Planning for Climate Change Impacts on Māori Coastal Ecosystems and Economies:

A Case Study of 5 Māori-owned land blocks in the Horowhenua Coastal Zone

Planning for Climate Change Impacts on Māori Coastal Ecosystems and Economies: A Case Study of 5 Māori-owned land blocks in the Horowhenua Coastal Zone

* Derrylea Hardy[1]
Aroha Spinks[2]
Jane Richardson[1]
Moira Poutama[2]
Murray Patterson[1]
Huhana Smith[3]
Martin Manning[4]

[1]School of People, Environment and Planning, Massey University; [2]Huia Te Taiao;
[3]Whiti o Rehua School of Art, Toi Rauwhārangi College of Creative Arts, Massey University, Wellington; [4]Independent Contractor.

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Ko ngā mahi ō inaianei, hei oranga mō apōpō

For the communities of tomorrow, who shall benefit from our efforts today[1]

[1] https://www.deepsouthchallenge.co.nz/

Horowhenua Coastal Climate Change Research Team (Project C01X1412)

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Palmerston North

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EXECUTIVE SUMMARY

This report summarises the research undertaken in the research project, 'Risk Management Planning for Climate Change Impacts on Māori Coastal Ecosystems and Economies' (C01X1412), which was undertaken from August 2017 to June 2019, with Māori coastal communities in the Horowhenua. It follows on from Phase 1 of this research, entitled 'Adaptation Strategies to Address Climate Change Impacts on Coastal Māori Communities' (CO1X1445).

Funding for this research came from the Vision Mātauranga programme of the Deep South Te Kōmata o Te Tonga National Science Challenge. In this project, our research team explored adaptations to address the impacts of climate change on coastal communities. The research sought to provide Māori coastal land owners with information, capability and tools to enable them to envisage adaptation strategies that are economically, environmentally and culturally sustainable; and will enhance and restore Māori cultural relationships to the coast, in the face of likely impacts from climate change.

The project was organised around wānanga, hui, hīkoi and an exhibition with stakeholders and the research team, as a way of co-producing and communicating new knowledge and capability to identify, respond and adapt to potential climate change impacts. The research team engaged with Māori land owners in the Horowhenua flood plain and coastal region between Ōhau River and Waikawa River. In early stages of this research, the research team explored with land owners the key findings from the Phase 1 project (2015-2017). This included the potential effects of projected climate change impacts on the case study rohe, the recommended adaptation pathway (Protect, Adapt/Anticipate, Retreat; see Appendix B), and exploration of the expansion of wetlands on Tahamata Incoporporation farm and linking to Incorporation of Ransfield's contiguous wetland.

Discussion with land owners then identified the following Preferred Land Use Adaptation Options for focussed research in Phase 2:

1) Use of harakeke as a means of income generation from production of harakeke-sourced products, particularly fine fibre products from muka;
2) Riparian planting and other water quality enhancement activities to increase the abundance of taonga species (e.g. tuna and īnanga) for customary take purposes, and potential commercial sale in the future; and
3) Construction of sustainable papakāinga (housing).

The research team explored each of these preferred Land Use Adaptations, to assess the degree to which they would increase the resilience of the case study farms to cope with the likely climate change impacts that are increasingly occurring in the rohe. These factors include increased inundation from sea level rise; increased frequency and intensity of flood events with resultant damage to coastal land, waterways and infrastructure; increased erosion; and increased "wetness" of soil resulting in more areas being puggy and/or returning to wetlands over time. All of these factors negatively impact on the suitability of current land use practices on various areas of farm land. The alternative land use adaptations were explored in terms of their enhancement of socio-cultural and ecological values, as well as the economic contribution they could make. The research identified the establishment process, associated set-up and maintenance costs and potential revenue streams for the harakeke and kaimoana options, as well as a broad overview of papakāinga and how they could complement other adaptation options.

As the research progressed, it became apparent that harakeke and taonga species-based industries at the local small-scale level are niche markets, for which additional research is required to gain detailed business case feasibility data. The information that is known for each option is summarised in the report, and recommendations made for ongoing research.

Using the available data, a risk assessment tool was developed that, given local conditions, aids Māori communities to assess the risks and benefits associated with alternate coastal land use adaptation strategies. This decision-making tool drew on the Mātauranga Māori, Climate Change/ Geomorphology and Ecological Economics research conducted previously in Phase 1. In this Phase 2 project, the risk assessment tool was applied to analysing the economic benefits across the value chain for the production of high-grade harakeke fibres for high-end clothing products. Such use of the risk assessment tool highlights the uncertainties and risks involved in such ventures, and it is presented as a tool that could be applied in the future to other products apart from high-grade harakeke fibre products. It can assist stakeholders to assess the risks and value trade-offs between various alternative land use options, to address climate change impacts for their rohe. The risk assessment tool can be used as a reliable platform to assess various 'what if' scenarios such as, for example, 'what if' the price of harakeke leaves falls from 52 cents a kilogram to 32 cents a kilogram? The learnings from this assessment of the harakeke fine fibre production value chain can be applied to other adaptation options. Inferences are made on the impact of planting riparian margins on water quality and resultant abundance of freshwater taonga species.

Transition Action Plans were then co-developed with land owners, to guide the implementation of their Preferred Adaptation scenarios. Explicit consideration of iwi and hapū perspectives was critical to a clear sense of inter-generational stewardship as an active exercise of kaitiakitanga. It is important to note that maximising economic return is not necessarily the primary consideration when assessing alternative land uses for Māori coastal land, and cultural and ecological considerations can in some cases be of equal or greater importance. This understanding must be taken into account when 'trade-offs' are required in land use decision. Thus, Transition Action Plans for adaptation to climate change must be holistic and sensitive to the fact that cultural and economic needs of whānau will vary and a "one size fits all" approach is inadequate. The report recommends key factors that coastal Māori communities should consider when developing Transition Action Plans for their rohe and local conditions. An overview of key findings and recommendations for ongoing research are also provided in the final chapter. It is hoped that this report will also be of assistance to other coastal groups attempting to adapt to changing conditions in the face of climate change.

Contents

ACKNOWLEDGEMENTS

We would like to acknowledge and thank the whānau who participated in this research from the five Māori land blocks included in the study – Te Hatete Trust, Gardiner Lease Block, Taratoa Pekapeka Block, Incorporation of Ransfield's farm and Tahamata Incorporation. We would also like to acknowledge and thank the many other people, groups, kura children and other researchers who joined us at various hui, wānanga and hīkoi, as well as those who participated in and attended the exhibition at Māorilands in January, and at other activities associated with this project, as outlined in Chapter 3 of this report.

1 INTRODUCTION

1.1 Overview and Project Funding

This report gives an account of the research project entitled, *Risk Management Planning for Climate Change Impacts on Māori Coastal Ecosystems and Economies* (C01X1412). The report provides the stakeholders and funders of the project with an overview of how the project was conducted and the main research findings. It is also hoped that the research findings are beneficial to other Māori coastal communities throughout New Zealand who are grappling with the impacts of climate change in their rohe, and considering how they can adapt to be resilient and better prepared.

The Deep South Te Kōmata o Te Tonga National Science Challenge (NSC)[2] is hosted by the National Institute of Water and Atmospheric Research (NIWA). It has a mission to enable New Zealanders to adapt, manage risk and thrive in a changing climate. The Deep South NSC is working to understand the role of the Antarctic and Southern Ocean in determining New Zealand's future climate and the impact this role has on key economic sectors, infrastructure and natural resources.

This research is funded by one of the five programmes in the Deep South NSC – "*Vision Mātauranga"* – which aims to strengthen the capacity and capability of iwi/hapū/whānau and Māori business to deal with climate change impacts, risks and adaptation; Ko ngā mahi inaianei hei oranga mo rātou apopo. The five strategic elements of the *Vision Mātauranga* (VM) programme are: Kaupapa Māori research principles; governance Māori; engagement, collaboration and partnerships; research capability, capacity and leadership; and transformative context and future-focused research. Vision Mātauranga science projects are built around four research themes:

i) Understanding climate change - linkages, pressure points and potential responses;
ii) Exploring adaptation options for Māori communities;
iii) Assistance to Māori businesses to aid decision-making and long-term sustainability;
iv) Products, services and systems derived from mātauranga Māori.

In early-2017, the Deep South NSC released a Request for Proposals for VM research, for projects to be conducted over an 18-24 month period, with funding available for up to $250,000 + GST per project. Our research team applied for funding to continue our Phase 1 research[3], and was granted $300,000 + GST for a project of 18 months duration, from August 2017 to Jan 2019[4]. The project was designed to fit the following Deep South NSC theme: Exploring Adaptation Tracks for Māori Communities, but also relates to aspects of all of the Deep South NSC Vision Mātauranga Themes.

[2] See http://www.deepsouthchallenge.co.nz/programmes

[3] See: Smith, H., Allan, P., Bryant, M., Hardy, D., Manning, M., Patterson, M., Poutama, M., Richards, A., Richardson, J., Spinks, A. (2017). Adaptation Strategies to Address Climate Change Impacts on Coastal Māori Communities in Aotearoa New Zealand: A Case Study of Dairy Farming in the Horowhenua–Kāpiti Coastal Zone. Massey University, Palmerston North. Retrieve from: https://www.deepsouthchallenge.co.nz/projects/climate-change-coastal-maori-communities and https://www.deepsouthchallenge.co.nz/projects/risk-management-maori-coastal-assets

[4] Note that a 3-month extension was granted to the research team to enable completion of final outputs, and wānanga with stakeholders.

1.2 Research Aims and Approach

The aim of this research was to contribute to a framework for resilience in coastal Māori farming communities by identifying culturally-informed climate change adaptation strategies, taking the economic, environmental and cultural implications into consideration.

The project also sought to build Māori capacity to proactively and productively adapt to climate change, leading to new processes of effective social engagement for dealing with this issue.

Because of their relationship to the whenua, Māori have the potential to act as role models for other coastal farms in New Zealand. Thus, it is intended that the learning from this research may be applicable to other Māori faming coastal communities throughout New Zealand who are also tackling the impacts of climate change both now and into the future.

This cross-cultural, inter-disciplinary, collaborative, participatory action research project was designed around wānanga, hui, hīkoi and exhibition to bring together whānau land owners, stakeholders and the research team, as a way of co-producing new knowledge and capability to identify, respond and adapt to potential climate change impacts. The research team attempted to be as responsive as possible to end user priorities. There was therefore some iteration between the planned research phases, to enable findings to be explored with the local community.

The research team explored three adaptation options for participating case study farms, as prioritised by land owners and whānau. We did, however, identify numerous additional possibilities that can be further assessed in future research. The adaptation options assessed in this research were: harakeke, fisheries, and papakāinga developments. A comprehensive economic analysis of producing fine fibre from harakeke was undertaken, the learnings from which can be applied to other adaptation options. Inferences are made on the impact of planting riparian margins on water quality and resultant abundance of freshwater taonga species.

The final phase of the research involved a wānanga with the research team and landowners to consider the findings of this research and co-develop Transition Action Plans. These Transition Action Plans are living documents that should be adapted, built upon and developed in more detail as more information is gained and government policy adapts to meet the needs of coastal communities in the face of climate change.

An initial Transition Action Plan framework was developed by firstly considering the land use adaptation options that were preferred by landowners; i.e., harakeke, fisheries and papakāinga. Spatial mapping was undertaken, based on geomorphology and other physical conditions in the landscape, of what stepped changes could be made to the case study land blocks, to address inundation from sea level rise, flooding, and other climate change impacts.

Consideration was also given to Mātauranga Māori about harakeke, fisheries and papakāinga in this rohe. We also researched the activities of other entities around the country that are currently utilising harakeke, fisheries and papakāinga for ecological/cultural restoration and/or income-generation. Related research about climate change impacts and adaptations was also explored. A draft Transition Action Plan framework was thus discussed with landowners, and further co-developed with input from landowners at wānanga, before being finalised.

The detailed methods employed for the spatial mapping and ecological economics research that contributed to the Risk Assessment Tool and the Transition Action Plans are included at the beginning of those chapters, respectively.

1.3 Geographic Location of the Research

The study sites are located on the coast between the Ōhau River and the Waikawa Stream in the Holocene coastal dune belt that extends from north of the Manawatū River to Paekakariki. The coastal plain consists of a sequence of dunes and interdune peat swamps and lakes orientated parallel with the present day coast. The area is significant because this extensive flood plain supported valuable wetlands, for Māori communities in the region. In the early 1900s, 98% of these wetlands were drained for agricultural purposes, with increased dairying within the last 40 years. Māori farms in this region currently adopt industrialised, intensified farming practices because they are deemed profitable, despite downturns in the dairy market. Overall, such monocultural uses of Māori land holdings come at great environmental cost which, when coupled with the unpredictability of future climate change impacts, make these floodplain communities and their landholdings particularly vulnerable.

Below is a historical map of the region, from 1931.

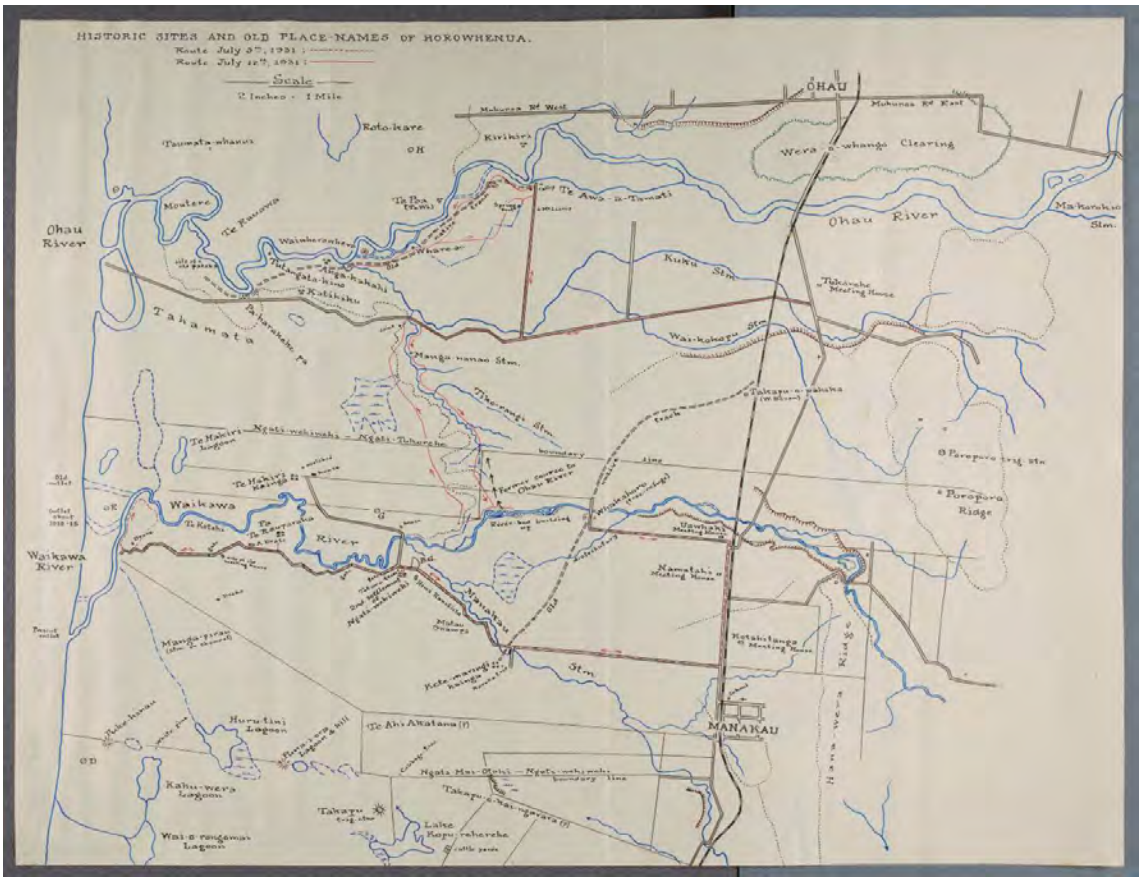


Figure 1.1 Historical map of the region, 1931. Source: Adkin[5]

Please refer to Chapter 4 for more information about the cultural significance of this rohe and the customary values and uses of the land. Also see additional maps of the area and the location of the land block case studies in this project, in Figures 5.1 – 5.3.

[5] Historic 1931 map of the Manakau area by George Leslie Adkin. Reference: Alexander Turnbull Library, Adkin Album 13, PA 1-q-002-27-map. Cited in H Potter, A Spinks, M Joy, M Baker, M Poutama, D Hardy (2017). The Porirua ki Manawatū Inland Waterways Historic Report, CFRT, pg 656.

1.4 The Horowhenua Coastal Climate Change Research Team

The research team was predominantly the same as for Phase 1, and included very experienced kaupapa Māori and action research experts and designers, climate change scientists and ecological economists, with a proven track record in successful complex cross-cultural, collaborative research projects. For example, Manaaki Taha Moana (MTM) (MAUX0907) received a gold rating from MBIE in 2014, and Phase 1 of this project, also funded by the Deep South National Science Challenge (CO1X1445) in 2015, was also favourably reviewed.

The co-leaders of the project were Professors Huhana Smith and Murray Patterson. Huhana Smith, Head of School Whiti o Rehua School of Art, Toi Rauwhārangi College of Creative Arts at Massey University, was the Research Leader Māori for the project. Murray Patterson is an Ecological Economist in the School of People Environment and Planning at Massey, who oversaw the ecological economics research and the development of the Risk Assessment Tool that helped inform the Transition Action Plans.

Working alongside the Māori Coastal Landowners, end users, stakeholders and community local experts, were iwi and hapū researchers from the rohe. These included Dr Aroha Spinks and Moira Poutama (Huia Te Taiao Ltd), who coordinated and led hui with landowners involved in the research, contributed Mātauranga Māori knowledge, investigated alternative land use options that were identified by landowners, and contributed to the written publications and the Māorilands exhibition. As for the Phase 1 research, Moira Poutama and Aroha Spinks were the Kairangahau/Iwi Researchers. Moira and Aroha explored harakeke, fisheries and papakāinga research, and organised the exhibition.

Derrylea Hardy led the research proposal development, managed the project, contributed to the research for the harakeke and fisheries land use options and the development of the Risk Assessment Tool, drafted the Transition Action Plans and Final Report, and contributed to the Māorilands exhibition and other outputs.

Dr Jane Richardson led the geomorphology and spatial mapping research, assessing factors such as the geomorphology, hydrology and soil type data of the case study rohe to produce maps that revealed which parts of the rohe would be most susceptible to climate change impacts associated with sea level rise and increased flooding events, over time. She then developed maps showing the location of adaptation options in the rohe, as the basis for Transition Action Plans, which were displayed at the exhibition, and contributed to all outputs.

Professor Martin Manning was an independent contractor to the project who was part of the IPCC Working Group I, NZ Climate Change Research Institute; he contributed current knowledge of climate change science to the project, including an up to date summary for the Exhibition and this report.

1.5 Other Outputs from this Project

This project worked with Māori coastal landowners to address the implications of climate change on their land, following on from the Phase 1 project[6]. In this research, we considered the

[6] See: Smith, H., Allan, P., Bryant, M., Hardy, D., Manning, M., Patterson, M., Poutama, M., Richards, A., Richardson, J., Spinks, A. (2017). Adaptation Strategies to Address Climate Change Impacts on Coastal Māori Communities in Aotearoa New Zealand: A Case Study of Dairy Farming in the Horowhenua–Kāpiti Coastal Zone. Massey University, Palmerston North.
Retrieve from: https://www.deepsouthchallenge.co.nz/projects/risk-management-Māori-coastal-assets

interdependence between cultural, economic and ecological issues to explore practical, culturally appropriate adaptive and diversified land use practices better suited to the changed conditions that are likely to result due to climate change impacts. Different land uses were explored the stakeholder groups that engaged in the research, but which are applicable across the rohe and throughout the country.

Transition Action Plans for the land blocks in the case study were explored, based upon the financial, ecological and socio-cultural information available to us about the preferred land use adaptation options. These plans can be updated as government policies related to climate change are implemented, more information comes to hand about the business case for investing in alternative land-based economic activities, and the impacts of climate change are increasingly felt on the land. These diversified practices and action plans will help Māori farming communities be more self-reliant, less vulnerable and therefore more resilient. The remainder of this report explores the development of these plans.

In addition to multiple wānanga/hui, this report is one of the main outputs required by the funder of the project, as described above. A number of additional outputs were also produced, including presentations at conferences in New Zealand and overseas, to communicate the research methods and findings. An exhibition at Māorilands Hub in Ōtaki was held in January 2019, which was another innovative means of communicating the research findings with end users, stakeholders and the local community. This built on the Phase 1 method of using art, visual culture and design to bridge the science complexities of climate change. Additional reports and journal articles are also underway to further explore the various findings of the study. The reports will be shared through libraries in the research rohe, the National Library and University libraries throughout New Zealand to foster widespread dissemination of research findings. Copies can also be downloadable from the Deep South National Science Challenge website (https://www.deepsouthchallenge.co.nz).

The research project also intends to produce other material for land owners who participated in this study, such as maps or other tools, as deemed useful by those participants at the final wānanga with whānau and landowners.

1.6 Ongoing Research

From the outset, it was intended that this project would be one part of ongoing research that explores, with tangata whenua, the implications of what is required to adapt livelihoods to the reality of climate change impacts on the coastal zone. We aim to extend this research further, including through the examination of ways for Māori communities to transition to a carbon zero economy, with a focus on energy transitions through things such as ‘off the grid’ papakāinga. Other possibilities include the implementation of harakeke planting (based on furthering the proof of concept of taking muka (extracted and processed harakeke fibre) to a spinnable thread for a sustainable fabric industry), and fisheries restoration initiatives.

1.7 Outline of the Report

This chapter has provided an overview of the background and aims of the research, the research funding, the location of the research case studies, the research team and the potential for continuation of this research. Chapter 2 provides an overview of the relevant climate change science and research conducted primarily here in New Zealand. The report then goes on to describe the stakeholder engagement processes that were undertaken, including with local whānau and land owners, other researchers and central or local government (Chapter 3). Chapter 4 outlines local Mātauranga Māori and focussed research that was undertaken for the three preferred adaptation

options – harakeke, fisheries, and papakāinga. The geomorphology and spatial mapping analysis are outlined in Chapter 5, which informed the Transition Action Planning. The ecological economics analysis to develop the Risk Assessment Tool is summarised in Chapter 6, with a comprehensive economic analysis applied to the development of a potential fine fibre industry from muka. Chapter 7 provides an overview of the latest Wai-o-Papa exhibition for this project. The issues considered in development of Transition Action Plans are outlined in Chapter 8, along with a summation of the key findings and recommendations from the research, including proposed ongoing research. Appendices are found at the end of the report.

Variance in tone and style between chapters of this report are reflective of the multidisciplinary nature of this research, which drew on a diversity of research knowledge bases, methods and reporting techniques.

2 CLIMATE CHANGE SCIENCE AND RESEARCH

Phase 1 of this research examined the most recent climate change science with a view to informing decision making about how Māori coastal communities could adapt for likely future impacts in the coastal zone. A summary of the climate change science that informed that Phase 1 research, prepared by the climate change science expert advisor on the research team, Professor Martin Manning, is included in the Technical Report that summarises the Phase 1 research[7]. He prepared a further summary update the public exhibition in Ōtaki in January 2019 (see Chapter 7), and this is presented in Section 2.1 below. Section 2.2 presents other relevant research and investigations into the impacts of climate change for New Zealand into the future, which also guided the development of the Transition Action Planning undertaken in this project.

2.1 Climate Change as at January 2019 – New Zealand and the World

Growing evidence for climate change was seen when NIWA reported that 2018 had our second highest average temperature on record, as evidenced in Figure 2.1 below.

