processes rather than cultivation for commercial benefit".

Although these responses were very useful, they lacked an in-depth specificity in exchange for a larger sample pool. Our semi-structured hapū interviews provided a depth which paired nicely with the hapū survey. Of the two community members we interviewed, we found similar patterns as in the survey. The team found the responses that deepened our understanding of *why* a greenhouse fits in with Māori culture particularly useful. One interviewee explained that Māori "believe in life, we believe in nurturing a seed to full growth. The whole cycle" (Keepa, 2016). These two sets of results together allowed the team to target the recommendations more specifically to the hapū's culture and needs.

In order to allow the hapū to commercialize their greenhouse products, should they desire to do so, the team measured the market through restaurant interviews and customer surveys. Understanding restaurants' needs gave the hapū specific potential business partners, and surveying customers in Rotorua provided the hapū tools to approach other restaurants with market data.

Primarily, the market data assessed responses to candidate crops and responses to potential marketing angles for greenhouse products, which included the crop being organic, locally sourced, Māori-grown, and produced with clean energy. The team found that all four of these labels drew positive responses. Figure 5 details the average response to the selected labels (n=41).

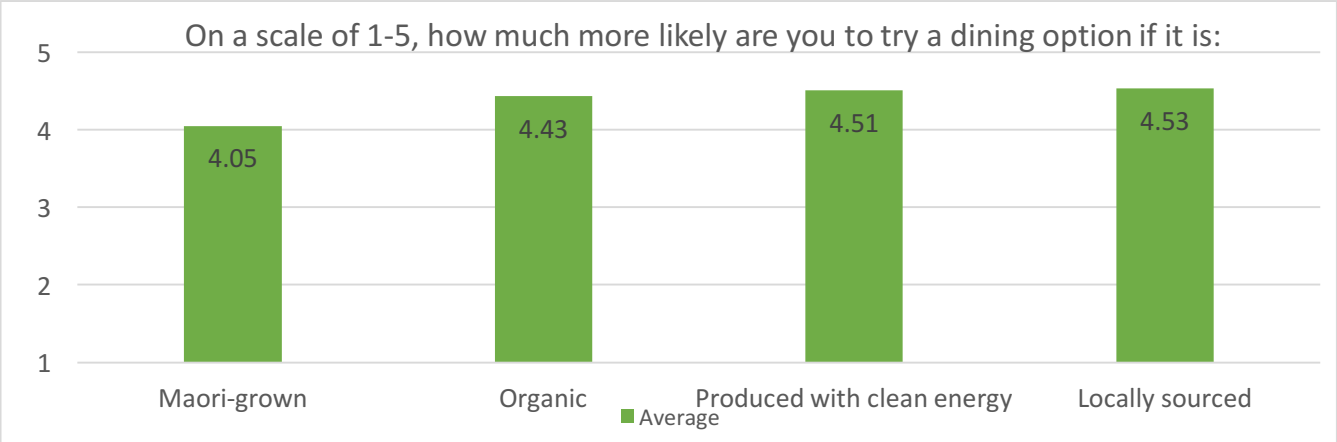

Figure 5: Consumer Response to Labels

The surveys also collected data about customers' responses to the team's candidate crops (Figure 6). Out of the 41 respondents, 32 had eaten watercress previously. Of those 32, 29 would be willing to try it again. Similarly, 25 had eaten koura previously, and 22 of those would be willing to try it again.

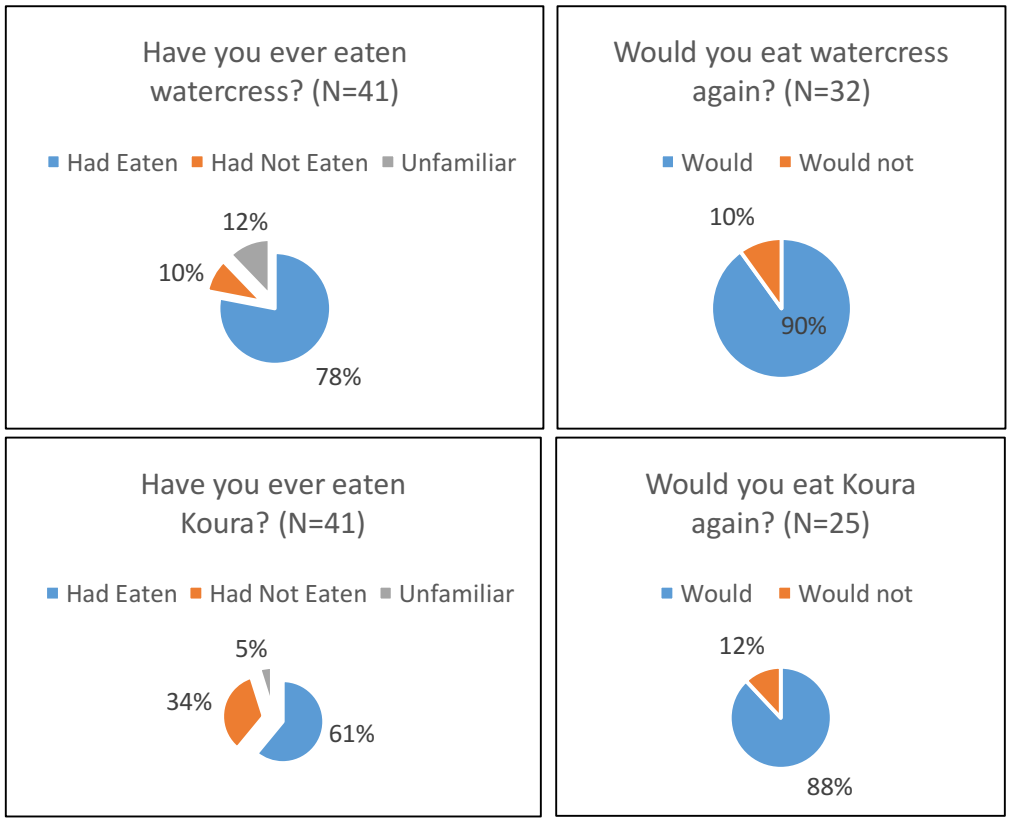

Figure 6: Customer Response to Candidate Crops

These results were promising, because they indicate an already existing market for the team's candidate crops. In a similar vein, the team interviewed representatives from restaurants in the Eat Streat area in Rotorua as well as the luxurious Treetops Lodge right in Horohoro. Of the six establishments interviewed, four expressed interest in potentially buying one of the candidate crops from a Ngāti Kea Ngāti Tuara greenhouse. This set of data suggests that both restaurants and customers in the Rotorua area are interested in the candidate crops.

With a positive reaction for a greenhouse from the community and surrounding businesses promising market potential for the candidate crops, the team conducted further research through technical literature reviews and utilized the information gained in the PlentyFlora interview. The interview yielded information regarding the geothermal heat source used within their greenhouse and their varying successes and failures. This interview also answered our questions regarding potential problems surrounding the greenhouse structure and weather conditions specific to the region. Further research into greenhouse structure revealed the biggest constraint is water supply, which must be approved by a resource consent from the Waikato Regional Council. The resource consent process may take years, but NKNT is patient as their goals are long-term. Although this constraint prevented the team from recommending exact specifications for a greenhouse, literature review indicated a general system for growing – one large water recycle circuit, pressurized with a pump powered by the turbine's power output.

The team converted our interaction with Mr. Oneroa into a comprehensive maintenance manual, so the community can be further involved in care of the micro-hydro system. The hapū's request for a solution to the turbine intake congestion resulted in review of technical literature. The following section outlines this recommendation.

Recommendations

The team chose to present its discoveries in a manner that would allow the hapū to take our findings and choose for themselves which option they would like to explore. We constructed a series of flowcharts to guide their decision-making regarding greenhouse size, crop selection, and purpose. Therefore, the team did not select one specific greenhouse configuration, but rather presented a series of recommendations contingent on the community's desires. In brief, however, the team believes that an aquaponic greenhouse can accommodate the requests of the community, whether it be for job creation, education, or commercial benefit. Additionally, the team recommends that the hapū first perform hydroponic growing trials, such as the one seen in Figure 7, to grow crops cheaply and check the taste and quality of product before committing to a larger structure.

Figure 7: Hydroponic Trial Example (plantazoid.com)

Regarding the problem of habitual congestion of the micro-hydro's intake, the team recommended that NKNT implement a floating boom device in conjunction with the existing screen. The boom, as Figure 8 shows, would stretch from further upstream to just beyond the intake inlet, almost parallel to the flow of the river. This mechanism would direct floating debris downstream without requiring cleaning. As a secondary measure, the existing screen would require much less regular maintenance, but would still offer protection against any non-floating debris and, most importantly, from fish and other wildlife entering the system.

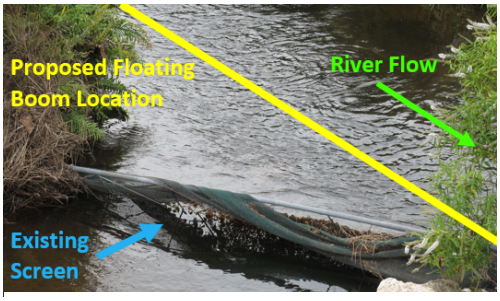

Figure 8: Proposed Floating Boom Location

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Chapter 1: Introduction

The world-wide pursuit of clean, renewable energy resources has emerged in response to the irreversible environmental repercussions of more traditional, non-renewable energy options. Hydroelectric power, just one form of clean alternative energy available in New Zealand, has seen particular growth in the country, particularly since the turn of the century. In the year 2011, hydropower produced 57.6% of New Zealand's overall electricity. Eleven percent of that production came from "small hydropower" systems, which produce less than 10 MW of electricity (Esser, Liu & Masera 2013).

The Māori, New Zealand's native people, have values deeply rooted in the conservation of resources and respect for the environment. In December 2013 the Māori community of Ngāti Kea Ngāti Tuara (NKNT) in Horohoro installed a series of three micro-hydroelectric turbines to power their *hapū* (village). The turbines utilize the potential energy of a small waterfall in the nearby Pokaitu stream to produce clean, sustainable electricity. Because the system operates without the use of a dam or reservoir, it has virtually no impact on the surrounding ecosystem. Currently, it produces more than enough electricity to power the hapū's *marae* (traditional meeting-house). However, the system's intake suffers from congestion due to debris in the water column, causing it to be less efficient than possible.

The hapū currently sells the surplus energy back to the electric grid for an insignificant profit. Consequently, the hapū has expressed interest in undertaking a project to use the excess energy produced by their micro-hydro power system in a more effective manner. Our project sponsor, Dr. Maria Bargh of Victoria University of Wellington and a member of the NKNT hapū, conveyed to us the community's desire to construct a greenhouse that would utilize the available electricity, for which the hapū has already determined a preliminary site. Green agriculture can employ the micro-hydro power in a manner that aligns with local cultural values. NKNT's location in Horohoro, about 16 kilometers south of popular tourist destination Rotorua, places the community in a geographically favorable position to sell greenhouse products in specialty markets.

Our team created a full feasibility report that explores the design parameters and requirements necessary to construct a greenhouse capable of fulfilling the needs of the community. To accomplish these goals, the team worked closely with Dr. Bargh and members of the hapū, conducted a market analysis in the local region, and reviewed pertinent literature before making ultimate recommendations to the community. Additionally, we documented regular maintenance of the micro-hydro system, and recommended a strategy to alleviate the current intake congestion problem. In completing these goals,

the team believes that it has delivered a report capable of benefiting the Ngāti Kea Ngāti Tuara community. The potential impacts for the hapū include job creation, new educational opportunities, new sources of profit and revenue, and restoration of indigenous species.

Chapter 2: Background

This chapter provides the cultural, political, economic, and technical context necessary to understand the hapū's micro-hydro power system and the possibilities of using the available energy for the operation of a greenhouse.

The chapter begins with a discussion of the current conditions of the hapū, including population statistics and information on the economy of Rotorua. Included in this section is a brief discussion of the economics of Māori communities that serves to situate NKNT in a larger economic context. Next, there is a summary of the Māori values pertinent to the project. An overview of both the technology of micro-hydro systems and the system currently in use at NKNT follows. The chapter then addresses the design factors the team considered in the final feasibility report presented to the hapū. These parameters include crop selection, building materials, growing technologies, size, and the markets of surrounding area.

2.1 Economic Profile of the NKNT Hapū and the Horohoro Region

Ngāti Kea Ngāti Tuara is located in the central North Island of New Zealand in a farming district called Horohoro, situated approximately 16 kilometers southwest of Rotorua, which is one of the Bay of Plenty's largest urban areas. The hapū's Kearoa Marae, as shown in Figure 9, lies next to the Pokaitu Stream. The hapū has approximately 1,500 members; 10% of hapū members live overseas and about 30% live in other parts of the country. The remaining 60% live in the Bay of Plenty area, although few live in Horohoro itself.

Figure 9: Kearoa Marae at Ngāti Kea Ngāti Tuara Hapū

2.1.1 Economic Profile of Māori Communities

The Māori economy heavily contributes to multiple New Zealand industries, including fishing, tourism, energy and agriculture. Twenty-nine percent of the collective asset base in New Zealand resides in the Bay of Plenty Region, with the majority of that being in agriculture and forestry (He Mauri Ohooho, 2014).

Nearly 90% of Māori people in New Zealand live on the North Island and over 25% live in the Bay of Plenty Region. The average Māori adult makes NZ$14,800 per year and only one in twenty make more than NZ$50,000 per year. Due to their relative economic disparity and abundance of youth, it is of utmost importance that the Māori plan for long-term success by making the best use of their available resources and ensuring the youth's education on economic and environmental sustainability. The Bay of Connections, a governance group of industry leaders and economic development agencies, focuses on and encourages Māori employment as a path toward sustainability. The plan emphasizes leadership and governance for the Māori as well as self-sovereignty over their own economies and cultures. In order to achieve these ends, it highlights the need for sustainability, connectivity, and education (He Mauri Ohooho, 2014). One group successful in implementing these goals is Indigenous New Zealand Cuisine (INZC), which has found success in growing crops with a greenhouse and selling to local tourist destination resorts and restaurants. INZC connects the Māori-grown food and delicacies to buyers to help growers export to markets around the world.

The NKNT hapū is located near Rotorua, which "has been the biggest contributor to the Māori economy within the wider Bay of Plenty" (He Mauri Ohooho, 2014). In 2010, forestry, property and business services, health and community services, and cultural and recreation services comprised more than half of the total Māori GDP in Rotorua. The total Māori GDP for these services in 2010 totaled NZ$387 million (He Mauri Ohooho, 2014).

Tourism constitutes a significant proportion of the Bay of Plenty's revenue, accounting for 3% of the region's overall GDP at NZ$387 million per year (Slack & Schluze, 2013). Rotorua in particular considers tourism an integral part to their existing economy. Additionally, tourism has promising potentials for future growth. However, growth in the area has stagnated, dropping in percent growth across many categories from 2009 until 2010 (RDC, 2011). While there are many factors contributing to the decline in the area's growth, unsuccessful branding and lack of meaningful innovation have particularly damaged the tourism industry (RDC, 2011). Currently, "tourism in Rotorua is ... based on Māori culture, geothermal attractions, lakes and the natural environment" (RDC, 2011). Although some

aspects of Rotorua's economy may be suffering from stagnation, the investment potential in the area leaves the hapū with an advantageous market to utilize via a greenhouse.

2.2 Guiding Māori Values

Our project requires a keen awareness of Māori cultural values. These values ultimately shaped our decision-making throughout the course of the project. We were able to get a sense of them first hand when we visited the Kearoa Marae in Horohoro and saw the *tuarongo*, the back wall of a marae, often dedicated to ancestry, seen in Figure 10.

Figure 10: Tuarongo of the Kearoa Marae in Horohoro

The team chose a set of three critical cultural coordinates from the "list of traditional values" (NKNT, 2013) provided in Ngāti Kea Ngāti Tuara's Iwi Hauora (Health and Well-Being) Plan. These three coordinates are whakapapa, katiakitanga, and no te hapū. The team evaluated greenhouse design factors and ideas to ensure they are consistent with these values. Dr. Maria Bargh details a similar approach in her 2012 article for the *Journal of Enterprising Communities* wherein she describes four pan-Māori cultural coordinates one could use to navigate Māori affairs. Brief explanations of each of these values and how they are relevant to the project follow.

Whakapapa, found in humans, non-human animals, as well as the natural environment, denotes genealogy (Bargh, 2012). As an individual develops, they develop their own whakapapa. As these individuals interact with one another and with the environment, the group itself develops a whakapapa. The whakapapa formed is unique to each individual and group, and is non-interchangeable. Thus, a river has its own whakapapa, and the Māori in the area have a whakapapa in relation to the river as well. This means that, in interacting with the environment, the team will be interacting with a distinct entity that has its own specific genealogy. Both waste from runoff and tire treads would damage a specific whakapapa rather than the environment as a whole.

Kaitiakitanga implies, in a rough sense, guardianship (Bargh, 2012). Kaitiakitanga applies especially to the relationship between tribes and the environment. Dr. Bargh notes that this value finds particular resonance with the balance of natural resource consumption (Bargh, 2012). However, as a value, katiakitanga goes beyond balance and stands for active protection of the environment. There is thus a normative quality to katiakitanga.

In the context of this project, no te hapū indicates a strong desire for communal benefit over the

benefit of any one individual (NKNT, 2013). This principle directed how our team initially considered project options and further on shaped our thinking surrounding a greenhouse endeavor. No te hapū also impacted the team's mindset when recommending who would work in the greenhouse.

2.2.1 NKNT's Quadruple Bottom Line

Ngāti Kea Ngāti Tuara conducts business with a quadruple bottom line. Any community endeavor must satisfy economic, environmental, social, and cultural standards. In other words, any recommendation made by our team must not only be profitable, but also environmentally clean, beneficial to the community as a whole (e.g. through job creation), and culturally aligned with the values held by the hapū. The team considered decisions and made recommendations according to this approach, adopted directly from the Ngāti Kea Ngāti Tuara Hapū's Strategic Plan (Berryman-Kemp, 2016).

2.3 Micro-hydro Power Systems

There is currently a huge untapped potential for hydropower systems in New Zealand, particularly in the Bay of Plenty region (World Small Hydropower Development Report 2013: New Zealand, 2013). The Ngāti Kea Ngāti Taura hapū joined the pursuit of hydroelectric power in December of 2013 with the installation of their micro-hydro facility. Now they seek to utilize their system's full potential by applying the available electricity to better the community and the environment.

Micro-hydro power systems, by definition, produce less than 100 kilowatts (kW) of electricity and present a clean, alternative energy option for those with nearby running water in the form of rivers or streams. A kilowatt measures energy at a given moment, not over time, whereas a kilowatt hour is a measure of total energy used in a specific period of time. To put this in perspective, a 10kW system can produce about enough electricity to power a large home, small resort, or farm (Energy.gov, 2015). With some systems capable of operating in as little as 13 inches of rushing water, almost any stream or river can produce hydroelectric power. Micro-hydro systems require a "head", or altitude drop, to generate power. Water enters an intake and travels down the penstock where turbines convert its kinetic energy to rotational energy. This mechanical energy is the source of the electricity produced. Figure 11 displays a simplified diagram of a micro-hydro system overlaid by NKNT's setup.

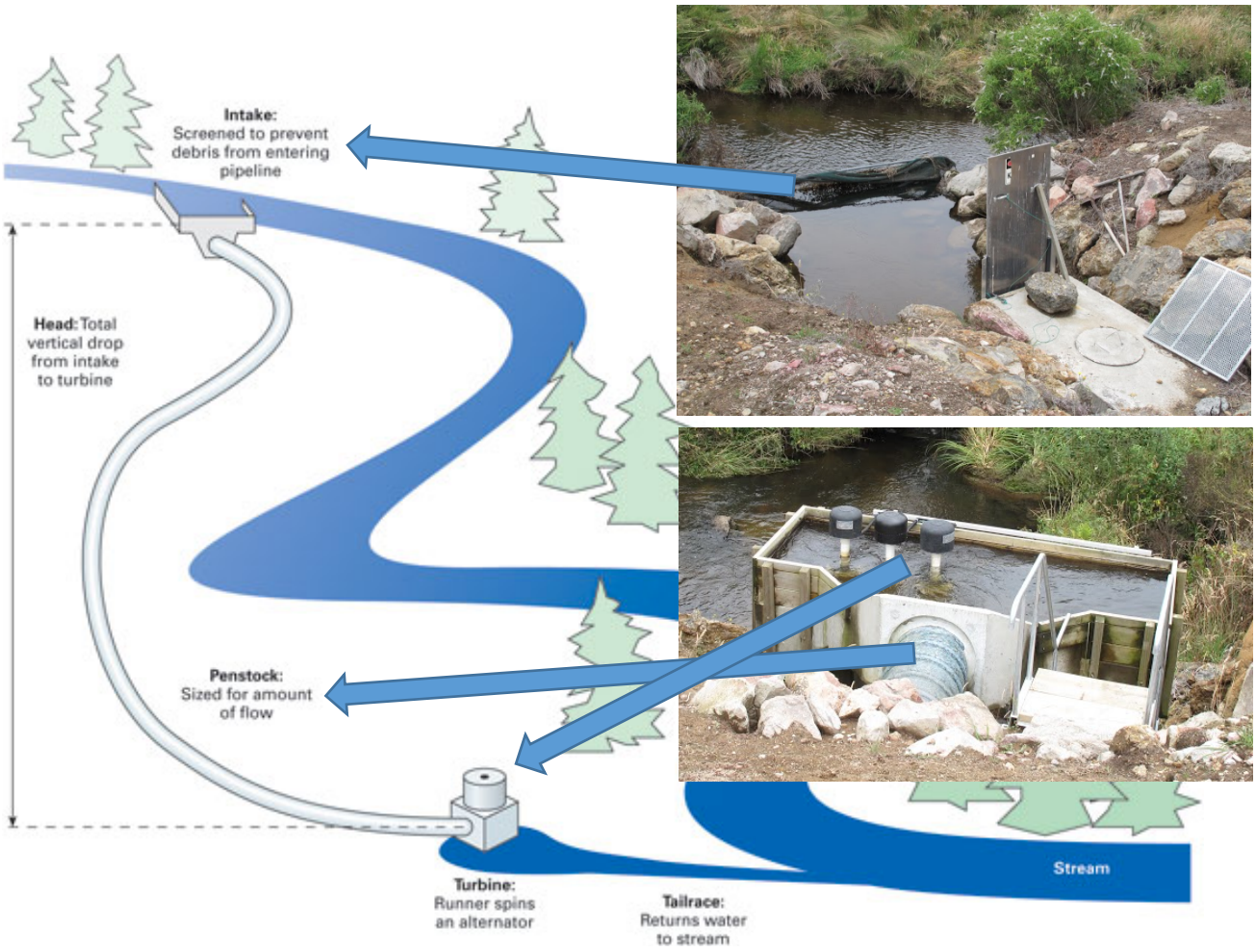


Figure 11: Diagram of the Micro-Hydro System with Photos taken at NKNT

Micro-hydro power systems have many benefits. For one, they are very reliable and only require a surprisingly small amount of flow (AENews, 2006). Since micro-hydro power is a "run-of-the-river" system, it does not require a dam or reservoir. The environmental impacts are relatively low in comparison to larger hydropower systems. Water returns to the river with little impact on the surrounding ecosystem. Inexpensive and ideal for small communities and villages, micro-hydro power presents a great opportunity to use existing natural resources in order to produce electricity for these communities or sell it back to the grid.

Although mostly efficient and reliable, there are some downsides to micro-hydro power. The size of the rushing water source is the limiting factor and does not allow for expansion. For this reason, finding sites that are suitable for micro-hydro power to use in growing communities can be a challenge. Micro-hydro power may also be seasonal, with the flow rate fluctuating between summer and winter months. Although thought to generate very clean energy with little environmental impact, a micro-hydro can have adverse effects on an ecosystem. Fish may get caught in the screen of the intake, but

this is uncommon as long as the screen complies with the regulations set forth by the resource consent for the project. Depending on the location of the stream, debris may also be a factor. In the case of NKNT's system, the current screen in front of the intake prohibits much of the debris from entering, but it does allow some smaller foliage, such as pine needles, to pass through. This means a hapū member must regularly clear out the intake and turbines. The following section explains the situation at Horohoro in more detail.