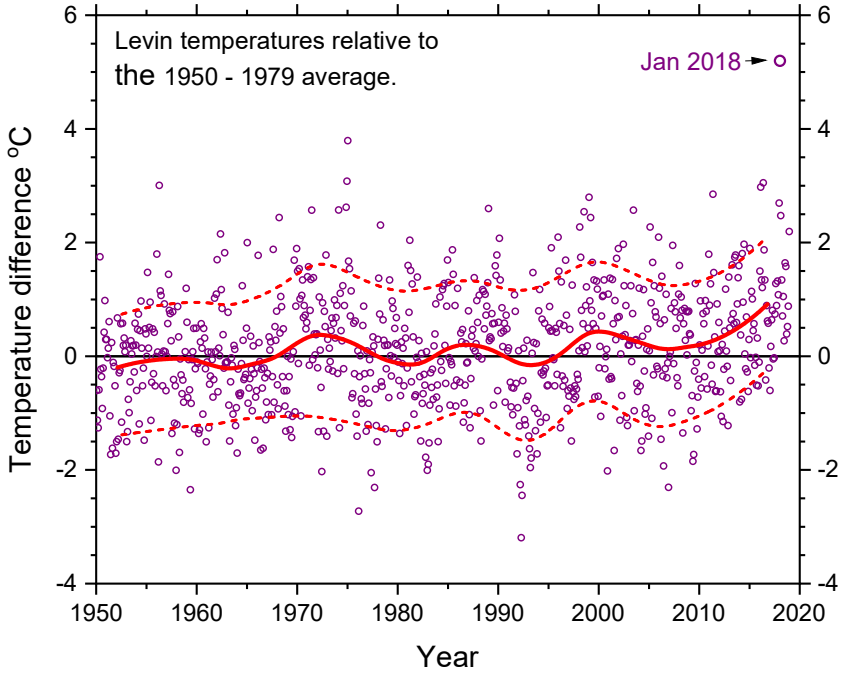


Figure 2.1 Levin temperatures relative to the 1950-1979 average. Source: NIWA 2018[8]

The warmest year, 2016, had a strong El Niño (ENSO) and this natural variability increases surface temperatures significantly, whereas 2018 was not an El Niño and almost as warm. The NIWA Annual

[7] Smith et al. (2017). Retrieve from: https://www.deepsouthchallenge.co.nz/projects/risk-management-Māori-coastal-assets

[8] Sourced from: https://www.niwa.co.nz/climate/summaries/annual-climate-summary-2018

Climate summary for 2018 gives more detail on the trends across New Zealand and on daily minimum temperatures warming more than daily maximum ones.

For the Horowhenua region, Levin monthly temperatures are shown here after removing a seasonal cycle of winter – summer differences. There is a lot of short-term variability but smoothed curves for the running averages and 10%-ile and 90%-ile are showing temperature increase becoming more significant after 2010. Also, January 2018 was by far the warmest month on record in New Zealand and that is seen very clearly for the Horowhenua region.

Figures 2.2-2.3 show the impacts of recent storm events in the rohe and surrounds.

Figure 2.2 Photo taken during recent storm showing destruction of Gita Cyclone on Centennial Highway or State Highway 1 in Kāpiti region, near Pukerua Bay, 2018

Figure 2.3 Image of low tide at Waikawa beach accessway taken out by Cyclone Gita in 2018[9]

However, it is becoming clear that the changes are much more than just an increase in temperatures. Severe wind and storm damage events made 2018 the second most costly year for the insurance industry, with the worst being just one year earlier[10]. Two major cyclones occurring in February, with coastal wave heights as high as 15 m, made some of New Zealand's vulnerability to these effects quite obvious.

Some aspects of climate change around New Zealand are moderated significantly by the ocean that acts as a huge heat sink. So, its effects have been both more obvious and more serious in many other places. For example, during December a heat wave across southern Australia made temperatures 10°C warmer than normal[11] while Queensland had both extensive wild fires and very heavy rain events in its coastal regions.

A recent review used 170 separate studies of these types of extreme climate events and showed that increases in atmospheric greenhouse gases was the predominant cause for higher temperatures, more drought, worse flooding, and the intensity of storm events[12].

The United Nations Paris agreement, of December 2015, indicated that governments would start to reduce greenhouse gas emissions and do this in ways that would keep the long term warming well below 2°C. But, so far, the nationally determined contributions (NDCs) for achieving this are known to be clearly inadequate[13].

To make matters worse, after four years when emissions of the dominant greenhouse gas, CO_2, had not changed by much, there was a significant increase (2.7%) during 2018[14]. While this is clearly a growing concern, there are also indications that the rapid decrease in costs for solar energy could

[9] https://waikawabeach.org.nz/2018/the-morning-after-ex-tc-gita/
[10] https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=12175720
[11] https://www.theguardian.com/australia-news/2018/dec/26/australia-heatwave-2018-weather-new-year
[12] Schiermeier, Q. (2018), Climate as Culprit, Nature, 560, 20-22.
[13] http://wedocs.unep.org/bitstream/handle/20.500.11822/26895/EGR2018_FullReport_EN.pdf
[14] Le Quéré, C., et al. (2018), Global Carbon Budget 2018, *Earth System Science Data*, *10*, 2141-2194.

still lead to net zero CO_2 emissions by 2050[15] in which case impacts may not get much worse, as seen in Figure 2.4 below.

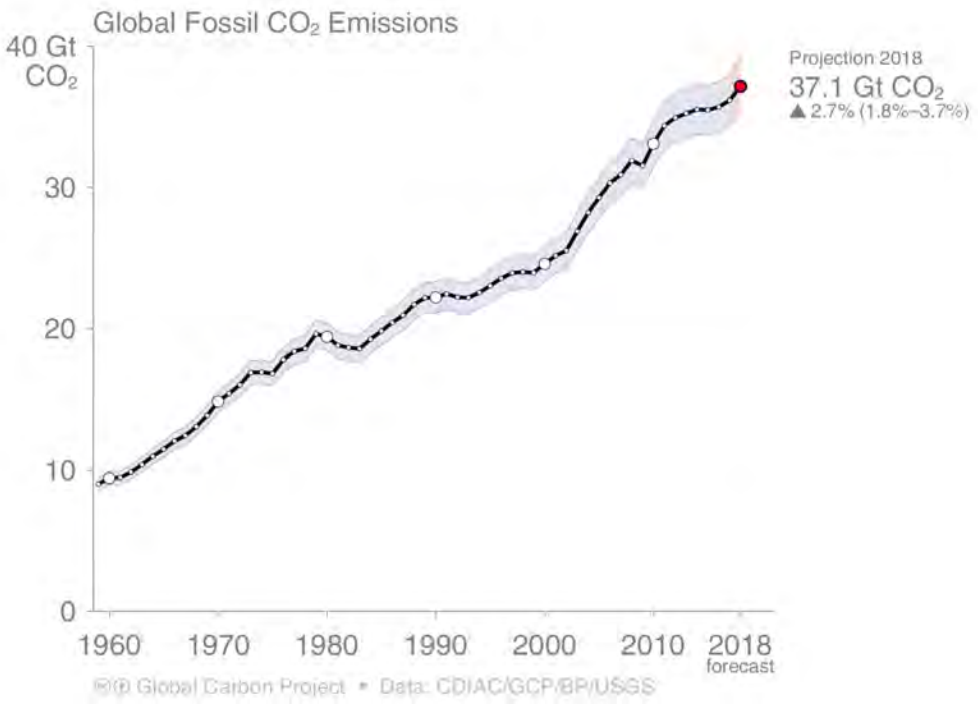


Figure 2.4 Global Fossil CO_2 Emissions, 1960-2018. Source: Figueres et al., 2018[13]

A 2018 Special Report by the Intergovernmental Panel on Climate Change (IPCC)[16] considered the target of limiting global temperature change to 1.5°C in response to a request from the United Nations. The final version of this report was released in November 2018 and concluded that current government NDCs would lead to a global average warming of about 3°C and, unless much larger emissions reductions took place well before 2030, the 1.5°C target would not be met.

[15] Figueres, C., C. L. Quéré, A. Mahindra, O. Bäte, G. Whiteman, G. Peters, and D. Guan (2018), Emissions are still rising: ramp up the cuts, *Nature*, 564, 27-30.

[16] IPCC, 2018: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

A key figure from that IPCC report is shown below, which makes clear that achieving this target would be much more feasible if methane emissions decreased by at least 35% by 2050.

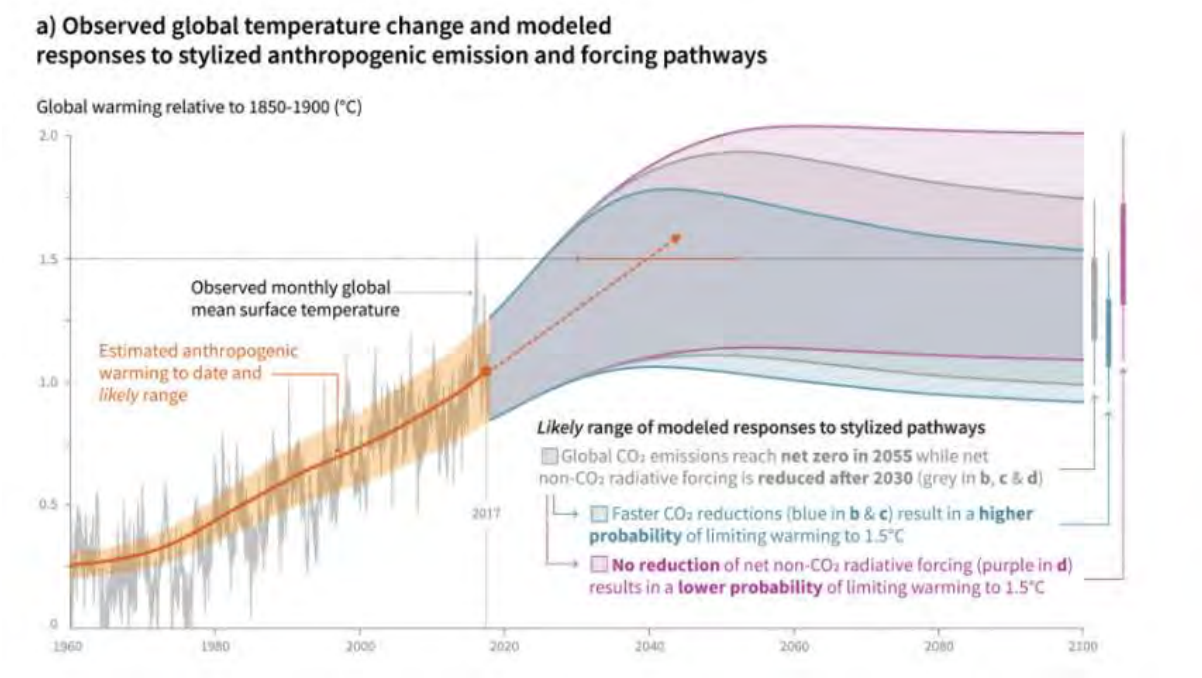


Figure 2.5 Global Temperature Change Projections for Stylised Anthropogenic Future Pathways Source: IPCC, 2018[14].

Rapid cuts in greenhouse gas emissions can definitely reduce the amount of long-term global warming. The science is also clear that this would reduce the rate of ice loss in Greenland and Antarctica that are currently making increasing contributions to sea level rise. However, it will take much longer for sea level to become stable again and a recent study has shown that large amounts of ice in both Greenland and Antarctica are expected to have tipping points in the range 1.5°C – 2°C above which there will be some irreversible ice loss[17].

Planning for New Zealand coastal changes, and identifying vulnerable areas, has to deal with much larger variability at a regional level than is seen in global mean sea level rise. For example, Figure 2.6 compares satellite data for regional sea level to the west of the Horowhenua coastline with that for the global average.

While the 25-year average rate for regional change (+6 mm/yr) is significantly larger than the global average, this occurs despite there being very little change for 12 years. Much larger variability in sea level at a 100 km scale is seen in five year average rates for this offshore Horowhenua region that vary from –12 to +31 mm/yr. While some of this can be related to El Niño Southern Oscillation and other natural cycles, it can also reflect shifts in a convergence zone between southward and northward moving water in the Tasman Sea. Given that increases of ~150 mm have already been seen over a five-year period, and that variability may be increasing, the time scale for adaptation to future changes clearly needs to follow a precautionary approach.

[17] Pattyn, F., et al. (2018), The Greenland and Antarctic ice sheets under 1.5 °C global warming, *Nature Climate Change*, 8, in press.

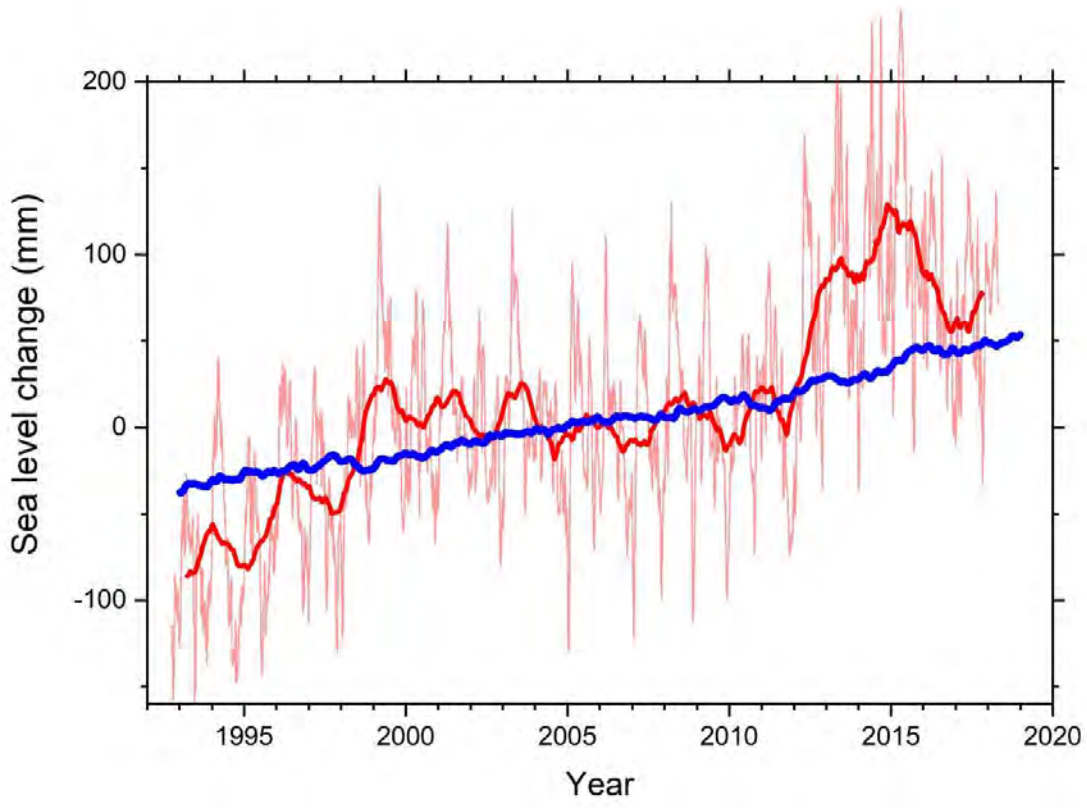


Figure 2.6 Satellite data for global average sea level (blue) is compared to that for the average over 5 locations to the west of the Horowhenua region (red) with 5-day average (thin line) and 12-month average (thick line) variations[18]

An analysis of coastal management strategies for New Zealand has developed a dynamic adaptive policy pathways (DAPP) approach, initially used in the Netherlands[19]. This has considered links between sea level rise, groundwater response, and the increase in extent and frequency of coastal flooding. The adaptation strategy identifies trigger points at which responses need to be taken and sets out an approach for New Zealand starting in 2021 where 10-year monitoring periods become used together with community engagement. A comparison of different New Zealand sites from that study, in Figure 2.7, shows three phases of response and for three different scenarios of future climate change. While there are differences between the scenario that keeps to 2°C (RCP2.6) and the worst case (RCP8.5), in some places these differences are small.

[18] Data have been taken from ftp://podaac-ftp.jpl.nasa.gov/allData/merged_alt/L4/cdr_grid and from https://climate.nasa.gov/vital-signs/sea-level/

[19] Stephens, S. A., R. G. Bell, and J. Lawrence (2018), Developing signals to trigger adaptation to sea-level rise, *Environmental Research Letters*, 13, 104004.

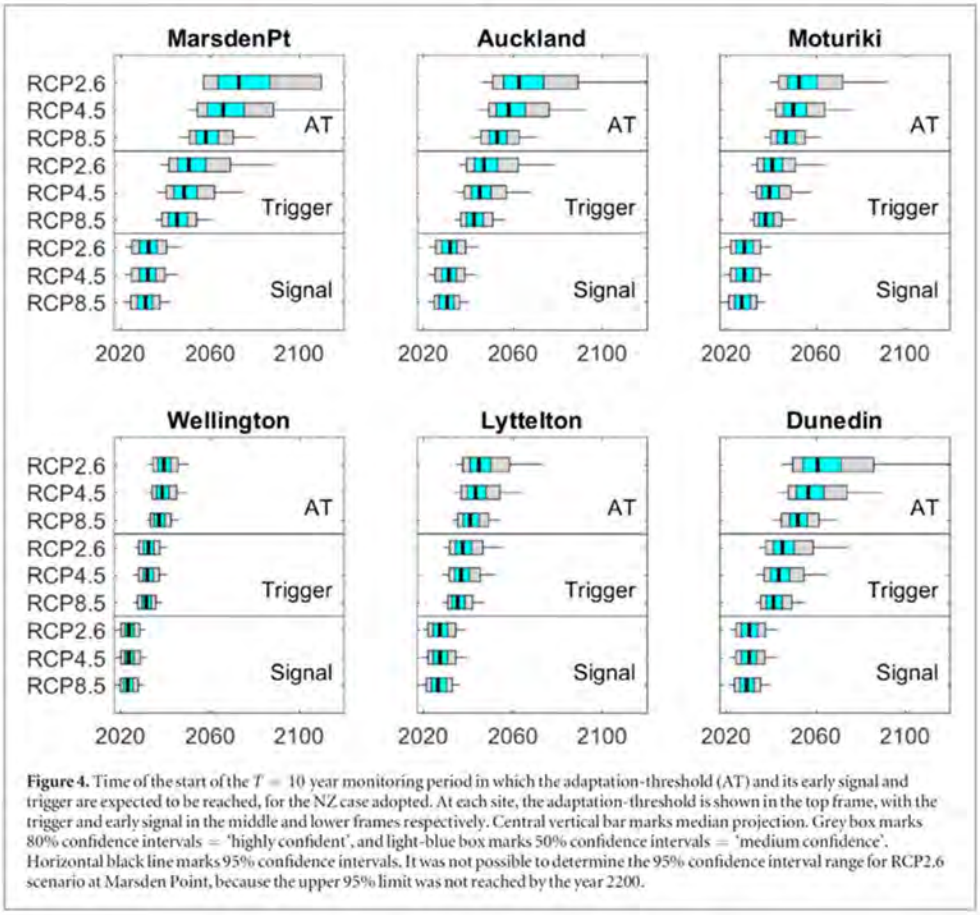


Figure 4. Time of the start of the $T = 10$ year monitoring period in which the adaptation-threshold (AT) and its early signal and trigger are expected to be reached, for the NZ case adopted. At each site, the adaptation-threshold is shown in the top frame, with the trigger and early signal in the middle and lower frames respectively. Central vertical bar marks median projection. Grey box marks 80% confidence intervals = 'highly confident', and light-blue box marks 50% confidence intervals = 'medium confidence'. Horizontal black line marks 95% confidence intervals. It was not possible to determine the 95% confidence interval range for RCP2.6 scenario at Marsden Point, because the upper 95% limit was not reached by the year 2200.

Figure 2.7 Trigger points at which responses need to be taken at different sites in NZ.
Source: Stephens et al.[19]

Research published in April 2018 by Zemp et al. (2019)[20] reveals that reveals glaciers here and worldwide have been having a larger impact on sea level rise than scientists first thought (see Figure 2.8).

[20] Zemp, M., et al. (2019). Global glacier mass changes and their contributions to sea-level rise from 1961 to 2016. *Nature*. https://www.nature.com/articles/s41586-019-1071-0
Also see: https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12220542

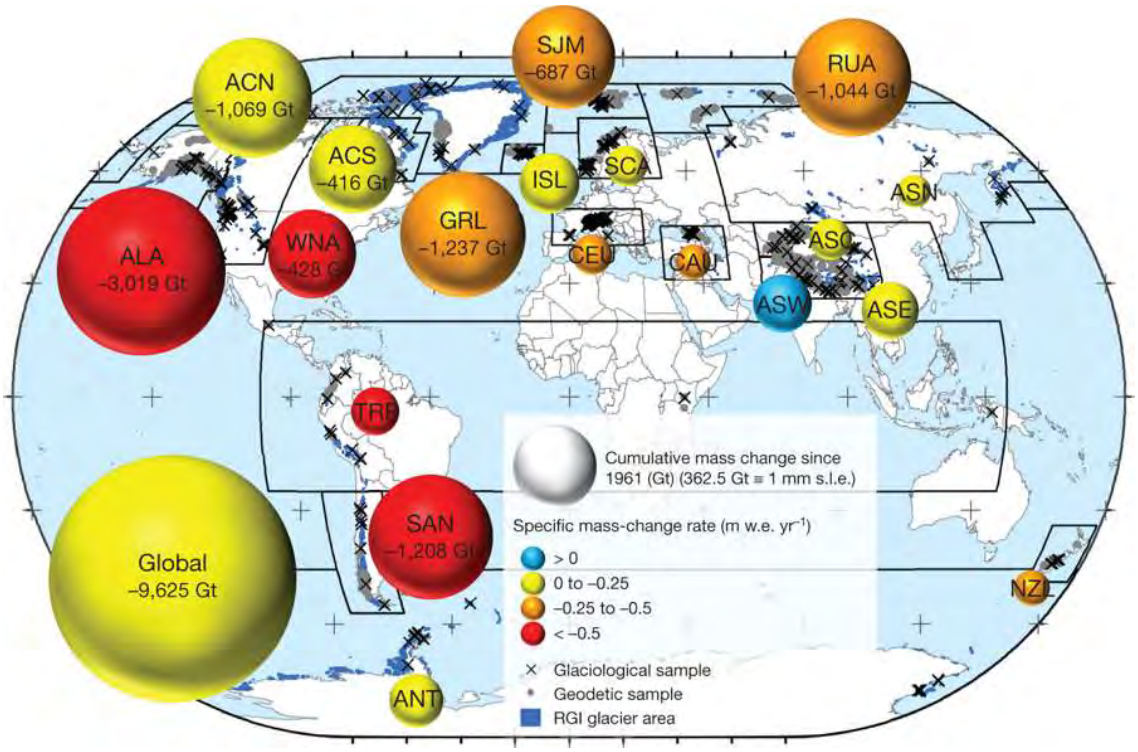


Figure 2.8 Regional glacier contributions to sea-level rise from 1961 to 2016[20]

According to Salinger et al. (2019)[21], New Zealand's glaciers have experienced a "huge loss" of ice in little more than four decades, under a trend only worsening with climate change. A third of the country's glaciers have melted and flowed into rivers since the late 1970s. As glaciers are extremely sensitive to shifts in temperature, scientists regard them as useful 'coalmine canaries' for climate change. Looking ahead, conditions like those the country saw in its record-hot summer of 2017/18 - which, according to Salinger, triggered the largest melt ever observed on the alps with the loss of a massive 3.6 cubic kilometres - would become typical.

This analysis for New Zealand sites suggests that those that are tide dominated will see the effects of sea level rise before those that have become naturally adapted to storm surges. This is quite relevant for the Ōhau coastline.

2.2 Other Climate Change Adaptation Research in New Zealand

To further inform transition action planning for our coastal communities, we assessed findings of other research being undertaken in New Zealand, and societal attitudinal changes as reported in the media. A summary is provided below, in an attempt to communicate the latest research findings to local communities, such as those we have engaged with in this research. It is hoped that this summary is helpful to other coastal communities who are attempting to grapple with the impacts of climate change in their rohe, and are working through adaptation processes to deal with it.

[21] Salinger, M. J., Fitzharris, B.B., Chinn, T. (2019). Atmospheric circulation and ice volume changes for the small and medium glaciers of New Zealand's Southern Alps mountain range 1977–2018. *International Journal of Climatology*. https://doi.org/10.1002/joc.6072.
Also see: https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12172299

Climate change research and its relevance to New Zealand is increasingly reported in the media[22],[23]. Indeed, there is a social and political groundswell to acknowledge the seriousness of climate change and its impacts both here and internationally. Businesses are increasingly realising the need to adapt; for example the Warehouse taking steps to offset their carbon emissions[24]. A recent article that is very pertinent to coastal Māori highlighted the impact of changing ocean acidity on kaimoana[25], asking if New Zealand's unique kaimoana can actually survive climate change. If ocean acidity levels continue to increase, this could threaten a sea food harvest worth at least $320 million a year to the economy, and centuries of cultural tradition[25]. A research consortium is examining this issue in relation to three species – pāua, snapper and greenshell mussels, with results yet to come.

Significant reports include the Stocktake of Climate Change Research[26], which revealed serious issues facing New Zealand, including impacts that may already be irreversible[27]. The Deep South National Science Challenge[28] has funded multiple projects, which explore various issues that New Zealanders will face due to the impacts of climate change. Key findings from those studies of relevance to this research were taken into account when developing Transition Action Plans, as outlined below.

2.2.1 Economics of Climate Change Risks Such as Flooding and Drought Events

In the coming decades, more and more New Zealand communities will be exposed to flooding and coastal erosion made worse by climate change. Some communities will be resilient but others may find the physical, social, financial or emotional consequences difficult to recover from. These climate change impacts are unlike other natural hazards because they will incrementally worsen over time - the Parliamentary Commissioner for the Environment called sea level rise a "slowly unfolding red zone"[29].

Drought brought on by increased temperatures and lack of rainfall has catastrophic impacts on stock, crops, the land, biodiversity, fire risk, people's health and wellbeing, and the economy. The current drought being experienced in Australia has been costed by the Commonwealth Bank at A$12 billion (NZ$12.5 billion)[30]. As global temperatures rise, the likelihood of a heat wave in New Zealand rises. Data shows conclusively that temperatures have already risen by 1°C in New Zealand over the 77 years 1931-2008, with 2018 being the country's warmest year since records began and the five warmest years on record have occurred in the previous 20 years[30]. The most obvious impact of heat waves and drought is on crops. However, livestock also have to be culled if the pasture cannot support high stock rates, and when the drought breaks, meat production falls as farmers rebuild their herds. Growing conditions on farms are very different depending on whether we have a La

[22] For example, see: https://www.stuff.co.nz/environment/climate-news/108819497/quick-save-the-planet-we-must-confront-climate-change?rm=m

[23] https://www.stuff.co.nz/environment/climate-news/113047555/new-report-paints-a-grim-picture-of-wider-manawat-environment

[24] https://www.stuff.co.nz/business/111289662/climate-of-change-big-business-sets-up-decarbonisation-funds

[25] https://www.stuff.co.nz/environment/climate-news/110574352/acid-seas-can-new-zealands-unique-kaimoana-survive-climate-change

[26] http://www.mfe.govt.nz/publications/climate-change/adapting-climate-change-new-zealand-stocktake-report-climate-change

[27] https://www.stuff.co.nz/environment/98020081/some-new-zealand-climate-change-impacts-may-already-be-irreversible-government-report-says

[28] See: http://www.deepsouthchallenge.co.nz

[29] http://www.voxy.co.nz/national/5/308878

[30] https://www.stuff.co.nz/business/farming/110619887/think-its-dry-spare-a-thought-for-our-aussie-neighbours

Nina or El Nino weather pattern. La Nina brings wet weather with more storms to eastern New Zealand while El Nino brings hot, dry weather particularly to east coast regions and, very often, droughts. If higher global temperatures hit New Zealand, we could be looking at hotter El Nino conditions than usual, which would affect our farmers and our food production[30]. Farmers are encouraged to plant trees to provide shelter for animals during increasing hot periods[31], and planting of natives along riparian corridors alongside waterways is one way to provide such stock cover and protect the integrity of waterways.

Likewise, increasingly severe and frequent flooding events significantly impact on people's homes, livelihoods and primary income sources. According to Walsh[31], floods are already the most frequent economically damaging natural hazard in New Zealand, and are projected to increase with climate change and sea level rise. Floods have caused almost $300 million in damages since only 2014 (not including the New Year floods of 2017/18 or more recent flooding), with particularly disruptive impacts on homes and farming[32]. The most common method of managing flood risk in New Zealand is through flood mitigation schemes, in which flood-related infrastructure is funded via targeted property rates and government budget. Walsh points out that many of these schemes were implemented last century, with mounting evidence that land use and population changes mean they're insufficient for future risk.

According to White[33], "the way climate change is predicted to affect our stormwater and wastewater will have a considerable impact on many aspects of NZ life, including health, disaster resilience, drinking water, ecology, and transport, not to mention how flooding or infrastructure failure will impact on communities". Much of New Zealand's storm- and waste-water infrastructure was not designed for the challenges climate change will bring, from sea level rise to the predicted changes in precipitation frequency and intensity. The asset value of stormwater and wastewater assets in New Zealand being well over $20 billion. This includes 24,000 kilometres of public wastewater networks with more than 3,000 pumping stations, and over 17,000 kilometres of stormwater networks[33].

A "risk census" of infrastructure by NIWA in 2015 found billions of dollars of infrastructure was in low lying areas that would be prone to flooding. They include nearly 70,000 buildings, 2000km of road, and five airports. The area carrying the most risk is Christchurch, followed by Hawke's Bay[34].

Likewise, New Zealand is not well-prepared to cope with a future involving more drought in some areas, and it may well have the single most significant future impact on the New Zealand economy[35]. Treasury estimated recently that droughts ranked number one for climate change-related costs[36]. Frame et al. (2018) estimated that the economic losses from droughts between mid-2007 and mid-

[31] https://www.stuff.co.nz/business/farming/110582797/waikato-farmers-encouraged-to-plant-trees-to-protect-stock-from-summer-heat
[32] https://www.deepsouthchallenge.co.nz/projects/flood-mitigation-schemes-are-they-working-flood-prone-areas
[33] https://motu.nz/our-work/environment-and-resources/climate-change-impacts/climate-change-and-stormwater-and-wastewater-systems/
[34] https://www.stuff.co.nz/environment/99843080/government-lacks-coordinated-plan-for-climate-change-withheld-report-shows
[35] https://motu.nz/our-work/environment-and-resources/climate-change-impacts/drought-and-climate-change-adaptation-impacts-and-projections
[36] https://www.deepsouthchallenge.co.nz/projects/drinking-water-drought-and-climate-change

2017 was $720 million[36]. The drought in 2012-2013, for example, cost the country $1.5b, and was an event partly influenced by climate change[37].

As climate changes into the future, water supply systems will have to be adapted accordingly, such as research into new sources of water, new technologies and storage capacities[38] and better management of water usage. We also need to consider more purposefully how we manage the quality and quantity of our current freshwater sources, so that we don't jeopardise them for the future.

The impacts of climate change on GDP, employment and personal incomes is also being investigated, including through research identifying risks climate change poses to the tourism sector and how all those involved with tourism can manage risks to the sector in New Zealand[39]. As coastal communities consider how to adapt land use practices in areas that may no longer be best suited to agriculture and other pastoral activities, another issues that needs to be considered is the role that tourism could play a role in supplementing incomes, especially in the case study rohe.

2.2.2 Socio-cultural and Health Impacts of Climate Change

Climate change is already having an enormous impact on human health, globally, with increased risks of malnutrition, dengue fever, vibrio and malaria having markedly increased around the planet. Increases in extreme weather events, which in 2017 numbered 712 events resulting in US $326 billion in economic losses, were bringing with them injuries and deaths, displacement, post-traumatic stress, and other short and long-term impacts to health[40]. Climate change is also driving migration in some regions, with significant geopolitical impacts.

New Zealand-based environmental and occupational health expert Professor Tord Kjellstrom, found hotter temperatures cost workers 153 billion productive hours in 2017, in turn impacting family incomes and agricultural output to compound the risks to health. The worst hit regions were India, southeast Asia, and sub-Saharan Africa, and South America, but Kjellstrom added impacts on New Zealand's labour force would also become more pronounced as heat levels climbed[40]. It is evident that soaring temperatures in New Zealand, and worldwide, will forever change the way we live[41].

A study published in the Lancet tracks 41 indicators across five key domains in health and climate change, made 3 key conclusions:

> IMPACT: Present day changes in heat waves labour capacity, vector-borne disease, and food security provide early warning of compounded and overwhelming impacts expected if temperature continues to rise.
>
> DELAY: A lack of progress in reducing emissions and building adaptive capacity threatens both human lives and the viability of the national health systems they depend on, with the potential to disrupt core public health infrastructure and overwhelm health services.

[37] https://www.stuff.co.nz/environment/99843080/government-lacks-coordinated-plan-for-climate-change-withheld-report-shows
[38] For example, see https://www.deepsouthchallenge.co.nz/sites/default/files/2017-10/0900%20Wednesday%20Matiu%20Daniel%20Collins.pdf
[39] https://www.deepsouthchallenge.co.nz/projects/culture-climate-change
[40] https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12168485
[41] https://www.radionz.co.nz/national/programmes/checkpoint/audio/2018629310/hotter-weather-will-change-new-zealand-forever

OPPORTUNITY: Despite these delays, trends in a number of sectors see the beginning of a low-carbon transition, and it is clear that the nature and scale of the response to climate change will be the determining factor in shaping the health of nations for centuries to come.

Local and indigenous people play a critical role in preserving biodiversity and ecosystems. Research by Bond et al. (2019)[42] found that plants traditionally used in Māori craft and medicine may become less available because of the effects of climate change. Climate change added to problems already being experienced due to polluted water and soil, invasive species, and habitat destruction, which are already causing people to have trouble finding the resources they need[43]. Plants may expand or shift their range as global temperatures continue to rise, but if they become inaccessible to the people who use them, ancient biocultural connections could be lost, as reduced local access to species is typically associated with a loss of biocultural knowledge[43].

Climate change-mediated shifts in the ranges of these species are likely to affect intergenerational human-environment relationships, sense of place, cultural identity and knowledge on a regional scale, as well as cultural identity and social cohesion on a national scale. Bond et al. state that ecological changes are a critical issue for indigenous people around the world because they transform resource availability and landscapes in ways that affect cultural identity, knowledge, sense of place, and social cohesion. It may be necessary to transfer important plants to other accessible habitats that have less drastic climate impacts. By doing this, future generations may continue to harvest these plants and maintain their biocultural heritage[43].

2.2.3 Addressing the Burden of Risk – Public and Private Sector Policy and Initiatives to Support Climate Change Adaptation

It is critical that government incentives at the central, regional and local level work together to provide incentives that collectively encourage transformative changes for resilience. This is imperative because, as the effects of these changes become more frequent through flooding, coastal inundation and drought, we'll have less time to recover and there will be cumulative consequences[44]. Over 300,000 New Zealanders live below three metres of land elevation, putting them in danger from sea level rises[45]. This requires us to look at long term solutions, instead of short term stop-gap measures.

New Zealand's Climate Change Minister, has released a range of information about climate change issues, policy and adaptations required[46]. He acknowledges "future generations are at the mercy, or benefit, of policies we're putting in place today. So those policies need to take account of the clear warnings which reports like 'Global environmental consequences of twenty-first-century ice-sheet melt'[47] are giving us". With the longer term intention of setting up a Climate Change Commission[48],

[42] Bond, M.O., Anderson, A.J., Henare, T.H.A., Wehi, P.M. (2019). Effects of climatically shifting species distributions on biocultural relationships. People and Nature, 1(1), 87-102. Retrieved: https://doi.org/10.1002/pan3.15

[43] https://www.stuff.co.nz/environment/climate-news/111587449/climate-change-threatens-use-of-traditional-mori-plants--study-shows

[44] https://www.deepsouthchallenge.co.nz/projects/climate-change-cascade-effect

[45] https://www.newshub.co.nz/home/new-zealand/2019/02/significant-proportion-of-new-zealanders-under-threat-of-sea-level-rise.html

[46] https://www.beehive.govt.nz/portfolio/labour-led-government-2017-2020/climate-change

[47] https://www.nature.com/articles/s41586-019-0889-9

[48] https://www.stuff.co.nz/environment/climate-news/109366271/new-zealand-needs-a-climate-commission-that-can-act-independently-from-political-pressures;
https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12066123

an interim measure has been the establishment of a Climate Change Committee[49] to begin investigating how New Zealand will transition to a net zero emissions economy by 2050[50] and consider other matters such as how agriculture can be brought in to the Emissions Trading Scheme.

The Energy Efficiency and Conservation Authority also has a role in climate change policy and planning[51]. The government is also examining a range of possibilities[52] to resource adaptations, as outlined in its Climate Change Adaptation Technical Working Group's (CCATWG) report. The Climate Change Minister noted, "the problem would require an integrated response, involving central government, local body authorities, and the insurance and banking industries". He also stated that one of the risks that needs to be dealt with is some people may continue to make poor choices if there's a big pot of money sitting there to deal with the adaptation challenge, and they won't personally have to bear the costs of failing to prepare adequately.

In a world beset by climate change, the Māori Climate Change Commission[53] provides independent Māori-focused research and advice that will contribute to Aotearoa meeting its obligations under the 2015 Paris Agreement on greenhouse-gas-emissions (NZ's commitment is to reduce those emissions by 30% below 2005 levels by 2030). That research and advice will be based on a Māori world view, and will be available to Māori, to politicians, government agencies, media, other New Zealanders, and to the global community. The Commissioner will facilitate opportunities for Māori to learn about climate change, and programmes that will help Māori play their part in Aotearoa's campaign to clean up the world. Māori landowners attempting to adapt to climate change could engage with this Office regarding potential adaptations.

The Ministry for the Environment has some responsibility for addressing climate change, and the transition to a low carbon economy[54], with a summary of "what the government is doing" provided on their website[55]. They provided a summary of New Zealand's atmosphere and climate[56], greenhouse gas inventory[57], our emissions tracker[58], as well as information about likely climate change impacts in New Zealand[59], including for each region[60].

The Ministry for Primary Industries (MPI) also has a key responsibility for climate change reduction, mitigation and adaptation[61]. It commissioned a report, Climate Finance Landscape for Aotearoa New Zealand[62], which includes a snapshot of key existing climate finance flows and instruments available to the Government and private sector such as grants, debt and bonds. The report also outlines the enabling environment required to better facilitate the flows of finance toward low emissions and

[49] https://www.radionz.co.nz/news/political/355315/climate-change-committee-members-announced; https://www.beehive.govt.nz/release/interim-climate-change-committee-announced
[50] https://www.radionz.co.nz/news/political/346467/govt-moves-towards-carbon-neutral-by-2050
[51] https://www.eeca.govt.nz/resources-and-tools/research-publications-and-resources/climate-change/
[52] https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=12057866
[53] http://www.maoriclimatecommission.co.nz/purpose/climate-change/
[54] https://www.mfe.govt.nz/climate-change
[55] https://www.mfe.govt.nz/climate-change/what-government-doing
[56] https://www.mfe.govt.nz/node/23740/
[57] https://www.mfe.govt.nz/node/16634
[58] https://www.mfe.govt.nz/node/23646
[59] https://www.mfe.govt.nz/node/16596
[60] https://www.mfe.govt.nz/climate-change/likely-impacts-of-climate-change/how-could-climate-change-affect-my-region
[61] https://www.mpi.govt.nz/funding-and-programmes/
[62] https://www.mfe.govt.nz/publications/climate-change/climate-finance-landscape-aotearoa-new-zealand-preliminary-survey

climate-resilient outcomes. The Government is supporting the introduction of a Green Investment Fund, to invest in assets that reduce carbon emissions, which will mobilise additional private capital to bring forward projects that support long term objectives for emissions reduction. It is proposed that the fund receive a $100m capital injection from Government and it operates independently. The Government is also looking into the disclosure of climate risk in New Zealand and methods for tracking the mobilisation of climate finance. Both are potentially important enabling conditions that would support the scaling up and directing of finance flows towards climate-aligned outcomes[62].

The MPI has a fund to support forestry-based erosion control initiatives[63]. This is in addition to the Government's 1 Billion Trees initiative[64], and Emissions Trading Scheme[65]. MPI also have a Sustainable Land Management and Climate Change (SLMACC) Research Programme helps the agriculture and forestry sectors with the challenges arising from climate change[66]. The SLMACC fund has a Hill Country Erosion Fund, an Afforestation Grant Scheme, and a Permanent Forest Sink Initiative. A list of reports from research they have funded can be found on their website, including a report by Cradock-Henry (2018) that reviews climate change adaptation in New Zealand's primary industries[67].

MPI also works with tangata whenua to help them maximise their natural resources and assets, with a focus in agribusiness and the research of customary fisheries[68]. Their Customary Fisheries Research Fund[69] may be useful to landowners in this case study rohe, and should be explored further. It is available to assist tangata whenua manage their customary fisheries by providing financial assistance to undertake fisheries research. MPI also support innovative projects to grow New Zealand's food and fibre industries sustainably[70], which is also relevant to landowners in this case study rohe.

While such initiatives are making a start at tackling adaptations for the Primary Industry sector, this level of funding is inadequate to cover the likely future impacts of climate change.

The Provincial Growth Fund[71] is another initiative that can assist with climate change adaptation. The Fund aims to lift productivity potential in the provinces, with priorities to: enhance economic development opportunities; create sustainable jobs; enable Māori to reach their full potential; increase social inclusion and participation; build resilient communities; help meet New Zealand's climate change targets.

The Ministry for the Environment (MfE)[72] state that, "local government entities have responsibilities under the Resource Management Act to prepare and respond to the impacts of climate change. The Ministry provides information to local government on dealing with the impacts of climate change".

[63] https://www.mpi.govt.nz/funding-and-programmes/forestry/erosion-control-funding-programme/
[64] https://www.teururakau.govt.nz/funding-and-programmes/forestry/planting-one-billion-trees/
[65] https://www.teururakau.govt.nz/funding-and-programmes/forestry/emissions-trading-scheme/
[66] https://www.mpi.govt.nz/funding-and-programmes/forestry/sustainable-land-management-and-climate-change-research-programme/
[67] Cradock-Henry, N., Flood, S., Buelow, F., Blackett, P. and Wreford, A. (2018). Mind the gaps: Synthesis and systematic review of climate change adaptation in New Zealand's primary industries. Prepared for MPI. MPI Technical Paper No: 2018/54.
[68] https://www.mpi.govt.nz/funding-and-programmes/maori-in-the-primary-industries/
[69] https://www.fisheries.govt.nz/funding-and-programmes/maori-in-the-primary-industries/customary-fisheries-research-fund/
[70] https://www.mpi.govt.nz/funding-and-programmes/sustainable-food-and-fibre-futures/
[71] https://www.mpi.govt.nz/funding-and-programmes/other-programmes/regional-economic-development/
[72] http://www.mfe.govt.nz/publications/climate-change/coastal-hazards-and-climate-change-guidance-local-government

In 2017, they published guidance[73] for local governments on coastal hazards and climate change[74]. However, according to Bell, New Zealand does not have a coordinated plan to address the effects of climate change[75]. Sixty-three of the country's 78 councils have coastal boundaries, at different stages when it comes to addressing coastal hazards with some having barely given it a thought[76]. This is particularly concerning, given the plethora of research that has been conducted to date that clearly shows the urgency of New Zealand understanding how climate change is going to impact on New Zealand's people, ecosystems, biodiversity, infrastructure, and economy.

Hawkes Bay Regional Council are reportedly[77] the Council leading the way in New Zealand in determining how, when, where and who pays for climate change. In 2014 the Hastings District Council, Napier City Council and Hawke's Bay Regional Council agreed to work together to establish solutions for areas that were affected, and how residents would be involved in dealing with all of this. They recognise that the 'tricky bit' is broaching subjects like funding and when the pathways should be kicked into action. Head of the strategy for the initiative, Peter Beaven, says that a conversation is needed about how the government supports and resources the implementation of adaptation pathways, which currently they are not doing. Martin Bates, a community representative for the Clifton/Te Awanga, in the project, comments:

> "We've got some real problems because the Government's been completely inactive in this space until very recently. I compare that to Britain where the Government has been right round the entire coastline and told local bodies what they had to do, and helped fund it… At the end of the day the ratepayer will be paying for it. It's people's lives we're talking about. The council for many decades has been allowing new development along the coast, so they have some responsibility in this. In each community there is a great deal of misunderstanding about what the threats are and what has or hasn't happened. Getting it on the table, out in the open and making sure the information is fed back to the community is important. We've done that through public meetings, a newsletter and making sure the four representatives were talking to people. The idea of the adaptive pathways, that there wasn't one solution, was key"[77].

However, Beavan notes the principle that "you should not be publicly funding a private benefit ... but you do need to evaluate whether there is also a public benefit, through beach access and so on, then you need to consider affordability. If it's just plainly unaffordable for those private landowners, say a $2000 annual rates increase, then you need to decide if some of it should become a public cost… With any of the coastal works undertaken we'll have to go through an assessment of who the beneficiaries are and then work out the split of public and private spending. That public spending will include the entire community and that's where we'll form some sort of general rate to reflect the fact that we're all at fault here because we've all caused global warming"[77].

The project is also looking at the logistics and costs of "Managed Retreat" – this is an adaptation option put forward in the recommendations from Phase 1 of this study in the Horowhenua-Kāpiti

[73] http://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/coastal-hazards-guide-final.pdf
[74] https://www.mfe.govt.nz/climate-change/technical-guidance/guidance-local-government-preparing-climate-change
[75] https://www.stuff.co.nz/environment/99843080/government-lacks-coordinated-plan-for-climate-change-withheld-report-shows
[76] https://www.stuff.co.nz/environment/climate-news/110159587/the-nz-council-leading-the-way-in-determining-how-when-where-and-who-pays-for-climate-change
[77] https://www.stuff.co.nz/environment/climate-news/110159587/the-nz-council-leading-the-way-in-determining-how-when-where-and-who-pays-for-climate-change

coastline. The study assessed the cost of removing utilities and anything left of any houses or buildings and reinstate that section as part of a coastline people would want to come to, at $50,000. This is over and above the cost of actual house removal. Multiply that cost by the number of people who may need to move along the coastline in the future, as the impacts of climate change are increasingly felt, and it is clear that the cost is enormous, and there is currently no agreement about who will pay for that cost.

In Hawkes Bay, an inter-generational fund is being set up to support adaptations, which will build up over the next 10 to 20 years. A plan is also being considered in Napier and Hastings, where ratepayers could be taxed an extra $30 a year to protect land from sea level rise.[78] The rates, proposed to be collected from 2021, would be used for infrastructure deemed to be in the 'public good'. The portion to be paid by individuals or specific affected groups for 'private good' would be collected through a targeted rate when there was clarity around what sort of work was required. It's likely that debt funding would also be required and applied for at the time. The cost to Hastings and Napier residents of protecting their coastline over the next 100 years has been estimated to be between $131.2million and $286.5million, with a rating impact of $3.2m a year over the first 20 years[78].

Within the last few years, the local Kāpiti Coast District Council attempt to map coastal hazards resulted in an outcry by local residents. This reponse is a reminder of how critical it is that communication around such exercises is handled carefully. Kāpiti Coast District Council was taken to court by a group of ratepayers after adding 2,800 properties to its assessed coastal hazard zones, meaning a warning was added to those properties' Land Information Memorandums (Lims)[79]. This is where a regional natural hazard strategy such as that being undertaken in the Hawkes Bay, could be positively implemented in the Kāpiti/Horowhenua/Manawatū. Additionally, it is important that Councils and other agencies employ a culturally-appropriate process to engage local communities in a way that people feel empowered and part of the process rather than feeling like something is being done to them by an outside agency. Local Government New Zealand has sought legislative change to let it act on climate change adaptation.

GWRC has taken an adaptive management approach to dealing with ongoing and severe erosion, preferring to relocate assets and abandon some coastal tracks in the knowledge that building defensive infrastructure would be costly, unlikely to be successful over the long term and out of place in QEP's natural environment[80]. GWRC parks manager Amanda Cox said the plan was about ‘adapting to circumstances’, acknowledging the futility of attempting to fight against the immeasurable forces that erode these shores: “The better course is to allow natural coastal processes to take place while protecting key assets and enabling access"[80]. Amanda Cox said a recent study of the park's coastal edge estimated up to 40m of fore-dunes could be lost in a large storm or within the next 50 years through erosion: "With the onset of sea level rise, more and more extreme rainfall events and the increasing frequency and intensity of storms, we're moving to protect assets, restore the fore-dunes and re-establish opportunities for people to use and enjoy the area"[81]. Cox said the coastal edge of the park was a "dynamic natural landscape, vulnerable to erosion and the

[78] https://www.stuff.co.nz/environment/climate-news/113059841/plan-to-make-napier-and-hastings-ratepayers-pay-30-a-year-for-defences-against-coastal-erosion
[79] https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=12057866
[80] https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12221286
[81] https://www.stuff.co.nz/environment/111930510/buildings-parks-and-roads-may-retreat-inland-as-part-of-bufferzone-proposed-for-kpiti-coast

effects of climate change" and no stranger to weather-induced damage[81]. The Kāpiti Coast Mayor reflected that this is the first signal to the district that this is what's coming in the future.