2.4 Existing Micro-hydro Power System at the Ngāti Kea Ngāti Tuara Hapū

Horohoro is home to the installation of a micro-hydro power system in the Pokaitu Stream. The system borders the Kearoa Marae, a meeting ground and cultural center for the hapū, as shown in Figure 12. The micro-hydro facility powers a church, nearby farm, Māori language immersion play-center and Horohoro Primary School all in the area. The objective of the installation was to help the

Figure 12: Map of Hapū and Available Land for Greenhouse Construction (PowerSpout, 2014)

community become more sustainable and self-sufficient and act as an example of how micro-hydro power can be an environmentally friendly resource in rural areas (PowerSpout, 2014, p. 22). The system operates with an intake that runs perpendicular to the river to minimize the intake velocity and the resulting threat to fish and eels. In 2011, the Marae used around 19,000 kWh. The existing three-turbine, micro-hydro power system can produce up to 23,000 kWh/year, which leaves excess electricity to be sold back to the electric grid and allows the community to produce for itself what would have cost

$4000 per year otherwise (Watson, M., 2014). Although Meridian Energy Limited, the hapū's current power company, buys back the excess electricity, it is not enough to bring significant profit to the community. They recently decreased their price from buying the electricity back at 25 cents per kWh down to just seven cents per kWh. Meridian also charges the hapū to have electric lines run out to Horohoro, so the community still has to pay the power company a varying amount each month. The power bills, while significantly less than before the installation, vary between $3 and $300, depending on the month. The weather directly impacts the system's production as a caretaker has to shut the turbines off during floods. The Ngāti Kea Ngāti Taura hapū look to utilize their available energy in a more effective and sustainable manner.

2.4.1 Problems with Debris

Micro-hydro intake systems filter and transfer water from the source to the turbines. Due to the small scale of micro-hydro power relative to larger forms of hydroelectric power, leaves and debris can be problematic for the intake of the system. In *Serious Microhydro: Water Power Solutions from the Experts,* Jerry Ostermeier (2008) outlines self-cleaning intake designs to address this common hindrance of debris congestion. The most common style of intake is a simple pipe with a screen, which is cost-effective but requires frequent cleaning. In the case of the micro-hydro facility at the NKNT Hapū, there is a fine mesh draped over a grate, as seen in Figure 13. Pine needles and other small debris penetrate the screen and cause the turbines to stall. When this happens, a worker must manually clear the intake, sometimes multiple times per day, before the turbine can generate power again. For this reason, the facility at Horohoro is not producing energy to its potential.

Figure 13: Current Solution for Debris

A solution that mitigates the effect of debris on the micro-hydro would allow the hapū to benefit from the receipt of more energy and less required maintenance. As mentioned, the system has a low velocity intake designed to meet the hapū's environmental standards. Our recommendation aims to accommodate for these characteristics in a cost-effective manner so that the hapū can receive the full potential of their current system. We must be able to estimate the amount of available power and ensure its consistency to outline a potential greenhouse project.

2.4.2 Power Production Potential

Ngāti Kea Ngāti Taura's existing system has three turbines that generate electricity. However, the hapū does have resource consent and the potential to add three more turbines into the existing headstock. Figure 14 illustrates the existing turbines with water drained from the headstock.

Figure 14: Turbines at NKNT

If the hapū decides to double the number of turbines, the system would produce about twice as much power, meaning they would need to purchase and install another inverter. This would change the scale and potential of the greenhouse and offer the community the potential to undertake other projects in the future.

2.5 Overview of Greenhouse Initiative for NKNT

Although the members of Ngāti Kea Ngāti Tuara are interested in constructing a greenhouse, meeting the needs of the community required our team to consider many design and construction parameters. Among these considerations are crop selection, building materials, size, growing technologies, construction time, construction cost, and labor costs. In order for the greenhouse to be

economically feasible and culturally consistent with the community's values, our team's final recommendations held these considerations in high regard.

Crop selection is the most fundamental of the factors and had a substantial effect on the remaining design parameters. The community previously expressed interest in growing watercress, a leafy green aquatic plant, or koura, a kind of freshwater crayfish that is a culturally important livestock. The crop or livestock that the hapū will harvest directly influenced the technological options considered by the team, such as hydroponics, heating systems, and water pumps. The crop(s) and the growing system required are strong indicators of what size greenhouse is appropriate, how long the greenhouse will take to build, and how much initial capital it will require.

However, the greenhouse must also produce products that the hapū can sell in an economically feasible way. While it is important that the greenhouse be economically stable, it is not required that the greenhouse bring in a substantial profit, as there are other potential benefits that we will discuss further on. The market value of the crop alone is not a good indicator of its feasibility; our team considered the cost of operation and labor in their own right. The cost of labor is a function of the available labor pool in the surrounding area, as well as the skill and quantity of labor the greenhouse will require.

2.6 Potential Crops and their Production Methods

According to the Food and Agriculture Organization of the United Nations, aquaculture is the one of the fastest growing rural industries in New Zealand (Jeffs, 2005). As displayed in Figure 15, the industry has exploded since the 1980s. Aquaculture contributes greatly to the employment and economic activity of rural areas and has the potential to do the same for Horohoro.

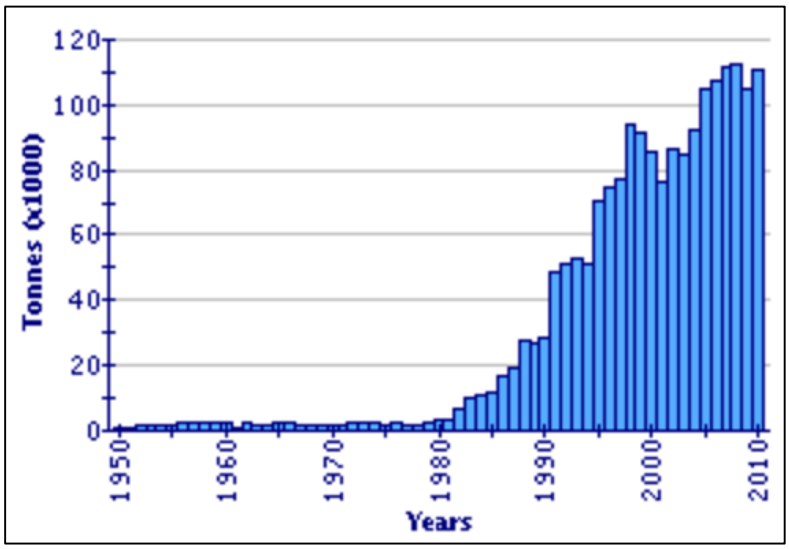


Figure 15: Aquaculture Production Growth in New Zealand (Jeffs, 2005)

Aquaculture is the process of farming fish, shellfish, or plants for consumption. Hydroponics harvests plants without soil in a nutrient-enriched recirculating water system (George, 2014, p. 7). Aquaponics is a "symbiotic cultivation of plants and aquatic animals in a recirculating environment. It is similar to a hydroponics

system except instead of adding nutrients, [fish are relied on] as nutrient-generators" (potfish.org, 2012). The following sections detail the applications of each method for potential crops.

2.6.1 Watercress

Watercress, a hardy perennial plant and strong candidate crop, grows rapidly and thrives in hydroponic cultivation. It is a known as a "super-food" with "antioxidant effects and presence of anti-cancer fighting compounds" (George, 2014, p.7). When harvested in the wild, it often grows in manure or near geothermal waters, such as those present in Horohoro. This poses a problem to the purity of the plant, as manure can contribute to parasites and geothermal waters may cause the plants to contain arsenic. Due to these concerns, there is a potential for hydroponically grown watercress in Horohoro. The hapū could cultivate watercress in their greenhouse and grow it year-round. Watercress also grows relatively quickly. Workers first harvest watercress 6-10 weeks after they sowed the seeds when the sprouts are 6-8 inches long (George, 2014, p. 7).

The market for watercress may be unstable as some think it to be a passing fad in New Zealand. However, a Washington Post article from 2014 had watercress topping a list containing 41 super-foods (Bernstein, 2014). Experts have revered this plant for its health benefits since 400 BC when Hippocrates, the father of medicine, located his hospital by a stream so he could grow watercress to help his patients (Watercress.co.uk, 2015).

There is potential to sell watercress to local restaurants, supermarkets, and local farmers' markets in the region. If the hapū grew watercress hydroponically and without contamination, it would meet New Zealand's demands and food safety standard. The corresponding price differentials follow (George, 2014, p. 10):

- Wild watercress NZ$2 - $4 a bunch
- Hydroponic watercress NZ$4 – 5 a bunch
- Pesticide-free watercress NZ$20.14 for 500g
- Baby watercress NZ$4-5 for 100g.

Another added benefit of watercress is that it is a nitrogen-fixing plant. This gives it an innate ability to deal with the waste produced by a koura farm (George, 2014, p. 8). The next section expands upon the idea of an aquaponic system with koura and watercress.

2.6.2 Koura

Koura, a type of freshwater crayfish, is a delicacy in New Zealand. The two species of Koura in the country, the Northern Koura and Southern Koura, sell for high prices at local markets. Many

attribute their high value to their slow growing process; a farmer must grow Koura for 2-3 years before the fish reach market size. Additionally, they hibernate in the winter, slowing down their reproduction time (George, 2014, p. 6).

Currently, the demand for Koura is higher than the production rate. Furthermore, there is not a successful Koura farm in the area. The initial Māori feasibility report recommends "funding be sought to start building a koura farm to help restore local populations of koura and increase to commercial production (George, 2014, p. 7). The market consists of Koura for consumption and as an aquarium fish. Presently, wholesale prices of live koura for eating range from NZ$65 - $98 per kg. Current approximate price for aquarium koura is NZ$25-$30 each (George, 2014, p. 9). Aquaponics would allow the hapū to grow koura within the greenhouse. The system would recycle the water used for the koura and could reuse it to facilitate the growth of watercress. The option to grow both koura and watercress in a symbiotic system is a promising one and the team has evaluated its potential using the methods outlined in the following chapter. Further market analysis while in New Zealand helped our team determine the viability of this option within the context of the NKNT Hapū.

2.6.3 Benefits of Hydroponics

Hydroponics would offer a clean and manageable environment in which to cultivate a plant. It requires a steady power supply for pumps and lighting, which the micro-hydro system would supply in Ngāti Kea Ngāti Taura's case. Naturally grown watercress in New Zealand is often subject to farm runoff, which can contaminate the plant. Food safety is an increasing concern of consumers; because hydroponically grown watercress is safer to eat than watercress grown in the wild, crops grown with hydroponics are in high demand.

Although hydroponic farming does require labor, the more intensive work needed for traditional farming is not required in hydroponics. Thus, labor costs for the hapū would be less if they choose to select this recommendation.

Hydroponic systems are incredibly efficient. Plants grown using hydroponics use an estimated 1/10 of the water used by the same plants grown traditionally (Vandenberg, et al., 2015). Furthermore, because plants do not need to compete for space in the absence of soil, hydroponics allows for more production per unit area. Plants grown hydroponically typically grow at a faster rate and to a larger size.

The efficiency of hydroponics, especially given how well it aligns with Māori cultural values, makes it a very appealing option. The use of hydroponics to employ the hapū's excess electricity would further strengthen the marketability of the final product.

The main drawback of hydroponics is cost. Because hydroponic equipment is capital intensive, the hapū may not be willing to invest in this type of venture. However, the efficiency and marketability of a hydroponic system make it an attractive option despite its high initial cost.

2.7 Market in Horohoro and Surrounding Areas

Part of the tourist industry relies on gourmet and fine dining, which has seen success in serving koura, a type of crayfish, and watercress, an aquatic leafy green (George, 2014). These items, and others, are candidate solutions to utilize Ngāti Kea Ngāti Tuara's available hydroelectric energy (George, 2014). In the area, "large tourism and wood processing companies have recently completed, or are planning, new investment to leverage greater value," (RDC, 2011). The hapū is well-situated to collaborate with local tourist industries.

2.7.1 Treetops Lodge & Estate

Treetops Lodge & Estate is a high-end resort located just 4km from the NKNT Hapū in Horohoro. The lodge currently has a vegetable garden where guests can accompany the chef to select fruits, vegetables, and indigenous species for consumption (Treetops.co.nz, 2015). Dr. Maria Bargh alluded to this resort as a possible business partner to which the hapū can sell the crops the greenhouse produces. The lodge's current interest in involving their guests in the culinary process bodes well for the hapū as it may lead to a more in-depth partnership in the future.

2.7.2 Hobbiton Movie Set

The Hobbiton movie set is an extremely popular tourist attraction with 240,000 visitors in 2013 and 800,000 since it opened in 2002 (Media.newzealand.com, 2015). The attraction is a 1 hour and 15 minute car ride away from Horohoro; buses run from hotels in Rotorua to the attraction daily. Hobbiton also boasts "Farm Stays", a type of visit that features a three-course dinner with fresh New Zealand produce (Hobbiton Tours, 2015). Therefore, this attraction offers a promising market for the hapū to sell its produce.

2.7.3 Farmers' Markets and Grocery Stores

There are four farmers' markets in the Bay of Plenty and Wakaito Region: Tauranga Farmers' Market, Waikato Farmers' Market, Cambridge Farmers' Market, and Hamilton Farmers' Market (Farmersmarkets.org.nz, 2015). These markets sell food from local growers and food makers and appear well attended with dozens of stallholders. This venue would require a hapū member to rent and staff a spot at the markets to sell the crops. Farmers' markets are more appropriate for some crops,

particularly produce, than others, such as raw fish. We will consider each market more closely after determining which crop to farm. In addition to the farmers' markets, a few local grocery stores may also be worth contacting.

2.7.4 Eat Streat

The hub of Rotorua's restaurant industry, "Eat Streat" presents tourists with a range of fine dining options in close proximity with each other. Having recently undergone a NZ$2 million renovation, Eat Streat touts itself as "one of the coolest hot spots in the city" (Eat Streat, 2014). It is a pedestrian street in the center of town, just a short walk away from Lake Rotorua. The large amount of tourism that comes to Eat Streat provides a favorable market in which the hapū can prosper.

2.8 Greenhouse Design Options

The crop grown and purpose of a greenhouse both affect its structure, its technological requirements, and its construction components. Depending on the choices the hapū select, the greenhouse can feature several different design options. Of particular interest are hydroponics, aquanponics, and the possibility for a trial greenhouse.

2.8.1 PlentyFlora

PlentyFlora is a glasshouse located five minutes from the Ngāti Kea Ngāti Tuara Hapū. PlentyFlora heats their greenhouse using geothermal energy from two geothermal bores. They drilled a new bore two years ago, which produces 65°C geothermal fluid. PlentyFlora uses this directly in the greenhouse, mainly for air heating in an overhead system. The system injects the cooled geothermal water back into the shallow geothermal reservoir. A bio diesel peak heating system on a fan coil gives the plants hot air when needed (Lind, Bradshaw & Bell, 2015).

2.8.2 Materials for Construction

The team considered three candidate materials for the construction of the proposed greenhouse. Glass is the most expensive option, depicted in Figure 16, and can cost hundreds of thousands of dollars. It is also the most durable option, lasting 40-50 years. Advantages include that glass is non-combustible, resistant to UV radiation and air pollutant degradation, and would be relatively easy for the hapū to maintain. Negatively, harsh weather

Figure 16: Glasshouse (Agricultural Structures, 2010)

conditions can easily damage the glass. Rotorua has a temperate climate and lies off of the fault line that runs through New Zealand, lessening the concerns surrounding weather and earthquakes.

Polyethylene film, shown in Figure 17, is the cheapest option, and costs just a fraction of the glass option in the thousands of dollar range. It is the simplest form of covering and is very flexible. However, this option does not come without its downfalls, most notably life expectancy. Photochemical degradation processes in all plastics from ultraviolet radiation, air pollutants, and chemicals from pest control all result in plastic's life expectancy of only 3-5 years.

Figure 17: Thin Film Greenhouse (American Society of Agricultural and Biological Engineers)

Rigid panels fall under the category of polyethylene material. This option, displayed in Figure 18, is more expensive than the film but has a life expectancy of 10-15 years and is easier to maintain. Greenhouse designers can space the panels wider apart, creating less shade on the crops than glass. The downside of this option is that it has low air infiltration. This improves energy savings but contributes to humidity, which affects crop production (Giacomelli, 2001).

Figure 18: Rigid Panel Greenhouse (The Big Greenhouse Project, 2007)

2.8.3 Ground and Water Considerations

In order for construction to take place at Ngāti Kea Ngāti Taura, the land must be well-drained, level, of good water quality, and have access to roads for materials and products. Figure 19 shows part of the plot of land. From our initial observation and conversations, the plot seems to fit these parameters. The bulldozed section currently measures 25 by 50 meters and has the potential to expand. As of late January, 2016 it has a number of potted plants. It is also important to note that a healthy water supply is an essential component for the greenhouse. A water quality test determines the water's pH, hardness, salinity, and dissolved minerals.

Figure 19: Current Plot for Greenhouse

There are other elements of physical structure the team considered. One type of growing system, called ground-to-ground or Quonset, is initially cheaper. This option's biggest limitation is space. On the other hand, a gutter-connected structure presents an alternative option and allows the hapū to expand the structure in the future. This design can share environmental control systems and other equipment, including heating, cooling, and irrigation. The downside is that there is no isolation for disease or pest control.

2.8.4 Trial Greenhouse Possibilities

A trial greenhouse is a possible solution if the hapū does not feel the economy is stable enough for a more permanent structure, or if the initial expenses related to building and maintaining a greenhouse are too high for the hapū to absorb. A small-scale trial hydroponic system, shown in Figure 20, is a good first step. This allows the hapū to gauge necessary nutrient inputs, growing speeds and taste.

Figure 21: Homemade Hydroponic Trial Tub (plantozoid.com, 2015)

A trial greenhouse, such as a hoop house as seen in Figure 21 is a non-permanent solution and much cheaper alternative. Mobile hoops allow for the better use of cover crops and crop rotation, while increasing crop production. A full-time hoop house farmer could fit about ten hoop houses onto one acre and earn about $25,000 a year. The downside to a hoop house is that it has no ventilation fans or heater, harming plant growth. This also means that the hapū would need someone to open it every morning and close it every afternoon. A solution to this is removing the plastic skin and then covering half of the hoop house with shade cloth. Builders can install sprinklers on the ground or attach them to the top of the hoop house for cooling and irrigation (DeVault, 2003).

Figure 20: Hoop House (Agricultural Structures, 2010)

2.9 Summary of Main Considerations

Many parameters are relevant to designing a greenhouse. For our purposes, the team selected a list of considerations to focus on. To produce a greenhouse capable of benefiting the community, our team provided recommendations concerning crop selection, available markets, construction, and operation. Hence, the team created methods to assess the relevant variables and process them in an understandable way.

Chapter 3: Methodology

The goal of this project was to develop a feasibility plan for a greenhouse that provides the members of the Ngāti Kea Ngāti Tuara Hapū with an effective strategy to utilize the available energy produced by the community's micro-hydroelectric power system. The project also investigated a solution for the turbine's intake congestion problem. In order to accomplish the goals of the project, our team developed the following objectives and methods, depicted in Figure 22:

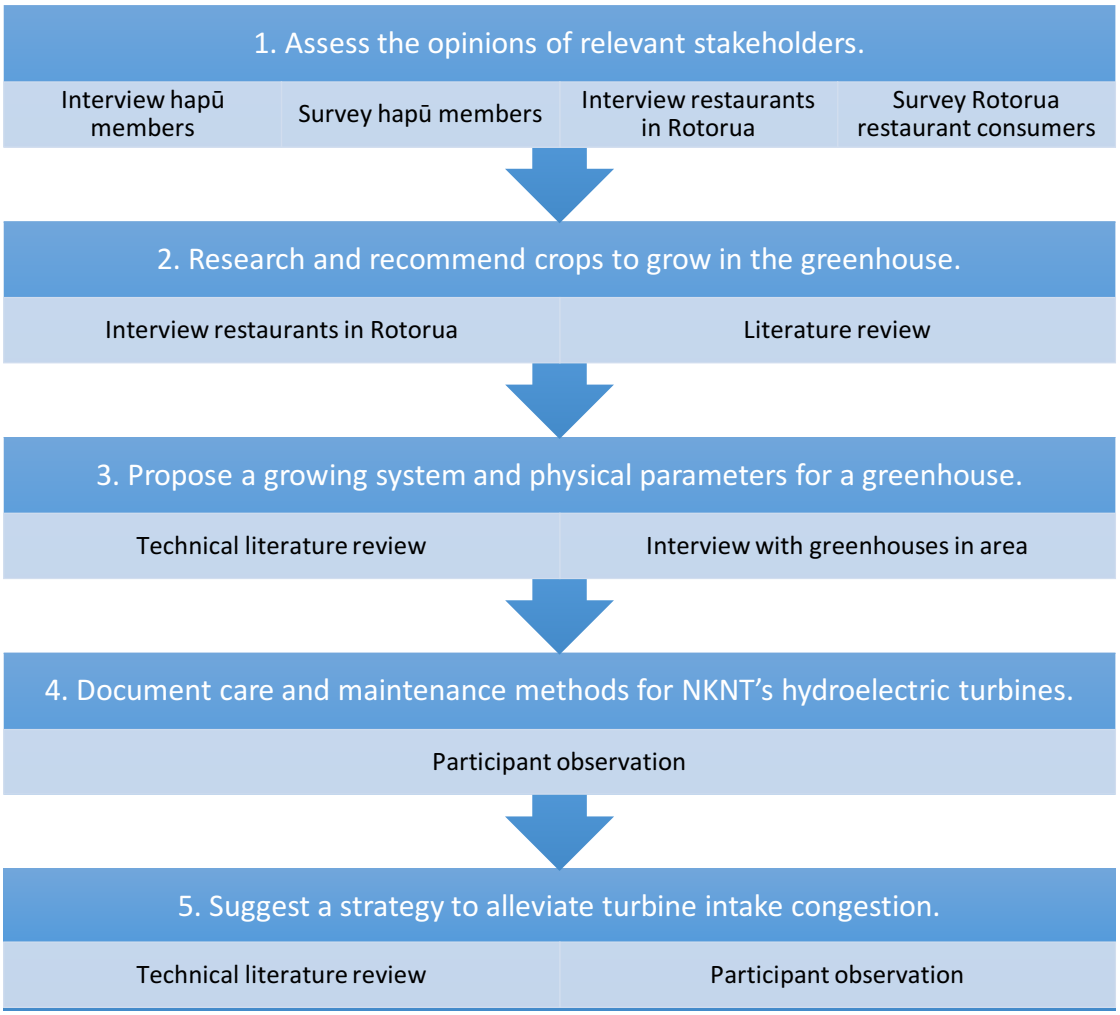


Figure 22: Outline of Methodology

The team utilized four main methods: literature reviews, interviews, surveys, and participant observation. Most data collection occurred during the team's visit to Horohoro and Rotorua, which lasted from January 27th through January 31st. Our project sponsor, Dr. Bargh, provided transportation for the entire team, both to Rotorua from our office in Wellington, as well as to our major interview sites, detailed in later sections of this chapter.

3.1 Assess the Opinions of Relevant Stakeholders

After the team identified relevant stakeholders through background research, the team constructed five different tools designed to ascertain the stakeholders' perspectives. These tools are the Interview with NKNT Hapū Members (Appendix A), the Hapū Member Online Survey (Appendix Q), Interview with Restaurants (Appendix B), Survey for Restaurants (Appendix E), and Rotorua Street Survey (Appendix D).

The most important stakeholder group is the hapū members themselves. The team first met with members of the Runanga Board, Eru and Kataraina George, Ngāti Kea Ngāti Tuara's project manager Eugene Berryman-Kemp, and hapū members Robyn Bargh and Bob Young (Dr. Bargh's grandfather) on Thursday, January 28th. In speaking with these representatives of the community, the team furthered our understanding of the hapū's current state, its goals, and the guidelines by which it will ultimately achieve these goals. Mr. Berryman-Kemp reviewed several documents with us, including the hapū's strategic plan and monthly power bills that outline their energy consumption and how much electricity the micro-hydro system produces. The team posed questions, similar to those outlined in the hapū interview, to Mr. Berryman-Kemp about his thoughts on the greenhouse project and viable crops to grow within a hapū greenhouse. Through this conversation, the team gained a direct understanding of the community's needs and expectations for this project. While we did not digitally record this interaction, a member of the team took notes during the conversation. His responses solidified past research and ensured us we were proceeding in the right direction with our upcoming hapū member and restaurant interviews.

The team then conducted semi-structured interviews with general members of the hapū, as the project is fundamentally concerned with synthesizing the needs of the community and representing them accordingly in our recommendations. We set up interviews through Dr. Bargh and her contacts in the community. Dr. Bargh posted an information sheet, found in Appendix F, on NKNT's Facebook group page informing the hapū members of our background, purpose, and the interview process. We were able to conduct two interviews as a result of the Facebook post. The two interviews took place on Saturday January 30th, one in-person and the other via Skype. We conducted these interviews at the Runanga office in Rotorua. There were two team members present for each interview, a note-taker and an interviewer. Appendix A outlines the questions we asked this stakeholder group. Generally, the questions were exploratory, and allowed the interviewee to speak openly about their excitement or concerns about the project. The team gauged members' responses to the candidate recommendations and allowed time for them to provide us with any other thoughts they had. The main purpose of these

questions was to gather an understanding of the hapū members' opinions of the greenhouse, if they thought it was a sustainable option, and if they had any other ideas in mind.

Since the team could only secure two face-to-face interviews with hapū members, in order to get a wider view of the community's thoughts on the project, the team created an online survey, found in Appendix Q. Dr. Bargh posted the online survey on NKNT's Facebook page. In one week we were able to gather 16 responses that supplement the other interviews and informal conversations.

Two other crucial stakeholder groups the team addressed were potential business partners of the hapū, mainly restaurants, as well as their consumers (both tourists and locals) in Rotorua. These stakeholders had a less direct influence on the project but played a large role in our market analysis. The team conducted face-to-face interviews with five restaurants in town, guided by the questions found in Appendix B. We requested that those who declined an interview complete a short survey, displayed in Appendix E, designed to provide us with useful information in the absence of a full interview. Table 1 outlines each restaurant interaction.

Restaurant name	Interviewee Title	Tool used	Location
Solace Café & Restaurant	Manager/bar tender	Semi-structured interview	Eat Streat
Atticus Finch	Owner/operator	Semi-structured interview	Eat Streat
Mac's Steakhouse	Manager	Semi-structured interview	Eat Streat
Shire's Rest Café	Shift Manager	Restaurant survey	Matamata
Brew Craft Beer Beer Pub	Chef	Semi-structured interview	Eat Streat
Nuvolari Restaurant	Chef/Kitchen head	Semi-structured interview	Eat Streat
Treetops Lodge	General Manager	Semi-structured interview	Phone interview

Table 1: Completed Restaurant Interviews

In order to gain the perspective of Treetops Lodge and Estate, located just down the road from Ngāti Kea Ngāti Tuara, the team reached out to the luxurious lodging option via email. We secured a phone interview with Peter White, general manager of Treetops, on February 18th to discuss the hapū's aspirations and the possibility of a business partnership.

Consumers, both locals and tourists alike, answered surveys (found in Appendix D) in the vicinity of Eat Streat. The team used these surveys to gather information on the local demand for candidate crops and an indication of the most effective marketing angle to be utilized by NKNT. Section 3.2 provides a more detailed description of business interviews and consumer surveys.

3.2 Research and Recommend Crops to Grow in the Greenhouse

Because the greenhouse is for the benefit of the hapū, the members' opinions are most important in selecting a crop. Even if a crop could see widespread commercial success, an objection from the hapū to this crop would deem it unsuitable. With this in mind, our team included questions surrounding crop selection in our interviews and surveys with the hapū members.

As alluded to in Section 3.1, the two hapū members we interviewed and 16 hapū members who completed the online survey also provided their opinions on candidate crops and their own crop suggestions for the team to further explore. We fully transcribed the recorded conversations (see Appendices G and H). The team analyzed these transcriptions and data, looking for key words, phrases and ideas and summarized the overarching themes. We conducted the hapū member survey via Google Forms and thus the results were already summarized into graphics. Appendix R holds the raw data for these surveys. From these conversations and survey results we further enhanced our sense of the community's values and what they would like to see in a greenhouse project. A careful review of these ideas allowed the team to cross-reference the needs of the hapū with the needs of other stakeholders.

For the crop to be commercially viable, the team had to gain an understanding of the market in the region surrounding Horohoro. For our purposes, the team divided the market into two primary categories: the restaurants and the consumers. To understand the market meant to understand the wants and needs of each of these two groups. The team targeted a hub of upscale restaurants located in a part of town playfully called "Eat Streat". We decided the restaurants we wanted to approach before our trip based upon their menus and website. The week before our trip we sent out emails to these establishments requesting to set up an interview, but received no responses. With no interview schedule, we dedicated the afternoon of Friday, January 29th to walk around Eat Streat and approach restaurants during their slower hours in hopes of speaking with managers or chefs on the spot. We conducted semi-structured restaurant interviews, guided by the questions found in Appendix B, in teams of two which consisted of a note-taker and interviewer. Many restaurants were happy to speak with us while, naturally, others were not so enthusiastic to take time out of their busy days. Figure 23 shows which restaurants we approached and the outcome of these encounters. With the interviewee's consent, we recorded these conversations. Our primary goal was to understand whether or not the businesses were interested in our candidate crops, watercress and koura. Some of the other questions lent themselves to "snowball" style inquiry, where we hoped to learn of other potential crops and opportunities for the hapū.

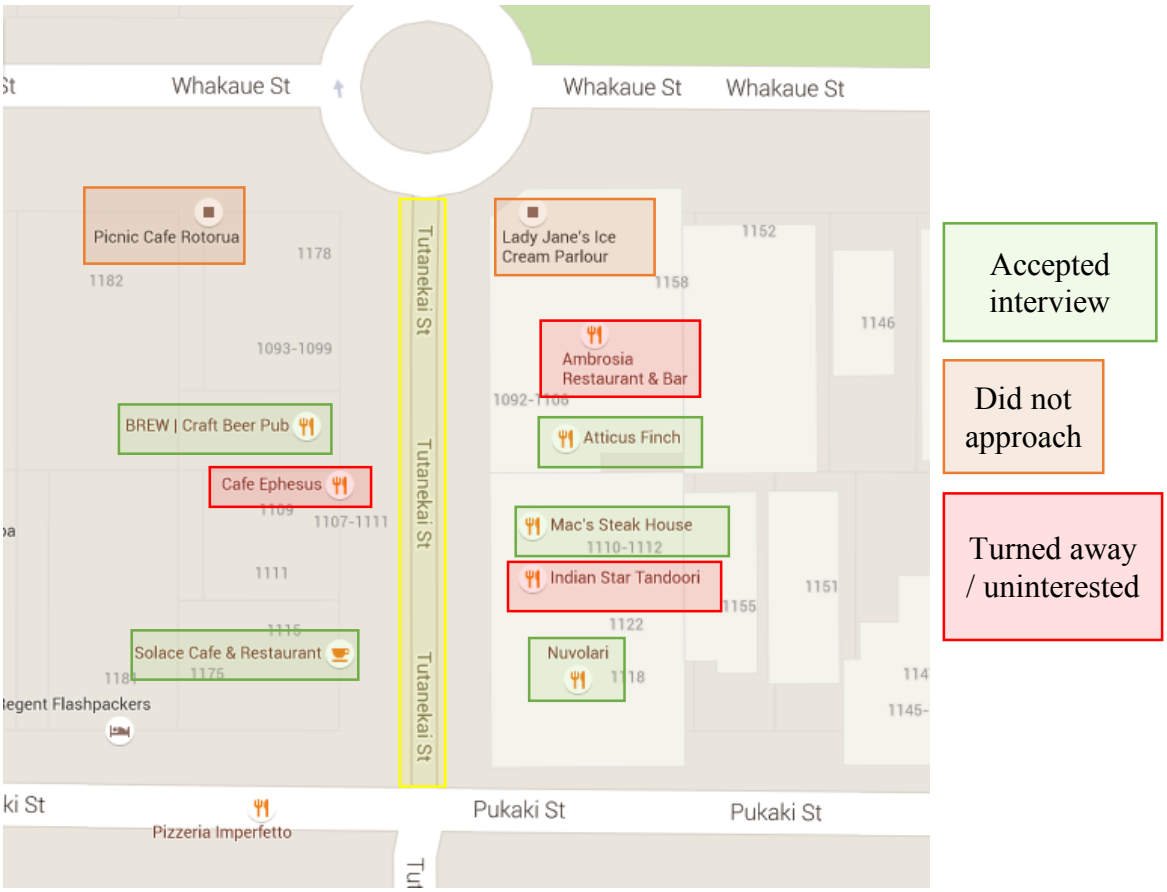


Figure 23: Map of Eat Streat (Google Maps, 2016)

In addition to gaining the restaurants' perspectives, the team conducted surveys to ascertain the desires of the customers. These customers, including locals and tourists, formed another stakeholder group. We deemed it important to determine consumer interest in addition to speaking with local businesses. The team distributed quick, one-page surveys (Appendix D) in the vicinity of Eat Streat, and gathered 42 responses over the course of our weekend in Rotorua. To distribute these surveys, team members wore nametags and held clipboards that displayed the WPI logo and the words "FOOD SURVEY" to catch the attention of passersby. To encourage survey taking, the team offered lollipops to anyone who returned a completed survey. The team developed these survey questions to understand the public's opinion on potential crops and their likelihood to purchase food grown under circumstances specific to NKNT (Māori-grown, grown using clean energy, organic, locally sourced). Demographic information helped identify any trends in responses. The answers produced quantitative, statistical data which the team processed using spreadsheets. The team entered the responses into Microsoft Excel and organized results based on gender and other demographic information. This data has helped us build narratives that the team can present to the hapū. The hapū can then use this information when approaching business once the project has reached a commercial level.

3.3 Propose a Growing System and Physical Parameters for a Greenhouse

In order to recommend a growing system and a series of physical parameters for the greenhouse, the team first had to gather the necessary information about each option and then compare the options in a meaningful way. To gather information on growing methods and types of greenhouses, the team reviewed technical literature and interviewed a current greenhouse manager. The information we gathered from technical literature reviews was heavily dependent on our market analysis and hapū interviews, as each crop requires different growing technologies. With this data gathered, the team could then compare each option, weighing their pros and cons.

The team began data collection with an interview with PlentyFlora's owner Harald Esendam. PlentyFlora, a flower greenhouse near Horohoro, had a structure that seemed similar to many of the options available for the proposal. Thus, the team decided that an interview with Mr. Esendam would serve well to guide our investigation. The team contacted PlentyFlora a week prior to our visit to Horohoro. The interview occurred on January 29th with two team members present and lasted approximately one hour. The questions we asked provoked responses that offered more knowledge of the geothermal heating system, the expenses of starting and maintaining the greenhouse, and the management and staff operations within the greenhouse.

Literature review helped us better understand the principles of greenhouse design. The team used these reviews to learn about successes and failures, not only regarding the structure of the greenhouse but also the crops grown inside. We found these sources on the web, particularly through the Victoria University in Wellington online library collection. The university provided the team with the login credentials necessary to access the relevant information.

An initial cost analysis by Kataraina George showed that glass greenhouses cost, depending on size, hundreds of thousands of dollars, while rigid panel and thin film greenhouses cost much less but sacrifice longevity consequently (George, 2014). We used the information gathered from literature review to conduct this cost analysis.

The team used SWOT to consolidate strengths, weaknesses, opportunities, and threats for each crop, greenhouse structure option, and growing system. Tables 2 and 3 include two example SWOT analyses applicable to our project. The final SWOT analyses are included in the Section 4.2.5 and 4.3.4 The team learned about New Zealand's weather conditions, the land on which the greenhouse will stand, as well as the materials and prices needed for the construction of the greenhouse through literature review. Because the actual construction of the greenhouse requires a professional contracting firm, the team saw it fit to approximate physical parameters and technologies with information derived from literature review. The hapū will know more when they approach and hire an actual firm to undertake the project.

Strengths	Weaknesses	Opportunities	Threats
Land available	Trial and error as learn to grow koura	Local market	Already well developed farms in competition
Build off koura restoration projects	Underdeveloped market for koura	Restaurant market	Cold winters
Water available	Slow growers	Potential export market	
Power available	Good quality water imperative	Current farms not meeting demand	

Table 2: SWOT Analysis for Koura Farm (George, 2014)

Strengths	Weaknesses	Opportunities	Threats
Land available	Do not store well	Local market	Potential increase in market is 'just a fad'
Water available		Restaurant market	
Power available			
Easy, hardy plant to grow			

Table 3: SWOT Analysis for a Hydroponic Watercress Glass House (George, 2014)

3.4 Document Care and Maintenance Methods for NKNT's Hydroelectric Turbines

To begin addressing the problem of intake congestion for the micro- hydro system, the team had a first-hand look at the system in order to understand exactly how the debris affected turbine operation. Dr. Maria Bargh set up a meeting with maintenance worker and hapū member Riki Oneroa. This participant observation pictured in Figure 24 took place on our first full day in Horohoro, Januray 28th. Mr. Oneroa provided us with a bounty of information regarding maintenance under both typical and unusual circumstances (e.g. flooding). With consent, we recorded our encounter, both digitally and through written notes, and trailed Mr. Oneroa around the site as he walked us through the daily routine of caring for the turbines. He is currently the only person who maintains and cares for the turbines, and

therefore the only person who knows what to do in varying circumstances. The team documented his specialized knowledge of the micro-hydro so that it will be available for future reference.

Figure 24: Team Members Marty and Paige Listening to Mr. Oneroa

With an upcoming project in mind that would be heavily dependent on the turbines, it is necessary that members of the community be involved in the proper operation and maintenance of the system. It is also essential that the system be able to provide a consistent power flow. For this to happen, the hapū must first address the problem of intake congestion.

3.5 Suggest a Strategy to Alleviate Turbine Intake Congestion

Our conversation with Mr. Oneroa greatly helped us get a grasp on the problem specific to the hapū's system. Additionally, we got an up-close look at the intake congestion, seen in Figures 25 and 26. With this information, the team directed their research to specific technical reviewed literature on turbine intake congestion and case studies from projects with similar problems. Victoria University's online library was of particular use in this capacity, as was mentioned in Section 3.3. Scott Davis' book *Serious Microhydro: Water Power Solutions from the Experts* was one such book the team discovered online. The team used Davis' analysis of intake congestion to great effect. Our recommendation can be found in Section 5.4.

Figure 25: A Close Look at the Intake Congestion

Figure 26: Team Member Paige Examining the Intake Screen

3.6 Project Timeline

The team's work progressed as displayed in Table 4.

Week 1: Jan 18-24	Week 2: Jan 25-31	Week 3: Feb 1-Feb 7	Week 4: Feb 8-14	Week 5: Feb 15-21	Week 6: Feb 22-28	Week 7: Feb 29-March 1	March 1
Study Māori language, customs	Interview NKNT hapū members	Update background and methodology	Research potential crops and greenhouse structures	Send out online survey to hapū members	Interview with Treetops	Finalize report	Final Presenta-tion
Finalize interview questions, surveys	Interview restaurants and PlentyFlora	Transcribe micro-hydro interview with Mr. Riki Oneroa	Research past intake congestion solutions	Determine crop recommend-ation	Email Waikato Regional Council regarding resource consent	Practice presenta-tion	
Contact local businesses	Survey tourists	Create micro-hydro maintenance manual	Select recommenda-tion to address intake congestion	Determine greenhouse structure / technologies to suggest	Create flow charts for recommenda-tions to give the hapū		
Set up NKNT hapū member interviews	Tour micro-hydro facility at Horohoro	Input data and begin to analyze interviews and surveys	Record voice-over PowerPoint presentation to show at Te Runanga Board Meeting		Create and finalize final presentation		

Table 4: Project Timeline

Key:
Completed in Rotorua/Horohoro
Completed in Wellington

Chapter 4: Results and Discussion

The team categorized our results in a manner that mirrors objectives and methodology. We have presented our results in the following order, starting with the opinions of stakeholders. Section 4.1 includes a summary of the hapū member interviews, the hapū survey, the restaurant interviews, and the restaurant surveys, as well as a discussion of the significance of our results. In this section, the primary emphasis is on portraying the opinions of the major stakeholder groups as it relates to the project in a broad sense. The next section, 4.2, encompasses the same stakeholder groups, but is concerned with the stakeholder groups' opinions of specific crops. Throughout the course of the project, the team kept watercress and koura as the two forerunner candidates. Section 4.2 explores their suitability in the eyes of our stakeholder groups. The following section, 4.3, shifts into a discussion of technical literature in order to review the applicable growing systems and greenhouse structures for our candidate crops. Section 4.4 presents the team's observations for turbine maintenance and routine care. The chapter ends with Section 4.5, which outlines the result of our research towards solving the intake congestion issue.

4.1 Objective 1: Assess the Opinions of Relevant Stakeholders

Although there are many potential stakeholders in this project, after our initial research the team concluded that there were three categories of stakeholders of particular importance. These groups are the hapū members, nearby restaurants, and restaurant customers. The purpose of this section is to ascertain the initial opinions of our primary stakeholder groups concerning the project in general. This includes environmental, cultural, social, economic, and historical views a stakeholder might hold about an agricultural greenhouse at Ngāti Kea Ngāti Tuara.

4.1.1 Hapū Member Interviews

The team conducted two twenty-minute, semi-structured interviews with hapū members Wiremu Keepa and Joanne "Jo" Heap and had several informal conversations with other members of the hapū community, including Dr. Bargh. The transcriptions for these two formal interviews are contained in Appendices G and H, respectively. This section summarizes some of the key sentiments shared throughout the interview process.

We asked the interviewees about the premise of a project to utilize the electricity and what they would like to see come out of it. Ms. Heap was, "keen to see it used to benefit the hapū and the environment…whatever that might look like" and was open to suggestions (Heap, 2016). At the mention of a greenhouse as a possibility, she said, "it sounds like a good idea. It would be a source of

food, healthy food, for the members of the hapū and community" (Heap, 2016). Similarly, Wiremu Keepa shared an enthusiasm for the project, exclaiming, "Let's do a glasshouse!" (Keepa, 2016).

The interviewees also shared ways in which they thought such a project could benefit the community. Both interviewees immediately mentioned that it would be a good source of food. Ms. Heap expanded that the project would also be, "a good role model for our families. I think [that for] Māori in general, our health tends to be not great. To lead the way and show our people how to produce our own food… and eat healthy, I think [there are] huge benefits there" (Heap, 2016). Mr. Keepa also mentioned that job creation could be a great benefit since unemployment rates are high and Ms. Heap added, "as long as there is good training and support systems and people who are interested in that work" such a project could be successful (Heap, 2016).

According to our interviewees, a greenhouse also fits in with traditional Māori values. Mr. Keepa sums up this sentiment very nicely explaining that "...if we can nurture life from a seed using other means, other than naturally in the soil with the sun… if we can do it in a glasshouse and if we can still produce goods from a seed, that would still be ideal. Because… Māori, we believe in life, we believe in nurturing a seed to full growth, the whole cycle" (Keepa, 2016).

The interviewees also informed us about any Māori-run businesses they knew so we could look into them and see if they were applicable ventures from which to learn. Mr. Keepa and Ms. Heap both knew of a few, mainly within the realm of agriculture and forestry - dairy, manuka honey, and kiwi fruit, for example. We supplemented these two hapū member interviews with an online survey for hapū members that we did not have the chance to speak with in person.

4.1.2 The Hapū Member Survey

The team created a survey on Google Forms and passed it along to Dr. Bargh to put on NKNT's Facebook page. The survey, which was open for one week during February 15th through 22nd, generated 16 responses, all from members of the hapū. The survey allowed the team to receive additional feedback from hapū members and included sections for open responses. It provided us with a better understanding of how the hapū members viewed the idea of a greenhouse: if they thought it would benefit the community, what to grown inside of it, and if they had a cultural connection to the proposed crop choices. In the survey, 93% of respondents said they think a greenhouse would benefit the community. Figure 27 displays just how the members believe the hapū could benefit from such a project.

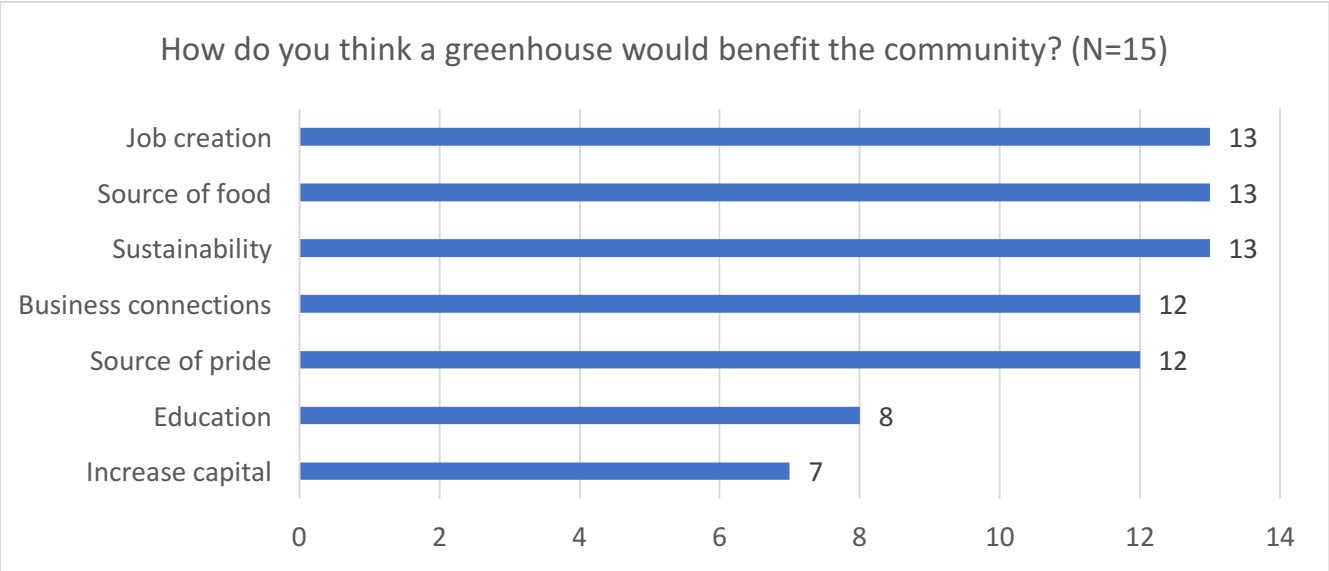


Figure 27: Greenhouse Benefit to Community Survey Responses

It is important to note that increasing capital is at the bottom of the hapū's list of priorities. While this aspect does fall under the economic portion of their "Quadruple Bottom Line", the social, environmental and cultural values come first.

4.1.3 Restaurant Interviews

Restaurants form an important stakeholder group for the commercial success of any product grown in an NKNT greenhouse. Thus, we wanted to understand how businesses in the area currently relate to or support Māori-owned business, what their current food supply is like, and the problems they already have in their day-to-day affairs. Table 5 shows all of the businesses we approached and the result of these encounters.

Out of the twelve businesses we approached, we were able to speak directly with six of them and got a survey back from one, making a total of seven data points that we were able to analyze. Four of the restaurants, including Treetops Lodge, were interested in supporting a Māori community in one form or another. One restaurant, Solace, was not opposed to the idea, but did not see a particular benefit to working with a Māori community. Two of the restaurants that denied us interviews turned us away because of their need for international products. We handed out surveys to be completed by two other restaurants, Craft Bar and Kitchen as well as one to supplement our interview with Mac's Steakhouse, but they were never returned. Five out of the seven restaurant representatives we spoke with had little to no familiarity or relationships with the Ngāti Kea Ngāti Tuara Hapū. When asked if they would be interested in working with NKNT, their primary concerns were not being able to receive a large enough quantity from the hapū or the absence of the discussed crops from the menu.

	Restaurant	Contact Method	Expressed Interest
1.	Solace Café & Restaurant	Face-to-face interview	Yes
2.	Atticus Finch	Face-to-face interview	Yes
3.	Mac's Steakhouse	Face-to-face interview, survey – not returned	Yes
4.	Treetops Lodge	Phone interview	Yes
5.	Nuvolari Restaurant	Face-to-face interview	No
6.	Brew Craft Beer Beer Pub	Face-to-face interview	No
7.	Shire's Rest Café	Survey	No
8.	Indian Star Tandoori	Denied interview	No
9.	Wild Rice Thai Cuisine	Denied interview	No
10.	Ambrosia Restaurant & Bar	Denied interview	
11.	Café Ephesus	Denied interview	
12.	Craft Bar and Kitchen	Survey – not returned	

Table 5: Restaurant Encounters

The owner of Atticus Finch, Cherry Te Kiri, one of the two restaurant representatives we spoke with who had a direct relationship with the Māori because her husband is from a different Māori tribe, mentioned that she does try and support Māori businesses, such as Te Arawa Fresh Seafood but "their business is not the greatest" (Te Kiri, 2016). She also mentioned inconsistencies in her current supplier and the quality of the produce. This is discussed further in Section 4.2.2.

Kunal Sharma, the manager from Solace, who employs a Māori chef and duty manager, expressed that, "people come here to learn about Māori culture… I am promoting a lot of things about Māori" (Sharma, 2016). He was very interested in a partnership with a Māori community and responded well to the idea of selling Māori products. He continued on and mentioned that "We also take feedback. We change the menu based on what people want" (Sharma, 2016). This was promising information as the hapū can take the information gained from our street surveys, which will be discussed in the next section, and present it to restaurants like Solace who are doing the same thing – keeping up with the market based on its desires.

4.1.4 Rotorua Street Surveys

The bustling tourist destination of Rotorua provided a large pool of people to survey. In total, the team conducted 42 surveys. The respondents were relatively well-distributed among our two fundamental categories, gender and place of residence (see Figure 28). Our responses came from 23 women and 19 men, which came from a pool of 24 visitors and 18 Rotorua locals.