In the photo above left, the erosion is obvious all along the proposed buffer zone[82]. In the photo above right, high seas on SH1 between Pukerua Bay and Paekakariki are shown. The threat of sea level rise and more frequent storms has prompted a plan to relocate a portion of the Kāpiti Coast[83].

The proposed relocation work was in the region of $350,000 but that was likely to change. The main objectives of the plan were to move existing visitor facilities and infrastructure to areas outside the zone, restore the fore-dunes and provide sustainable access to the fore-dunes and the beach, and introduce interpretive signage[83]. Greater Wellington's Environmental Committee chairwoman Sue Kedgley said that, following consultation, the plan would get underway "sooner rather than later". "It does indicate we are going to have to start looking seriously at coastal erosion. Far better to take action now and face the future than sit on our hands and do nothing. It's a sign of the future." While Kedgley was unsure of the costs involved, she did say Kāpiti wasn't the only coastline under the regional council's microscope. "We are going to be looking at some intensive, community-led consultation, which will look at the most vulnerable areas in our region"[83].


In the photo above left, Kāpiti Coast resident Paul Lynch lost 10 metres of land during a storm in 2016, including this unused tennis court[84]. Above right, about 200 metres of Kāpiti Coast foreshore was reinforced with rocks in 2007[85].

As with any natural hazard, economic downturn, or epidemic during which vulnerable communities are typically the ones to experience disadvantage, the impacts of climate change are also most likely to impact adversely on already vulnerable populations. Much research within the Vision Mātauranga

[82] Source: VIRGINIA FALLON/STUFF
[83] Source: File photo; MAARTEN HOLL/STUFF
[84] Source: KEVIN STENT/FAIRFAX NZ
[85] Source: Stuff

theme in the Deep South National Science Challenge is looking at how Māori will thus be impacted, and how the risks can be mitigated or minimised.

Importantly, the role of the insurance industry is the focus of three studies in the Deep South National Science Challenge[86], which investigate the legal, economic and ethical dimensions of who should pay for damage caused by climate change events.

Iorns investigates the "tipping points" at which insurance companies might decide to refuse insurance to coastal property owners, and asks, what happens next?[87] She is also looking at to what extent can or should homeowners rely on the Earthquake Commission (EQC), or on local or central government, to compensate them if their homes become uninsurable, or uninhabitable, due to sea level rise, or because of associated climate risks like storm surges or coastal erosion[88]. She states that one of the key trends in international climate litigation is in trying to establish who is liable for taking (or not taking) adaptation measures. She gives an example of a recent Australian case whereby residents sought damages from their local council, both to pay for shoreline protection and to compensate them for the loss of property value from rising seas. She argued that the loss was in part the fault of the council and its earlier inaction. The project is also investigating the Crown's Treaty of Waitangi obligations in relation to sea level rise, given that Māori communities are likely to be disproportionately affected by sea level rise. Where communities have limited economic power and access to finance, and little or no insurance cover, effective policy options for uninsurable Māori housing are critical. The research has analysed where sea-level rise risks currently fall across different parties, and they are now identifying and evaluating the policy options available to local, regional and national government when the tipping point of uninsurability is reached.

Storey is looking at continuing demand by home owners for coastal housing (which incentivises intensive coastal developments), despite the risks escalating coastal hazards; and the fact that climate risk is likely not currently incorporated into the price of residential coastal property[88]. She points out that evidence from overseas suggests that high insurance premiums and the unavailability of insurance has a stronger impact on private decision making than the uncertain risk of extreme events. Storey's project therefore explores how coastal housing markets impacted by climate change might respond to "insurance retreat" – if insurance becomes unavailable. Her project will identify the locations around New Zealand most likely to lose access to insurance within the next few decades, as the likelihood of extreme events increases.

The question of who pays the price for dealing with the impacts of sea level rise is increasingly being considered by communities, and explored by the media[89]. Ellis is investigating risk distribution related to sea level rise[90] between individuals, insurance, local and central government; whether this should be viewed as an individual or collective responsibility; and which approach delivers the best

[86] https://idealog.co.nz/etc/2017/10/insurance-canary-coalmine-climate-change
[87] https://www.deepsouthchallenge.co.nz/projects/sea-level-rise-housing-and-insurance-liability-and-compensation
[88] Ibid.
[89] https://www.radionz.co.nz/news/national/377600/sea-level-rise-threatens-major-nz-infrastructure-report; https://www.radionz.co.nz/national/programmes/afternoons/audio/2018674418/who-s-responsible-for-safeguarding-against-sea-level-rise;
http://community.scoop.co.nz/2018/12/the-vulnerable-shouldnt-shoulder-sea-level-rise-burden/;
https://www.stuff.co.nz/environment/climate-news/98001955/how-climate-change-could-send-your-insurance-costs-soaring;
https://www.sciencemediacentre.co.nz/2017/04/28/climate-change-and-insurance-expert-reaction/;
[90] https://www.deepsouthchallenge.co.nz/projects/how-should-risks-sea-level-rise-be-shared

and fairest outcomes. Ellis stated, “Sea-level rise as a whole poses the threat of a 'perfect moral storm of risk transfer' - without a solid, fair legal framework, the disadvantaged would bear the brunt of the problem... The problem is we don't have a predictable, legal framework outlying where those risks should lie.”[91]

Unfortunately, there are examples of decisions being made that only increase people’s risk, such as land developments in areas that are at high risk of adverse effects due to climate change. For example, according to Ellis[92], New Zealand coastal property owners have an incentive to keep investing in areas that may one day be in a flood zone, due to the unspoken assumption that the government won’t let communities go under, even if they can't get private insurance. This leads some developers gain profit now by building in flood/sea level-prone areas now, under the assumption that future costs of relocations or seawalls, if they are needed, will be shared among many. The incentives to build will become even more perverse if we decide what communities to defend based mostly on the value of property at stake, she says. At the extreme: “The rich will get seawalls while the poor get moved,” says Ellis. “That doesn’t embody who we are as people.” She recommended that:

> “the most important, immediate step New Zealand can take towards an ethically robust sea-level rise policy is to bring certainty and consistency into the legislative framework, ending the collective action problems and risk transfers associated with legal “gappiness.” Central government should also resource adaptation nationwide, so that community resilience does not vary with ratepayer capacity. At the local level, deliberately inclusive and robust community engagement (such as citizen jury processes) should be used to engage the public as early and as deeply as possible[93].

A 2015 report to the Parliamentary Commissioner for the Environment found New Zealand has 43,683 houses within 1.5m of high tide and 8806 within 50cm[94]. Such homes may become ineligible for insurance in the future[95]; given that insurance policies are one year policies in New Zealand, insurance can retreat very quickly from places where they think the risk is too high. Recent research examined the way that current insurance-based institutions in New Zealand might respond to climate change[96]. They noted that most current climate change insurance risks fall into two categories of physical risks: direct physical risks relating to losses resulting from weather-related event; and indirect risks relating to the impacts on residents and communities that may arise through cascading impacts or disruption. “Climate change may make the calculation of actuarially precise premiums more difficult both because climate change increases the categories of risks which may require insurance and, because the hazard’s frequency and intensity are changing over time rendering historical data less relevant.”

Insurance Council chief executive Tim Grafton said insurers would eventually stop offering cover to coastal homes, but it would be gradual and well signalled[97]. "Insurance will signal in a gradual way areas and localities around the country where the risks are becoming increasingly higher… For

[91] https://interactives.stuff.co.nz/2018/11/beach-road/
[92] https://www.newsroom.co.nz/2018/12/05/351236/playing-chicken-with-the-government-on-rising-seas
[93] https://www.deepsouthchallenge.co.nz/projects/how-should-risks-sea-level-rise-be-shared
[94] https://www.radionz.co.nz/news/national/329709/sea-level-prone-homes-set-for-insurance-cutoff
[95] https://www.deepsouthchallenge.co.nz/projects/climate-change-and-withdrawal-insurance
[96] https://motu.nz/assets/Documents/our-work/environment-and-resources/climate-change-impacts/Insurance-Housing-and-Climate-Adaptation2.pdf
[97] https://www.radionz.co.nz/news/national/329709/sea-level-prone-homes-set-for-insurance-cutoff

insurance it is a slow, but steady signalling that the risks are getting higher. Obviously when they get too high then insurance does not insure certainty. It insures accidental and unexpected risks."

Another Deep South project led by Storey[98] is identifying those locations most likely to lose access to insurance within the next few decades (as the probability of extreme events increases, by conducting extreme sea-level analysis for the Auckland region and Tauranga coastlines, and extreme rainfall analysis for the Coromandel coastline, followed by coastal flood inundation mapping for these regions. The project will estimate the direct economic losses on residential property of an extreme coastal storm making landfall in Tauranga City, to determine whether this size event could trigger reinsurance retreat (the withdrawal of the international insurers, who insure our local insurance companies) from other coastal locations in New Zealand. We are also developing a model to price future climate risk, using valuation methods from the real estate industry. Using this information, we can explore how to better inform coastal property owners' decision-making with respect to climate change.

A study by Stephenson[99] is surveying councils around New Zealand to see how they are engaging with their communities on adaptation processes, to develop a suite of recommendations for policy, process and adaptation practice. Stephenson states that decision-making institutions such as councils will need to be proactive in working with exposed communities. They will need to anticipate the support that communities will require, and will need to offer equitable solutions. Iwi and community members will need to be involved in climate change adaptation processes, and be in a position to make informed decisions about their future.[100]

Climate scientist Jim Salinger states that local and regional councils have largely taken on the bulk of the work in preparing for higher sea levels[101] and that central government needed to play more of a role. "Because of the magnitude of costs, and potential ability not to be able to cover with insurance, a national policy statement developed between central and local government is required to set policy on storm risk and flooding, especially due to sea level rise." This would discourage development in the areas likely to face problems because of climate change.

2.2.4 Decision Making Tools to Assist in Adaptation to Climate Change

Various decision making toolsets have been developed nationwide to assist New Zealanders in transitioning to more resilient futures in the face of climate change[102]. We recommend that coastal communities who are reconsidering the future uses of their land, make use of these tools when developing Transition Action Plans, in addition to the tools described in this report.

There are various accounts of Māori journeying into the Southern Ocean. An interesting project in the Deep South National Science Challenge is looking at how such stories frame our ongoing

[98] https://www.deepsouthchallenge.co.nz/projects/climate-change-and-withdrawal-insurance
[99] http://www.voxy.co.nz/national/5/308878
[100] Huhana Smith was invited to talk on 20 February 2018 about engaging the community in adapting to climate change, particularly the adapation planning work of Phase 1 and Transition Action Plans devised within Phase 2. The invitation came from Dr Carol Stephenson of the South Dunedin Future Academic Reference Group, who are also working alongside Dunedin City Council and South Dunedin community.
[101] https://www.radionz.co.nz/news/national/329709/sea-level-prone-homes-set-for-insurance-cutoff
[102] For example, see:
https://www.deepsouthchallenge.co.nz/projects/tools-decision-makers; AND
https://www.deepsouthchallenge.co.nz/projects/making-robust-decisions-about-new-zealands-water

relationship with the Antarctic and our responses to climate change[103]. Researchers are working with hapū and iwi from Te Waipounamu and Rekohu to better understand the extent and nature of the relationships Māori had with the Antarctic and Southern Oceans, and to identify local challenges associated with climate change through both tribal stories and contemporary living arrangements.

The primary sector has been a key part of New Zealand's growth for a long time. Agriculture, forestry and fishing are all central to our modern economy, including for at least one of the farms in our case study rohe. A study focussed on climate change and its effect on our agricultural land[104]. Land that had the capacity for sustained production has historically been classified as suitable for agriculture. However, "climate change has the potential to drastically affect the viability of land for use in agriculture and other primary industries. Land once suitable for farming may be rendered unusable by the effects of climate change or extreme weather events". Furthermore, it is important to consider economic, environmental, social and cultural values when deciding how to use a piece of land. This study aimed to better understand the impact climate change will have on the land's suitability. Will previously productive pieces of agricultural land become unsuitable? Why? Secondly, we seek to understand the flow-on effects of these changes to land use. What will the economic impact be if lots of land becomes unsuitable for agriculture? How will we adapt?

Studying the causes and effects of changing land use, can enable those who work in the primary industries to make informed decisions. The researchers developed a conceptual framework to understand the effect of climate change on land-use suitability, and are using this to create an operational forecasting tool. By incorporating the effects of climate change into their decision making, our primary sector can make effective choices while still meeting soil, water quality and economic objectives[105].

A further study by Awatere[106] focussed on climate-resilient Māori forestry and agriculture. The study included economic modelling and native afforestation within Māori owned and managed land in the Waiapu catchment on East Coast. The area has already experienced significant flooding, and this expected to worsen in our changing climate. To help landowners reduce the risks of increased erosion under climate change, and to maximise their revenue, the project used kaupapa Māori, bio-physical and economic assessment tools to understand and evaluate different land-use decisions, with a range of social, economic, environmental and cultural benefits. These included alternative forestry (mānuka, kānuka, tōtara, mataī, puriri, harakeke and kawakawa), horticulture (including honey, olives and olive oil, lemons and hemp) and other business options derived from mātauranga Māori. Under all future climate change scenarios, the research found that re-foresting the land – particularly with indigenous species – would result in a significant reduction of soil erosion for the Waiapu catchment. Significantly, afforestation would also help realise the core values and aspirations of Māori landowners, which include kaitiakitanga (sustainable resource management), manaakitanga (reciprocal obligations) and whakatipu rawa (growing the asset base).

Another Vision Mātauranga project is working with landowners and whānau in Omaio[107] who have for many generations been sustained by ancestral lands, forests, rivers and the moana, all of which bear tīpuna names. While the coastal lands of Omaio hold some of the most productive soils in New

[103] https://www.deepsouthchallenge.co.nz/sites/default/files/2017-10/1130%20Tuesday%20Matiu%20Sandra%20Morrison.pdf
[104] https://www.deepsouthchallenge.co.nz/projects/climate-change-its-effect-our-agricultural-land
[105] https://www.deepsouthchallenge.co.nz/sites/default/files/2017-09/0930%20Tuesday%20Te%20Puni%20Ausseil%20Baisden.pdf
[106] https://www.deepsouthchallenge.co.nz/projects/climate-resilient-forestry-horticulture
[107] https://www.deepsouthchallenge.co.nz/projects/climate-friendly-high-value-crops-whanau-omaio

Zealand and have ideal growing conditions for high-value horticulture crops like kiwifruit, they are currently only utilised for low-value maize, which provides no employment for whānau and contribute little to growing the local economy. Their research has already established that shifting from low to high-value crops could generate significant income, create a hundred local jobs for whānau and 500 jobs across the wider district. Nevertheless, recent extreme weather events and longer, dryer summers mean that the whānau of Omaio (represented through Te Rau Aroha Charitable Trust) need to better understand their future climate, before investing in climate dependent crops.

Another study is investigating the sustainability of drinking water supplies for three isolated communities of the Far North – Te Kao, Pawarenga and Motukaraka[108]. An important research learning is that older people have always been resourceful and have treasured water, so strategising about climate change doesn't feel like something new. Kaumātua are used to working with the elements and have the experience to adapt, conserve and innovate, including tapping old water sources. Their final report[109] concludes that their findings have far-reaching implications for kaitiakitanga of indigenous flora and fauna, sustainability practices and policy.

Working with coastal hapū from Tangoio Marae in the northern Hawke's Bay, another Vision Mātauranga project[110] created a flood adaptation game, 'Marae-opoly', to assess how sea level rise and extreme floods might impact marae assets. To support the hapū's decision-making process, the project also carried out hydrological and hydrodynamic modelling, to identify how the marae might mitigate flood impacts in the future. Marae-Opoly is an indigenous participatory decision making tool that helps players (and communities) work through uncertain and complex climate change impacts – making trade-offs and developing strategies for the future, and assessing how well these strategies have served them. Published reports detail the research[111] and modelling[112] underpinning decision making tool.

Research led by Lawrence is focussing on adaptive pathways to the future[113] i.e., how we make decisions today, with tomorrow in mind. The research involved presenting a range of options, from accommodation sea-level rises with seawalls and raising floor levels, right through to residents retreating from coastal areas. The key is to take steps now that don't knock out dependencies in the future. The aim is to shift people's thinking from a reactive mode to one of thinking about the implications of their decisions today so that they're sustainable over a long term future and allow us to adjust our actions as we go forward. The studies largely looked at people's assets – their homes and land – and presented them with the longer-term consequences of shorter term decisions. For instance, a seawall might keep their home protected for 10 or 20 years, but there will need to be another action before then too.

Further research by Lawrence on the "cascading impacts" of climate change[114], looked at how the effects of climate change might propagate through communities, through the economy, and through

[108] https://www.deepsouthchallenge.co.nz/projects/drinking-water-te-hiku-o-te-ika
[109] https://www.deepsouthchallenge.co.nz/sites/default/files/2018-09/Te%20Hiku%20Climate%20Change%20final%20report%20June%202018.pdf
[110] https://www.deepsouthchallenge.co.nz/projects/exploring-coastal-adaptation-pathways-tangoio-marae
[111] https://www.deepsouthchallenge.co.nz/sites/default/files/2018-11/Tangoio%20NIWA%20Client%20report%20FINAL%20Aug%202018.pdf
[112] https://www.deepsouthchallenge.co.nz/sites/default/files/2018-11/Modelling%20Report%20FINAL.pdf
[113] https://www.radionz.co.nz/national/programmes/ninetonoon/audio/2018682284/the-cascade-effect-re-thinking-climate-resilience
[114] https://www.deepsouthchallenge.co.nz/projects/climate-change-cascade-effect

the way New Zealand does business. This research has examined how climate change impacts set up cascades that are far reaching and amplify the initial climate change impacts by setting up feedbacks that can result in virtuous and viscous cycles. The impacts of increases in temperature, rainfall, sea levels and extreme events will cascade across all sectors of society. Our assets, communities and social and economic interactions will all be affected.

As the effects of these changes become more frequent through flooding, coastal inundation and drought, we'll have less time to recover and there will be cumulative consequences. In addition, as different sectors respond to the changes, there is potential for impacts to compound through the economy. Lawrence states, "To date, we've been very good at identifying individual hazards but when climate change comes along it exacerbates those and creates new ones… Essentially, the current attitude of tackling incidents like major fires and storms as one-off events, and re-building and re-funding in time for the next one, is going to end. We have to reframe what the problem is and because of that, we have to look at how our systems work, right through to the ability to anticipate these events and do something beforehand. In other words, to better plan for them and to avoid them."

The research concluded that "linear consideration of impacts conceal flow-on and feedback loops, which can lead to maladaptive responses that breach thresholds. Such linear thinking can constrain consideration of the full suite of impacts that impinge on the robustness of decisions… the distance from impact to an action may be quite large – between systems geographically and temporally. Such teleconnections can be scaled at a systems level, driving implications elsewhere at smaller scale. Cascades thinking can help bridge the gap between hazards risk reduction and climate change adaptation, because it enables the full import of the initial stressor to be transparent, in space and time as the hazard risk changes and increases with time. It also enables the full human systems exposure and its change to be considered as climate change impacts intensify, suggesting responses that can be more transformative"[115].

This climate change research, toolsets and communications in the media outlined in this chapter can help to inform transition action planning for our coastal communities, and were accordingly considered when formulating frameworks for tool development in this research – see Chapter 8.

[115] https://www.deepsouthchallenge.co.nz/sites/default/files/2019-02/The%20Cascade%20Effect%20FINAL%20REPORT.pdf

3 STAKEHOLDER ENGAGEMENT

Embedded in the design of this research was meaningful engagement processes with land owners and other stakeholders in the local community, as well as with the research and academic community. Therefore, significant stakeholder engagement processes were implemented throughout this research. This chapter provides a record of this extensive stakeholder engagement, and portrays the depth and spread of engagement processes that occurred. It is hoped that the processes outlined in this chapter might be informative for other researchers attempting to engage in community-based research where local Māori should be included in the research process. Figure 3.1 provides a simplified version of engagement steps utilised by our research team in this project.

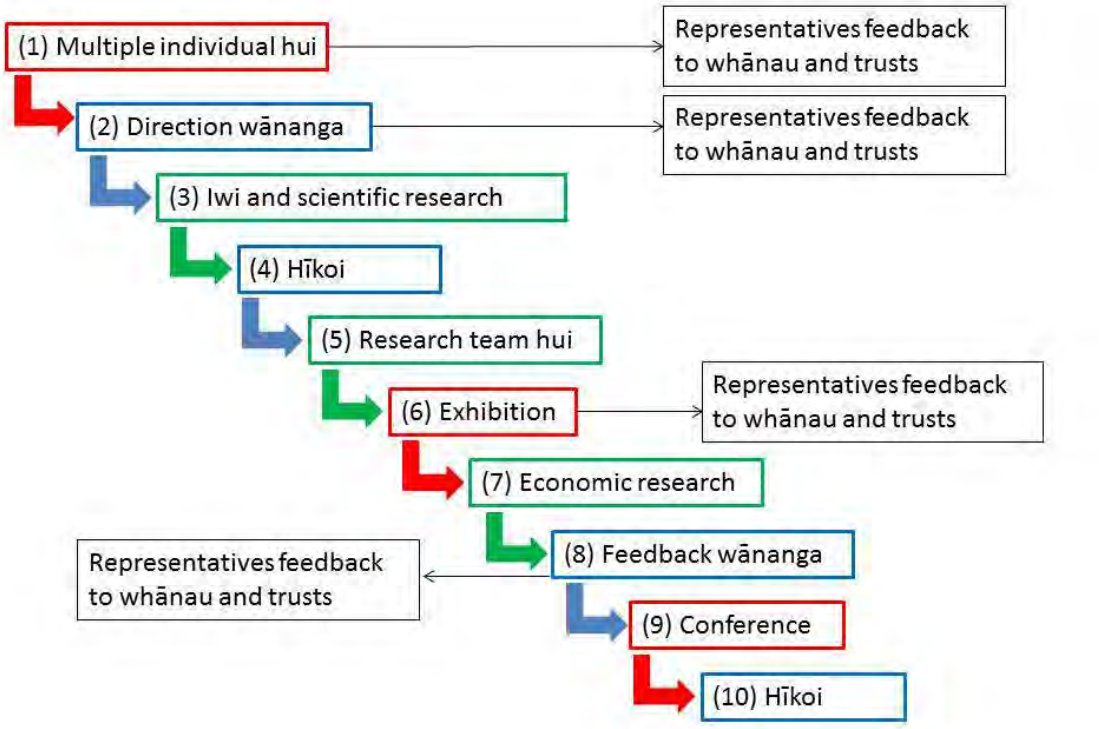


Figure 3.1 Stakeholder Engagement Process in this Phase 2 Research Project

A short explanation of steps is below:

1) Iwi researcher conducted multiple initial hui with representatives of Māori land block owners (at locations chosen by the representatives) within the case study area. A4 project brief brochures were left with participants.

2) This wānanga was held at a local marae. Our research team presented a range of opportunities for climate change adaptations discovered during the phase 1 project. Whānau representatives selected three priority adaptations for the research team to explore further.

3) Iwi and scientific researchers conducted further research focussed on the three options. Communicating regularly with each other (email, phone and hui).

4) A number of hīkoi were conducted on the land with land owners, research team members and other collaborative partners (e.g. Tyler Harlen & Derek Kawiti). Iwi researchers conducted trips in New Zealand to look at the potential of options.

5) Three research team hui were held (two in the case study area and one at Massey University) to discuss the research being collated and identify gaps.

6) Exhibition in the local township of Ōtaki highlighted the science along with local artists, weavers, carvers etc. Draft transition action maps were displayed. This was the first opportunity for whānau members to provide feedback to their whānau and then the team about the draft maps.

7) The details from the draft transition maps were then fed to our ecological economics researcher.

8) All research was collated into a draft report presented to the whānau representatives at the Feedback Wānanga. Representatives discussed the results with whānau members and trustees and provided feedback to the team via email and face to face discussions.

9) Iwi researchers presented at a national conference. Whānau members also attended.

10) A hīkoi is planned to wrap up phase 2. Copies of the final outputs (e.g. transition action maps, hard and electronic copies of this report, and powerpoint presentations given at various wānanga) will be given to the whānau representatives.