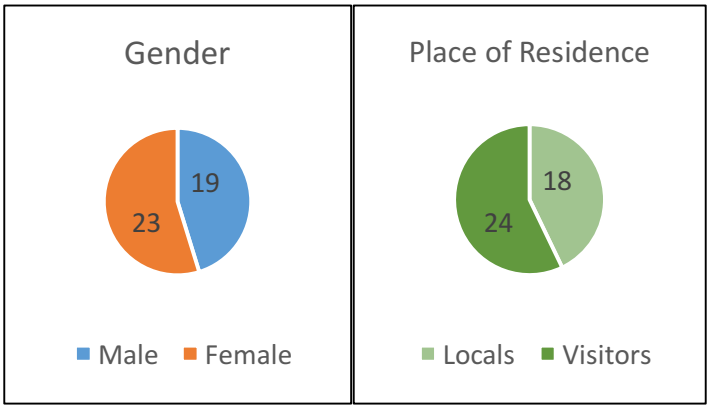


Figure 28: Demographics of Survey Respondents (n=42)

The survey of "Eat Streat" pedestrians asked for ratings of certain labels to gauge the population's inclination to buy products that are Māori-grown, locally sourced, organic, and produced with clean energy. The last question of the Rotorua Street Survey (Appendix D) asks, "On a scale of 1-5, (with 1 not likely at all and 5 being extremely likely), how much more likely are you to try a dining option if: a Māori village produced the ingredients, the ingredients were locally sourced, the ingredients were organic, the ingredients were produced with clean energy." Figure 29 displays these responses.

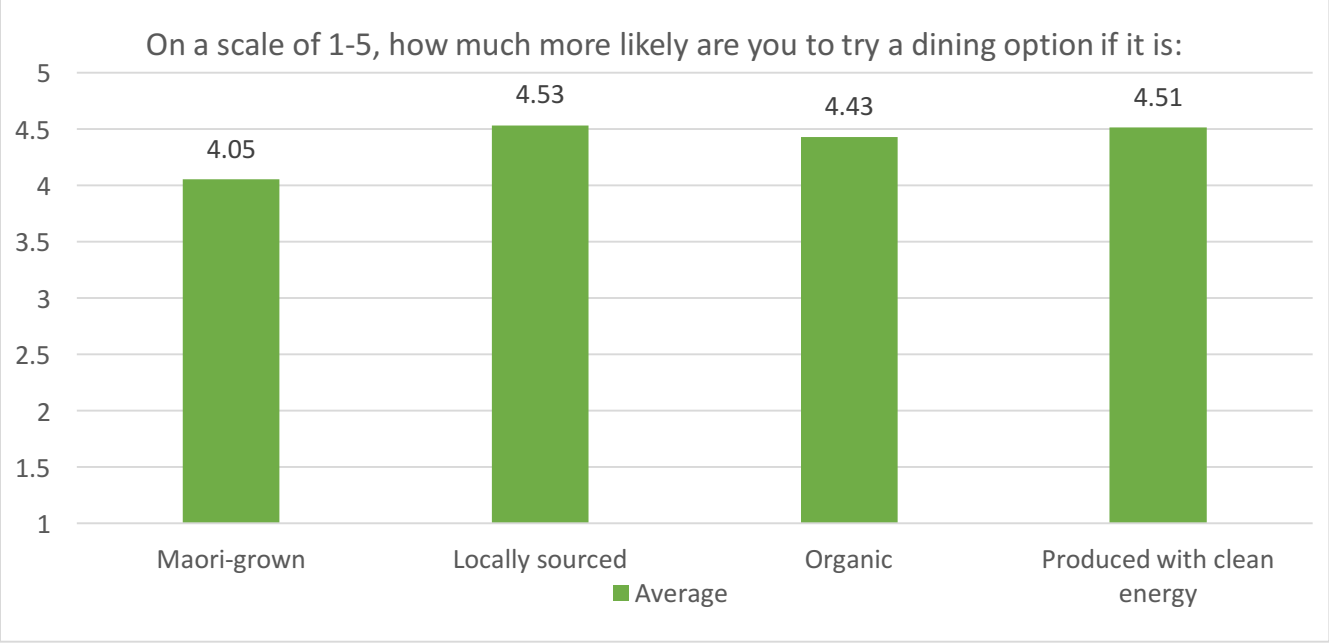


Figure 29: Response to Final Question of Rotorua Street Survey

This bar graph displays the average rating for all respondents regarding these labels for the crops the hapū could produce and sell to local businesses. Encouragingly, they all ranked over 4, which is promising information that the hapū can use as branding strategies when the greenhouse reaches a commercial stage.

4.1.5 Presentation to Runanga Board

On February 12th, 2016, Te Runanga o Ngāti Kea Ngāti Tuara, the hapū's representative board, held a meeting to discuss several matters of the community, including the possibility of constructing a greenhouse. Our team prepared a brief presentation, during which we disclosed our findings to date and plans for the coming weeks. We posted the presentation on YouTube and requested the board play this video during the meeting. The members of the board received the video very well, and they informed us that it sparked much conversation, even among their quieter members. The following week, project manager Eugene Berryman-Kemp sent an email to the team with general feedback, questions, and guidance for further research. This feedback allowed us to address specific questions and concerns the Runanga had at this point. The link for the video is here.

4.1.6 Summary of Objective 1

As we have made clear, the opinions of the hapū are the most important for our project. Where the views of restaurants and customers are important for gauging a commercial venture, not all successful commercial ventures will fit with the hapū's values, and something that fits with the hapū's values need not necessarily be a commercial venture. From our interviewees and the online hapū survey respondents, the team got a sense that members of the hapū community would favor the construction of a greenhouse, insofar as a greenhouse can benefit the community. Our limited data suggests members of the community believe that the hapū would consider job creation, a source of food, and sustainability, among other things, as benefits from a greenhouse. Although the community would certainly favor increased profit, it was not in the top three most important factors based on survey results. This suggests that the greenhouse could still benefit the community, even if it was only economically sustainable, as opposed to highly profitable.

Restaurant interviews indicate that the main determinant in the development of advantageous relationships between the greenhouse and local restaurants will be the supply and quality of products. The hapū would need to be reliable and be able to deliver and produce crops in quality condition. Restaurant representatives implied that potential for a NKNT greenhouse project would be promising.

Sections 4.2 and 4.3 discuss in detail crop selection and exactly what it would take to grow such crops in an economic fashion.

The consumer survey data is fairly well-distributed across key demographic indicators. Thus, we believe that the responses accurately represent the background state of affairs in Rotorua. The team considers consumer opinion of labels such as "Māori-grown" and "organic" to be stakeholder opinion, as most of these labels are "mainstream". The team anticipated that all respondents would have heard of these labels and would likely already have an opinion concerning them.

4.2 Objective 2: Research and Recommend Crops to Grow in the Greenhouse

In order to understand which crops to recommend the hapū grow, the team again turned to its primary stakeholders. The team focused on gauging responses to its two candidate crops, watercress and koura, while still enquiring about other possibilities.

4.2.1 Hapū Member Interviews

Interviewing Hapū members to confirm community approval for the greenhouse project as a whole was the first step in our process, completed in Objective 1. Next we wanted to determine exactly what crops would be best to recommend be grown in the greenhouse.

One interviewee, Joanne Heap, felt a deep connection to the idea of growing watercress in the greenhouse and recalled, "It takes me back to my childhood and it's just such a Māori food… fetching it from the river when I was a kid, so just those links to the area. When I was a kid it grew everywhere on our river. I don't know whether it still does, but I don't think so. And also koura; there used to be *heaps* living in the river… I used to go with my dad to collect them… [There are] links to my memories of the area, my childhood. Those two things are very Māori." (Heap, 2016). Similarly, Mr. Keepa was excited at the mention of koura and watercress as well but he did warn, "hydroponic watercress has a different taste than grown in streams. A company up north grew hydroponically and I don't think it succeeded. The stocks were good the leaves were small, but the taste was totally different. I think the company has folded" (Keepa 2016). This is important information to keep in mind. There are a lot of variables, which will be discussed in Section 4.3, regarding how to grow hydroponic watercress. These variables may play into the taste and thus could be adjusted to create a crop that tastes similar to its stream-side counterparts. Both interviewees also mentioned other crops to look into including kumara (sweet potato), tomatoes, and puha (a leafy green similar to watercress).

When asked about similar projects in other Māori communities, neither interviewee had much to say. One said he knew of one project, which utilized geothermal, but that a lot of maraes have

become run down due to little or no income. The overall message we received through these interviews was that they want to see their hapū succeed with a project that is consistent with their values.

4.2.2 The Hapū Member Survey

This survey supplied us with responses to our specific crop options. The survey asked if the hapū member would be in favor of growing watercress and koura and if they felt a cultural connection to either one. Both crops received positive results. Koura polled slightly better in our survey, with 75% of respondents saying they would be in favor of growing koura grown in the greenhouse and 81% confirming a cultural connection to the animal. In comparison, 69% of respondents said they would be in favor of growing watercress and 73% believed they had a cultural connection to the plant. Koura was favored heavily as a restoration project and one respondent noted, "Koura are rarely seen these days. Education and sustainability would be just some of the many benefits for the hapū" (Appendix R). We purposefully created the survey with open responses to allow the hapū members to write their own comments or concerns. Both koura and watercress received some favorable and objectionable comments for consideration. Some objections surrounding koura were due to concerns with taking koura from its natural habitat, which would not be an issue if the project was geared for restoration. Another objection to koura was how its waste would impact a aquaponic system, which is a topic on which the hapū will have to conduct further research. The objections to watercress were related to economic feasibility, as watercress does not have a high profit margin. Appendix R holds the complete raw data for the survey results.

4.2.3 Restaurant Interviews

We asked five restaurants in interviews about their knowledge regarding watercress and koura. All six restaurants said they were familiar with watercress and three said they use it frequently within their restaurant, specifically in "catch-of-the-day" meals and salads. Koura had a very different reaction; each restaurant said they were familiar with it, but that it was not sold there because it didn't fit in with the restaurant's menu, was too expensive, or most commonly, too difficult to find.

We then proceeded to ask about their supplier. Solace buys their watercress for $2.90 a bunch from Fenton Quality Produce, a local pop-up fruit and veggie shop. Atticus Finch also has used Fenton in the past. Both Atticus Finch and Mac's Steakhouse more frequently use Bidvest as their supplier. Atticus Finch said they paid $12.55 for 250 grams of watercress from Bidvest. When asked if they would be interested in buying this product from the NKNT greenhouse, four out of the six establishments with which we had full interviews seemed agreeable to the idea. Atticus Finch owner,

Cherry Te Kiri, was quick to state, “if I could get a decent supply of regular watercress I would definitely be interested. The problem is I can’t get it and the occasional time I can it is not delivered in the best condition” (Te Kiri, 2016). She went on to state that the greenhouse would have to be reliable and produce their watercress in pristine condition. It is very difficult for restaurants around this area because they have to call in their food orders the night before and hope they arrive in good condition. Otherwise they must make quick adjustments to the menu. She also suggested some common herbs used in her dishes and recommended we look into curry, dill, Italian parsley, basil, and chives.

4.2.4 Rotorua Street Surveys

In addition to gaining the perspective of some local restaurants, we also surveyed consumers to measure their interest in the potential crops. Figure 30 provides data regarding watercress and koura from the 42 surveys we conducted in the vicinity of Eat Streat. We asked respondents if they had eaten both watercress and koura, and their likelihood to do so again. The results, below, were very encouraging for each of them.

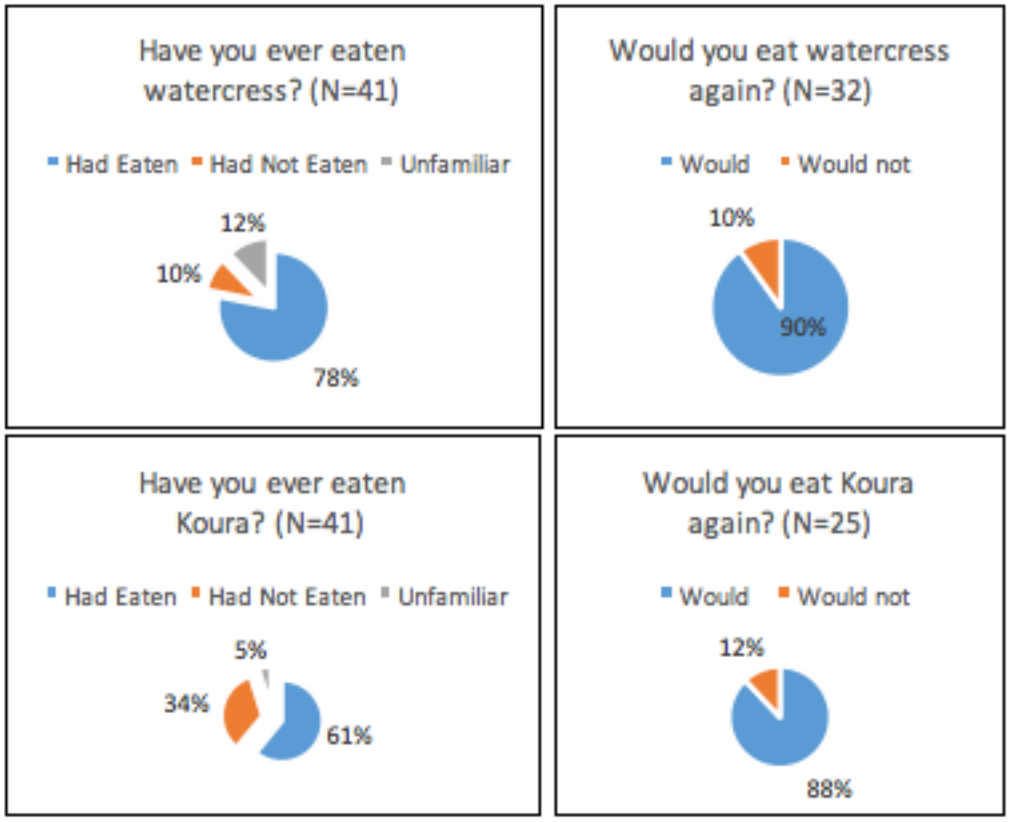


Figure 30: Response to Koura and Watercress from Rotorua Street Survey

4.2.5 SWOT Analyses for Potential Crops

In order to present our findings in an easy-to-understand way, the team performed a SWOT analysis for each potential crop option. A SWOT analysis takes the main strengths and weaknesses for each crop option and lists them alongside the potential opportunities and threats for each option. Thus, the team consolidated the most relevant information for each crop in one table each.

Strengths	**Weaknesses**	**Opportunities**	**Threats**
High margin of profit	Growing processes less well-documented	Restoration project	Might require special knowledge
Cultural connection	Might be difficult to scale up production	Additional funding from trusts or grants	Might be more prone to catastrophic failure
Desirable in market		Can be grown in an aquaponic system	
Favorable in hapū community			

Table 6: Koura SWOT Analysis

Strengths	**Weaknesses**	**Opportunities**	**Threats**
Easy to grow	Low margin of profit	Can be grown in an aquaponics system	
Fast-growing	Might have a high number of low-volume buyers		
Desirable in market	Might require a trial greenhouse		
Cultural connection			
Favorable in hapū community			

Table 7: Watercress SWOT Analysis

Strengths	**Weaknesses**	**Opportunities**	**Threats**
Unknown	No data yet collected	Might corner a niche market	Substantial time required to investigate

Table 8: Alternative Choices SWOT Analysis

4.2.6 Summary of Objective 2

Although varying in nature, each of these tools culminates into a unified set of results. The interviewed members of the hapū expressed a general approval of watercress and koura as candidate crops, expressing several different potential benefits for each crop. Similar to Section 4.1, it seems as

though the hapū would consider many different crops suitable, provided that the crops were to benefit the community.

Four out of the six restaurants with which we had complete interviews responded with enthusiasm for our candidate crops. This indicates that a market for these crops, particularly if they are high quality, exists. If we combine the background concerns of the restaurant market from Section 4.1 with the response to watercress and koura specifically, we can see that a niche market exists in the Rotorua area for high-quality, consistently-supplied watercress and koura. Thus, it seems as though there already exists a market to accommodate a commercial venture.

In a similar vein, a surprisingly large number of respondents claim to have tried koura before. The team believes that this may be due to some respondents confusing koura for other types of freshwater crayfish. Nonetheless, for both watercress and koura, large numbers of customers indicated that they not only tried these products, but also, in both cases, over 85% of those who had tried either watercress or koura would try it again. These numbers are useful in crafting a business proposition because they allow the hapū to demonstrate to a specific buyer that customers desire such products.

4.3 Objective 3: Propose a Growing System and Physical Parameters for a Greenhouse.

In order to grow watercress in a greenhouse, there are several broad design parameters to consider: water supply, irrigation, nutrients and nutrient distribution, and growing apparatuses. Some of these parameters are constrained by external variables such as water supply and land space. These parameters include quantity of plant capable of being grown, initial water quality and the need for filtration, and maximum greenhouse size. Others, such as growing method, are instead the result of almost purely design considerations.

4.3.1 Water Supply and Irrigation

Perhaps the greatest limitation to the size of our greenhouse is the available supply of water. Hydroponic growing requires a constant flow of water, necessitating constant input. In his book *Hydroponic Food Production*, Howard Resh recommends that a successful greenhouse have at its disposal "at least one-half gallon of water per plant per day" (Resh 2012). To this end, the team has contacted the Waikato District Council seeking an approximation of the quantity of water the hapū would be able to take from nearby springs or the Pokaitu stream.

Irrigation can be done relatively easily. Because the greenhouse utilizes hydroponic technology, the challenge is more to *circulate* the water than it is to *distribute* it. Hydroponically grown plants float

atop a bath of water rather than grow in a layer of soil. Thus, a pump system is most effective for circulation as opposed to a sprinkler system. The hydroelectric energy can be used to operate the pump without any operational cost.

4.3.2 Growing Apparatuses

There are a number of ways to grow plants hydroponically. For our investigation, the team pursued primarily the floating bed technique, and the nutrient film technique. Both of these methods utilize recirculated streams of water with nutrients suspended in the water column. Nutrient film technique involves narrow, long channels into which a grower places plants. A thin film of water, which cycles quickly through the channels, feeds the roots of the plants (Resh, 2012).

Floating raft technique uses a much deeper tank of water. Floating Styrofoam rafts harbor the plants, allowing the roots to submerge without drowning the plant. The greater depth of water promotes symbiotic bacteria growth. These bacteria are beneficial to koura, which allows the floating raft technique to work in an aquaponics context. Nutrient film technique, while very efficient, has difficulty sustaining bacteria due to the relative shallowness of the film. While not impossible, nutrient film does not promote the same kind of growth. Nutrient film technique is also more expensive and more difficult to design.

4.3.3 Nutrient Distribution

Every plant needs nutrients to survive and thrive. In a hydroponic greenhouse, water suspends the nutrients due to lack of a soil to use. There are many different techniques to prepare nutrient solutions such as mixing together vitamin powders. However, the team discovered that premade nutrient solutions are easily available. Because the team chose not to finalize crop selection, leaving it to the hapū, we did not divert resources into examining the nutrient options for each crop beyond seeing if nutrients were generally available.

4.3.4. SWOT Analyses for Greenhouse Parameters

Similar to the SWOT analyses for the candidate crops (contained in 4.2.5), the team produced the following SWOT analyses to consolidate the most important strengths, weaknesses, opportunities, and threats for each relevant design option. The team collected less data on structure and growing systems as compared to crops, but the analyses are still illustrative.

Greenhouse Structure

Strengths	Weaknesses	Opportunities	Threats
Safe, steady approach	Requires design of a small hydroponic system	Can try experimental growing approaches at little risk	Runs the risk of falling through/losing interest
Low initial cost			Might not scale to full-size production
Can investigate many options easily			

Table 9: Trial Greenhouse Method SWOT Analysis

Growing System

Strengths	**Weaknesses**	**Opportunities**	**Threats**
Cheap	Not as water efficient		
Easy to build			
Easy to fix			
Modular			
Easier to use aquaponically			

Table 10: Floating Raft SWOT Analysis

Strengths	**Weaknesses**	**Opportunities**	**Threats**
Efficient	More difficult to use aquaponically		
Smaller water usage			
Scales up to large production			

Table 11: Nutrient Film Technique SWOT Analysis

4.3.5 Summary of Objective 3

These general solutions apply to many crop options. Although the team did not collect as much data for growing systems as for crops, the solutions found apply to many different growing situations. For example, the hapū could use nutrient film technique to grow almost any plant. Beyond a general strategy, the specifics of each design will be particular to what the hapū chooses in the future.

4.4 Objective 4: Document Care and Maintenance Methods for NKNT's Hydroelectric Turbines.

The deliverable from this set of results, a maintenance guide, is very different from our other deliverables. The documentation is more the result of compilation, through our conversation with Mr. Oneroa, than it is of outright research. Appendix S contains the manual in its entirety. Section 3.4 explains the manner in which we acquired the information in the manual. In speaking with Riki Oneroa, the micro-hydro's sole maintainer, our team was able to gather information regarding care for

the unit during both standard and unusual circumstances. Dr. Bargh requested the documentation of this information for Ngati Kea Ngati Taura's reference.

4.5 Objective 5: Suggest a Strategy to Alleviate Turbine Intake Congestion.

4.5.1 Participant Observation with Mr. Riki Oneroa

After participating in regular maintenance of the micro-hydro, specifically the clearing of its intake screen, our team, with the help of Riki Oneroa, gained a better understanding of the congestion problem and how the hapū can address it.

4.5.2 Literature Reviews

In *Serious Microhydro*, Jerry Ostermeier outlines several intake designs and their various benefits and downfalls. Because the system at Ngati Kea Ngati Taura is a "low head" design, meaning there is only a small drop in elevation, and the channel for the intake diverts the water almost perpendicular to the stream before entering the penstock, resulting in very slow-moving water prior to intake. We can best address a scenario like this using a "slow water zone diversion". One type of solution is a "floating boom", which stretches across the mouth of the intake channel and stops debris from entering the system while allowing water to flow beneath it. This concept requires slow water flow, as the debris must be afloat for the boom to perform its function. In the case of Ngati Kea Ngati Taura's system, because the flow of the river itself is slow, we recommend that the design set the boom at an angle almost parallel to the river flow, stretching from further upstream to the downstream end of the channel dug for the penstock. Should the debris be unsettled in this case, the hapū should insert a gabion just upstream of the boom to further diminish the flow of the river before it reaches the boom, as Figure 31 displays. A gabion is simply a wire cage filled with rocks that extends from the bank to deflect the main flow of the river enough to allow debris to settle and the boom to perform its function. However, we do not anticipate that the hapū will need to implement a gabion with the boom. For a more detailed description of our recommendation for a floating boom, refer to Section 5.4.

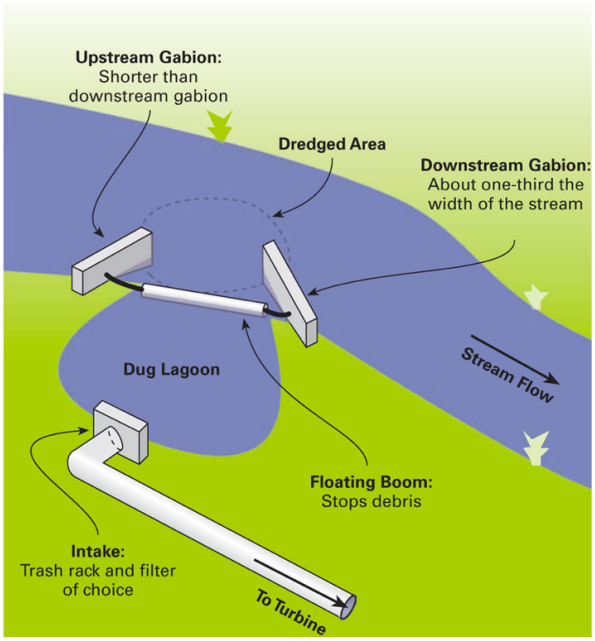


Figure 32: Floating Boom (*Serious Microhydro*, 2010)

4.5.3 Summary of Objective 5

This result deals more closely with a method than with a specific solution. The specific dimensions, materials, and construction require experimentation. The team does not believe that there is a precise solution which we can draw from a textbook, but that this proposed concept contains useful information nonetheless.

Chapter 5: Recommendations and Conclusion

The team structured its recommendations in two ways: through addressing each objective individually and through constructing multiple flow charts. We did not want to provide only one option to Ngāti Kea Ngāti Tuara, as this would take control away from the hapū and might make some of the data the team collected effectively worthless. Instead, to give power back to the hapū, the team produced a flow chart that provides the criteria necessary for the hapū to choose which ideas for a greenhouse that it would like to consider. Sections 5.7 through 5.11 contain the flow charts and their explanations.