3.1 Engagement with Whānau Land Owners and Local Community in the Case Study Rohe

3.1.1 Whānau Land Owners

Initial Korero to establish support for our research team to seek ongoing funding from the Deep South National Science Challenge occurred in 2017. A newsletter was produced by the research team summarising the Phase 1 research, and outlining what was proposed for this ongoing research. This newsletter was given to interested whānau, hapū and land owners at these hui. An i-book pdf was also produced, and hard copies printed for disseminating information on Phase 1 activities as grounding for Phase 2, to hapū and whānau of coastal blocks in case study area between Ōhau and south of Waikawa Rivers.

A series of stakeholder engagement occurred in mid-2017, including:
*Members of Te Hatete Trust whānau attended Dowse Exhibition, 22 July 2017-09-27

*Moira Poutama & Te Whao Gregory attended National Māori Tuna Conference Whanganui, 16-18 July 2017.

Once funding was secured, a list of all the Māori land blocks in the case study area was compiled, with the associated number of owners & trusts (& trustee names) of each land block – see below.

Contact was then made with people from those land blocks to clarify their interest and agreement to participate in Phase 2. Initial stakeholder engagement also involved sharing results of the Phase 1 research, and discussing alternate land uses with whānau land owners. The following five farm blocks were thus included in the case study: Paora Pohatira, Te Hatete, Tahamata, Ransfield and Pekapeka.

No	BLOCK DESCRIPTION	MANGEMENT STRUCTURE TYPE	ACTIVE ADMIN	SHARESTATUS
1	Ōhau 3A 1 A2A 7 Ōhau 2A No 1A	Leased to Tahamata Inc	James Mackie	172/1
2	MK 4D1 2B4	Te Hatete Leased to Ransfield Inc	M Poutama	40
3	MK 4D1 No1C	Te Tumu Paeroa - MLC Leased to Gardiner Farm	Albert Gardiner	219
4	MK 4E Sec 2B No8	Paora Pohatira Trust – Ahu Whenua Trust	Albert Gardiner Horace Cook, Hoko Gardiner, Colleen Harper	12
5	Ōhau 8, 9, 10	Ransfield Inc Leased to Tracey Lambert	Rangi Ransfield, Marshall & Sally Petly	10
6	Ōhau 11	Gas Pipeline Easement	HDC	1
7	Ōhau 4, 5	Kawenata Ransfield Inc-Kawenata NWR	Marshall Petley	0
8	Ōhau 3A No1B No1	Taratoa Pekpeka Trust Ahu Whenua	Pataka Moore/Ana Harrison, Hohepa Paurini	157

Numerous hui and end user engagement activities occurred with various end users in the last quarter of 2017, as follows:

* 15/09/17 – hui with Te Hatete representatives
* 18/09/17 – Tahamata Tahamata Chair and Board approval gained
*20/11/17 – hui with Pekapeka Taratoa Ahu Whenua Trust representatives
*20/11/17 – hui with Incorporation of Ransfields representatives
*21/11/17 – hui with Pekapeka Taratoa Ahu Whenua Trust representative
*23-24/11/17 – contact with Te Tumu Paeroa, regarding process to contact Trustees
*24/11/17 – hui with Paora Pohatira Trust representative
*25/11/17 – attendance at Tahamata Inc AGM; presented our research and invited Board members and shareholders to upcoming hui in December and February
*28/11/17 – hui with Incorporation of Ransfields representatives
*28/11/17 – hui with Te Hatete Trust representatives
*28/11/17 – hui with Pekapeka Taratoa Ahu Whenua Trust representative
*28/11/17 – hui with Paora Pohatira Trust representative
*28-29/11/17 – hui with Tahamata Board, Taratoa Pekapeka Trust, and Te Hatete Trust reps
*3/12/17 – attendance at Ngāti Tukorehe AGM; presented our research and invited komiti members to our Hui in Feb 2018.
* 16/01/18 – hui with Ransfield Trustee and Ngāti Tukorehe representatives
*17/1/18 – hui with Hatete Trust representatives

This stage of this project focussed on end user engagement with potential land owners in the case study area to give them opportunities to reflect on the Phase 1 project findings; invited to participate in this Phase 2 project (a brochure/handout outlining the Phase 2 project was produced for distribution at these hui/wānanga); and opportunity to consider preferred adaptation options to adapt to climate change impacts on their coastal land. This critical stage was fundamental to the ongoing success in this research, whereby local Māori land owners were actively engaged in working with the research team to assess likely climate change impacts on their coastal land, work through alternative land use strategies to accommodate those climate change impacts, and come up with Transition Action Plans.

Our main *Stakeholder Engagement Hui* was held on 2 December 2017, at Ngāti Tukorehe Marae from 12.30 -3.30pm. Feedback for this hui was great with a high level of interest, support, and buy-in for this kaupapa and rangahau from those present and those unable to make it. Moira Poutama continued to engage with either the Chairperson or Trustees of the land blocks within the case study and gained their agreement in principal to engage with this research. A number of representatives were unable to attend and sent in apologies due to marae working bees happening at the same time, and also unexpected whānau or farm demands. This is an important consideration when working with local whānau and hapū, who have multiple responsibilities that call upon their time, and often make it difficult to attend research hui. Thus, informal communication with Māori research team members who are strongly connected to stakeholders in the rohe, is an important mechanism to keep stakeholder engagement flowing.

<u>Stakeholder Engagement 2018-2019</u>

*16/1/18 – hui with Ransfield Trustee and Ngati Tukorehe representatives
*17/1/18 – hui with Hatete Trust representatives
*26/1 – 4/2/18 – emails sent to wide group within rohe with Climate Change Research Panui and Research Update.

*4/2/18 – wānanga with representatives from participating coastal land blocks
* 5/3/18 – hui with Hatete Trust representatives
* 6/3/18 – hīkoi with Hatete Trust representatives and met Jan Mitchell at their Raglan restoration initiative – NitroEELS (tuna, īnanga, kanae artificial ponds)
*9/3/18 – email to Wehiwehi Trust Chairperson
*19/3/18 – hui with Tahamata Board
*1/4/18 – hui with Ransfield Farm representative
*10/4/18 – attendance at Wehiwehi Kotahitanga Trust AGM & Wehiwehi Marae Hui

*By the end of April 2018, Consent Forms were signed off for participation in the research by the following farms: Ransfield Farm, Te Hatete Trust, Pekapeka Taratoa.

*3/5/18 – hui at Tukorehe Marae and hīkoi to the study sites to discuss potential collaboration with VuW artists, 'Tono ki te whānau o Tukorehe kia tautoko tenei Kaupapa'. Powhiri and presentation about projects and the potential to collaborate, attended by whānau members. Visits to Te Hatete Trust, Waikawa Beach then to Tahamata Kuku Beach. Email to all stakeholders also sent out.
*10/5/18 – hui with TWoR Pūtaiao kaiako regarding a presentation at TWoR to include our research.
*14/5/18 – hui regarding preparation of the maps for the different adaptation options and to determine what data is available.
*18/5/18 - hui with stakeholders re: Waikawa coastal erosion.
*24/5/18 – hui with whānau research team members regarding proposed sites on the case study farms for various adaptation options.

*7/6/18 - hīkoi to Kuku and Waikawa land blocks to establish a potential site on the Te Hatete land block for a Masters' student experiment with a 'dune stabilisation technique' that could be used to structural ground posts for a papakāinga.
*19/6 - 21/6/18 – hīkoi for dune stabilisation and papakāinga potential project.
*30/10/18 – hui with land owners representatives to confirm locations of adaptation options on each land block.

Throughout 2019, various communications occurred to publicise the Exhibition held at Māorilands in January 2019.

Final Whānau Wānanga

Panui were sent to landowners to attend the whānau hui at Ngāti Tukorehe marae on 12 April 2019, where an overview of the research findings were presented by the research team, a draft Transition Action Plan was discussed and feedback provided by land users as to their preferences for ongoing research and actions (see Conclusions chapter). The list of attendees at this final hui is on the next page. Section 8.3 provides an overview of the outcome of that final Whānau Wānanga.

Name	Block
Marshall Petly	Ransfield Inc
Sallyy Petly	Ransfield Inc
Ana Harrison	Pekapeka Taratoa
Ema Jacobs	Pekapeka Taratoa
Albert Gardiner	MK2 B8
Ryan Gardiner	MK2 B8
Lindsay Poutama	Te Hatete Trust
Myra Poutama	Te Hatete Trust
Cathy Tate Jamison	Tahamata Inc
Yvonne Wehipeihana-Wilson	Ngāti Tukorehe ki te Tonga
Donna Rawiri	Ngati Wehiwehi
Rangimarkus Heke	Ngati Tukorehe ki te Tonga
Moira Poutama	CC Roopu/Te Hatete Trust
Aroha Spinks	CC Roopu
Derrylea Hardy	CC Roopu
Murray Patterson	CC Roopu
Martin Manning	CC Roopu
Jane Richardson	CC Roopu

Whānau members of the land blocks attended the Deep South National Science Challenge annual conference in May 2019, alongside the research team, and participated in workshops and other engagement processes at that forum.

Discussions are underway with Pekapeka-Taratoa representatives in regards to organising a hikoi with Moira and their whānau to their land locked block (7/06/19).

A hīkoi is planned to wrap up Phase 2. At this time, copies of the final outputs (e.g. transition action maps, hard and electronic copies of this report, and powerpoint presentations given at various wānanga) will be given to the whānau representatives.

3.1.2 Local Kura

Children of Ngāti Tukorehe and Ngāti Wehiwehi attend Ōtaki Primary School. Aroha Spinks liaised with staff at Ōtaki School on the 16th, 18th and 22nd of May, 2018. Aroha, Huhana Smith, Moira Poutama and Architect student, Tyler Harlen, attended a hui with the Principal – Chris Derbidge, regarding the potential of students being involved in this project. At a later date Aroha then met with teacher Janeen (Jin) Marino (Ngāti Raukawa, Ngāti Kapu) at Ōtaki Primary School, who was keen to include a wānanga (presentation and hīkoi) in Term 4, under their 'Tangaroa' and 'career' kaupapa. Although it had been envisaged by the research team to include a clay demonstration and studies of architecture involving Tyler and his work, the desires of the kura and their kaupapa were prioritised.

Jin recommended involving the two oldest classrooms (Te Mutunga and Te Whiri) in the Te Reo speaking unit (Te Korowai Whakamana). She also suggested taking the students to the local hapū-led Lake Waiorongomai restoration project by the end of 2018, and then to wider case study area (Waikawa to Ōhau) early 2019. Lake Waiorongomai is culturally significant to Ngā Hapū o Ōtaki and just south of the Waikawa River. Access to the Waiorongomai 10 Block and restoration area was given kaumātua approval (19/11/18). Teachers Jin Marino and Tammy Nepata (Ngāti Kahungunu, Ngāti Tuwharetoa, Ngāti Maniapoto) selected the wānanga date in December to coincide with a bike ride by students the next day to Ōtaki beach.

On 11 December 2018, Aroha provided a presentation to students on her career in the seafood industry, fisheries qualifications, leading onto research work (including this project) with her cousins that support local whānau, hapū and iwi environmental aspirations. The presentation was followed by a hīkoi to Lake Waiorongomai, where students observed the ancestral landscape and water quality, as well as participated in collecting and observing aquatic insects.

Older students in Te Mutunga then conducted a karakia and cut harakeke blades as the younger students looked on from a dune ridge. Students from Te Mutunga created a contemporary hīnaki harakeke art piece for display in the January Exhibition, unfortunately it was unavailable due to the summer school holiday. However, photos of the art and students working on it are below and were displayed at the exhibition (also see Section 7.4).

Students enjoyed the beach trip the following day and created contemporary papakāinga inspired whare from drift wood.

Continuing on from the wānanga was a graphic art tutorial for Te Whiti students – Āwhina Osborne (Ngāti Raukawa, Ngāti Motai) and Parearohi Edgington (Ngāti Maniapoto) – with local artist Nick Antunovich. Āwhina and Parearohi created prints that were inspired by climate change and tangaroa. Examples of this art work by Āwhina are over; on the left is Hinemoana (Goddess of the sea) by Parearohi and on the right is Papatūānuku (Earth Mother). In the facial expression, Āwhina captures a 10 year olds interpretation of a response by Papatūānuku to the environmental impacts of people. The original drawings, these prints and others were also displayed at the January exhibition (see Section 7.4).

Jin also mentioned that Papatūānuku is a kaupapa on their curriculum in 2019. So a follow up wānanga remains a potential that students will learn about architecture and building with local natural earth materials, as well as visit the case study rohe.

The research in our project supported their fourth term kaupapa: 'Tangaroa'[116]. A list of Ōtaki Primary School/Te Korowai Whakamana, Te Whiri and Te Mutunga Wānanga and Hīkoi is over:

Lake Waiorongomai (11/12/18)

- Presentation by Aroha Spinks seafood industry career
- Aquatic insect monitoring
- Harakeke collection by Te Mutunga

Ōtaki Beach (12/12/18)

- Bike ride to the beach from kura
- Drift wood collection
- Creating papakāinga inspired constructions

Te Mutunga Students (17/12/18)

- Utilised harakeke to create a collective piece
- Tuihana provided guidance to students
- Hīnaki

Graphic Art Tutorial (16/12/18)

- Āwhina Osborne and Parearohi Edgington
  design pieces inspired by the hīkoi
- Received a tutorial from local Graphic Artist Nick Antunovic
- Developed further ideas together
- Final designs approved by Āwhina and Parearohi

[116] Graphics contact: nicka1_mail@yahoo.com

3.1.3 Engagement with Te Wānanga o Raukawa Kaitiakitanga Pūtaiao students

Aroha Spinks had the opportunity to discuss the objectives and outcomes to date of this project during a presentation to Te Wānanga o Raukawa[117] Kaitiakitanga Pūtaiao[118] students on the 4th of August 2018. She then took the students and kaiāwhina (Chris Wilson, Ngāti Hinerangi) on a hīkoi to the case study rohe. The photos below were taken on the Taratoa Pekapeka Block.

During the hīkoi to the block students walked through a pine forest noting the scarcity of native flora then compared that to the natural dune flora which remains on the Taratoa Pekapeka Block. From an aspect on the block students were able to view nearby whānau restoration activities, the Te Hākari Kawenata[119] (approximately 20 years) as well as the Ransfield Kawenata (approximately 4 years). Importantly permission to access the block was provided by a whānau member.

Hīkoi such as this one provide sensory experiences of theory discussed in presentations, to reality within ancestral landscapes. Students were able to discuss the Phase 2 adaptations being considered by the whānau and the research team for this coastal landscape as well as other ideas they had. Discussions continued for relevance, opportunities or concerns regarding their own iwi/hapū/whānau whenua. In this case the project, presentation and hīkoi contributed to knowledge sharing, pūkengatanga[120] and inspired students from iwi around Aotearoa.

3.1.4 Wai o Papa/Waterlands Public Exhibition – Phase 1

The final exhibition of the Phase 1 'Adaptation Strategies for climate change' research by Kei Uta Collective was held at The Dowse Art Museum, Lower Hutt. This exhibition was underpinned by cultural knowledge of place from Horowhenua hapū informants. It was coalesced as the final iteration of the 'Whakatairangitia: rere ki uta, rere ki tai' theme, which first featured in the dairy shed exhibition from 11-16 March 2017. It was then repurposed into the 'This Time of Useful Consciousness-Political Ecology Now' - a critically important climate change exhibition curated by Senior Curator Melanie Oliver, which was held from April to July 2017 and was well attended by many. See Appendix A for examples of Phase 1 exhibitions.

[117] www.wananga.com

[118] Diploma in Environmental Management.

[119] Covenant. Department of Conservation - Ngā Whenua Rāhui Fund provides protection for Māori landowners through the use of 25 year renewable kawenata (covenants). For further details see: https://www.doc.govt.nz/get-involved/funding/nga-whenua-rahui/

[120] Teaching, learning and educating in a Māori way, passing on knowledge so that others become learned.

3.1.5 Wai o Papa/Waterlands Public Exhibition – Phase 2

A week-long exhibition was held in January 2019, which was attended by approximately 400 people. This exhibition followed on from previous Wai-o-papa exhibitions spanning Phase 1 and Phase 2, and was held in the Māoriland Hub venue, Ōtaki from 22-26 January 2019. This is home to the globally famous Māoriland Indigenous Film Festival. The purpose of this latest research exhibition was to generate further dialogue and ideas that might help strengthen iwi and hapū resilience to climate change stressors.

Under the banner of 'Ngā Mahi Nō Inaianei, Hei Oranga Mō Apōpō' (For Communities of Tomorrow who will Benefit from our Efforts Today) this culture/art/design/science exhibition highlighted environmental and climate change threats that are of particular concern to rural Māori, particularly for the coastal area between the Ōhau and Waikawa Rivers. The research team reiterated that while we have customarily had an evolving and adaptable relationship with our lands, waters and resources, we are now more vulnerable to the economic, social, cultural and physical impacts of climate change as we experience more frequent and damaging hazards for our coastal holdings.

The exhibition shared proposed a series of Transition Action Plans for diversifying economies, alongside other opportunities for renewing the harakeke (New Zealand flax) industry and enhancing local fisheries such as tuna (eel) and īnanga (whitebait) within more coastal Māori farms. We also shared ideas for papakāinga (Māori inter-generational housing) or seasonal housing that benefits associated Māori shareholder communities and whānau (family) land trusts located within the case study region.

The exhibition also displayed the installation of Tyler Harlen, final year Masters student from Victoria University, who developed innovative site-sourced coastal erosion mitigation devices, which were made by high-pressure forced injections into sand moulds. His associated digital computations and coastal erosion prototypes (that looked like tree root systems) emulated the concept of Māori grounding to their whenua or lands. These were well received by the whānau group. Tyler took inspiration from the land, whakapapa and connectivity to create root-like sculptures using a natural concrete made from locally-sourced sand, clay and soil. His idea to inject sand, clay and soil composite into local sand dunes and therefore to stabilise them from the inside, is to prevent them from collapsing under the increasing force of the rising sea.

Not only did design and art feature in exhibition but also whatu raranga (weaving), whakairo (carving) and tā moko (Māori skin marking/carving) demonstrations helped ground the exhibition in a distinctly kaupapa Māori way. Similarly, KAITIAKI was a contemporary dance work that took place on Saturday 26 January that wove together dance, waiata and music. Embodying elements, cosmological narratives and landscapes, performer Dolina Wehipeihana explored whenua, whakapapa and her home-coming to rohe. Accompanied by vocalist Waimihi Hotere and acclaimed electronic musician Paddy Free, with choreography by leading Māori choreographer, Louise Potiki Bryant, sound and movement combined in this striking solo performance. KAITIAKI is at the first stage of development towards a work that explores adapting to the impact of climate change on coastal Māori communities, the inter-connectedness of the environment and people, and the journey of restoring well-being to both through concerted acts of kaitiakitanga. This dance event was sponsored by Creative New Zealand.

During this exhibition, $168 was raised in Koha for plants on the Waikawa Stream. Alastair Cole from Landcare said they will match this koha dollar for dollar for contribution towards the related Waikawa Stream catchment project that Moira Poutama and Aroha Spinks are also involved in.

Some landowners and whanāu connected to the case study rohe attended the Deep South National Science Challenge annual conference in May 2019, alongside the research team, and participated in workshops and other engagement processes at that forum.

3.2 Engagement with Other Research/Government Groups

If ongoing funding is secured to enable this research to be continued, and adaptation options implemented, we aim to continue to liaise with all of these groups for ongoing advice, assistance with implementation and monitoring. To this end, Professor Smith is advising key Massey staff, Dr Faith Kane (School of Design, CoCA), Eve Kawana Brown (Massey, Taranaki), Rangi Te Kanawa of Muka Ltd and AgResearch, Massey University, Palmerston North on *He Aho Tapu Hou – A New Sacred Thread: Taking Muka to Fine Fabric.* This funding application was submitted to the Science for Technological Innovation NSC Seed Projects funding round for 2019.

3.2.1 Massey University

*Massey University, Whiti o Rehua School of Art, Toirauwhārangi College of Creative Art Students, Wānanga and Hīkoi was hosted by Huhana Smith, on 26-28th September 2018. The photos below show Prof Smith presenting the research; and the students observing the rohe at the Waikawa river mouth, where the accessway to the beach (on Māori land) had been taken out by Cyclone Gita's storm surges early in 2018.

*Massey University Researchers with a focus on Harakeke:

A series of hui were held with Dr Faith Kane and Rangi Te Kanawa on developments within the harakeke industry on 19 July 2017 and 23 August 2017; these were followed up with ongoing hui throughout 2018 with a wide representation across Massey University who are undertaking research related to harakeke in various ways. This included research into the role of harakeke in environmental and cultural restoration projects; characterisation of harakeke species; harakeke fine fibre for sustainable fabric industry; and harakeke as an energy conductor for batteries.

There was another Harakeke Hui at Massey in Wellington on 9 Sept 2018, attended by numerous people at Massey University with an interest in harakeke research. This was followed up with a hui with Rangi Te Kanawa, Moira Poutama, Aroha Spinks and Eve Kawana-Brown regarding Rangi Te Kanawa's research over many decades to produce muka of a very high quality for fine fibre products. This will be the basis of one of the detailed research topics in this project. (See above details about possible He Aho Tapu Hou research project, as mentioned earlier.)

3.2.2 Other NZ Researcher and/or Government Departments[121]

*Department of Conservation Week
Moira Poutama and Aroha Spinks attended the DOC Conservation Week Wānanga held at Te Takere in Levin, on the 21st of September 2018. They did a presentation on the past and current mahi in the rohe. Over 50 people were in attendance, including Ōhau Primary school students, Wehiwehi marae representatives, Forest and Bird Society, DoC and others from the local community.

*Ministry for the Environment
Three members of the research team met with Dan Zwatch, Climate Change Senior Policy Maker from the Ministry for Environment in Wellington, on 28th August 2018. Dan recommended a number of things which will aid our efforts to engage with planners and the community, and research gaps that require ongoing investigation in New Zealand. Dan noted that MfEs "Freshwater remedial fund" might be able to help with implementation of adaptation options if they show the link between climate change and freshwater. It was suggested by our iwi researchers that MfE could look at a team building exercise with our project whereby they could bring their climate change department to our case study area and marae. Dan showed great interest in this and the team will follow up on this opportunity.

*Met with Alastair Cole Manaaki Whenua/Landcare NZ, at Ōtaki Library, 15 September 2017.

*Liaised with researchers from NIWA regarding the impact of waterway restoration on taonga species and kaimoana; NIWA staff (Erica and Cindy) provided us with two interim reports and discussed the variable factors that would influence results, from their research in Waikato which resulted in a 50% increase in whitebait after 5 years; other species such as kokopu were present after 5yrs that were not initially found at sample site. We were notified of a local wellington Māori scientist who could also provide advice.

*In Sept 2018, liaised with Doctors Baker and Williams, and Kathryn Reeve regarding riparian habitat enrichment project for eel/whitebait growth; also seeking input from specialists at Cawthron Institute.

*Attended the Deep South Climate Change NSC Webinar on 19 September 2018.

[121] Also see the full list of outputs, including conferences presentations, in section 4.4.

*Visited Manaaki Whenua site in Christchurch on 12 October 2018, and saw the Rene Orchinson collection of over 50 varieties of Harakeke. Had a hui with Katarina Tawiri (kaitiaki of the collection), and discussed varieties with Muka etc.

3.2.3 Other Coastal Restoration/Adaptation Practitioners

*Moira Poutama and Te Whao Gregory attended the 3rd National Conservation Conference Hui Taiao Māori Te Ao Turoa, Ahipara, 2-4 March 2018. While there, they liaised with a number of researchers/practitioners regarding this project, e.g., Hank Dunn/Ora Barlow, Toheroa Kuia - Betsy Young and Ana Berich. They also had an impromptu visit to Whare Uku/Mudbrick Building where they saw three houses built in Ahipara. They visited with Ruebin Taipari Whare Uku Builder – He creates Mudbrick Houses that cost $2000-$2,500 per square meter; this cost is reduced if building yourself. Uses locally sourced fibres such as harakeke.

* In mid-2018, Moira Poutama and Aroha Spinks liaised with Whareuku, or Earth House – a University of Auckland collective founded to create a low-cost earthen housing solution for rural Māori communities; Nitro EELS in Raglan; and visited an off the grid whare up in the hills behind Te Horo which has great potential.

*In August to October 2018, Moira Poutama and Aroha Spinks investigated options around harakeke and mud brick whare in the South Island:
-Visited Templeton Flax mill operation and museum on 9 October 2018 and met Vaughan Templeton, the sixth generation in his family to be involved with the flax mill operation and history (see chapter 4 for more information about their harakeke production).
-Liaised with James Keswick, and had a hui on 10 October 2018 with Bill Broker at his sustainably-sourced home in Wanaka, constructed by himself out of cabbage tree leaves, harakeke and plaster. Bill has many years of experience building log cabins and other plastered straw filled walls etc. He is retired now, but has volunteered to show others how it is done (contact details: wjbrooker@gmail.com).

*Moira Poutama and Aroha Spinks liaised with Cindy Baker regarding research conducted at NIWA by herself and Kathryn Reeve, amongst others, to restore inland waterway fisheries through habitat restoration initiatives. See Box 2 in Section 4.2.2.

*Moira Poutama and Aroha Spinks attended a hui at Levin Eel Company in Levin on 28 November 2018; they met with Eric Kuijgen and got details about quota, licenses and prices that he would pay to receive the live eels or fresh whitebait. He has agreed to provide us with their company video for our exhibition.

*Moira Poutama spoke to Paul Decker of Manaaki Whitebait in Warkworth on 27 November 2018; they are successfully commercially selling whitebait and kokopu. Aimed to have a follow up hui with him in late December or January, but this was not able to happen due to Christmas season schedules.

*Aroha Spinks Hui with Peter Spinks (ex-Farmer and grower for NZ Hothouse) on 18 October 2018 regarding the potential of a harakeke industry and likely production costs of the growing and processing.

*Moira Poutama and Aroha Spinks spoke to Charles Young on 27 November 2018, who continued the ground-breaking research of Charles Mitchell, now Nitro EELS. Based near Raglan, he is willing to meet with us early next year if possible, or during the potential of a Phase 3 research project. He

states eels are the ultimate nitrogen mitigation (3-5% per annum) and all farmers should be considering this.

* Moira Poutama and Aroha Spinks spoke with a local whānau member on 14 November 2018 regarding his mud brick home in Manakau. He confirmed that he and his wife would be willing to share with us their knowledge on the techniques they used. Follow up meeting to be held depending on future funding of Phase 3.

*Moira Poutama and Aroha Spinks sent a map of case study rohe with potential papakāinga sites, produced by Dr Richardson, to a Māori builder in Rotorua, on 26 November 2018 to see if he can quote us on prices to build the mud brick home/s that have harakeke in them. Follow up meeting to be held in Rotorua depending on future funding of Phase 3.

It is important to note that these practitioners/researchers showed enormous generosity in sharing their knowledge and insights with our research team. The south island road trip visit to the the flax mill operation to see the harakeke product drying on lines was "beautiful, and just really informing to see the operation in work" (reflection by Aroha Spinks of our research team). If we ever get a harakeke mill operation funded in our rohe, Vaughan has volunteered to come up and help engineers design an even better factory set up than the one he has in Riverton.

The hīkoi to the see the whare in Wanaka was also very memorable for the researchers, who commented, "Nothing beats seeing it in person, meeting Bill and hearing about the process".

Likewise, "seeing the different varieties in the Rene Orchiston collection [at Manaaki Whenua] and the knowledge of the kaitiaki looking after it was just amazing".

3.3 Engagement with International Researchers and Artists

3.3.1 University of Technology, Sydney

Ongoing talks with Professor Penny Allan and Martin Bryant from the University of Technology, Sydney regarding other funding opportunities from Australia to engage them for Australian indigenous knowledge-based projects that link directly with ours in Horowhenua. This was followed up with Professor Huhana Smith's attendance at their one day workshop on 12 October 2017 in Sydney to speak about projects to staff and students, to meet with Dean of Architecture, and talk more about the planning for the Artists Wānanga. This visit resulted in agreement to co-develop an international exhibition, subject to funding being gained, and a publication on the use of exhibitions as research methods – currently corralled by Alex Keeble (Deep South) and Nicola Legat. While funding has not yet been sourced for an international exhibition, an international Artists Wānanga was held at Kuku, in February 2019 (see below). The later publication idea is now been spearheaded by both Professors Allan and Smith, and socialised with the artist group.

3.3.2 Drawing Ecologies at Tukorehe Marae, Kuku, Horowhenua

The Drawing Open Research Collaborative[122], founded in 2016 by Emma Febvre Richards (Massey University) and Monique Jansen (Auckland University of Technology), have been planning to work alongside the Deep South National Science Challenge research project since 2017.

With grateful support from the Massey University Strategic International Visitor (SIF) fund in 2018, the Drawing Open Research Collaborative were able to include international artist, Tania Kovats, amongst the formidable group of artists and designers who converged at the first 'Drawing

[122] The Drawing Open Collaborative is located at https://www.drawingopen.com

Ecologies' wānanga (intensive learning forum according to Māori principles), held at Tukorehe Marae, Kuku, Horowhenua, 11-16February 2019. Deep South NSC research funds supported Judy Watson to attend, and also Professor Frances Whitehead with co-funding support from Dist. Professor Anne Noble's research fund.

While some 25 Māori and non Māori contemporary artists were invited, the final number was a good sized group whose expertise spanned indigenous culture and practice, tā moko, art, landscape architecture, design, nature and ecologies. Amongst the 12 artist participants were: Sean Bennett Ogden and Tipi Wehipeihana (alongside kuia Aunty Yvonne Wehipeihana-Wilson) from Kuku in the case study rohe. Massey University's Jonathan Kay, Marilyn Jones and Maria O'Toole worked alongside Martin Bryant and Louisa King (University Technology, Sydney), Carl Douglas (AUT) and the invited Government House Matairangi Mahi Toi international residency artists - Frances Whitehead (Chicago, USA), Tania Kovats (Bath Spa, UK) and Amel Nafti (Valence, France). Indigenous artist and Waanyi woman, Judy Watson (Brisbane/Griffith University), also responded to the recent research findings of Phase 1 (2015-2017) and Phase 2 (2017-2019) Deep South NSC Vision Mātauranga projects.

The 'Drawing Ecologies' wānanga brought a new iteration of the Kei Uta collective together, an expanding and contracting team of visual language experts and other disciplines who are open to using our successful Mātauranga Māori research methodologies such as whakapapa (interconnected genealogies), hīkoi (walking talking meetings) and korero tuku iho (local oral narratives of place). To this end, over four days Huhana Smith walked this group through the lower reaches of the Ōhau River, the contiguous wetland projects across Māori shareholder farms, across dune ridgelines to beaches and to coastal protection projects, which are all within ancestral landscapes of great importance to hapū of Ngāti Tukorehe and other related hapū located towards Waikawa. We also stood on 1000 year old dune systems on Incorporation of Ransfield's farm, got hot and bothered in the Waikawa dunefields and cooled ourselves in the moana (sea) at Waikawa. We completed the last of our walks in the cooling forests surrounding Lake Waiwiri or Papaitonga, a last remnant of low land forest around a freshwater lake within sand country.

Back at the marae, extensive 'drawing as expanded practice' was undertaken during productive artmaking moments. The collaborative stencilled artwork led by Judy Watson (which is shown here in progress) focused on what is important to hapū – namely harvesting of tuna (eels) and īnanga (whitebait).

There were a series of presentations by artists about their practice and other evening 'check in' sessions to fathom the scope of what this initial gathering might manifest for future opportunties. While it was an intensive learning period and a dynamic convergence of like-minded people using their respective visual systems. They were grounded by Ngāti Tukorehe whānau in ways that might enable their visual systems to help our other related coastal landholders adapt more quickly to our fast changing climate between the Ōhau and Waikawa Rivers.

3.3.3 Tania Kovats Public Talk at City Gallery, Wellington

On Friday 22 February 2019, award-winning British artist Tania Kovats talked about her sculpture, drawing, writing and large scale public work during a public talk at City Gallery, Wellington. Tania's work explores her experience and understanding of landscape, environmental concerns, and her preoccupation with the sea. She has published about the maritime imagination and is developing sculptural prototypes as part of a coral reef restoration project. Presented in partnership with Whiti o Rehua School of Art, Massey University, Tania Kovats was in New Zealand as lead researcher for Drawing Open: an international research community's 'Drawing Ecologies' project (aligned with the Deep South National Science Challenge Vision Mātauranga project), coordinated by Emma Febvre-Richards (College of Creative Arts, Massey University), Monique Jansen (School of Art & Design, AUT) and Dr Huhana Smith (College of Creative Arts, Massey University).

3.3.4 Matairangi Mahi Toi International Artists residency, Government House, Wellington

The Government House and College of Creative Arts, Massey University Matairangi Mahi Toi international residency was organised as part of the Deep South research relationship and was supported by Massey University International Visitor Research Fund (IVRF) too. While this residency featured international artists - Tania Kovats (Bath Spa, UK), Frances Whitehead (Chicago, USA) and Amel Nafti (Valence, France), they were also invited alongside indigenous artist Judy Watson (Brisbane), Martin Bryant and PhD student Louisa King (University of Technology, Sydney).

These internationals are now newly minted members of the expanded Kei Uta Collective, who are working alongside all other willing artists and researchers listed above.

The purpose of the Governor General's collaborative residency is to advocate on behalf of collective research efforts made by artists and designers in tackling some of the world's 'wicked' problems. These include food sovereignty, water health, the disruptions and shocks wrought by the impacts of climate change on nature/humans, and other planetary boundaries/problems humanity faces.

3.3.5 Xichang University

Members of the research team met with Chunlin Bian, visiting scholar to Massey University, on 25 September 2018 to discuss satellite images and google projection mapping.

3.4 Outputs

The following is a list of presentations that have been made by members of the research team to national and international audiences and conferences, as well as reports, articles and other written material published in relation to the research. These more formal methods are also important stakeholder engagement activities to record, as they show how extensively this research is being

taken up by other groups around the country and indeed the world, who also grapple with how to adapt for the impending impacts of climate change.

*Presentation at the Deep South National Science Challenge Climate Change Symposium, 4-6 September 2017.

* Presentation at Creative Time on '*Mātauranga Māori, art, design and science exhibitions'* 26 September-3 October 2017. Dr Huhana Smith was one of the invited keynotes to speak at The Creative Time Summit in Toronto, Canada, on *Climate change research, art and design*. See creativetime.org for full video of presentation. On 29 September she gave her 10-minute visual presentation and 1 October 2017 (1 hour presentation with 30 participants).

*12 October 2017 Dr Huhana Smith presented in the Cultures and Resources session, at the '*Resources, Ecologies and Indigenous Knowledge; what can landscape architecture do? Research Seminar'* at University of Technology, Sydney, entitled, Art and Design collaborations in Aotearoa New Zealand/ Multidisciplinary, collaborative Research projects underpinned by Mātauranga Māori.

*16 October 2017 Dr Huhana Smith was invited to present with a panel on Climate Change for Māori and Pacific communities on Māori TV. Very compelling group of people who would all like to stay in touch over CC matters. See *Media Take* show online for details.

*26 September 2017 Dr Huhana Smith conducted an interview led by New Zealand artist Amy Howden Chapman living in New York about the socio-cultural practices of art and design for transformation around climate change issues. Interview resulted in an article released in early 2018.

*Allan, Bryant, Smith. 2018. '*Mātauranga Māori, Art and Design for addressing climate change impacts in farming practices'*–The Plan Journal, Bologna, Italy.

*Yvonne O'Hara journalist from Allied Press, was funded by Aotearoa Science Fund to write a series of articles about climate change and its impact on Otago and Southland. Dr Huhana Smith conducted an interview with her and sent relevant information for this article, which appeared on 7 November 2017 in regional newspapers.

*13 December 2017 - Dr Huhana Smith completed an interview for the Autumn 2018 volume of '*Art News'* with Julian McKinnon, PHD candidate from Elam Art school, Auckland University.

*December 2017, Jane Richardson was interviewed and appeared in a video, which was part of a Curious Minds project for a short climate education video for students in lower decile schools in Manawatū, during which she spoke about our project.

*Jagadish Thakar has been working with local science teachers and Black Sheep Design (a local public relations company) to produce a 10-minute animation video focussing on climate science, climate impacts in NZ and Manawatū, and actions.

*Smith, H and Richardson, J., et al. 21-23 Feb 2018. '*Moving from Phase One to Two: Mātauranga Māori, Art, Design, Ecological Economics and Climate Change Science*'. Pacific Climate change conference, Te Papa, Wellington.

*Smith, H and Richardson, J. 15 March 2018, '*Moving from Phase One to Two: Mātauranga Māori, Art, Design, Ecological Economics and Climate Change Science*'; Invited presentation at the Climate Communication Summit with the Massey Business School. The summit aimed to broaden understanding of effective communication and public engagement methodologies with climate change and to advance the interface between researchers and policy. Coordinated by Dr Pam

Feetham from Te Pou Aro Korero, School of Communication, Journalism and Marketing, Massey University, Palmerston North.

*Smith, H., 22 March 2018. Invited presentation at the Coastal Restoration Trust's annual hui.

*Huhana Smith was interviewed about the project for Radio Waatea based in Wellington.

*Richardson, J. 22 Feb 2018, '*Understanding flow and water from a geological perspective'*. Presented at SCANZ2018 He Punawai Hohourongo Peace, Water, Power, Parihaka.

*Richardson, J. 15 March 2018, '*Understanding flow and water from a geological perspective*'. Interactive forum with researchers and government representatives at the Climate Communication Summit, NZ, Massey University Wellington, 15 March, 2018.

*Smith, H. Presented at the Climate Change and Local Government conference, Wellington, 22 June 2018.

*Hui with Te Puni Kokiri, 4 July, with Eve Kawana Brown, Rangi Te Kanawa and Huhana Smith to talk about harakeke sustainable industry funding.

*Smith, H. Presented at a Hui Symposium in New Plymouth, 29 July, as part of the Vital Transformations Exhibition featuring ART – Science and Environment projects.

*Spinks, A. 2018. Te Wānanga o Raukawa – presentation on Treaty & Inland Waterways to Putaiao Third Year students from around NZ.

*Richardson, J. 2018. Panel Discussion on Art and Science at the Strange Climes: Ecology, Moving Image and the Senses exhibition; at AUT exhibition by AUT artists Andrew Denton and Janine Randerson, Pah Homestead, Hillsborough Auckland, 22nd April.

* Richardson, J., 2018. Presentation: artists can join with environmental scientists, Indigenous, or other invested communities to keep the climate issue on the public agenda? at Art and Science at the Strange Climes: Ecology, Moving Image and the Senses exhibition, Auckland, 22nd April.

*Richardson, J. 14 May 2018. Presentation to the Manchester Street School senior pupils about Climate Change, Palmerston North.

*Smith, H. 2018. Lecture to Post Human students in the Whiti o Rehua School of Fine Arts: exhibition and the actions by the Deep South research team to creating turangawaewae projects as part of 'Risks Assessments' research.

*Smith, H. April to May 2018. Attendee at, '*After the End of the World*' exhibition, Centre for Contemporary Culture, Barcelona (CCCB). This opportunity was to expressly investigate large-scale environmental exhibitions as research dissemination methods, especially for the complex knowledge that is being shared to general audiences through a contemporary art lens. It was an exhibition about 'how the Earth has been irreversibly transformed into the Anthropocene planet after two centuries of human impact on natural systems... it was also an exhibition about our society's responsibility to the generations who will be born and grow up in it'.

*Smith, H. 22 June 2018. "*Māori landholders leading in adaption strategies for their coastlines'- a coastal case study from Ōhau to Waikawa rivers, Horowhenua*". Presentation at the SOLGM New Zealand Society of Local Government Managers and their Climate Change and Local Government Forum at Mac Brewery, Wellington.

*Smith, H. 7 Sept 2018. "*Strategies for engaging with iwi/Māori communities - innovative and creative ways for Councils undertaking community engagement*". Presentation to Local Government New Zealand, Climate Change Symposium, Mac's Function Centre. Attendees included: Mayors, Chairs, Chief Executives and elected members of councils from across the country, as well as central government officials and other key stakeholders.

*Smith, H. September 28-30 2018. Invited by University of Otago and Toda Peace Institute to the "*Climate Change and Conflict in Oceania: Challenges for Peacebuilding*" workshop in Auckland.

*Smith H, 2018, "*Collaborative strategies for re-enhancing hapū connections to lands and making changes with our climate*", in Dürr, E; Schorch, P & Emde, S (eds.) Experiencing Pacific Environments Pasts, Presents, Futures: the Contemporary Pacific, Munich, Germany. (Note: citation not completely accurate at present)

*Richardson et al. (2018). *Transforming knowledge production and communication to address climate change through art-science cross cultural collaboration*. Presented at the Vital Transformations exhibition and hui held at JD Reid Gallery, Nga Motu New Plymouth, 28 July.

*Smith, H. (2018). ESFO conference-inspired chapter for publication: "*Experiencing Pacific Environments Pasts, Presents, Futures*", published by The Contemporary Pacific from Munich.

*Spinks, A and Poutama, P. (2018). *Coastal Restoration and Adaptation to Climate Change Impacts on Māori Communities*, Presentation to DOC-led Conservation week celebration, Te Takere, Levin, 21/09/18.

*November 2017, Aroha Spinks was interviewed by Stuff Correspondent and appeared in a Stuff article online and in national newspapers.

*Richardson et al. (2019). *Wai o Papa-Waterlands: coastal resilience through art-science-cross cultural collaboration*, to be presented at the 4th European Climate Change Adaptation Conference, Lisbon, 27-31 May, 2019.

*Richardson et al. (2019). *Art-science-indigenous knowledge collaboration in Aotearoa-New Zealand: blending diverse knowledge for transformational climate change adaptation*; to be presented at the 4th European Climate Change Adaptation Conference, Lisbon, 27-31 May, 2019.

*Patterson, M.G., Richardson, J., Hardy, D.J., Smith, H. 2018, *The Real Economics of the Adaptation to Climate Change on the Tahamata Dairy Farm – Assessing Future Scenarios from an Integrated Economic Production and Ecosystem Services Valuation Approach*. Horowhenua Coastal Climate Change Research Team, Massey University, Palmerston North, 69p. ISBN (digital): 978-0-9951027-2-9 ISBN (print): 978-0-9951027-3-6

*Smith, H., Penny Allan & Martin Bryant, 2018, 'Mātauranga Māori, Art and Design for addressing climate change impacts in farming practices', *The Plan Journal,* Bologna, Italy.

*Smith, H., Penny Allan & Martin Bryant, 2017/2018, '*Mātauranga Māori, art and design: unconventional ways for addressing climate change impacts'* in Geoffrey V. Davis & G. N Devy (eds.) Key Concepts in Indigenous Studies, Routledge Press: Australia.

* Smith, H., 2018, '*Moving from Phase One to Two: Mātauranga Māori, Art, Design, Ecological Economics and Climate Change Science'*, European Society for Oceanists publication, Ludwig-Maximilians-Universität, Munich, Germany.

*Smith, H., 2020 'Collaborative Strategies for Re-Enhancing Hapū Connections to Lands and Making Changes with Our Climate'. In: Dürr, Eveline, Philipp Schorch and Sina Emde (eds.): *Experiencing Pacific Environments: Pasts, Presents, Futures.* Special Issue: The Contemporary Pacific. (NUMBER AND PAGES NOT YET AVAILABLE).

*Smith, H., Bryant M, Allan P. 2018. *Mātauranga Māori, art and design: unconventional ways for addressing ways climate change impacts*; in Key Concept in Indigenous Studies, Routledge Press [Publication pending].

*Toda Peace Institute. 2018. *Climate Change and Conflict in the Pacific: Prevention, Management and the Enhancement of Community Resilience*, Summary Report of the Climate Change workshop, Auckland, November 2018, Policy Brief No. 27.

*Smith, H., 2019. *KEI UTA COLLECTIVE – Specialists using museums and exhibitions as platforms to increase access to, and participation with culture, whilst changing with a changing climate,* Emerging out of the United Nations Museums without Borders in the Circum-Pacific Region Symposium, Puebla, Mexico.

*Spinks, A. et al. 2019. *Climate Change Adaptation for Māori Communities on the Horowhenua Coast*. Report to the Deep South National Science Challenge, Maritime Room, Auckland, 6 May 2019.

*Spinks, A. 2019. Invited Panelist, *Kei aku ringa taku āpopo* (Chaired by Mihingarangi Forbes, The Hui), Deep South National Science Challenge Conference Changing with our Climate, Maritime Room, Auckland, 8 May 2019. (Hapū and iwi Māori taking the future into their own hands and what the rest of Aotearoa can learn).

*Smith, H. et al. 2019. Invited panellist, *Kua tārewa te Manuka* (Chaired by Patrick Crewsdon) with specialists talking about policy, insurance issues and concrete examples of where climate research has been applied successfully, and when research has not achieved its full potential, either because it was lost in translation, or framed in a way that was not relevant or useful for decision makers. Deep South National Science Challenge Conference *Changing with our Climate*, Maritime Room, Auckland, 8 May 2019.

*Spinks, A. Invited speaker, Lake Waiorongomai restoration project; and leader of breakout group discussions on hapū-led research and action, *DOC Restoration Day symposium, Listening to Whenua Listening to Tangata Whenua*, Waikanae, 18 May 2019

*Smith, H. 2019. Final speaker for DOC *Restoration Day* symposium, *Listening to Whenua Listening to Tangata Whenua,* Waikanae, 18 May 2019.

*Smith, H. Accepted for publication in 2020. *Collaborative Strategies for Re-Enhancing Hapū Connections to Lands and Making Changes with Our Climate*. In: Dürr, Eveline, Philipp Schorch and Sina Emde (eds.): Experiencing Pacific Environments: Pasts, Presents, Futures. Special Issue: The Contemporary Pacific. [NUMBER AND PAGES NOT YET AVAILABLE].

The project has also been reported in the media. For example, see:

https://www.stuff.co.nz/environment/climate-news/108755375/maori-are-among-the-most-vulnerable-to-climate-change?rm=a

https://www.stuff.co.nz/environment/climate-news/110587713/climate-change-scientists-look-to-maori-and-other-indigenous-people-for-answers

4 EXPLORATION OF PREFERRED ALTERNATE LAND USES: MĀTAURANGA MĀORI, HĪKOI, RELATED ENTERPRISES

During the wānanga and other end user engagement activities undertaken to design the research and identify priorities for detailed research in this project (see Chapter 3), three potential land use adaptations were prioritised by whānau land owners (and/or their representatives who were the liaisons with the research team). The preferred alternate land for detailed research in this project were harakeke, fisheries, and papakāinga. Exploratory research for each of these prioritised adaptation options are described in this research, for landowners to consider. For each, we provide examples of Mātauranga Māori and cultural values that informed decision making about adaptation to climate change. This chapter also explores how our transition action planning was informed by knowledge gathered during a hīkoi to specific sites elsewhere in New Zealand where such land uses are being researched/trialed, or are in operation. Various related enterprises identified in the literature were also explored to inform the preferred adaptation options in this project.

4.1 Land Use Adaptation Option 1 Explored - Harakeke

In Phase 1 (immediately, and over the next 5 years), our research considered that harakeke (Phormium tenax) planting would be conducted primarily to restore habitat; and in Phase 2 (over the next 5-30 years), harakeke planting would be expanded for commercial uses.

It should be noted that the initial phase of the fisheries expansion adaptation option includes riparian planting – in that case, the purpose of the riparian planting is to restore habitat for the enhancement of fisheries. However, such riparian planting could include harakeke plants, which would also enable expansion of the harakeke production land use, explored below. Thus, much of the information depicted in Section 4.2 for Phase 1 fencing and planting is relevant to this scenario, for the use of harakeke along riparian strips.

4.1.1 Mātauranga Māori: Harakeke

Harakeke fibre has a long and time-honoured place in New Zealand's textile history. Long before the arrival of Europeans, Māori were extracting it to make items such as fishing nets, baskets, mats and rope. Māori used muka scraped from harakeke using a mussel shell to make things such as piupiu, kakahu (all forms of Māori clothing), poi, whaariki, tukutuku panels, kete, taaniko (handwoven borders), animal traps and weapons.

According to Wood et al. (2017, p.47)[123], "swamps were similarly perceived differently by Māori and Pākehā. Harakeke/flax was valued by both cultures and was cut by Māori as a point of entry into the money economy. The swamps, however, were much more than flax: for Māori they provided a diversity of habitats and a richness of mahinga kai, matched only by the estuaries. For Pākehā, if the economic returns from flax diminished, the swamps could be drained, and the land converted to pasture".