The size of resource consent for water consumption will be the largest determinant of the scale of production within the potential greenhouse. Ngāti Kea Ngāti Tuara will need to make determinations regarding size and production after they have obtained resource consent from local councils for the use of water from either the Pokaitu Stream or surrounding springs. The flow chart begins accordingly; categorizing the scale of water the hapū is allotted as "a little", a "medium amount", or "a lot".

5.1 Assess the Opinions of Relevant Stakeholders

Our findings from both hapū interviews and the hapū survey indicated that the community would welcome a greenhouse in Ngāti Kea Ngāti Tuara. Similarly, the restaurant interviews and market surveys demonstrated that the secondary stakeholders, restaurants and consumers, would also welcome the construction of a greenhouse that produces watercress and koura. Provided the hapū can find an economically feasible way to implement the greenhouse, the team believes that a greenhouse would be a good fit for the community.

5.2 Research and Recommend Crops to Grow in the Greenhouse

Based on the analysis of our data, the team believes that watercress and koura could be successful crops. Our two interviews and sixteen online surveys showed that members of the Ngāti Kea Ngāti Tuara Hapū approved of watercress, and even more so koura, as candidate crops. The restoration of koura is an especially attractive option because of its agreement with NKNT's cultural values and its potential to warrant a larger resource consent.

However, due to concerns regarding the taste of hydroponically grown watercress, our initial recommendation is that the hapū conduct a trial for watercress, which can be done with a large rubber bin to simulate a hydroponics system. Although the Runanga board believes there is no concern with

the watercress' taste, the team still recommends that a trial take place before the hapū commits such a large investment.

The taste trial would take place on a very small scale, and at a very low cost. Our team has identified one method that would suit this application. Plantozoid.com has an article entitled, "The Ultimate Guide for Starting Your Own Hydroponic Garden" which details instructions on how to do just that. It includes nutrient solutions and instructions for trial systems.

Should the community deem hydroponic watercress unfavorable, koura is still a suitable choice. From the hapū interviews and surveys, the team has also identified puha, kumara, tomatoes, cucumbers, kamokamo, silver bait, and mushrooms as other recommended crops the hapū can investigate.

5.3 Propose a Growing System and Physical Parameters for a Greenhouse

The scale of production within the greenhouse will depend largely on resource consent for water usage. The amount of water Ngāti Kea Ngāti Tuara can take from the Pokaito Stream or surrounding springs will likely be the limiting factor of production. This makes the restoration of koura all the more attractive, as local district councils may be more apt to grant a larger consent if the hapū uses water in part to restore local koura population. If the restoration is successful, it could eventually graduate to a commercial scale.

Although the team researched generalized growing processes, the exact function and requirements of a growing system remain unfinalized. In order to bring a greenhouse into fruition, the hapū should contact a greenhouse construction firm once they have decided on a more specific idea of what the greenhouse would grow, and what function it would serve.

5.4 Suggest a Strategy to Alleviate Turbine Intake Congestion

From our research the team concluded that a floating boom design (see Figure 28) would help alleviate turbine congestion. This will decrease the amount of time a worker has to maintain the system on a daily basis.

The small angle of the boom relative to the river allows for the debris to be redirected downstream, which would minimize regular maintenance of the system. As a precaution, we recommend that the hapū leave the current screen in place when implementing this new mechanism. This way, the screen will still stop any debris that passes underneath the boom, and would still protect any fish or wildlife that would otherwise be at risk. The result of this implementation would be much

less required cleaning of the existing screen due to much of the debris being diverted downstream by the floating boom, which was the main problem expressed to us by Mr. Oneroa.

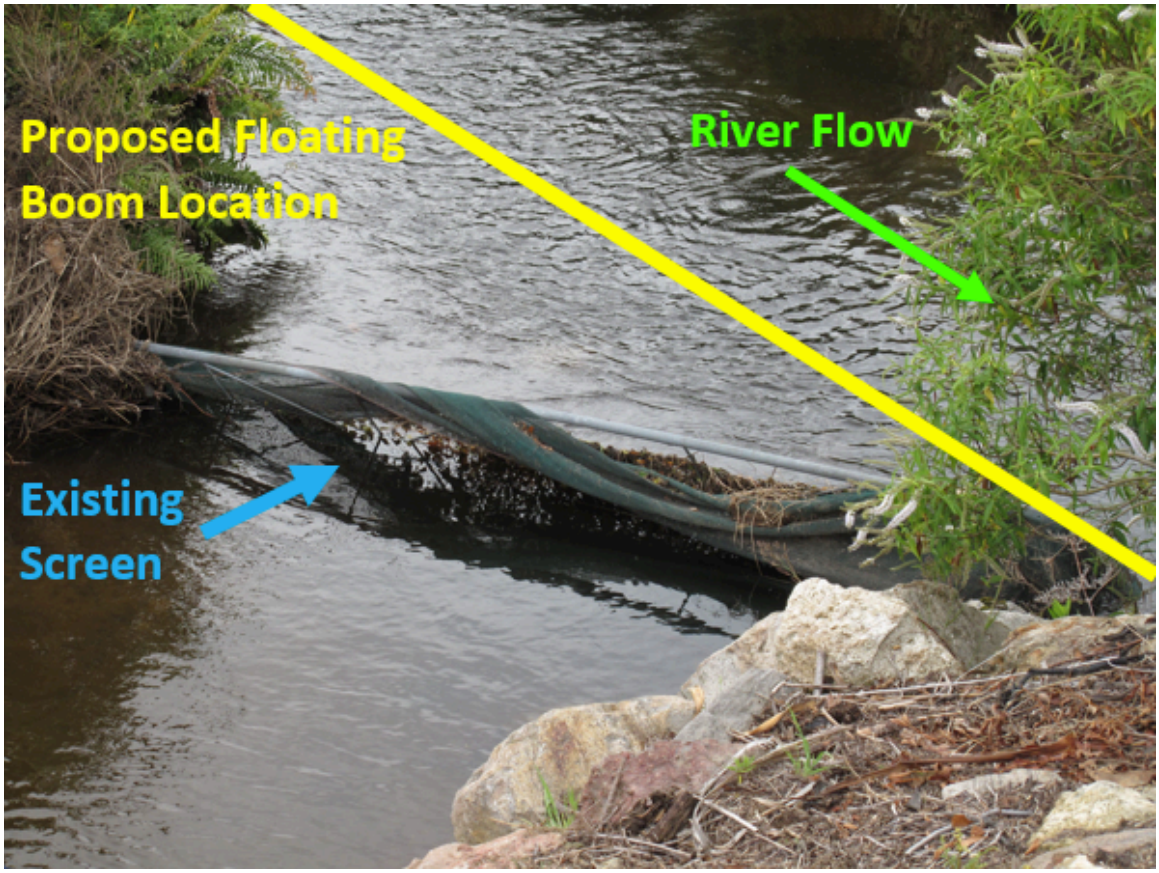


Figure 33: Proposed Floating Boom Solution for Congestion

5.5 Additional Considerations

In the interest of ensuring a consistent supply of power to the greenhouse, we recommend that the hapū investigate the installation of a battery to the micro-hydro system to store excess power in the case of inactivity of the turbines due to flooding or other limiting circumstances. This is important because the greenhouse would need a constant supply of electricity to power the water pumps and lighting. In heavy rainfall months such as August, the turbines have to be shut off quite frequently, so a battery might be necessary to ensure the success of a greenhouse.

5.6 Conclusion

Our team's research and analysis has allowed us to provide the Ngāti Kea Ngāti Tuara Hapū with the guidelines by which they can make decisions concerning their goal to construct a greenhouse in the community. Our contribution, we hope, will assist the hapū in continuing their outstanding commitment to a sustainable future in New Zealand. Ngāti Kea Ngāti Tuara has already established

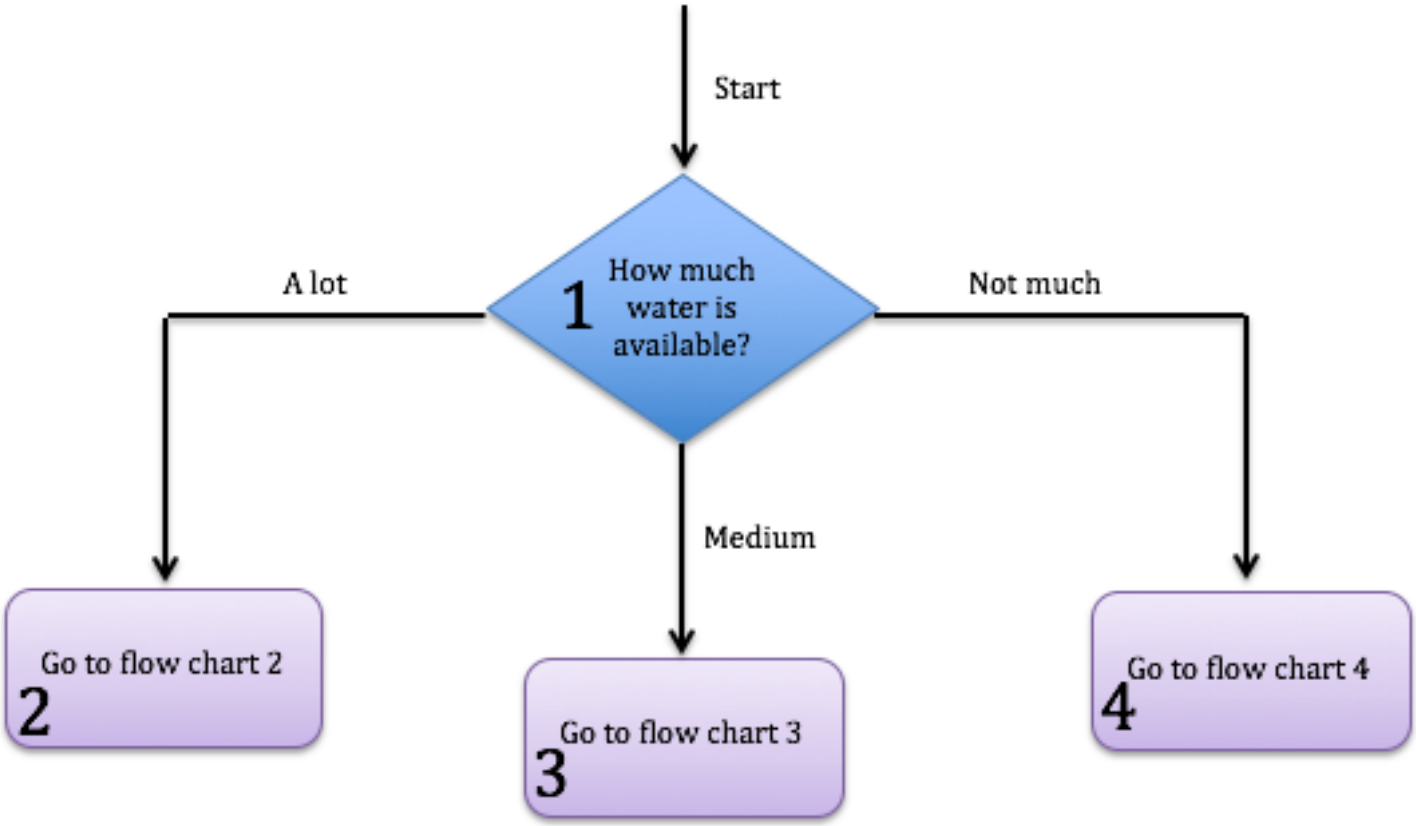
itself as a model for making such strides, and will continue to do so should they choose to construct a greenhouse that uses the excess clean energy generated by their micro-hydro power system. The purpose of our methods was to gain an understanding of hapū members, businesses, and consumers' desires, so that we could recommend options that satisfy all three. We designed these recommendations to allow Te Runanga to make informed decisions about their course of action regarding both the construction of a greenhouse and the maximization of the efficiency of the hapū's micro-hydro power system. Several varying options would satisfy, to different degrees, the four components of Ngāti Kea Ngāti Tuara's fourfold bottom line: economic, environmental, social, and cultural gain of the community. Survey results indicate which benefits that a greenhouse might bring to the community are most important to achieve, according to its members. With this information, Te Runanga o Ngāti Kea Ngāti Tuara can make determinations with this representation of the hapū members in mind.

Once the hapū has undergone the process of gaining resource consent for water usage from the Pokaitu Stream or nearby springs, they can begin to establish the details, specifically concerning the scale, of the greenhouse. However, the community may have difficulty obtaining consent given the limited allocation of such resources by the Waikato Regional Council. The hapū's best leverage, based on our knowledge, lies in the current illegal consumption of water in local springs for farming and the potential to use this water partially for the restoration of koura, which would certainly be commended by hapū members *and* the WRC. After gaining consent, the hapū will need to determine a location and develop a design for the structure and technology required to harvest selected crops. An additional project is the design and implementation of the floating boom mechanism recommended to alleviate congestion of the micro-hydro's intake. Although there is long way to go yet, we hope that this report has brought the Ngāti Kea Ngāti Tuara Hapū a step closer to bringing its latest aspiration into fruition.

5.7 Flow Chart Instructions

The team designed this flow chart to guide the hapū's decision-making process. Begin with Flow Chart 1, which directs to other flow charts based on the available supply of irrigation water. Each step has a number attached to it that corresponds to an explanation immediately following the chart. On the flow charts, a blue diamond (◆) indicates a choice, an orange box (▮) indicates an implication of a decision, and a purple box (▮) indicates a terminus.

5.8 Flow Chart 1



5.8.1 Explanation of Flow Chart 1

◆1: How much water is available?

Water availability is the biggest limiting factor in operating a greenhouse. A greenhouse can only be as large as the pool of water that irrigates its plants.

2: Go to 2

Flow Chart 2 gives guidelines for choosing a greenhouse when there is an ample supply of water.

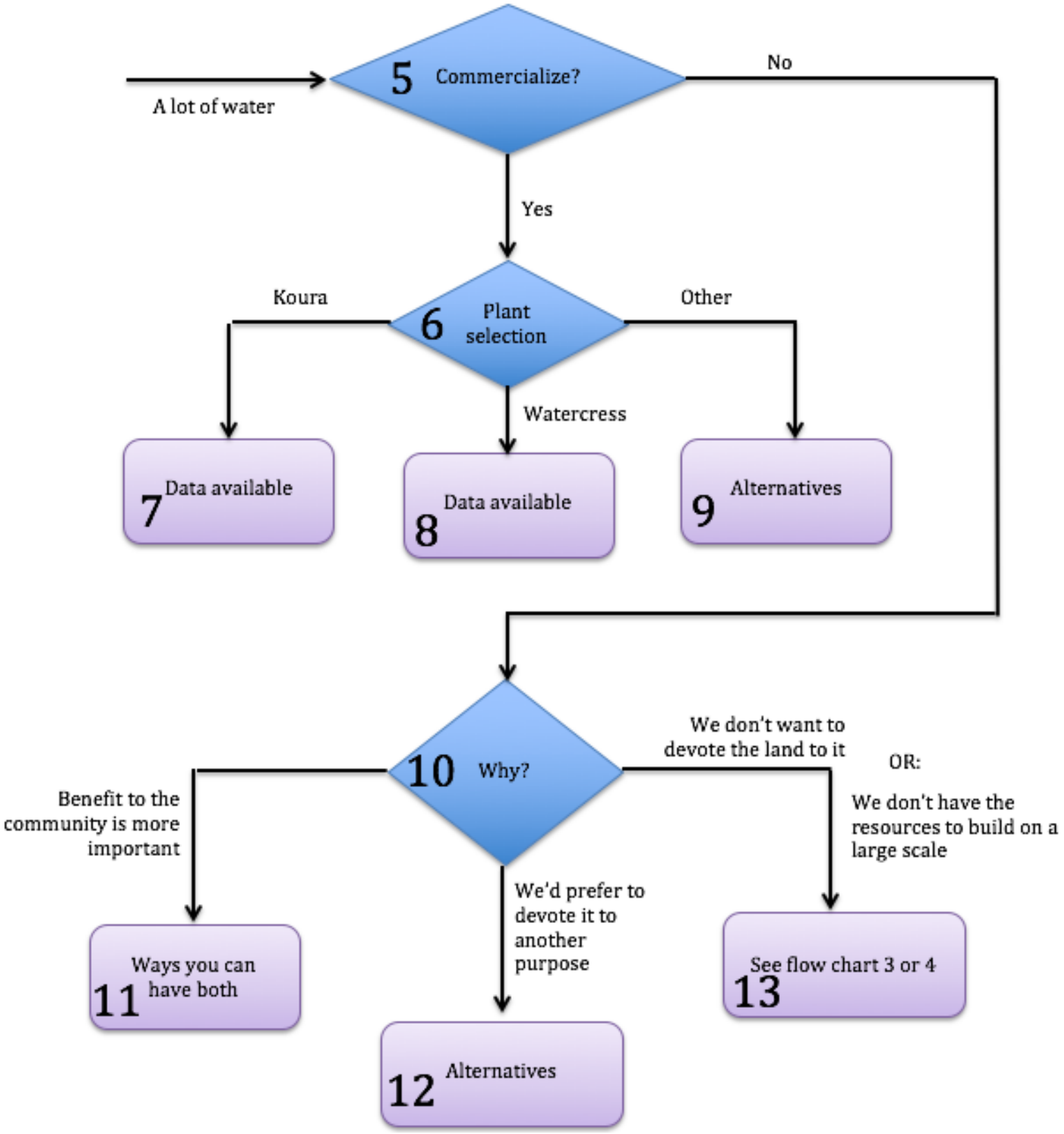
3: Go to 3

Flow chart 3 gives guidelines for choosing a greenhouse when there is a medium supply of water.

4: Go to 4

Flow chart 4 gives guidelines for choosing a greenhouse when there is a small supply of water.

5.9 Flow Chart 2



5.9.1 Explanation of Flow Chart 2

◆5: Commercialize?

Commercialization refers only to structuring the greenhouse in such that it can produce a profit. This option does not, in the strictest sense, refer to the style of the greenhouse, but it is nonetheless a fundamental choice.

◆6: Plant selection

A large supply of water means that the greenhouse can accommodate most crop selections, including low margin of profit crops. Note that there are ways to grow multiple crops simultaneously, such as an aquaponics system with both watercress and koura.

7: Koura data

The team collected data on koura which can be found in Section 4.2.4.

8: Watercress data

The team collected data on watercress which can be found in Section 4.2.4.

9: Other

The team did not collect specific data about other crops. However, other members of the hapū mentioned crops which can be found in Section 4.2.1.

◆10: Why?

Even if the hapū does not wish to build a greenhouse for commercial purposes, there are still ways in which a greenhouse could benefit the community. To best select another purpose, the hapū must first consider why it objects to a commercial greenhouse.

11: Ways you can have both

The team believes that profit and community benefit are not inherently opposed. We believe there are several ways in which the hapū could use either use profit to benefit the community, or make profit in such a way that it already benefits the community. These include:

1. A koura restoration project.
    a. It's possible to grow koura, designate a certain quantity of it to restoration, and sell the excess. This could also potentially allow the hapū to gain funding from environmental trusts, or other such organizations.
2. Job creation
    a. Members of the hapū cited job creation as one of the primary benefits of a community. However, to employ members of the hapū requires a source of profit.
3. Reinvesting profit
    a. A source of profit allows the hapū to reinvest in the community, whether it be through attempting other projects, investing in social or health programs, or another option.

Nonetheless, if the hapū does not wish for any commercial venture, some alternate purposes are delineated in step 12.

12: Alternative purposes

To fully outline other uses for a greenhouse is beyond the scope of our work. Nevertheless, there are a few other purposes for a greenhouse that the hapū can investigate. These include:

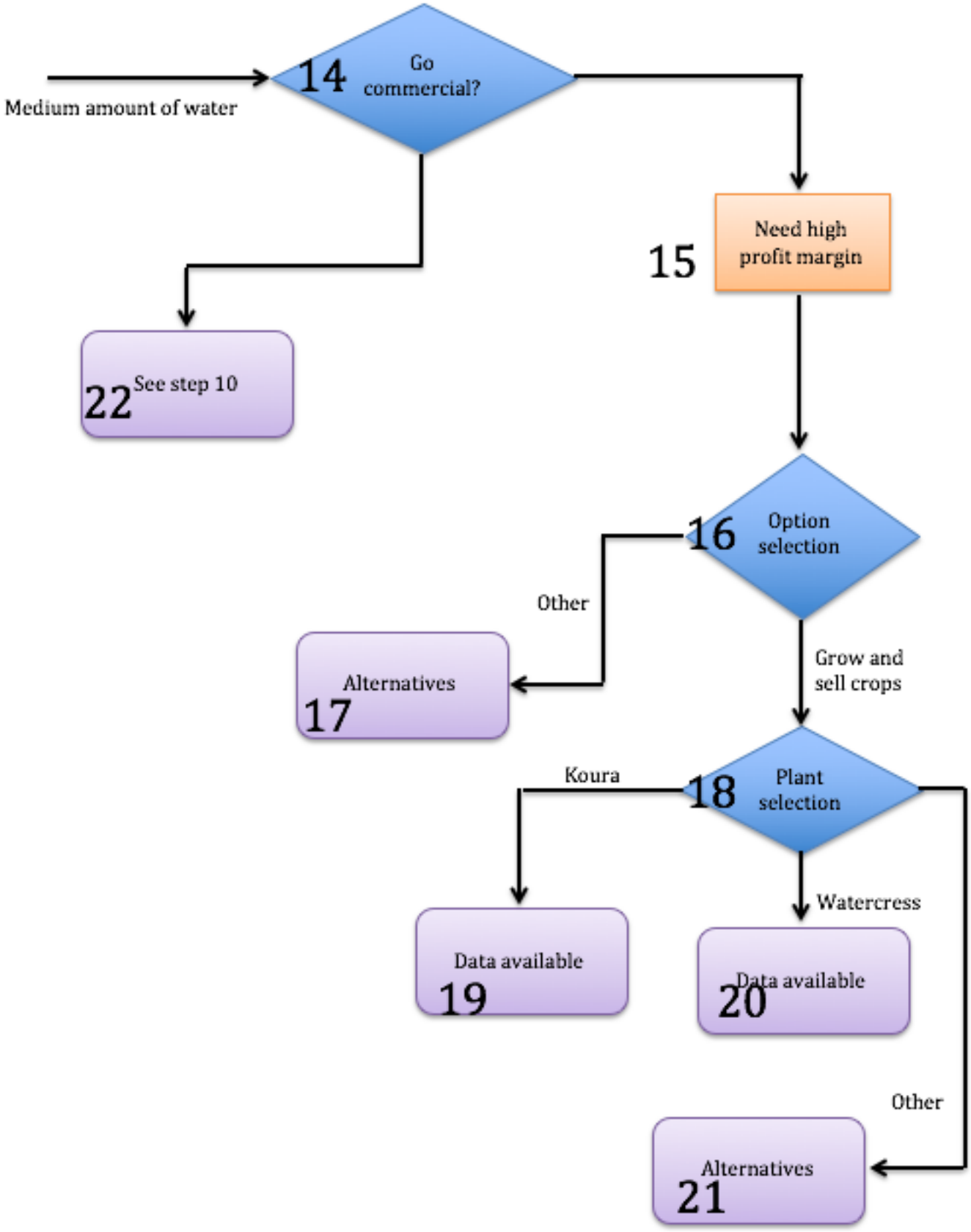
1. A koura restoration project.
2. Producing food solely for the hapū, possibly as ingredients.
3. A restoration project for another species.

There are many other ways to purpose a non-commercial greenhouse. To determine which of these options to explore will be the matter of debate among the hapū.

13: See flow charts 3 and 4

Flow charts 3 and 4 concern constructing a greenhouse of a smaller size.

5.10 Flow Chart 3



5.10.1 Explanation of Flow Chart 3

◆14: Commercialize?

The choice here is similar to number 5.

15: Need high profit margin

To commercialize a greenhouse without an abundant supply of water makes it difficult to grow crops with a low margin of profit such as leafy greens.

◆16: Option selection

It is possible to construct a commercial greenhouse that does more than grow crops to sell on the market. There are a few alternatives to such an approach that the hapū may want to consider.

17: Alternatives

The alternatives explored here are the same as in step 11.

◆18: Plant selection

The decision is similar to step 6, except that a medium-sized greenhouse makes a high margin crop more desirable.

19: Koura data available

The team collected data for koura, which is available in Section 4.2.4**.**

20: Watercress data available

The team collected data for watercress, which is available Section 4.2.4. Note, however, that watercress does not have a very margin of profit. If the decision to grow watercress is solely a commercial one, there may be better alternatives to explore.

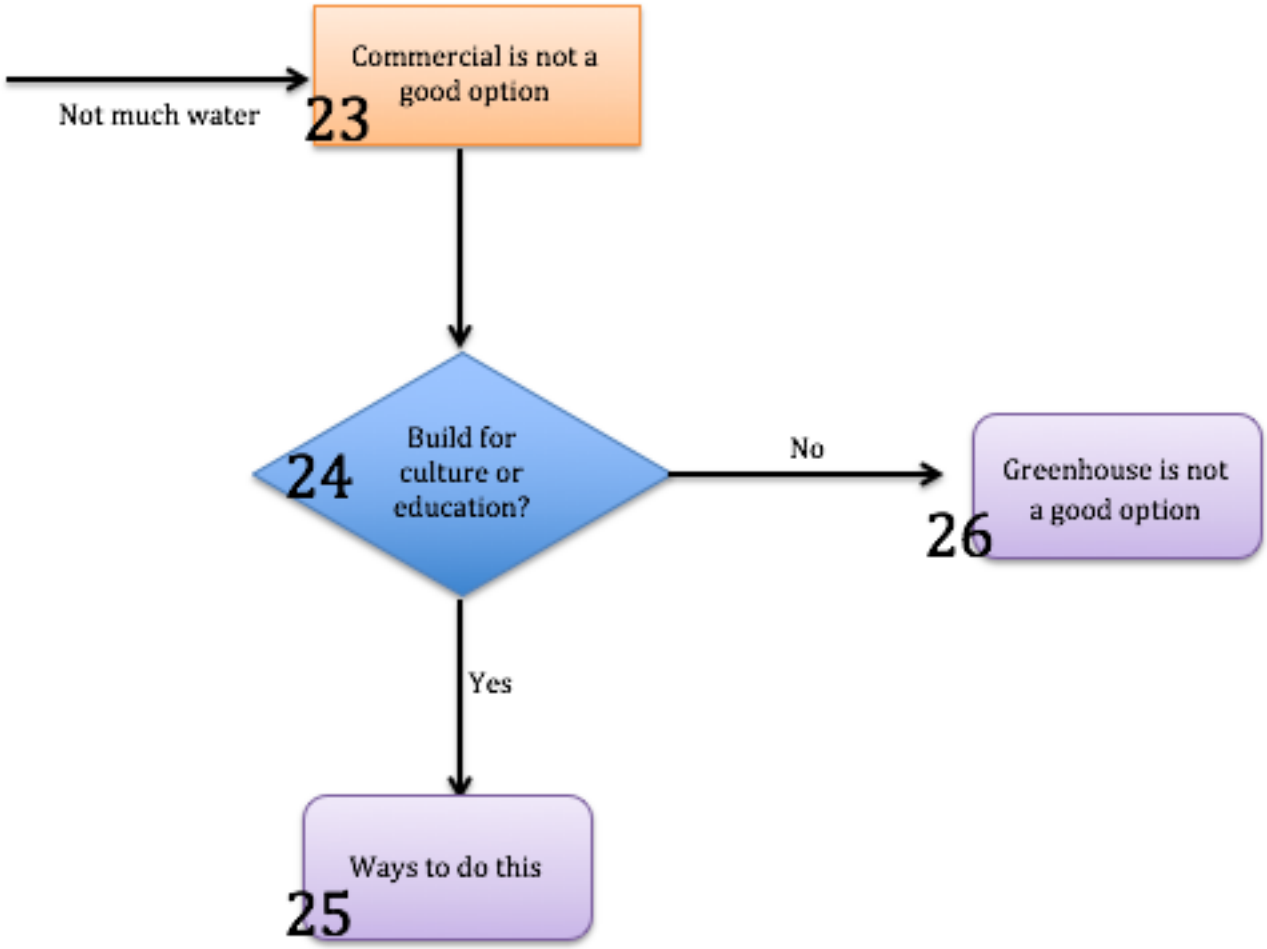
21: Alternatives

The alternatives explored here are the same as in step 9.

22: No commercial redirect to 10

The choices here are the same as proceeding from box number 10.

5.11 Flow Chart 4



5.11.1 Explanation of Flow Chart 4

23: Commercial is not a good option

Commercial production requires a certain amount of water to produce an adequate amount of products. If this threshold is not met, commercial production becomes unfeasible.

24: Build for culture or education?

However, there are ways the hapū could build a greenhouse

25: Ways to do this

This step is the same as step 12.

26: Greenhouse not a good option

If the resources to build on a medium or large scale do not exist, and the community does not wish to build a greenhouse for education or cultural reasons, then a greenhouse is not a good option for the community.

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Appendix A: Interview with NKNT Hapū Members

Interview Introduction

To begin each interview, our team asked the following questions:

- Can we record this interview?
- Can we quote your responses in a report?
- Can we use your name in a report?
- Can we attribute your quotes to you in a report?

Then, before proceeding, the interviewer will state the following: To protect your privacy, your name will not be stored next to your interview responses, either physically or digitally.

The interviewer will introduce the project to the interviewee before proceeding.

Preliminary information

- Name
- Age, sex, occupation
- Place of residence
- Relationship to the hapū

Questions

1. What do you know about the hydroelectric turbines in the hapū so far?
    a. How do you think the community views them? Why do you think this is?
2. Are you familiar with any efforts to utilize the excess electricity?
    a. Does it seem like the community as a whole views one approach more favorably than the others?
    b. Do you have any opinions on how the electricity should be used?
3. Have you heard of similar projects in other Māori communities? (involving hydroelectric, "clean" energy, "renewable" energy, "green" energy)
    a. What do you think about these projects?
4. Have you heard of any other successful Māori-owned business?
    a. What do you think about these businesses?
5. What do you think about a glasshouse? Would you like to see a glasshouse built in the hapū?
    a. If so, why do you think the community would benefit from a glasshouse?

b. If not, why do you think a glasshouse is not a good fit for the community?
    i. Further, is there another project that you think *would* suit the community's needs?
c. If you do not have a strong opinion, is there any information we could provide which would help inform your decision?

6. Do you think a glasshouse would provide jobs for the community?
    a. Can you, without naming names, think of any members of the community who would consider working in a hapū-owned glasshouse?
        i. If so, roughly how many people can you think of who would fit this description?
    b. If not, why don't you think so?
7. Our team is strongly considering recommending koura and/or watercress as the glasshouse's primary crop(s). Do you find either of these crops particularly likable or objectionable?
    a. If yes for either, why do you say so?
    b. Can you think of another crop that you consider to be a good fit for the community?
8. Do you have any other concerns or information that you'd like to share with us?

Appendix B: Interview with Restaurants

Interview introduction

To begin each interview, our team will ask the following questions:

- Can we record this interview?
- Can we quote your responses in a report?
- Can we use your name in a report?
- Can we attribute your quotes to you in a report?

Then, before proceeding, the interviewer will state the following: To protect your privacy, your name will not be stored next to your interview responses, either physically or digitally.

The interviewer will introduce the project to the interviewee before proceeding.

Preliminary Information

1. Name
2. Age, sex
3. Occupation
4. Place of employment and position

Questions

1. Are you familiar with the Ngāti Kea Ngāti Tuara Hapū?
    a. If so, could you describe what you know about them?
2. Has or does your company currently have business relations with Māori-owned businesses?
    a. If so, could you briefly describe the nature of those relations?
3. Does your company have a broad branding strategy?
    a. If so, what is it?
        i. If so, does the Māori community play any role in it?
    b. If not, how does your company market itself?
4. In your experience, does a food labeled "Māori-grown" sell better than the same product without that label?
5. Has or does your company currently sell koura?
    a. If so, does your company consider it a successful product?
    b. If so, how much does your company currently pay for each unit of koura?
    c. If so, who currently sells you your koura?

        i. How often does your company place orders with this supplier?
    d. If you do not currently sell koura, in your judgment, would your company potentially find this product useful?
        i. What would this product's usefulness depend on?
        ii. How much would the company be willing to pay for this product?
6. Has or does your company currently sell watercress?
    a. If so, does your company consider it a successful product?
    b. If so, how much does your company currently pay for each unit of watercress?
    c. If so, who currently sells you your watercress?
        i. How often does your company place orders with this supplier?
    d. If you do not currently sell watercress, in your judgment, would your company potentially find this product useful?
        i. What would this product's usefulness depend on?
        ii. How much would the company be willing to pay for this product?
7. In your judgment, are there any other crops or agricultural products that your company would like to purchase?
    a. Are there any such crops that would strengthen your company's branding?
    b. Are there any such crops that, your company would prefer to purchase from a Māori grower?
8. Do you know of any other buyers who would be interested in buying the previously mentioned crops?
9. Do you know of any other buyers who would be interested in buying any sort of crop from Ngāti Kea Ngāti Tuara?

Appendix C: Interview with Greenhouse Managers

Interview introduction

To begin each interview, our team will ask the following questions:

- Can we record this interview?
- Can we quote your responses in a report?
- Can we use your name in a report?
- Can we attribute your quotes to you in a report?

Then, before proceeding, the interviewer will state the following: To protect your privacy, your name will not be stored next to your interview responses, either physically or digitally.

The interviewer will introduce the project to the interviewee before proceeding.

Preliminary Information

1. Name
2. Age, sex
3. Place of employment and position

Questions

1. What is the size of the greenhouse you work in?
2. How much does your greenhouse cost to run per month/year?
3. How much electricity does it use per month/year?
4. Do the cost, energy usage, and growing procedures fluctuate with the seasons?
5. What crops do you grow in your greenhouse?
6. What technology do you use to grow these crops (hydroponics, aquaponics, etc.)
7. Has or does your greenhouse currently grow koura or watercress?
    a. How much does it cost per unit?
    b. How much does it sell per unit?
    c. To whom do you sell it?
    d. What kind of climate control do you use to grow it?
    e. Have you faced any challenges in growing these crops?
    f. Is there any special knowledge a worker must know before growing it?
8. What is the management structure like in your greenhouse?
9. How long does it take a worker to learn to work in a greenhouse?

10. How many employees work at your greenhouse?
    a. How many are working at any given time?
11. What is your distribution method for the crops?
12. Do you have any other information about operating a greenhouse that you could share with us?

Appendix D: Rotorua Street Surveys

Survey Information

Our team conducted these surveys with tourists and locals in vicinity of Eat Streat in Rotorua.

How old are you? _____ What is your gender? (Male) / (Female)

Are you : (A local of this area) / (A visitor of this area)

From where are you visiting? _____

If you are visiting, what are your lodging arrangements while you are in the area?

_____

In a word, what made you want to visit this area? _____

_____

How would you rank your knowledge of Māori cuisine?

(I don't know anything about it) / (I know a little about it)

(I know a lot about it) / (I have excellent knowledge of it)

Have you ever eaten Māori food at a restaurant ? (Yes) / (No)

If so, what did you eat? _____

Have you ever eaten koura (freshwater crayfish? (Yes) / (No)
(I do not know what that is)

If so, would you eat it again? (Yes) / (No)

Have you ever eaten watercress? (Yes) / (No) / (I do not know what that is)

If so, would you eat it again? (Yes) / (No)

On a scale of 1 to 5 (with 1 not likely at all and 5 being extremely likely), how much more likely would you be to try a dining option if:

A Māori village produced the ingredients 1 ----- 2 ----- 3 ----- 4 ----- 5

The ingredients were locally sourced 1 ----- 2 ----- 3 ----- 4 ----- 5

The ingredients were organic 1 ----- 2 ----- 3 ----- 4 ----- 5

The ingredients were produced with clean energy 1 ----- 2 ----- 3 ----- 4 ----- 5

Appendix E: Survey for Restaurants

Survey Information

Our team distributed these surveys to restaurants in Rotorua and surrounding tourist attractions when a face-to-face interview was not possible.

The purpose of this survey is to help our project team gauge interest in various food products, specifically those grown by Māori businesses. Our team is from Worcester Polytechnic Institute in Worcester, Massachusetts.

General Questions

Does your company currently have any business relations with Māori-owned companies?

Does your company have a broad branding strategy? If so, what is it?

Has your company had success marketing products with any of the following labels? In a word, can you describe any experiences?

Māori-grown
Organic
Locally sourced
Produced with clean energy
Hydroponically grown

Of the above labels, please rank in order which of these labels makes for the most compelling marketing term. (1-most marketable, 5 – least marketable)

_____ Māori-grown _____Organic _____Locally sourced

_____ Produced with clean energy _____ Hydroponically grown

Specific Foods

Has or does your company currently sell koura (freshwater crayfish)? _____

If so, what dishes do you serve koura in?

If so, who currently provides your koura?

If you do not currently sell koura, do you think your company would find this product useful? What would this product's usefulness depend on?

Has or does your company currently sell watercress?

If so, what dishes do you serve watercress in?

If so, who currently provides your watercress?

If you do not currently sell watercress, do you think your company would find this product useful? What would this product's usefulness depend on?

In your judgment, are there any other crops or agricultural products that your company would like to purchase?

Are there any such crops that would strengthen your company's branding?

Are there any such crops that your company would prefer to purchase from a Māori grower?

Do you know of any other buyers who would be interested in buying the previously mentioned crops?

Do you know of any other buyers who would be interested in buying any sort of crop from a Māori grower?

Privacy information

Can we use these responses in a report? (Y) / (N)

I understand that these responses are non-binding (Y) / (N)

Appendix F: Information Sheet for NKNT Facebook Page

Information Sheet

Dr. Bargh posted this information sheet on NKNT's Facebook group page to solicit hapū members for us to interview.

Ngāti Kea Ngāti Tuara Electricity Utilization: Feasibility Plan for a Hydroponic Greenhouse

Kia ora!

Our names our Marty Fitzgerald, Paige Myatt, Allie Buckley and Nathan Peterson (pictured left to right) and we are a team of four university students from the States in our third year at Worcester Polytechnic Institute (WPI) located in Massachusetts. We are working with Dr. Maria Bargh at Victoria University of Wellington and Te Rūnanga o Ngāti Kea Ngāti Tuara to propose a potential use for the available electricity produced by the micro-hydroelectric turbines.

The Rūnanga has previously explored construction of a greenhouse that would use the energy to control a stable environment in which to grow crops, herbs, or livestock. Our team seeks to produce a feasibility report for the hapū's consideration detailing a plan to build a greenhouse to meet the needs of the community, with particular commitments to sustainable development, cost efficiency, and job creation.

To best understand the needs of the community, we seek to conduct interviews and focus groups with various members of the hapū. The interviews and focus groups will last between twenty and forty minutes and take place at a mutually agreeable location in Horohoro or Rotorua. There will be general questions concerning reactions to the project on a large scale, as well as on thoughts about specific crop options and other finer details. In addition, the process will provide time for interviewees and participants to express any of his or her own thoughts and ideas as he or she sees fit.

Interviewees and participants, with consent, will be digitally recorded and access to these recordings will be restricted to the team members. No information taken from the interview will be shared without the interviewee's consent. Before each interview, a team member will ask whether or not they can record this interview and/or quote responses in a report. If desired, full anonymity is possible. The team will take every precaution to protect the privacy of the interviewees.

This project has received approval from WPI's Internal Review Board. Documentation can be presented upon request. For more information please contact the team at horohoro@wpi.edu.

Appendix G: Hapū Interview with Wiremu Keepa

Interviewer: Marty
Note-taker: Paige

Interviewee name: Wiremu Keepa
Relation to Hapū: Hapū member through whakapapa
Age: 62

Mr. Wiremu Keepa consented to this interview being recorded and cited in our report. It took place in person on January 30th, 2016 in the Runanga office in Rotorua.

Marty: We'd like to speak with you today about those hydro electric turbines. So the idea there is they're currently running a surplus. They power the marae and a couple of the buildings, so the question becomes how do we use the energy in a cost-effective way that's also consistent with some of the cultural values?
Wiremu: I may not be able to answer it directly, but in a roundabout sort of way there will be benefits with regards to the power system. I'm not just saying the power system to the marae, but there are other things too, like it builds community pride and iwi pride. So that's where I'm coming from.

Marty: So what we're here for primarily is some members of the community have expressed interest in using the power to build a glasshouse. So we're investigating things such as what crop to grow, what the glasshouse would look like, and producing a feasibility report.
Wiremu: Ask me some questions, and I'll see what I can do.

Marty: So first, to start, what's your relationship to the hapū?
Wiremu: I am a hapū member through whakapapa.

Marty: Could I write your age down for the purpose of this interview?
Wiremu: Yes of course, 62.

Marty: Perfect. So you said we could record the interview?
Wiremu: Yeah that's right.

Marty: Can we quote any responses in a report?
Wiremu: Yes, you most certainly can. One of the reasons why I agreed to this is because I was a student also and I know how difficult it can be go get responses. I did an MBA. I think sometimes people get to precautious, with regards to responding. As far as I'm concerned I'm an advocate for what you guys do, regardless of what topic it is, so bring it on!

Marty: Thanks so much! So you said you were familiar with the hydro electric turbines, and that the community was proud of them, are there any other ways in which the turbines are viewed, or does it seem that people do not know a lot about it besides that the turbines are there? What's the general feeling in the community?

Wiremu: Well I feel that as a hapū iwi, Ngāti Kea Ngāti Tuara is extremely proactive in getting information out. They've got a web page. They have newsletters. They have regular, I mean really regular Hui at Kearoa Marae. Monthly meetings have really intensive AGMs. So information sharing is definitely there. And as I said, it's one of the more proactive of the marae that I affiliate to and I affiliate to quite a few around here. So I am proud of NKNT.

Marty: Great. Did you know before that there is excess electricity produced? Was that some thing that you were aware of?
Wiremu: I did

Marty: Had you heard of any efforts by the members of the community about utilizing that?
Wiremu: Well I don't know about members of the community. I think it's entirely up to the Marae Committee to decide what to do with the balance. I'd be hesitant to see people from outside the marae come knocking on the door asking for electricity. I think the project was to get it by the marae, for the marae. If there are any secondary users who may require this electricity they'd go through the Marae Committee. I think we're in early stages at the moment. Wait until we start accommodating the marae's needs first, before we start going out.

Marty: So if I understand your point, the form of the use is less important than the purpose of it. Is it most important that it benefits the marae and the community first?
Wiremu: Well I'll come from another angle also. Every marae is self-sustaining and with this initiative it will relieve financial burdens of providing electricity for the marae. If they can make a commercial benefit from it by selling it back to the grid, that's all well and good.

Marty: Have you heard of similar projects like these in other Māori communities involving hydro electric energy, clean energy production, green energy, or something to that effect?
Wiremu: No, but there is another marae that I belong to that we do utilize geothermal. Not necessarily for power supply, but for cooking and heating our waters and heating our marae. So there are other marae that are fortunate, if they are in the environment of geothermal, that will use it. Others may use the stream for fresh water for cleaning. But a lot of our marae are becoming run down and dilapidated because all marae require income. I think the number one priority is to look after the marae and look after the hapū members.

Marty: So to that end, with the financial have you heard of any successful Māori owned business in the area?
Wiremu: There's quite a few, actually. I'm a trustee on quite a few land blocks. And they're dairy, forestry, and at the moment we're looking at other land options which is Manuka honey, kiwi fruit. So with regards to Kearoa and the marae, I congratulate the committee for taking this initiative of investing in a power generator and utilizing our river.

Marty: So, we mentioned earlier that were interested in using this potentially for a glasshouse would you like to see a glasshouse built at the hapū?
Wiremu: Oh yeah, lets do a glasshouse! Like I said, I am a trustee on a few blocks. One of our blocks, I'm a trustee on a geothermal block. We are in cohorts with Mighty River Power, one of the biggest power generating companies. As a by-product we are going to establish a greenhouse.

We all know that the demand for food not only locally, nationally but internationally is really, really upon us. If ever there is a way we could utilize geothermal, do it.

Marty: So, aside from certain things like financial gain, what are some ways the community might benefit from glasshouse?
Wiremu: Well, I think job creation. Huge amounts of food. Utilizing natural resources – the sun. If it's geothermal, geothermal. With glasshouses I think since we get some real harsh winters here, we can grow food 24/7, 365 days of the year.

Marty: Being able to grow food around the clock is that playing to the idea self sufficiency and self-sustainability?
Wiremu: Not only self-sufficiency but I think we'll be able to create a niche market. Tomatoes that only come out in the summer, but if you can grow nice tomatoes in the winter, as an example, or cucumber or things that only come out in the summer. So if the glasshouse can provide offseason fruits and vegetables. Let's go ahead and do it.

Marty: Right, so you had mentioned the idea of job creation. So without necessarily naming names, can you think of people in the community who would actually work in such a greenhouse, from the hapū?
Wiremu: Yeah – a lot. Well, and I don't think its isolated to NKNT, but right across the board unemployment figures are really high. Now, if we can get our people, because I truly believe and I'm not belittling those who do work in glasshouses, but with some good training, the academia level may not be high. And like I said I'm not belittle glasshouse workers, but it could be suitable for our people because they like working with their hands. They are creative, they believe heavily in growth and the soil so I think it would be highly beneficially for a lot of our people.

Marty: Now, you had mentioned growth in the soil, is that specifically soil that's interesting there, for example we're thinking of growing hydroponically.
Wiremu: Ok then, if that's the case that's ok, because we believe in life and if we can nurture life from a seed using other means, other than naturally in the soil with the sun, but if we can do it in a glasshouse and if we can still produce goods from a seed that would still be ideal. Because like I said, Māori we believe in life, we believe in nurturing a seed to full growth, the whole cycle.

Marty: So to give you an idea of some of the crops we are thinking of there are two that we found to have some good traction, watercress and koura. Do you find any of these particularly likeable or objectionable in any regard?
Wiremu: No, that would be perfect! That would be absolutely perfect, although hydroponic watercress has a different taste than the natural watercress in streams. There was a company a little further up north from Rotorua and they grew hydroponic watercress but it didn't have the flavor and so I don't think it succeeded. It was done hydroponically, the stocks were good, the leaves were small, but the taste was totally different. I think the company has folded. I think that the area its about 30 km south of Auckland. I can't put a name to it, but I remember when I was driving past people said oh this was where they had the hydroponic plant. Sorry about that.

Marty: I'm sure we can find information about that somewhere. So were they the first company to break through into the idea of hydroponic watercress?
Wiremu: I think, for watercress, yeah. I commend them for doing it because really Māori love watercress. Love it, love it, love it. Our people find it hard to find the right streams around here. A lot of the streams are drying up and the growth of the watercress was hardly there. Some watercress sellers over here at the market place today have a secret spot. Years ago everybody knew were the spots were. You could pull into any stream anywhere around Rotorua and there was a lot of watercress. But now it's really hard. Nowadays we have to go to market place to get watercress. I think people would still prefer to get watercress there instead of hydroponic watercress because of taste, that's all.

Marty: So if the taste were the same, do you think people would care if it were hydroponically grown or not?
Wiremu: Well, if it can fill in that gap, then go ahead.

Marty: We've heard a little bit of back and forth between growing a crop that has traditional connotation like watercress or something like a tomato, which doesn't. Do you have any opinion one way or another whether one is a superior option?
Wiremu: I think price has got a lot to do with it. Anything that's beyond the average worker's salary space, it becomes into the exclusive food price range and our people wouldn't be into that.

Marty: In terms of growing, if you were to pick one for the community, do you think growing a traditional crop would be the superior option?
Wiremu: Well already we've got a lot of our marae do māra, you know gardens. We grow silver bait, carrots, potatoes, apart from providing food it's a morale booster and it brings the hapū together. Out of 1000 people, 3 or 4 might turn up. But those 3 or 4 might not turn up if it wasn't established.

Marty: To grow something that's not a traditional crop wouldn't be a problem as long as it provided benefit to the community?
Wiremu: Yeah, yeah sure. That's right. I mentioned kumara, watercress, tomatoes. There are some things really out of our price range that only grow 2 months out of the year and that's kamokamo. That'll be fantastic if that could be grown all year round. They'd be queuing up at the door for that stuff. We even like silver bait. Mushrooms, because I think they will do really well in a glasshouse. We love our mushrooms.

Marty: Would those be some of the main ones you think would make sense in this capacity?
Wiremu: That's only from my personal view. Some people may not like mushrooms. Some people may not like tomatoes as much as I do.

Marty: Are there any other concerns or information you'd like to share with us about such a project?
Wiremu: Well just going back to the hydro at our marae. I tip my hat to the committee members who established it. They are the only marae around here that have done something like that. There's another marae around here that has hooked up to geothermal to provide heating for the cooking. Tunohopu has done geothermal. There's some marae that have got no natural resources

so they really struggle. There used to be fundraising but now people haven't got the time, the effort or the money to contribute. So a lot of the Marae are finding it really, really difficult. They're going out of the traditional what happens on the marae and we're starting to now cater for groups. You know, sleep over, feed them, so we can get a bit of money coming through, because paying the bills, the electricity, rates and all that is ongoing.