Cultivating harakeke: To make kākaku (cloaks), weavers extracted and processed the inner fibre of harakeke, called muka. They used this to weave the base. They also used strips of the whole leaf – to create the thatch-like protective surface of pākē (rain capes) and to adorn other styles of cloak. Māori cherished harakeke and cultivated plants in special plantations, called pā harakeke. They grew

[123] Wood, V., Cant, G., Barrett-Whitehead, E., Roche, M., Hearn, T., Derby, M., Hodgkinson, B., Pryce, G. (2017). *Environmental and Natural Resource Issues Report*. A Report Commissioned by the Crown Forestry Rental Trust for the Waitangi Tribunal's Porirua ki Manawatū District Inquiry. Wellington, New Zealand: CFRT

many varieties for specific purposes – to produce clothing, fishing nets, bindings, baskets, and mats, and also to use in medicine.

Symbolism – the harakeke family: For Māori, the fan-shaped harakeke plant represents a whānau (family). This symbolism reflects the importance of the plant in Māori life. As depicted in the Figure 4.1 below[124], the rito, or inner shoot, is likened to a child and is never removed. A family must protect its offspring if it is to survive. The awhi rito, or protectors of the rito, stand on each side. They are seen as mātua (parents). Like the rito, they are never harvested. Only the outer leaves, likened to extended family members, are harvested.

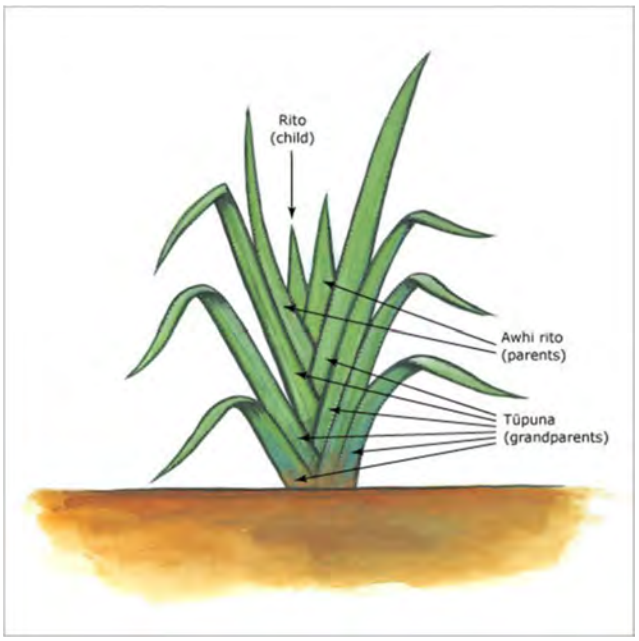


Figure 4.1 Symbolism – the harakeke family

Harvesting harakeke: Māori maintained many tikanga (protocols) to nurture harakeke. The protocols differed by iwi (tribe), but some, like those below, were commonly followed. Weavers say a karakia (prayer) before cutting the first blade of harakeke. They always cut on the diagonal, away from the plant's heart and from top to bottom. This helps rainwater drain away and prevents the heart from being flooded and dying. Harvesting is not permitted at night or in rain. No food can be taken into the pā harakeke. Customarily, pregnant or menstruating women do not harvest or weave, as they are in a tapu (sacred) state.

If using harakeke for commercial use, it would be more economical to harvest harakeke in a different way to that for customary use. For this climate change adaptation research, some commercial processes of growing and harvesting flax were investigated during our hīkoi, as outlined in Section 4.1.2 below.

Flax trade: Māori not only used harakeke themselves, they also traded it with early European explorers, who valued it for making ship rigging in particular. The Europeans named the plant flax because they thought it resembled the Linum plant. But harakeke is actually a type of lily, from the

[124] Te Ahukaramū Charles Royal, 'Te Waonui a Tāne – forest mythology - Symbolism of trees and plants', Te Ara - the Encyclopedia of New Zealand
https://teara.govt.nz/en/diagram/13162/harakeke-plant , accessed 8 April 2019

Hemerocallis family. From the 1820s and into the 1900s, European settlers exported large amounts to rope-makers overseas. See section 4.1.1.1 below.

At one time, flax milling was New Zealand's largest export earner and even before the commercial flax fibre strippers were invented, there were sailing ships using rope of fine harakeke fibre that had been hand stripped by Māori women. From the 1860s, a full-scale flax milling industry had evolved to supply a global rope and twine market[125]. The flax milling industry did not survive the decreased demand for military cordage after the First World War, or the twentieth century onslaught of synthetic fibres, disease, and the move by many land owners in the area to crop farming.

4.1.1.1 Flax Mill Operations in the Horowhenua-Manawatū

From 1839, ancestors in the case study region dealt in harakeke, pigs and potatoes for the markets appearing in a burgeoning Wellington. In the 1840s European settlers began purchasing flax fibre from Māori in the Horowhenua region. European settlers spun it into cordage sold in Wellington or exported to Australia. Kemp[126], writing in 1850 when the commercial production of flax fibre in much of the region had been underway for less than a decade, stated that 120 tons of fibre were already being produced a year at that time. By 1854, Ngāti Kapumanawawhiti[127] had substantial grain cultivations, a shop, a mill, flax ropewalks, orchards, as well as a merchant schooner for transporting produce to the growing markets in Wellington. The wheat crops grown by a bend in the Ōhau River by Ngāti Tūkorehe and at Waikawa by Ngāti Wehiwehi were transported and milled in the Catholic Pukekaraka mill at Ōtaki. It was alleged that the massive 1855 earthquake destroyed the grain mill,[128] and that the Ngāti Kapumanawawhiti schooner ran aground on the Ōtaki bar.

Figure 4.2 Tramway across Makerua Swamp to transport cut flax, 1907[129]

[125] http://www.biopolymernetwork.com/content/Technologies/71.aspx
[126] HT Kemp, 'Notes … embracing Statistical Returns in connection with the Native Population, and other Miscellaneous information within the Districts of Port Nicholson, Porirua, Waikanae, Ōtaki, Manawatū, Rangitikei, and Wairarapa, in the Province of New Munster, in the beginning of 1850', New Zealand Government Gazette (Province of New Munster), 21 August 1850, p. 83. Cited in Wood et al. (ibid.).
[127] Also known as Ngāti Kapu.
[128] Notes from St Mary's Church Pukekaraka File no 12004-150 Vol 2, New Zealand Historic Places Trust, Wellington
[129] Source, PNL&CS Digitisation ID 2011P_Fx88_004602. In Wood et al. (ibid), Figure 6.5, p219

Table 4.1 shows the distribution of flaxmills in the region, Turakina to Ōtaki, from 1869 to 1974[130]. Also see Figure 4.2 (photo of Makerua swamp), Figure 4.3 which shows the location of flax mills in the region[131] and Figure 4.4 (location of historical features in the rohe).

Table 4.1 Distribution of flaxmills in the region, Turakina to Otaki, from 1869 to 1974

Years	Total Mills	Turakina	Rangitikei	Oroua River	Makerua Swamp	Moutoa Swamp	Foxton Borough	Whirokino	Horowhenua	Ohau	Ōtaki
1869-1873	13	6	-	-	-	4	1	2	-	-	-
1874-1887	1	-	-	-	-	-	-	1	-	-	-
1888-1891	86	9	29	10	4	7	5	2	5	7	8
1892-1897	36	5	7	5	3	5	5	2	1	2	1
1898-1918	111	15	11	14	35	4	12	12	-	5	3
1919-1933	32	4	-	2	12	1	8	2	1	1	1
1934-1940	11	1	-	-	2	1	5	1	1	-	-
1941-1974	1	-	-	-	-	-	1	-	-	-	-

The first flaxmills were established on the banks of the Manawatū River in 1869[132]. Thomas Bevan arrived in Waikawa in 1844 to start a rope business made from Harakeke. His children arrived soon after with a local Māori guide Ropina in 1845. Thomas Bevan bought a schooner the 'Emma Jane' which he used to transport rope from Waikawa to other ports, such as Wellington[133].

By 1889 there were at least 50 flax mills within a ten mile radius of Foxton[134]. The number of flaxmills in the Ōhau region ranged from 7 in 1888 to only 1 by 1933[135]. The commercial ventures of Ngāti Kapumanawawhiti finally petered out when the market conditions for harakeke collapsed. With this downturn their ropewalk mill and shop went out of business. When Catholic Bishop Comte

[130] Data produced from handwritten table in Ian R Matheson Papers, Series 3/1, Box 50, Folder 1, Palmerston North City Archives, cited in Wood et al. (ibid), Table 6.1

[131] Location of Manawatū flax mills, adapted from original map drawn by Ian Metheson of Manawatū flax mills in 1912, which was reproduced by PT Kerr, 'The status of wetlands in the Manawatū', MAppSci thesis, Massey University, 2000, p. 28. Cited in Wood et al. (ibid.) p. 220

[132] Potter, H., Spinks, A., Joy, M., Baker, M., Poutama, M., & Hardy, D. (2017). Porirua ki Manawatū Inquiry: Inland waterways historical report. Kuku, New Zealand: Te Rangitāwhia Whakatupu Mātauranga Ltd. (Unpublished report commissioned for the Crown Forestry Rental Trust).
A Report Commissioned by the Crown Forestry Rental Trust for the Waitangi Tribunal's Porirua ki Manawatū District Inquiry. Wellington, New Zealand: CFRT, p.323

[133] Ron Averes, History of Waikawa Beach, Horowhenua. Otaki Historic Journal, volume 5. pp,75-77. Cited in Potter et al. 2017

[134] Potter et al. 2017, p.323

[135] Potter et al. 2017, p.324-325

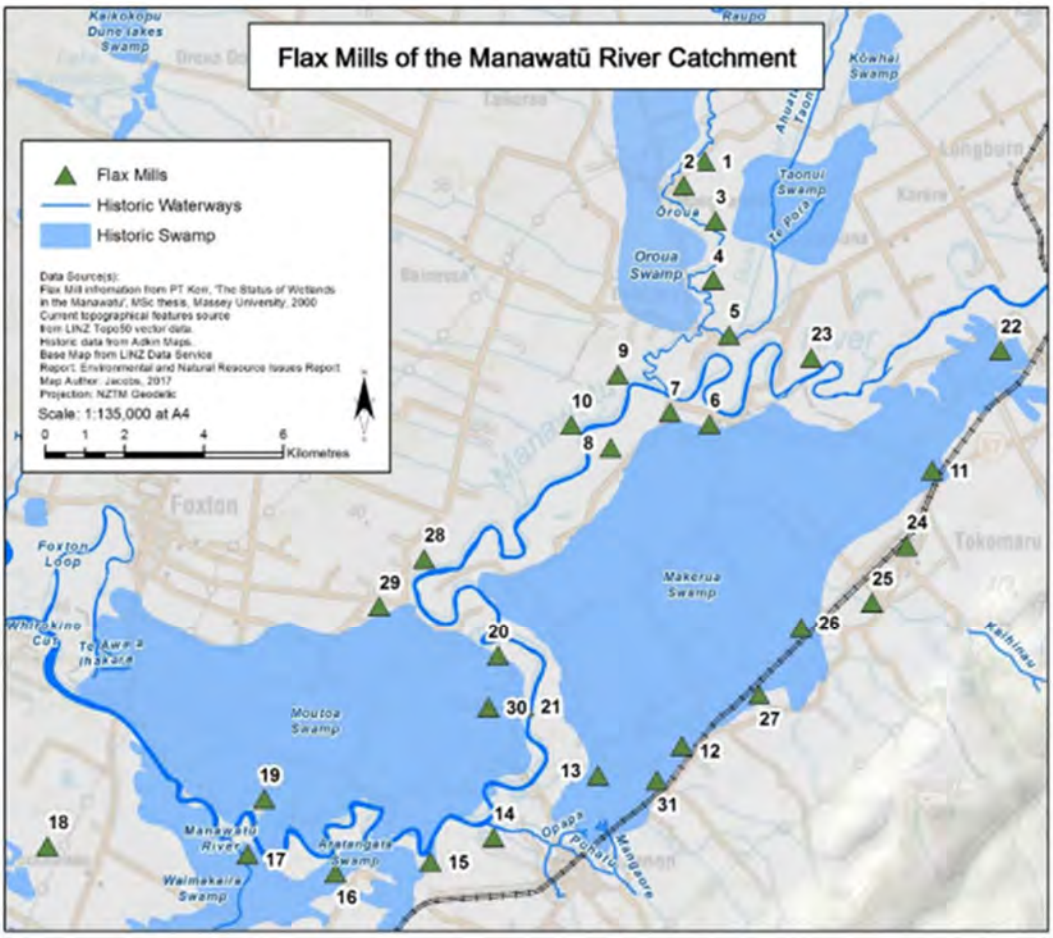
left the district a somewhat disillusioned Ngāti Kapumanawawhiti abandoned Catholic religious instruction.

In the Horowhenua, flax mills known to locals included Miranui and Makerua[136]. The Makerua swamp block was owned by A.L. Seifert Flax Milling Company Ltd who established the Miranui flax mill three miles north of Shannon in 1907. Makerua swamp was the largest commercial harakeke operation in the country, extending from Shannon to Linton along the East bank of the Manawatū river, covering approximately 22,000 acres[136]. A large number of men were employed to work in the Miranui flax mill which had seven stripping machines in the main building called the Welxa mil, and cut an average of of 22,000 tons per annum, with three acres of flax cut everyday[136]. The output of the mill was 2500 tons of hemp, and 400 tons of tow. It was owned by A.L. Seiferts flax dressing company who employed over 300 men and women[136].

Other mills operated further north, which also got their supplies from Makerua swamp (e.g. Mukapai Flax Mill and Whitanui mill). For many years flax milling was an amazing industry, providing 250,000 tons of exports every year. However, in 1914 a disease called yellow leaf spread through the flax, which made flax milling unprofitable so drainage work was carried out into the swamp, changing it to a fertile plain. Flax owners converted their flax land into farming.

Local sources state that there were over 19 flax mills just in the Foxton area alone. The number of flaxmills in the Ōhau region ranged from 7 in 1888 to only 1 by 1933.

[136] http://www.livingheritage.org.nz/Schools-Stories/Shannon-heritage/Flax-Mills



1	Smith & Seifert's mill	12	'Weka' mill	23	'River' mill
2	Jarvis' mill	13	Speirs' mill	24	Seifert's mill
3	Bell & Tennant's mill	14	Speirs' mill	25	Te Makanui mill
4	'Karere' mill	15	Dalziell's mill	26	Liggins' mill
5	Broad & Ingram's mill	16	Jupp's mill	27	Makapai mill
6	'Puke' mill	17	Porter's mill	28	Gibbs' mill
7	'Rangitane' mill	18	Poroutawhao mill	29	'Poplar' mill
8	'Kea' mill	19	'Rata' mill	30	'Whitinui' mill
9	Gibbs' & Nimmo's mill	20	Potu mill	31	'Miranui' mill
10	'Ariki' mill	21	'Titoki' mill		
11	Seifert's mill	22	Craw's mill		

Figure 4.3 Map of flax mills in the region, 1912

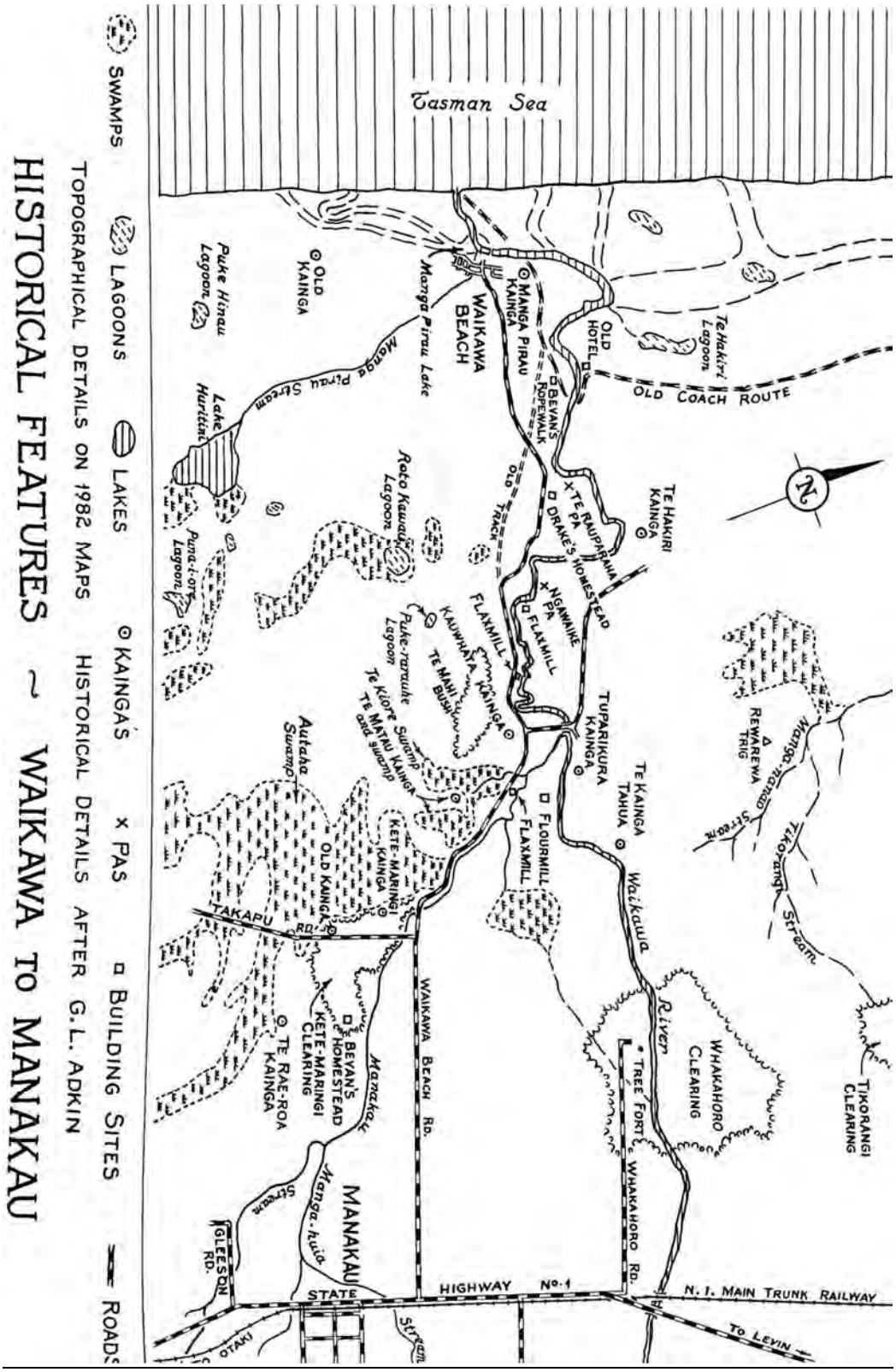


Figure 4.4 Map shoping topical features, Waikawa to Manakau[137]

[137] Source: Otaki Historical Journal, volume 5, 1982, produced by the Otaki Historical Society Inc, Otaki. P.62.

4.1.2 Hīkoi and Korero with other Harakeke Growers and Researchers

*Vaughn Templeton, Templeton Flax Mill Heritage Museum in Riverton, 9 October 2018

The Templeton family, near Riverton, have a restored 105-year-old working flax mill and museum on their 404 ha dairy farm, at Otaitai Bush, on the outskirts of Riverton[138]. The fibre produced from the flax by this mill is too coarse to be used as fabric, although several artists have bought the fibre to use in their work, including commissions from all over the world. Their harakeke technology is playing a role in movie-making, scientific research, and textile art. Janice Templeton, who deals with the flax fibre orders, said they had recently sold fibre to Cricket Hop Productions New Zealand, and to research organisations and are pleased to think the fibre was being used for ''something positive'' like research and the movies[138].

The mill was restored and turned into a working heritage museum in 2004 by volunteers led by Des Templeton. About 70 mills operated in Southland at one time, but the Templeton mill is the only operational one left in the country. The Templeton Flax Mill Heritage Trust now runs and operates, it with Mrs Templeton's son Vaughan as its Chairman. He, brother Kelvin, Vaughan's sons Luke and Peter, and trust members Stephen Logie and Howard Robertson, both of Wallacetown, are all involved with cutting harakeke flax that grows on the property, and the mill operation. The fibre was largely used to make rope. The mill, which is part of the Riverton Heritage Trail, is open to visitors, and the Templetons give talks about its operation and history as well as demonstrations by appointment[138].

The flax is slow-growing and takes about seven years before it is the right size to process at the mill. The family used the flax bushes as shelter for the sheep and cattle before the dairy conversion. ''The cows love it as they chew on the base and get nutrients out,'' Mrs Templeton said. Potential commercial uses are being explored, and feasibility studies would need to be completed before harakeke plantations were set up[138].

Vaughn Templeton took Moira Poutama and Aroha Spinks on a tour of their flax plantation and mill operation in October 2018, and provided information about the processes involved. Their multi-generational venture is nationally recognised as New Zealand's only authentic flax mill plant operating on its original site. The museum has retained a fibre stripping and cleaning capability and continues to sell flax fibre and this fibre has been used for subsequent research in new industrial uses, for example by BPN (see below).

According to Vaughn Templeton, they originally had 1000 acres planted in harakeke, which provide only 50% of the materials they needed; the other 50% was sourced from flax cut on the other local farms and provided to their mill. When the mill was in full time operations, they harvested 12 ton a day, which allowed them to break even. These 12 ton of flax leaves were put through a stripper machine, which resulted in 10 ton of vegetation byproduct, and 1.5 ton of 'fibre' product. They cut every 6-8 years to keep the plant healthy. Their flax fibre was used to make bailing twine, which was the main product from flax at that time.

Vaughn stated that is critical to have good freshwater for flax fibre plantations. Vaughn's father said that when they drained the swamps, the harakeke grew better. Peat soil is the best for flax. At their mill, they cut the flax differently to how Māori do it. It was more efficient to cut straight across the plant leaves; whereas, Māori leave three leaves in the middle.

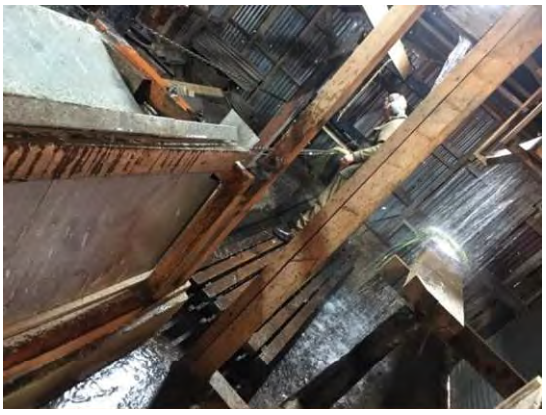
[138] https://www.odt.co.nz/rural-life/rural-life-other/century-old-flax-mill-still-business

Currently, Riverton Mill do tours of their flax plantation and mill twice a week in winder, and a bus load a week in summer.

Below are photos taken during the visit by Moira and Aroha (of our research team) to the mill. The photos depict each of the steps involved in producing fibre from harakeke.

From top left to bottom right:
-checking leaf lengths
-stripping the harakeke leaf,
-washing the fibre,
-washed fibre drying,
-fibre fed through another machine to strip it further,
-fibre drying
-resultant whiter fibre.


Vaughn (with Moira) checking lengths of leaf (above left) before putting similar sized leaves of harakeke through the stripping machine (above right).




Vaughn washing the fibre (above left); washed harakeke fibre drying (above right).


Vaughn (and Moira) checking the partially stripped fibre (above left); Vaughn feeding dry fibre into the next machine to remove further fibre (above right).


Fibre being re-stripped (above left); Stripped fibres, old photo of whānau & Mill workers on wall behind machine (above right).


Vaughn (and Moira) with fibre drying on outside fences (above left); Vaughn showing final fibre after processing (above right).

*Hui with Katarina Tawiri, Manaaki Whenua, Christchurch, 12 October 2018

Katarina Tawiri is a Research Technician at Manaaki Whenua. Katarina has been documenting the weaving and fibre properties of around 50 different varieties of harakeke from the Rene Orchiston Harakeke collection, located at Lincoln. A significant amount of research has been undertaken on NZ flax species by Manaaki Whenua, and this can be found on their website[139]. Their website includes an overview of how to establish a pa harakeke[140], and videos that document the harvesting and weaving process[141].

Katarina met with Moira Poutama and Aroha Spinks during their hīkoi in October 2018 and provided them with a tour of the harakeke plantations and research undertaken at this premises. Photos from the tour of the Rene Orchiston collection (below and over) provide a good depiction of pā harakeke.

[139] https://www.landcareresearch.co.nz/resources/collections/harakeke
[140] https://www.landcareresearch.co.nz/resources/collections/harakeke/establishing-a-pa-harakeke
[141] https://www.landcareresearch.co.nz/resources/collections/harakeke/video

Key information relayed by Katarina during the site visit is as follows.