Marty: Any concerns or ways you think the project might not suit the needs of the community?
Wiremu: If they didn't have this hydro scheme up there, its not that they'll be up against the wall financially looking for electricity. I just think that they've got a good board with good heads who are willing to make these sort of investments. Let me say some of the marae around here haven't got these particular people at their board there so they are floundering. This one is here it's bringing the people together and its truly believing in our marae and we're all happy chappies!

Appendix H: Hapū Interview with Joanne Heap

Interviewer: Marty
Note-taker: Paige

Interviewee name: Joanne "Jo" Heap
Relation to Hapū: whānau member, hapū member
Age: 40

Ms. Jo Heap consented to this interview being recorded and cited in our report. It took place over Skype on January 30th, 2016 in the Runanga office in Rotorua.

Marty: How does the community view the turbines?
Jo: All sorts of very positive about the hydro units.

Marty: General positivity?
Jo: General positivity. Yes. Sustainability.

Marty: Do you call it a source of pride for community?
Jo: Yup!

Marty: How do you view sustainable energy? Does it align with the values in the community?
Jo: Yes, definitely.

Marty: Are you familiar with the attempts to utilize the excess electricity?
Jo: I have heard talk of powering other houses in the area. Other than that, no.

Marty: To you, do you think the community is still relatively undecided?
Jo: To me, but at the moment I am not living right in the community. Not exactly sure. But the meetings I have attended there are a few ideas floating around. Still undecided.

Marty: Anything you would like to see the electricity used for?
Jo: Keen to see it Benefit hapū and environment, whatever that might look like. I am open to suggestions.

Marty: Any heard of any other clean energy initiatives at other marae?
Jo: No.

Marty: Are you familiar with any other Māori owned businesses? Industries?
Jo: I'm sure I know lots. Childcare center in Northland. Built with sustainable energy, built with other natural things like clay walls.

Marty: What about Māori in agriculture and food production?
Jo: I know quite a few people getting into honey. Can't think of anything else.

Marty: What do you think about the idea of a glass house for the marae? Positive? Negative?
Jo: It sounds like a good idea. Source of healthy food for the members of the hapū and community. Where it would be placed? What it would be made of? Generally sounds like a good idea.

Marty: What are your concerns surrounding physical placement? Would it interfere with other resources in the area?
Jo: Good question. I don't know. Haven't really thought about it. Just knowing the significance of the river. I probably need to think about it more. There may be none. I think that is a discussion to be had.

Marty: What are some ways a glasshouse would benefit the community? You mentioned possible food production?
Jo: Food production. A good role model for our families. I think Māori in general, our health tends to be not great. To lead the way and show our people how to produce our own food and healthy food and eat healthy. I think there's huge benefits there. A source of food when there is a hui at the Marae. That should cut down costs for the whānau who has the event.

Marty: What about the idea of job creation? Others have said it would be a good idea, especially for job creation?
Jo: Definitely potential. That would be another huge benefit. As long as there is good training and support systems and people who are interested in that work. Just thinking back when I was young. My dad had a farm, an orchard. He grew all sorts of things. Often he would employ locals and there were people who were keen to do it. Sometimes difficult because there weren't people who wanted to.

Marty: Anything that made it especially difficult or complicated?
Jo: Just the labor.

Marty: Without naming names, do you know people who would be interested in working in the glasshouse?
Jo: I don't know. I wouldn't have a clue really.

Marty: If you had a gut impulse, do you think there would be a few people would be interested?
Jo: I'd like to think there would be. Optimistically I like to think at least a few.

Marty: Within the glasshouse, we are currently considering koura and watercress. What do you think of those options?
Jo: Oh it makes my mouth water just the mention of those two words. Yes, that sounds perfect!

Marty: Does it have any particular significance besides they're good foods? Is it likeable in another capacity?
Jo: They're both just delicious. I was just reading something on the health benefits of watercress and it being a super food. It takes me back to my childhood and its just such a Māori food and yeah fetching it from the river when I was a kid. It used to just grow everywhere when I was a kid. I don't know if its like that anymore. And also koura - there used to be heaps living in the

river. I used to go with my dad to collect them. Links to my memories of the area. My memories. My childhood. Very Māori as well.

Marty: It fits well with the idea of a deep cultural connection?
Jo: Yes, yep.

Marty: In other greenhouses, they've found success growing tomato, not necessarily with a cultural connection. Is it preferable to have this connection?
Jo: I guess I would tend to side more with the cultural connection. If there were other things that didn't have such a deep cultural connection, as long as the production of those things still benefitted the hapū, the community, the marae, then I would be open to those types of crops being grown. Māori potatoes – it would be cool to see those produced.

Marty: Are there any other crops that come to mind?
Jo: Puha, otherwise I don't know.

Marty: Do you have any other concerns/information that you would like to share with us?
Jo: I really know very little about it, so no.

Marty: Is there information we could provide to community to help them make this decision?
Jo: Any other iwi hapū doing similar things? Look at those examples and learn from them. There must be some doing similar things. Learning form what other have done. Maintaining the manna of the land, the river and the marae and the people. Give us more information about project would be good. I don't know what I don't know. Thank you so much for doing this study it sounds great!

Appendix I: Restaurant Interview – Atticus Finch

Interviewer: Paige
Note-taker: Allie

Interviewee Name: Cherry Te Kiri
Position: Owner, operator

Ms. Cherry consented to this interview being recorded and cited in our report. It took place in person on January 29th, 2016 at her restaurant, Atticus Finch.

Paige: Are you familiar with Ngāti Kea Ngāti Tuara Hapū at all?
Cherry: Not that one in particular.

Paige: Do you have any relationships with Māori owned businesses currently?
Cherry: Yes, I'm married to a Te Kiri.

Paige: What is your overall branding strategy? What type of people do you appeal to? What is something special about your business?
Cherry: We do what we call contemporary New Zealand cuisine. We are a new country so we tend to look to outside of New Zealand for what we do foodwise. We tend to do a broad range of flavors. One of the main things we like to do is use fresh seasonal produce. For example, I would never use frozen corn outside of summer because summer you can get nice corn.

Paige: Have you had any experience selling Māori produced food?
Cherry: Not that I'm aware of. We do try and support Te Awara Seafoods but their service is not the greatest. For me it's about being able to get the product when I need it and there is some after sale service. That's probably the only supplier that would fit that bill.

Paige: The next couple questions have to do with certain crops we are looking into. Does your restaurant sell any dishes with koura, or freshwater crayfish, in them?
Cherry: No, because you can't get them.

Paige: Does your restaurant sell any dishes with watercress in them?
Cherry: Yes.

Paige: Do you know who your supplier is?
Cherry: Fresh - it's an arm of Bidvest. They sell fruits and vegetables.

Paige: How much do you pay for it?
Cherry: We buy the micro-cress at the moment. If I could get a decent supply of regular watercress I'd definitely be interested. Problem is I can't buy it and the occasional time that you can it is often not in the best condition. We have used it from Fenton Quality Produce. They sometimes have it. But we pay $12.55 for 250 grams of micro-cress.

Paige: The Māori are looking into growing watercress in a hydroponic greenhouse that would be powered using clean energy from a micro-hydro they just installed. Would that be something you would be interested in?
Cherry: Yes, it would. Is that all that they are looking at doing is watercress and koura?

Paige: Currently those are our two top options. Do you have any other suggestions?
Cherry: The thing that I struggle with the most is being able to get produce in pristine condition. So like when you look at the TV shows and when you look at what's happening overseas. The chefs can go to the market and pick what they want because it is the best possible. I am not able to do that. I have to ring up the night before and hope like hell that what comes in is good. Anything that is the best that it can be that you know and is seasonal, even corn for example, the last lot that I bought, half of it I wanted to send back. By the time you make the phone call, do the exchange, it just becomes a pain. You tend to say I'll just have to use it and and buy a couple of extra ones next time so if there's something that's not good then I'm covered. The other thing we use is truckloads of fresh herbs. It's really hard to get them in pristine condition and small amounts. We don't just use them for garnish we use them in a lot of our dishes so if we could get a supplier that could say "I could get you this this and that and its going be pristine every single time" I'd much rather look to a grower than a much larger company that doesn't actually care what I get.

Paige: Are there any specific herbs you would be interested in?
Cherry: Curry, dill, Italian parsley, basil, and chives. If we could get koura that would be fantastic! We go through 3 kilos of frozen prawns from Bidvest a day. If we could exchange that for something local that would be fantastic. That would be great.

Appendix J: Restaurant Interview – Mac's Steakhouse

Interviewer: Paige
Note-taker: Allie

Interviewee Name: Sid
Position: Restaurant manager

Mr. Sid consented to this interview being recorded and cited in our report. It took place in person on January 29th, 2016 at his restaurant, Mac's Stakehouse.

Paige: Are you familiar with Ngāti Kea Ngāti Tuara Hapū?
Sid: Not much.

Paige: Do you have any relationships with Māori owned businesses currently?
Sid: No, I do not.

Paige: Does your restaurant sell any dishes with koura in them?
Sid: No, we do not.

Paige: Does your restaurant sell any dishes with watercress in them?
Sid: Yes, we do.

Paige: Have you found this successful?
Sid: We use watercress in most of our catch of the day dishes we make. People seem to like it.

Paige: Who is your supplier?
Sid: Bidvest.

Paige: How much do you pay for watercress?
Sid: I am not sure. Our head chef orders. We don't use it everyday. Sometimes when we make special dishes we get watercress.

Paige: Would you have any interest in buying watercress if it was produced by a Māori community?
Sid: Yes, probably. I am not sure it makes a difference to us.

Paige: Do you have any interest in watercress that would be grown hydroponically, with clean energy in a Māori community?
Sid: Yes.

Paige: Do you have any other crops of interest?
Sid: I would have to talk to the head chef.

We asked for the head chef to fill out the survey found in Appendix E but it was not returned.

Appendix K: Restaurant Interview – Nuvolari

Interviewer: Paige
Note-taker: Allie

Interviewee Name: Peter Waiytong Wu
Position: Chef, kitchen head

Mr. Wu consented to this interview being recorded and cited in our report. It took place in person on January 29th, 2016 at his restaurant, Nuvolari.

Paige: Are you familiar with Ngāti Kea Ngāti Tuara Hapū?
Peter: No.

Paige: Do you have any relationships with Māori owned businesses currently?
Peter: No.

Paige: Does your restaurant sell any dishes with koura in them?
Peter: No because it is very expensive. I have done that before but not here. Its so expensive except at big hotels. If we order that it is only once a year.

Paige: Does your restaurant sell any dishes with watercress in them?
Peter: I've used that before but not here. For cooking for soup and salad.

Paige: Would you like to buy things from a Māori community?
Peter: No, not for us.

Paige: Do you have any interest in watercress that would be grown hydroponically, with clean energy?
Peter: Not so much here. We don't use it much.

Appendix L: Restaurant Interview – Brew Craft Beer Pub

Interviewer: Paige
Note-taker: Nate

Interviewee Name: Not given
Position: Chef

The chef consented to this interview being recorded and cited in our report. It took place in person on January 29th, 2016 at Brew Craft Beer Pub.

Paige: We are working with the Ngāti Kea Ngāti Tuara Hapū to produce a feasibility report to see if there is a market for a hapū-run greenhouse.
Chef: There is always a market. It comes down to whether they are competitive with other suppliers.

Paige: Does your restaurant sell any dishes with watercress in them?
Chef: We don't use it here but I am definitely familiar with it.

Paige: Does your restaurant sell any dishes with koura in them?
Chef: No, I am not even sure if you can use them. We can't commercially fish, buy, and sell trout. That might be the same. Can you legally farm koura? I'm sure if there was koura and people could use them there would be a market for it.

Paige: Do you have any relationships with Māori-owned businesses currently?
Chef: No. Our sheer volume alone we need to source commercially. We go through ridiculous volumes of food.

Appendix M: Restaurant Interview – Solace Café & Restaurant

Interviewer: Nate
Note-taker: Paige

Interviewee Name: Kunal Sharma
Position: Manager

Mr. Sharma consented to this interview being recorded and cited in our report. It took place in person on January 29th, 2016 at Solace Café & Restaurant.

Nate: Are you familiar with Ngāti Kea Ngāti Tuara Hapū at all?
Kunal: Not at all actually.

Nate: Do you have any relationships with Māori-owned businesses currently?
Kunal: Not really. We really support Māori culture. We are in Rotorua and this is the place Māori culture begins. As a mixologist, I was awarded for my drink Whaiaipo Rotorua - to be in love with Rotorua. It is a hangi inspired cocktail – there is smoke from cooking in the ground done with dry ice. We do support Māori culture. People come here to learn about Māori culture so we promote a lot of things about Māori.

Nate: What is your overall branding strategy?
Kunal: Rotorua is very different because it is a typical tourist place. They come straight to learn about Māori from all over New Zealand. I get a lot of people on tourist visa and working holiday. They are traveling and they get to know how to work in New Zealand. I keep a lot of working holiday people. I have a chef and duty manager that are Māori.

Nate: Does your restaurant sell any dishes with watercress in them?
Kunal: Yeah, yeah, yeah. We do. We buy a lot.

Nate: How much do you pay and who sells it to you?
Kunal: $2.90 a bunch. Fenton Produce fruit and veggie shop.

Nate: Does your restaurant sell any dishes with koura in them?
Kunal: No. We are a bigtime seafood restaurant, but we don't sell that, a lot of prawns.

Nate: Do you have any interest in watercress that would be grown hydroponically, with clean energy in a Māori community?
Kunal: It is all on our head chef. He decides what will work according to the street. Based off money. It depends on the season and weather. You never know.

Nate: We are going to be surveying tourists.
Kunal: We also take feedback. We change the menu based on what people want.

Nate: Are there any other crops or products you are interested in?
Kunal: Why not? Why not? Certainly! We are just starting to purchase breads made locally with Māori people. We wanted to promote that bread, instead of just some Italian or Focaccia bread. Why not promote some herbs and spices and bread from Māori culture? That's what people want as a tourist when they come they want to know about these breads. I will try and promote the Māori food or New Zealand product instead of an Italian or US or China product. Something that I want to promote was Thomson Whiskey made with manuka honey. I supported them with my award-winning cocktail.

Nate: Do you know if your watercress is grown hydroponically or not?
Kunal: No I don't go that deep. I have no idea. We just buy it.

Appendix N: Greenhouse Manager Interview – PlentyFlora

Interviewer: Marty
Note-taker: Allie

Interviewee Name: Harald Esendam
Position: Owner, manager

Mr. Esendam consented to this interview being recorded and cited in our report. It took place in person on January 29th, 2016 at PlentyFlora.

Marty: We are working with the Ngāti Kea Ngāti Tuara Hapū, We are interested in using some of the excess electricity produced from the hapū's micro-hydro system for a greenhouse. The hapū already powers all of their buildings, the marae, the church and so on. The excess electricity is being sold back to the grid, but not for a very high profit. So they are looking to channel some of that to build a glasshouse that will potentially grow watercress or koura. We figured that since the greenhouse here uses a lot of the same technologies through the geothermal heating, that it would be helpful if we could ask some questions pertaining to that?
Harald: Yup.

Marty: I read that this is a 2,600 square foot greenhouse. Is that correct?
Harald: Yes, it is 56 by 48.

Marty: Are there any metrics a greenhouse likes this draws? Like how much electricity over a week of over a month?
Harald: Not at the top of my head. I would need to check the bill.

Marty: Could you tell me more about the geothermal energy used here?
Harald: Geothermal is only for the heating of the glasshouse. We have two bores. One bore is going for 12 months, which is the main one, it feeds into an exchange system and then gets re-injected into the ground. We have an internal grit, the loops in the tables where the hot water is going through there. The other bore has a grit on top of the plants. You've got a post in the greenhouse about a meter. This bore is only run 4-5 months out of the year. It is very much related to getting rid of the high humidity. This is why we have almost no problems with mildew or fungus diseases. Auckland growers do have this, they are way more humid then we are. So there are two different systems, a kind of hybrid. System is coming in with about 60 degrees and it's going out with 50-55 degrees. Last winter we tried to not feed it back but feed it back into another heat exchange in our shed and warming up the water that's returned before it goes through the heat exchange. If you warm up 25 degrees or 30 degrees that is a huge difference. We can get higher temps in the greenhouse. 100% geothermal is doing our heating. In the past we had diesel – don't need that anymore.

Marty: So you inject water back into ground when it's done. What is the rational behind that, is that a necessary step to keep the geothermal energy strong?

Harald: This is the legality of it. We need to do it. Principal the bores are 300 meters of depth; we are bringing it in 80 meters of depth. In my limited knowledge of what's happening with that water it trickles down to the source and then comes back up. It is recycling in that sense. I'm not so sure if that is the case, but it sounds like it.

Marty: It is governed by resource consent?
Harald: Yes. It is. Before we started the business that was already in place. I feel good about it.

Marty: Has this been an initial investment or a high maintenance cost associated with it?
Harald: Not a lot of cost in the sense of the license fee. The $1000 per year is helping with the cost for energy. There is definitely a maintenance cost and initial investment of the bore $100,000. That is two holes, the bore and the reinjection. The maintenance cost has pumps and compressors involved. Just last weekend the pump was down; we have a technical man down every Saturday. We are about to have a service because fight now silica is building up in the heat exchange and pipe work that needs to be taken out and do maintenance on that.

Marty: Is there an outside contractor you use?
Harald: Yes, there is a contractor for the bore. We will do this for the winter and get the bore serviced. This work this can be easily $1000.

Marty: Do you have any idea if this bore is the average size? Larger? Smaller?
Harald: We were always too low in the past, but with the two bore systems working together, I think we might have a little bit of overkill. We could have a little bit of bigger area if we needed but we won't - our market isn't big enough. We are always looking for improvement. Based on last winter, we really need to be clean in the exchange and clean in the bore through the winter. We can get temps of over 60 degrees in the glasshouse. This translates to about 40 degrees, which is more than enough. Over 50 degrees in the entrance where the water comes in should be enough. We can do 60 degrees so I think there is a little bit of overkill right now. It has a screen to conserve the energy at the end of the day. Also acts as taking the direct radiation of the sunshine off the plants. Part of the energy storage as well. That bore goes for 12 months from May to September. Since this one was very on and off it was very handy to have two separate systems.

Marty: So you mentioned that humidity causes mildew and rot?
Harald: Mildew is a dry fungus – haven't seen a lot of this or mildew. We are starting to see a little bit of this, but that comes with this type of weather. Regarding fungus, we are doing a lot better then those in Auckland. Mildew causes spots on flowers. I am not involved on herbs or watercress.

Marty: Are there any other particular novel technologies you use to grow the flowers here?
Harald: People are always asking if this is hydroponics and to me this is not 100% hydroponics. You can say it is a semi-hydroponics system because each plant does have its own dripper and the coconut fibers we are using. It is going towards hydroponics. We have a new computer system. It's New Zealand made, it's pretty high up. If you are starting a greenhouse you really need to look into what's handy. You can get maybe quite simple systems for that. This one here is controlling not only the climate, but also the feeding. We can go to the beach and still change

the settings of the glasshouse. I don't think is a lot of other technical stuff in it. The Dutch started building a table, the pots are hanging from the system and each has their own dripper – preventing contamination. All the competition is Auckland is now doing the same thing so you don't have to bend over anymore. Paying back big time with staff not complaining of back problems. Bought second-hand and built myself. You can build a lot on your own.

Marty: Are a lot of things automated here?
Harald: Everything is automated. They control themselves, but you always have to make sure everything is working. It is a 24/7 job in that sense.

Marty: What is the management structure like here?
Harald: It is a small operation within itself but thousands of things to do. Chris is a manager. We are getting older and someone always has to be there because there is always something going wrong. For a while Connie and I did it ourselves, but you need a manager. We are the overhead. A lot of things are happening and I need someone to replace me. Tania is a supervisor and then we have two staff and my son works part time. Small teams need to have people with different responsibilities. Connie and I are the backup if someone is out we fill in. The staff has Tuesday off because they spray on Mondays. During the winter they only work 3 days compared to 4 in the summer. Last year we started to make a manual of all the processes we do. You start realizing all the things you never recorded. A lot in our heads but if you want to sell the business or get out knowledge to other people you need to do this. Also for the staff to look up is there is a problem.

Marty: What is the training required to work here?
Harald: It is learn on the job. Most of the time I train people. Chris had an education is horticulture. This position you need some insight and experience. Normal staff needs to be committed and there is training because you need to know how to pick the right flowers. Some people won't tune in so if they still haven't after 3 weeks they are let go. Margins are too small to make extra expenses.

Marty: What is your method of distribution?
Harald: Our market consists of 60 florists we deliver flowers to 1-3 times a week. Excess flowers go to auctions in Wellington and Auckland. Most of our advertising is done by word of mouth. We believe in 50% quality, 50% service.

Marty: Do you use a contractor to pick up flowers and deliver them?
Harald: We bring them end of the day each day. We put them in the boxes, then put them in the chiller, and then put them in to the carrier system. Overnight is the cooler time of day so that is when we transport them.

Marty: I have one final question; how do you decide on your price?
Harald: We have a summer price and a winter price. Winter price is lower. We also give discounts for big orders. The price is set to what we want it to be. For 12 years we had the same price. Last year we increased it little. Surprisingly price isn't the biggest thing to our customers.

Marty: Thank you for taking the time to speak with us.

Appendix O: Participant Observation – Micro-hydro System

Interviewers: Marty, Paige, Nate
Note-taker: Allie

Interviewee Name: Riki Oneroa
Position: Hapū maintenance worker

Mr. Oneroa consented to this interview being recorded and cited in our report. It took place in person on January 28th, 2016 at the Ngāti Kea Ngāti Tuara Hapū.

Riki: It spins around and goes through a draft and that create a vortex and that vortex makes that thing run about 1,200 reps per minute. All three are 50 liters. The motor is spinning around creating the power – like a washing machine.

Marty: That's how many kilowatts per each?
Riki: About 0.9 kilowatts each. We are going to have a look at the inverter which will tell us this information.

Paige: how often do you clean these?
Riki: Depends on the weather. Rough weather there is usually leaves, sticks, and other stuff that gets stuck in there.

Riki: (*re-opens the intake door*) The water is going to fill back up to the top.

Micro-hydro turbines start spinning.

Paige: *points to cracks in cement of the penstock.* Are any of these leaks a problem?
Riki: No they are really not much of a problem. We want to know if these [turbines] are very efficient for us. Would we be better off putting in a water wheel? Because right now this requires daily maintenance, where the water wheel would be able to work through a storm and wouldn't have to do much cleaning of it and maintaining it. Would that work better?

Marty: So you would have to demolish all of this? Have you looked into that? How much would it cost?
Riki: Well I am not that Internet savvy. You guys would be able to look into that.

Marty: Is the hapū aware that you are thinking of that?
Riki: We always throw ideas around. We wanted to see if you guys would come up with a better idea then this idea.

Nate: What is the daily maintenance that is required?
Riki: Everyday we have to check the inlet to make sure its not blocking up. Everyday it is filling it up with leaves and sticks. They have to shut down the whole thing everyday. I think if we had a water wheel it would require very little maintenance and wouldn't get clogged.

Paige: Where is most of the debris coming from? Upstream?
Riki: Basically, the debris is coming from all the trees upstream. Especially in the autumn the leaves are falling from the tree and we end up with them. *Walks over to intake grate.* So you can see all of the leaves. We have a gate out there to try to divert a lot of the debris to go down stream instead of coming this way. Every morning I have to climb down there a clear the grill of any leaves that have worked up over night. That is every day.

Walks team inside to inverter

Riki: So this is the inverter, it shows us how much power we are generating right now. At the moment we are producing 2.7 kilowatts of power. Up to date we have 33 kilos we produced today. Yesterday we sold 63.4 kilos. That is how much power the three turbines are creating.

Nate: So another three turbines would require another inverter?
Riki: Yes, this one can only do 3 kilowatts and it's about just doing that now. In the morning when I get here if it says about 2.5 then usually it tells me that either the inlet is blocked up or there is something stuck in one of the turbines, like a leaf or stick, and then the leaves bunched up.

Nate: So it has gotten all the way to the turbine?
Riki: Yes. During the fall sometimes you have to even clear it twice [per day] to make sure we are maintaining 2.7 kilowatts. *Talking about inverter.* So this was actually converted from a solar panel. We converted it for a micro hydro unit.

Marty: Who did the actual conversion process for that?
Riki: Guy named Michael Lawley from PowerSpout

Marty: If you wanted to expand or change you would need to give this guy a call?
Riki: If we wanted another one then they would just ship one over and we would install it ourselves.

Nate: But you would need another inverter?
Riki: Yes, we would need another one. Having the inverter on allows us to sell it back to the grid.

Paige: Does it come in as a direct or alternating current?
Riki: One or the other, I am not too sure. The inverter has a touch screen to give you all the information you will need. Yesterday we sold to Meridian Power 63.4 kilowatts.

Paige: So this powers this building?
Riki: Yeah the whole marae, all of the buildings here, as well as the farm over the road and over the stream.

Marty: So we are looking to record a maintenance system, and Maria mentioned a procedure specific to when it rains?
Riki: Yes, if we have gentle rain we can keep them going but harsh rain we shut them down because the [conditions] are very abrasive. After a storm there is too much mud so we just shut the intake and it diverts the water down the waterfall. When the water gets to be more clear then we open them back up.

Paige: Are you storing the power when this happens?
Riki: No, so when this happens we have to come in here shut these switches off and turn back on the power from the national grid. During august these are shut down quite often due to the heavy level of rain and the river flooding.

Paige: Have you looked into getting a battery?
Riki: No we haven't. They are quite expensive. But you might want to look into it.

Appendix P: Restaurant Interview – Treetops Lodge & Estate

Interviewers: Nate
Note-taker: Allie

Interviewee Name: Peter White
Position: General Manager

Mr. White consented to this interview being recorded and cited in our report. It took place over the phone on February 18th.

Nate: Are you familiar with the Ngāti Kea Ngāti Tuara Hapū right down the road from you?
Peter: Honestly, not as familiar as I should be.

Nate: I appreciate the honesty. So if I could I will explain what our purpose is. I am working with a team of four; we are University students from the States. And is it okay if I ask you a few questions? Would it be ok if I recorded this interview?
Peter: Yes, that sounds ok.

Nate: Great. Our project is to develop a feasibility report to present to the hapū concerning the construction of a greenhouse. So we have identified a few crops that we think would be ideal. One of them is watercress and the other is koura, which I mentioned in the email a few days ago. Are you familiar with the micro-hydro unit?
Peter: No I am not actually, I have heard of it, but that is all I have actually done.

Nate: So it is really great actually, what they are doing is using the energy from the Pokaitu stream and basically transferring it through some turbines to create the power. So they are actually creating enough power to run the community and they had some excess they are going to use to power the greenhouse. So the greenhouse would be run by this clean energy created by the river, which would be great.
Peter: I see, yup.

Nate: One of the crops we are thinking about is watercress. Do you guys offer watercress to your consumers?
Peter: We do indeed. On the estate here we have a number of freshwater springs. So we do actually have our own supply of watercress in a couple of those already. I couldn't honestly say if we used it as much as we could, whether it was something we could have in abundance for the entire year or if we would need to bring some more in if we were using it more often.

Nate: Ok. So you do have your own supply but it's quite seasonal?
Peter: A little bit yes.

Nate: Ok, great. The other livestock is koura. Are you familiar with this?
Peter: Yes. Absolutely. And from time to time we do use that on our menu as well.

Nate: Do you harvest those yourself also?
Peter: Yes, it is in those same springs. Very small. Not very much at all. On the estate itself we do some indigenous food trails. Where we will take people into the forest and explain to them a little bit more about the indigenous foods that are naturally available in the forest. And from time to time that has been the koura.

Nate: That is very interesting. I remember reading about that on your website. That seems like a really cool experience. Is the availability of koura also quite seasonal? Would you maybe be interested in buying anymore in the future?
Peter: I think definitely if it was locally sourced and coming from a sustained source, yes we definitely would.

Nate: Are there any other crops you may be interested in buying from the hapū?
Peter: It would depend on what they decide on what they are going to produce. I can't think of anything specifically off of the top of my head. Are they looking to something a little bit more from the indigenous crops? Or are you looking more at a commercial enterprise like micro-greens?

Nate: Right so it would be indigenous crops. They seem to be of more interest to the hapū members and that is where koura came about because that project would begin as a restoration project and then hopefully with time it would graduate into more of a commercial venture.

Peter: Because I imagine that it would be a lot more energy and trying to get tanks and separate them out from growing to an actual sellable product to be in. Do you know how long it would take to grow a koura to make it a sellable product?
Nate: It would be a few years. Couple years down the road at least. This project is in its preliminary stages we are just determining the feasibility, so all of this wouldn't be taking place for some time. But we just wanted to gauge some interest and have this conversation and we really do appreciate your time.

Peter: With the greenhouse are they heating the greenhouse? Would that be just predominately generated from the micro-hydro or would you more be using some of the geothermal heat coming out of the ground?
Nate: They have looked into both actually. But they do have a lot of excess from the micro-hydro system so they are looking to use that energy somehow. They are selling it back to grid right now and they are really not making much of a profit at all. The power company isn't paying them well for it. That is where the idea of a greenhouse came about. So they are looking to use that energy.

Peter: Yeah because there is another greenhouse that is just down the road, which they grow flowers and I know they use the geothermal, energy and keeping their greenhouse warm.
Nate: Right. Are you speaking about PlentyFlora?
Peter: Yes.
Nate: We have actually spoken to them as well, but we appreciate the reference.

Peter: Have you though about how big the greenhouse would be? Or is it too preliminary.
Nate: While it is preliminary but the production will largely depend on the resource consent we can get in order to take water from the either the stream or some local springs. We have been speaking to the local district council, and haven't heard back from them, but the size is going to depend largely on how much water we can actually take in order to grow these things. We are considering hydroponically grown watercress and maybe an aquaponic relationship between watercress and the koura.

Peter: Yeah I can understand that, and the correlation there and how they can possibly work together, and cleaning the water at the same time. What university are you studying from?
Nate: Our University in the States is called Worcester Polytechnic Institute, its an engineering school.
Peter: Whereabouts is that?
Nate: That is in Worcester, Massachusetts. Which is about one hour west of Boston.
Peter: One of my friends goes to school in the US.
Nate: The university we are currently studying at in New Zealand is Victoria University in Wellington.

Peter: Oh I see. And what made the Rotorua area your key interest?
Nate: Well we are working with School of Māori Studies at Victoria University. Our sponsor, the woman who has set us up with this, is a member of the Ngāti Kea Ngāti Tuara Hapū.
Peter: Oh I see. That makes sense then.
Nate: That is how it all ties together.

Peter: It is probably one of those projects that won't happen until after you graduate.
Nate: Yes, most likely that will be the case. We are just trying to provide them with as much information as possible and they expressed that Treetops was probably their number one prospect as far as maybe a potential business partner in the future.

Peter: There is always the potential. If you are providing a product that is very viable and at a good price, as well as keeping it local, that would be our preferred way to go, definitely.
Nate: Excellent, that is certainly encouraging for us to hear. I think that is all the questions that we wanted to ask of you. Again we really appreciate your time. Thank you.

Appendix Q: Hapū Member Online Survey

Hapū Survey Form

In 2013 Ngāti Kea Ngāti Tuara installed a micro-hydro power system that produces enough electricity to fully power the hapū's marae while still generating a surplus. Several members of the hapū are looking into the construction of a greenhouse that would use the surplus energy to grow crops, herbs, or livestock. The purpose of this survey is to understand the hapū's views on the greenhouse and a few of the potential crops.

* Required

1. **Are you a member of the hapū?** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No
   - ◯ Other: _____

2. **Do you think a greenhouse would benefit the community?**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

3. **How do you think a greenhouse might benefit the community? (check all that apply)**
   Check all that apply.
   - ☐ Job creation
   - ☐ Increase available capital
   - ☐ A source of pride
   - ☐ Source of food for the community
   - ☐ Increase commitment to sustainability
   - ☐ Create new business connections
   - ☐ Educational opportunity
   - ☐ Other: _____

4. **Would you be in favor of growing watercress in the greenhouse?**
   Mark only one oval.
   - ◯ Yes, I would favor it.
   - ◯ No, I would object to it.
   - ◯ I don't have an opinion.

5. **If you are in favor of growing watercress, why?**

6. **If you would object to growing watercress, why?**

7. **Do you feel as though the hapū has a cultural connection to watercress?**
Mark only one oval.

- ◯ Yes
- ◯ No

8. **Would you be in favor of growing koura in the greenhouse?**
Mark only one oval.

- ◯ Yes, I would favor it.
- ◯ No, I would object to it.
- ◯ I don't have an opinion.

9. **If you are in favor of growing koura, why?**

10. **If you would object to growing koura, why?**

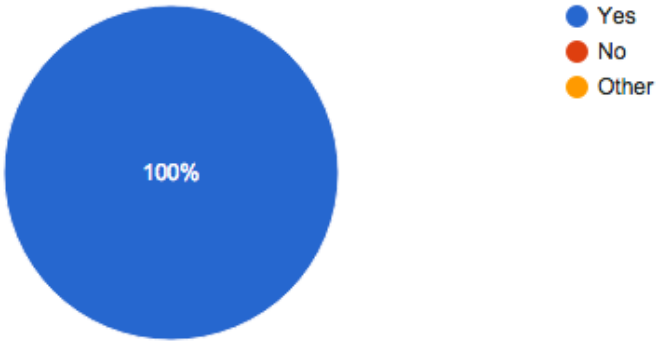
11. **Do you feel as though the hapū has a cultural connection to koura?**
Mark only one oval.

- ◯ Yes
- ◯ No

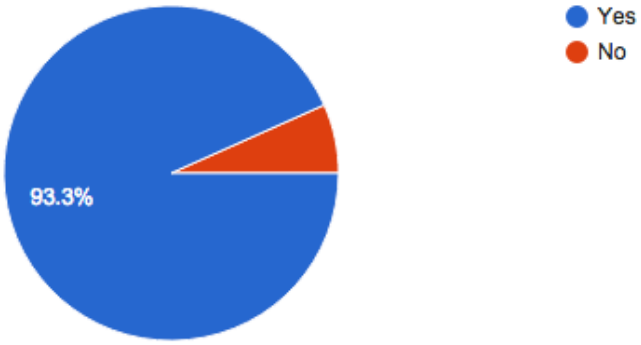
12. **If you have any other thoughts you'd like to share with us, we'd love to hear from you.**

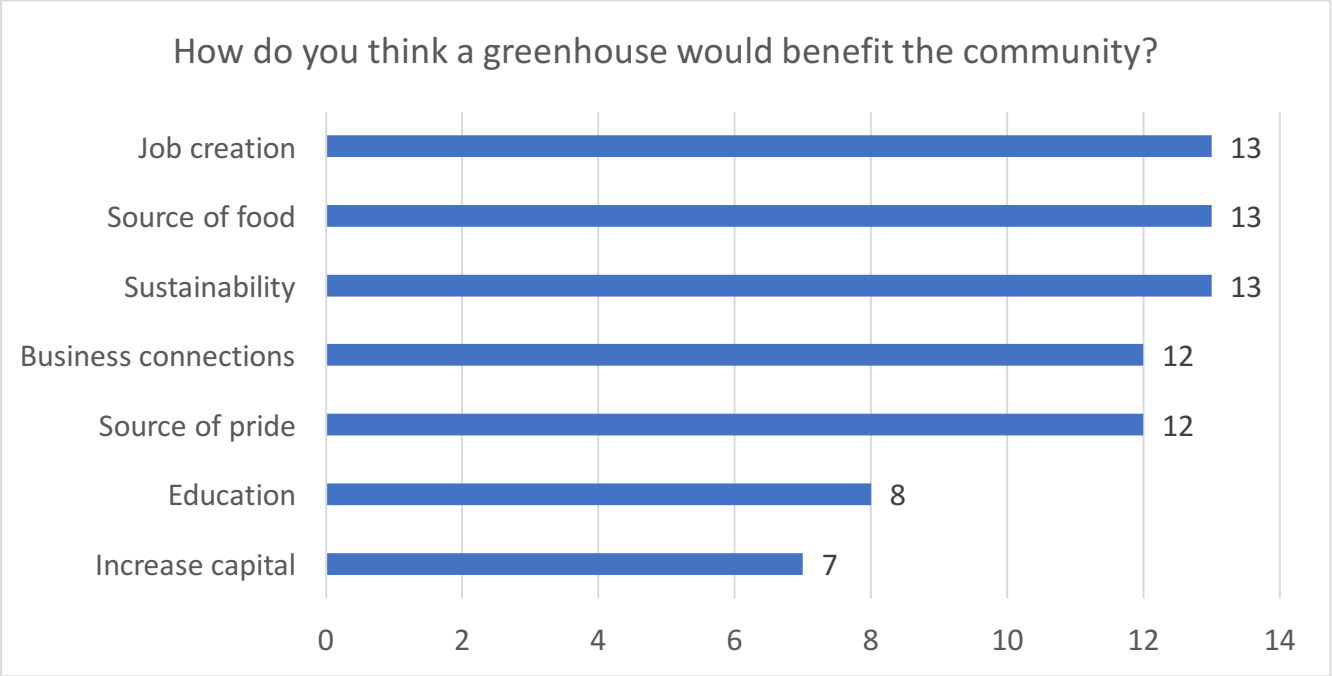
Appendix R: Hapū Member Survey – Raw Results

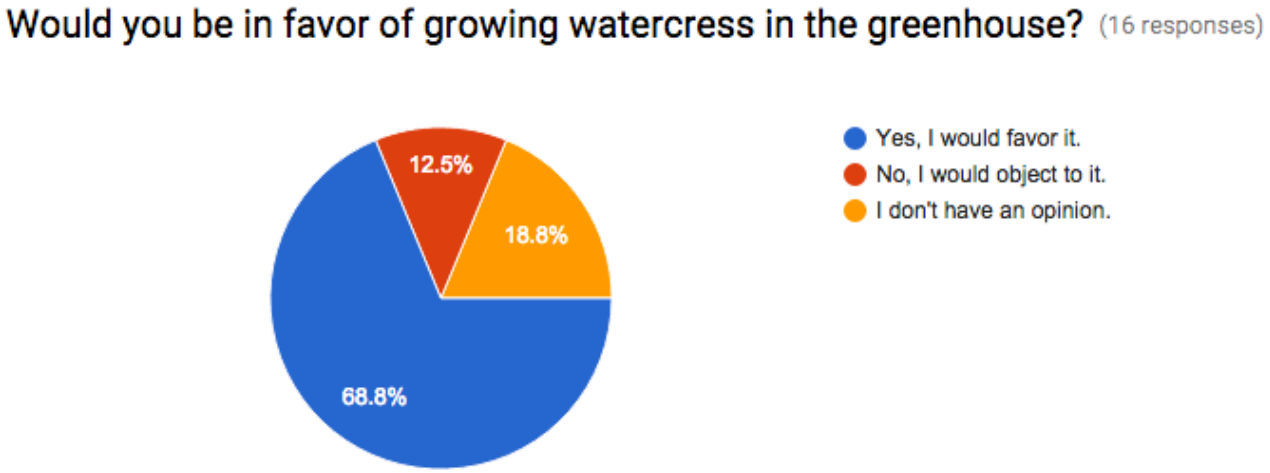
Are you a member of the hapū? (16 responses)

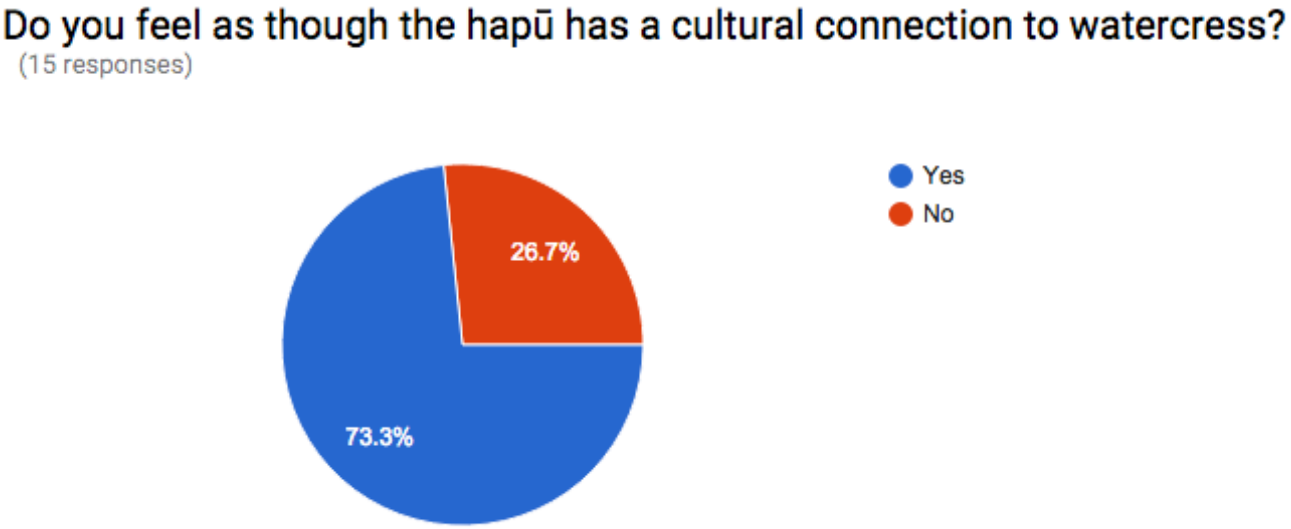


Do you think a greenhouse would benefit the community? (15 responses)




How do you think a greenhouse would benefit the community?
Job creation
Source of food
Sustainability
Business connections
Source of pride
Education
Increase capital
13
13
13
12
12
8
7
0
2
4
6
8
10
12
14


Would you be in favor of growing watercress in the greenhouse? (16 responses)
12.5%
18.8%
68.8%
Yes, I would favor it.
No, I would object to it.
I don't have an opinion.


Do you feel as though the hapū has a cultural connection to watercress?
(15 responses)
26.7%
73.3%
Yes
No

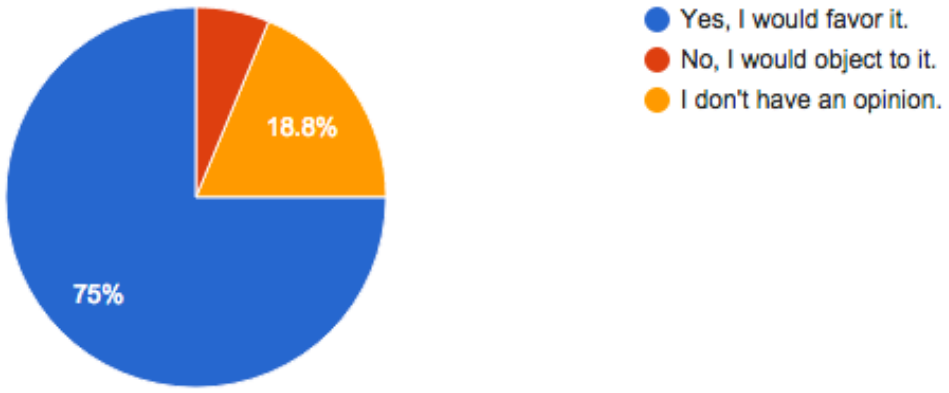
If you are in favor of growing watercress, why? (5 responses)

Healthy kai which many Maori love to eat
Watercress would be a great opportunity to begin from. Healthy source of kai for the hapu
easy to grow, good plant for aquaponics, people eat watercress
Sustainable food source, teach how to use and grow it. A safe food source free of contaminants.
Healthy Māori Option

If you would object to growing watercress, why? (4 responses)

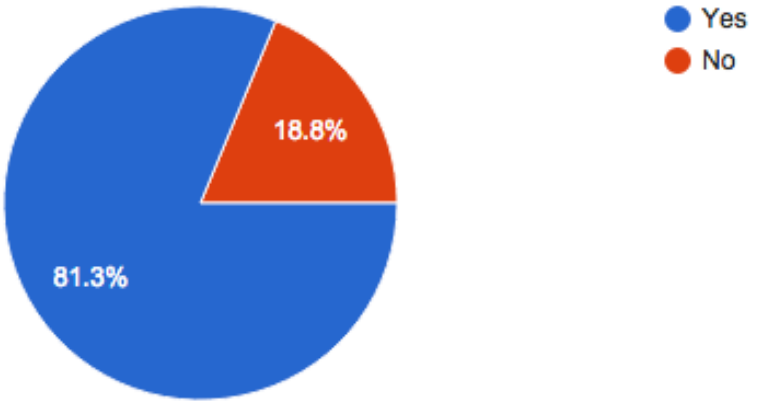
n/a
I would object if research showed growing watercress produced negative effects on the environment or require a resource we don't readily have available or can afford
Harakeke would be a better option teaching the art of weaving
there are more high quality/price plants which would make more money

Would you be in favor of growing koura in the greenhouse? (16 responses)



Do you feel as though the hapū has a cultural connection to koura?

(16 responses)



If you have any other thoughts you'd like to share with us, we'd love to hear from you.

(5 responses)

Great initiative, both the micro-hydro power system and a greenhouse, proud to be Ngāti Kea Ngāti Tuara. Would growing the watercress and the koura complement each other? as in an aquaponics system http://www.motherearthnews.com/organic-gardening/aquaponic-gardening-growing-fish-vegetables-together.aspx
I would like to see a greenhouse at Horohoro and at Tuara so that both groups can benefit from the greenhouse etc. Would be great to see Tuara community contributing to a greenhouse.
I remember my great grandmother taking my cousins to teach them how to catch koura. It would be good for all generations
Would be great to see the hapū getting involved with sustainability processes rather than cultivation for commercial benefit.
Investigate many more options to put in front of the hapu for feedback. Nga mihi

If you would object to growing koura, why? (2 responses)

It is Maori land we don't have a right to take from its natural habitat.
would have to check waste generated and what happens to it

Appendix S: Maintenance Manual for NKNT's Micro-hydro Power System

Maintenance Manual for NKNT's Micro-hydro Power System

Created from a participant observation with Mr. Riki Oneroa

Background

The three turbines currently produce 2.7 kilowatts when functioning properly. If the inverter (Figure 6) reads much less than this, often 2.5 kW or less, debris is blocking the system's intake screen or more substantial foliage has made its way into the turbines, halting their production. The following paragraphs outline what to do in varying scenarios.

Inlet Congestion

The screen guarding the intake of the system requires regular clearing. Currently one must clear debris from the system daily, although it may require more attention depending on the weather and season. Debris from upstream is especially high during the fall season, during which the system requires bi-daily maintenance to maintain energy production. Figure 1 shows foliage clogging the intake screen before it has been cleaned. One must wade into the river to remove the debris by hand, as seen in Figure 2.

Figure 1: Up-close Look at the Debris

Figure 2: Removing the Debris

Turbine Congestion

If debris does surpass the screen and travel through the penstock to the headstock, it can often clog the turbines themselves. By closing the gate seen in at the intake (Figure 3) and allowing the water in the headstock to drain, a worker can remove each turbine for cleaning. Figure 4 displays Mr. Oneroa attending to one of the turbines after draining the headstock.

Figure 3: System Intake

Figure 4: Mr. Riki Oneroa Examining a Turbine

Weather Conditions

The system can operate normally in a "gentle rain". However, during heavy rain and flooding, the intake gate needs to be shut to avoid damage to the turbines. Sediment that gets churned up during a storm is abrasive to the turbines. After such a storm, the micro-hydro system should remain stopped to avoid mud from entering the system. During these inactive circumstances, the inverter must be switched off and power from the grid be switched on, so that the hapū still has access to the electricity it needs. Mr. Onera has posted the shut-off procedure for the turbines is posted on the wall near the inverter. The instructions with corresponding pictures are below. The system is shut down most during the winter months (June, July, August), during which the most rainfall occurs.

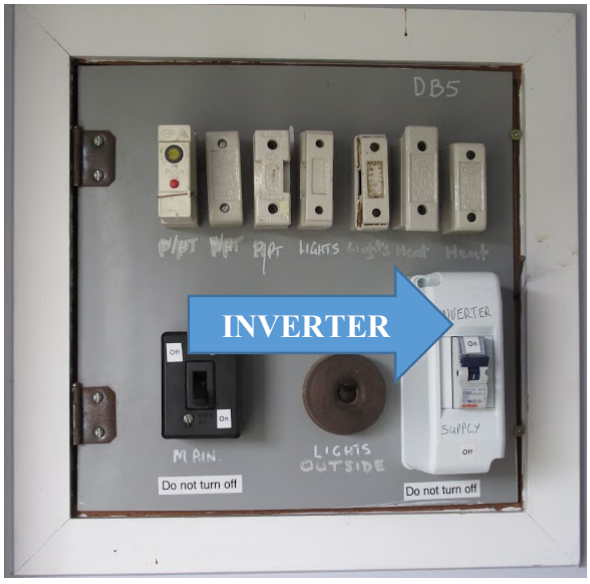


Figure 5: Distribution Board

Turbine Shut-Off Procedure

1. Turn off the Inverter A.C. Main Switch at distribution board near inverter (see Figure 5).
2. Turn off the AC and DC switches on bottom of inverter (pull out to lock if required) (see Figure 6).
3. Turn off the 3 turbine breakers located beside the hydro turbines.
4. Stop water flow by closing intake gate.

Figure 6: DC and AC Switches on Inverter

Figure 7: Intake for System