There are two scientific species of flax in New Zealand:
*phorium tenex – harakeke, from which we get muka. All harakeke have muka.
*phorium kokiannu – whararikі (this is a coastal variety, and does not provide muka suitable for fine fibre).

Questions for whānau to consider:

*Whānau could plant a few paddocks on a trial basis, and could seek external funding to offset income from the current lease arrangement and/or current income from farming).

*Whānau could liaise with Rangi Te Kanawa regarding trialling a prototype machine in this case study rohe to process locally-sourced harakeke leaves; or supply such locally sourced leaves to her, to process with her machine in Te Kuiti. This would enable whānau to ascertain how suitable the local conditions are to produce muka of a quality necessary to produce fine fibre that generates a premium on the local and export market.

*Can whānau in the Raukawa rohe source enough harakeke to enable a trial production run of locally-sourced harakeke being processed into muka and fine fibre? If not, could a collaboration with other iwi be considered, to source adequate quantities of harakeke to enable a feasible harakeke-based industry?

*Could whānau work with Massey and other research groups to look at the potential for nutrimetics, and the potential of harakeke as a gel/medicine?

*<u>Hui with Peter Spinks, 18 October 2018</u>

Peter Spinks provided information from his extensive background in farming and horticultural enterprises, regarding the potential for a harakeke industry[142]. This is summarised below.

For commercial scale harakeke production, plants could be planted in rows with a 2m track around the outside. These areas should not have stock inside them, even in the 2m areas between harakeke planted rows, because stock will push the fences over to get to the harakeke.

In an industrial scenario, you have to enable access to the harakeke. There are two main options to allow for this: a) provide 'tractor tracks' down each 'double row', as indicated in the above figure, or b) headland access with smaller '4WD motorbike' access for small trailers to go down each row and feed the big tractor and trailer[142]. Tractor tracks would be 3 metres wide (see Figure 4.5 below).

[142] Personal communication with Aroha Spinks, 18 October 2018

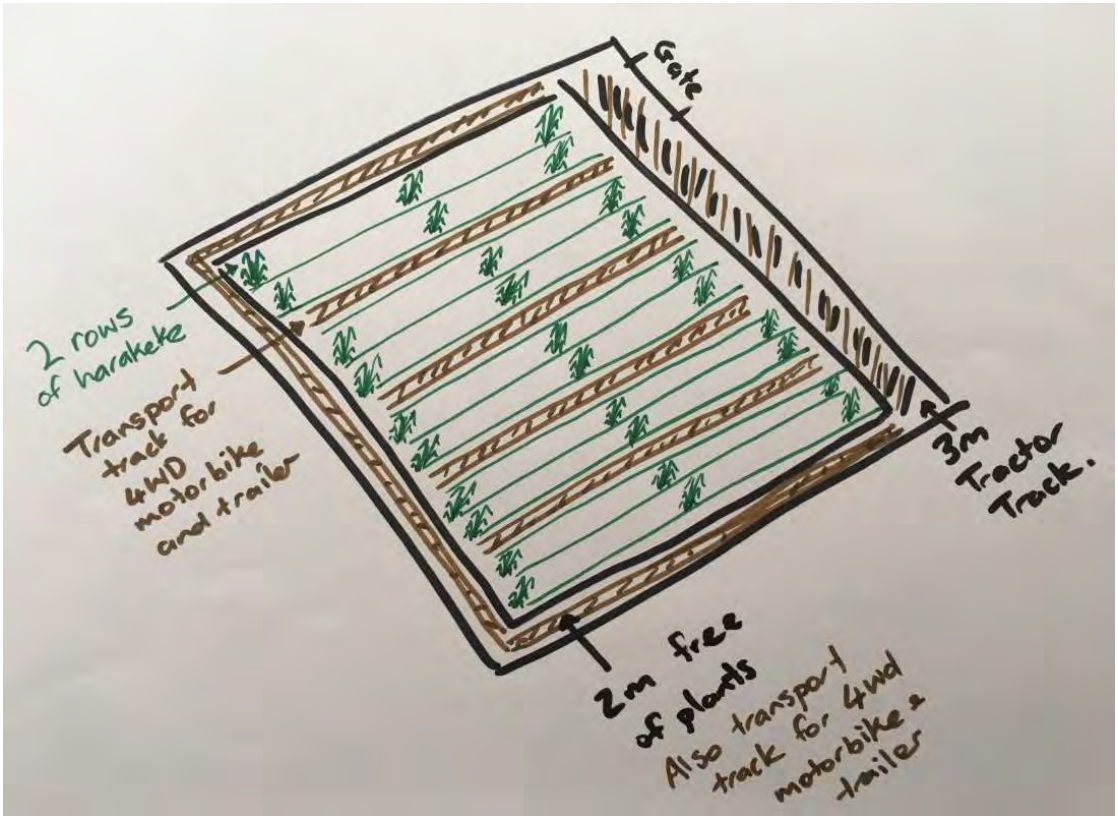


Figure 4.5 Planting Plan for Intensive Harakeke Production

Questions for whānau to consider include:

*Are there existing areas of harakeke where you could get started on trialling harakeke harvesting for commercial purposes?

*Are whānau/hapū/iwi able to pitch in and do the cutting process, initially, to help get a return in the short term? This is similar to what many small business owners do during the start up phase of new business operations. If this is possible, it makes it more economically viable to cover the initial years when you are paying for start up costs and haven't yet reached the point where you are getting larger revenues from your investment.

It is also important to consider other products that could be developed from harakeke planting, alongside the fibre. For example, seeds can be supplied to nutrimetics companies, for health shakes, salad toppings, nut seed mixes, etc.

Another option is that once you have larger paddocks planted, you could supply nurseries with small flax bushes, or groups undertaking restoration projects.

*Rangi Te Kanawa - Muka Production: For many years, the Māori members of our research team have liaised with Rangi te Kanawa regarding the use of muka from harakeke to produce fine fibre products.

Te Papa conservator Rangi Te Kanawa has, after 15 years of trying, produced a prototype machine to extract muka, instead of traditional hand extraction methods[143]. So far, machines produce a rougher,

[143] https://www.noted.co.nz/money/investment/focusing-on-the-flax-of-life/

industrial version of the fibre than muka, which forms the base of most Māori cloaks. Te Kanawa, who comes from a long line of weavers, says muka from her wooden machine can be spun into yarn. Her goal is to create a sustainable textile industry from the fibre for use in carpets, upholstery, manchester and apparel, while also helping to clean up New Zealand's waterways through the large-scale planting of harakeke. The next stage is producing fibre in greater quantities to prove it could work at scale, and developing a business case that would attract a commercial partner to pursue the opportunity[143].

Rangi te Kanawa provided the research team with information on which specific analysis was conducted in Chapter 6, to ascertain financial feasibility of muka production using her techniques. However, insufficient information is known at this time to enable adequate assessments to be made about the viability of such a muka-based fine fibre industry and ongoing research is recommended. To this end, and via the series of hui held from 2017-2019, funding is being sought to understand the process required to take muka to a thread using modified wool processing technologies and machinery.

4.1.3 Other Harakeke Ventures and Research Identified in the Literature

*Lack of Collaboration in the Industry: The harakeke industry was once thriving, with Māori relying on harakeke for making clothing, rope and medicine in the early 1900s. Of recent times, harakeke has increasingly been planted in small blocks near waterways by iwi, farmers and local councils. This has been actioned for areas within the case study region, particularly by Te Hākari dune wetland stream near the estuary and by the large wetland revitalisation project. A paddock is being returned to harakeke, as it is increasingly being considered for new commercial uses as it can be sustainably harvested, is environmentally friendly, has cultural resonance and could provide rural employment.

Efforts to revive the harakeke (New Zealand flax) industry are floundering, however, because of a lack of collaboration[144]. With the right leadership, recent taxpayer-funded research into possible uses of harakeke-based products could be turned into commercial success. A recent Rotorua forum on the native plant found plenty of interest in its multiple potential uses, including three parties with plans for ventures in natural health, skincare and textiles. But in the absence of industrial partners or a collective push to establish a large-scale, commercially viable industry, funding has been pulled for collaborative research undertaken by AgResearch, the Biopolymer Network and Scion[144].

The BioPolymer Network (BPN) was set up in 2005, is jointly owned by three of the government's Crown Research Institutes, Scion, Plant & Food, and AgResearch. BPN is looking to help set up New Zealand for a new economy based on sustainable products derived from biomaterials[145]. BPN's focus is on developing a portfolio of intellectual property in products based on materials from trees and plants, such as bio-based plastics. A harakeke fibre surfboard was created to demonstrate that it is possible to make a water-resistant composite material using biomaterials, and to show real-life, everyday applications of scientific research. Biomaterials like the harakeke fibre used in the surfboard may ultimately be used for a range of products including boat cabinetry or automotive panels, or for kitchen or bathroom flooring and benchtops. Other uses for biomaterials include cosmetics, shampoos, skin creams, and replacements for polystyrene and packaging[145].

[144] http://www.biopolymernetwork.com/content/Technologies/71.aspx
[145] http://www.scoop.co.nz/stories/SC0806/S00008.htm

According to Biopolymer Network chief executive Sarah Heine, "The world polystyrene market is worth about $US38 billion"[146]. The potential for New Zealand bio-products is thus substantial. The BPN website[147] does have information about their harakeke research and potential products, and this is a useful source for landowners who are contemplating diversification into harakeke for commercial purposes. The BPN research began with a focus on the industrial extraction of the fibre and the Templeton Flax Mill Heritage Museum in Riverton, which is nationally recognised as New Zealand's only authentic flax mill plant operating on its original site. The museum has retained a fibre stripping and cleaning capability and continues to sell flax fibre and this fibre was used for subsequent research in new industrial uses. See above section for more information gained during our hīkoi to this site.

However, BPN dropped work on harakeke fibre after failing to find commercial partners despite nearly a decade of research and producing a composite product that could replace fibreglass in a number of applications. Sarah Heine said she would be happy for someone else to pick up the research they have conducted, and put it to commercial use. But she thinks re-establishing the industry's viability requires a multi-use, collaborative approach that would see the lower-yielding fibre mixed with higher-yielding niche applications for other parts of the plant, such as the seeds[148].

Another player in the industry, Mark Henderson of Auckland-based 'Snowberry', says he'd be interested in working with other parties to develop a flax industry around multiple uses but doesn't have the funds or time to take the lead. "There's been some great science done, but that's at an end and there's been no return on it. That's a crying shame. The opportunity to develop the industry and take a collaborative approach is definitely there." He's surprised no iwi-backed operation with the requisite funding and commercialisation expertise has stepped forward[148].

A comprehensive study by the Sustainable Farming Fund in 2006[149] investigated increasing on-farm planting of harakeke to make the raw material available for new industries. Although research into developing new applications is already under way by crown research organisations, the report deemed it too soon to recommend large-scale planting without there being a clear market for an increased supply[149].

*Composite Products from Harakeke: Taxpayer-funded research by BPN (see above) resulted in the development of a composite product made from harakeke fibres to replace fibreglass in composites which gives them their strength and stiffness. BPN found that while structurally harakeke performed no better than other existing natural fibres such as sisal or hemp, it had one unique property that put it in a class of its own. It stood out against the other natural fibres as harakeke fibre produces a rich colour and aesthetic that you simply don't get from any of the mass produced fibre composites[150]. This could replace fibreglass in a number of applications, including boat cabinetry, automotive parts, kitchen and bathroom ware, wall coverings and surfboards. However, in a chicken-and-egg situation, companies are reluctant to commit to what are likely to be relatively small-scale niche uses, especially when there are only ad hoc plantings and no infrastructure for extracting harakeke fibre in large quantities. AgResearch textile scientist Peter Brorens says two or three local companies were interested in testing the composite, but manufacturers' equipment is

[146] https://www.nbr.co.nz/article/biopolymer-network-wins-prize-kiwinet-awards-polystyrene-alternative-huge-potential-b-174296
[147] http://www.biopolymernetwork.com/content/Technologies/71.aspx
[148] https://www.noted.co.nz/money/investment/focusing-on-the-flax-of-life/
[149] McGruddy, E. (2006). Integrating New Zealand Flax into Land Management Systems. Sustainable Farming Fund Project3/153. Retrieve: http://www.nzpcn.org.nz/publications/Harakeke-Report06.pdf
[150] http://www.biopolymernetwork.com/content/Technologies/71.aspx

not geared up to deal with natural fibres and likely returns don't justify the expense and hassle of making a change[151].

*Puma Darts, a company that made dart boards using processed sisal fibre was able to do the first stage processing and put through a tonne of harakeke fibre in to a yarn[152]. BPN built its own machine, using parts sourced from a Dunedin rope company, to carry out further processing to produce a special type of relatively coarse zero twist yarn or twine that could be incorporated as reinforcements into composites. Kraft paper making techniques were adapted to make a Harakeke fibre sheets specially engineered to work as composite reinforcement. The BPN team has come up innovative ways to use this fibre, such as creating fibre mat composites, decorative tiles, a prototype harakeke fibre surfboard, (with fibre added via a decorative mat laminate), and fibre reinforced bio-plastics. Existing composite industry methods such as Resin Transfer Moulding, Pultrusion, and Compression Moulding were used to get the best out of the fibre. Sample prototypes include pultruded rods, glossy harakeke fibre wall tiles, natural fibre wall tiles (that show off harakeke's beautiful texture), a sheet of decorative harakeke fibre laminate (incorporating harakeke fibre paper), a harakeke fibre dartboard and a sturdy harakeke fibre briefcase[152].

BPN's harakeke fibre surfboard was created to demonstrate that it is possible to make a water-resistant composite material using bio-materials, and to show real life, everyday applications of scientific research. Harakeke fibre was also used development of a new material in partnership with celebrated artist and furniture maker, David Trubridge. The material, a composite developed specifically for this project using bioplastic (polylactic acid) and harakeke fibre has drawn attention to the possibilities offered by new biomaterials[152].

*Non-fibre uses of Harakeke: Auckland-based skincare company Snowberry, for example, makes products that combine modern skin-renewal science and natural plant-based extracts[153]. It is already harvesting harakeke seeds to produce oil for its own and other local companies' products. Snowberry's bio-discovery division grows 12 varieties of indigenous plants, including 5000 harakeke plants on 22.5ha east of Wellsford. It plans to start exporting native plant extracts, including seed oil and gel from harakeke.

In the King Country, Māori trust Maraeroa C established a plantation in 2006 and uses it as a tourist attraction[154]. It's now growing enough flax to include gel in a range of herbal remedies and cosmetics it sells in China. Trust chief executive Daniel Benefield says that if a viable business opportunity presents itself in future for harvesting the leaf for fibre (muka), the trust will consider it.

4.1.4 Harakeke Planting in the Case Study Rohe

Phase 1 (activity that could take place immediately and over the next ~5 years)

In this project, the focus on harakeke in Phase 1 is about short term actions that could be started in the next 5 years to minimise ongoing degradation to the waterways, and improve habitat for taonga species.

As depicted in Figure 4.6 beow, if you had 10m of riparian planting for the purpose of restoring fisheries, if you also wanted to plant harakeke for industrial purposes, then you would plant an

[151] https://www.noted.co.nz/money/investment/focusing-on-the-flax-of-life/
[152] http://www.biopolymernetwork.com/content/Technologies/71.aspx
[153] https://www.noted.co.nz/money/investment/focusing-on-the-flax-of-life/
[154] https://www.noted.co.nz/money/investment/focusing-on-the-flax-of-life/

additional row of harakeke in the row closest to the fence. 2m needs to be left between the harakeke plant and the fence, otherwise the cows will break the fence down to get to the harakeke.

This means that you have:

Location of the fence is Point A.
Leave a gap of 2m, to Point B – then plant 3m of harakeke (to Point C).
Point C – start planting 5m riparian strip of plants best for fisheries restoration – to Point D.
So Point A to Point D is 10m, total.

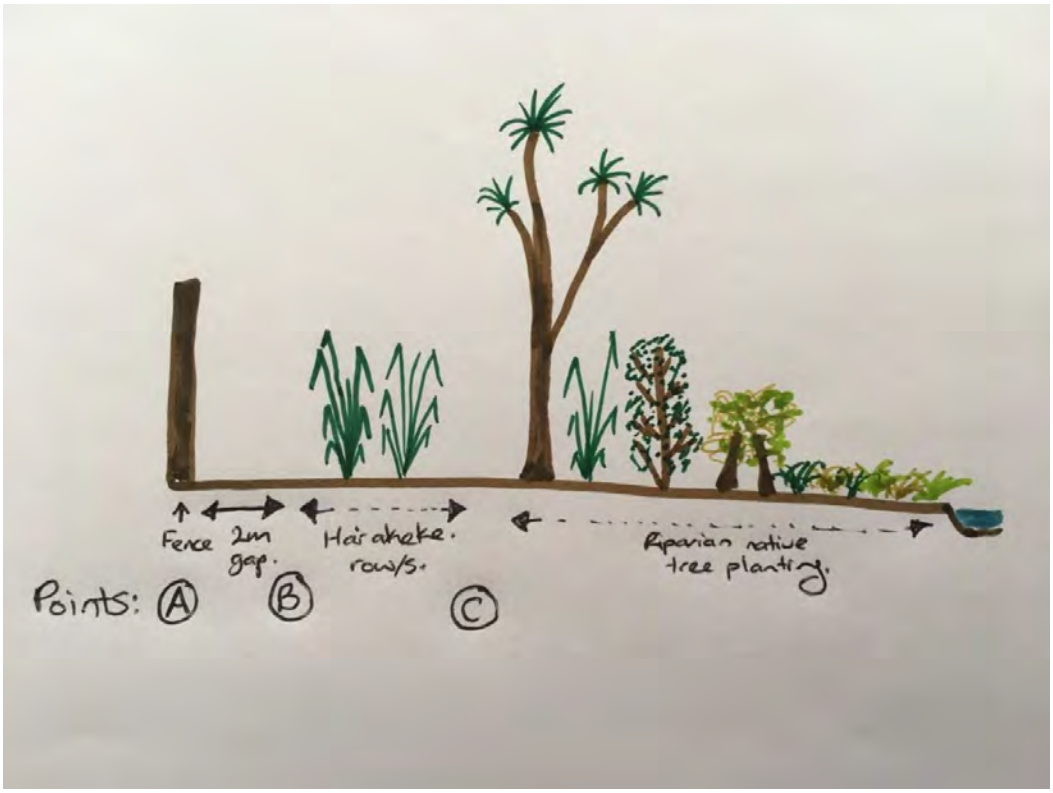


Figure 4.6 Riparian Planting Plan that includes Harakeke Strips

This would enable riparian margins for habitat restoration for fisheries AS WELL AS having a harakeke strip that could be accessed for cultural or commercial purposes.

A useful tool to assist in riparian management of inland waterways is the Riparian Planning Tool on the Dairy NZ website[155], which can assist in budgeting, mapping, and managing the processes involved in riparian planting.

Phase 2 (Over the next approx. 5-30 years):

Over a 30-year period, the harakeke would have grown to a state where it could be harvested for cultural or commercial purposes.

[155] https://www.dairynz.co.nz/environment/waterways/riparian-planner/

In addition to the harakeke riparian planting, if it was viable, "blocks" of land could also be planted in harakeke. Potential commercial uses include fine fibre and so forth. Costs associated with harakeke planting are the same as for the Fisheries Scenario (see section 4.2)

Potential commercial uses are being explored, and feasibility studies would need to be completed before harakeke plantations were set up.

Growing Requirements:

von Hochstetter (1867) provides more information about the flax operations in New Zealand during the 1800s and early 1900s, stating that the "flax plant attains its most luxuriant growth in the vicinity of swamps and rivers upon moist alluvial soil. Here the leaves grow to a length of 10 to 12 feet, and the flower-stalks to a height of 16 to 20 feet with a thickness of 2 to 3 inches. Large phormium bushes, therefore, indicate always a very fertile soil… the flax plant spreads on one hand into the swamps, and grows in the water, and ascends on the other hand on the dry slopes of the mountains to a very considerable height, without however attaining the above stated size" [156].

A report by Tararua District Council, based on the Ministry for Primary Industries' Sustainable Farming Fund's Flax Project[157], provides the following overview of harakeke growing requirements[158]:

Varietal selection: For environmental plantings, particularly in more rigorous (cold, frosty, exposed) environments, local varieties will be best adapted for local conditions. For commercial plantings, indications are that fine-fibre varieties will be of most interest in the future (including *P. tenax / P. cookianum* hybrids).

Propagation: Flax is easy to propagate on a small scale – by seed or by fan division. Most environmental/farm plantings are seedling stock sourced from the nursery trade, grown on for 2-3 years.

Planting: On a small scale, seedlings or fans can be planted into well-prepared holes. On a larger scale after a pre-plant spot spray, a two-person team can efficiently open a planting slit, for insertion and firming of the plant.

Spacing: In riparian plantings, closer spacings (1.5m) help to create interlocking root systems. In block or commercial plantings, more generous spacings (2-3m) facilitate optimum leaf growth, and ease of management and harvest.

Maintenance: Plants should be protected from stock in the first two years; and released from weeds in the spring/autumn/spring following planting. On weedy sites (eg. riparian plantings) flax is tolerant to spray-over by the triclopyr range of chemicals (Grazon™ etc) commonly used for blackberry and gorse control. In blocks or plantations inter-row mowing, or light grazing with sheep, can be used to control grass growth.

Health and Disease: Selection of fertile, free-draining sites supports healthy growth. Floods help reduce insect pest populations. Harakeke benefits from regular grooming, harvesting mature leaves, and clearing dead and decaying material from the base of the bush.

[156] http://www.enzb.auckland.ac.nz/document/?wid=441&page=1&action=null
[157] http://www.nzpcn.org.nz/publications/Harakeke-Report06.pdf
[158] https://tararuacropping.wordpress.com/flax/;
See also: https://tararuacropping.files.wordpress.com/2016/08/9527_tararua-flax-booklet.pdf

Harvest: For fibre and gel, only mature leaves should be harvested, leaving the central three young leaves in the heart of the fan. Harakeke seed ripens in autumn, and can be harvested when pods are dry.

4.2 Land Use Adaptation Option 2 Explored – Fisheries

This adaptation option examined the restoration of waterways for the purpose of restoring tuna and īnanga species, and potentially other fish species such as flounder, to enable improved customary take in the short term, and a potential fisheries industry in the longer term.

There are two scientific species of freshwater eels in New Zealand – the shortfin eel (*Anguiilla australis*) and the longfin eel (*Anguilla dieffenbachii*). The longfin eel is native to New Zealand, whilst the shortfin eel is also found in South Australia, Tasmania and New Caledonia. New Zealand freshwater eels are managed through the New Zealand Quota Management System to ensure a sustainable future.

As with the harakeke land use option described in Section 5.1, whānau might consider associated activities such as eco-tourism, tours and educational workshops/Wānanga, which are run by groups such as Riverton Flax Mill, and NitroEELS in Raglan, that could also be added over time, to any of the other adaptations developed on the farms.

4.2.1 Mātauranga Māori: Tuna and īnanga

Tuna and īnanga are taonga species that once were abundant within the regions waterways', historically they were part of the staple diet for Ngāti Wehiwehi and Ngāti Tukohere. Other local freshwater species were readily available including kōkopu, kākahi, koura etc. Within the Waikawa Stream and Ōhau River mouths kaimoana species that were common included: herrings; mullet; kahawai; patiki/flounder; piraroa; kokota; booboo; freshwater cockles etc. The Ōhau rivermouth as depicted in 1842-1845 is depicted in the Figure 4.7 below.

Figure 4.7 Sea coast near the River Ohau, looking towards Kapiti Island 1842-1845[159]

[159] This is likely Kuku Ohāu estuary beach. Source: Drawn by S C Brees, engraved by H Melville 1849. ATL Ref E-070-012. Cited in Wood, et al. (2017). Environmental and Natural Resource Issues Report. A Report

Wood et al. (2017, p.50)[160] summarise the traditional seasonal availability of key foodstuffs in the Horowhenua/Manawatū rohe (see Table 4.1 below).

Table 4.1 Seasonal availability of key foodstuffs in Horowhenua / Manawatū
(note **bold type** refers to important periods of surplus harvest)

	Wetlands & Waterways	Forests	Marine	Preserved, Cultivations
Spring	**inanga**		pipi (tuatua)	dried eel (shortfin), kūmara (stored)
Summer	ducks, **tuna (eel-longfin), inanga**	tawhara, hīnau berries	**pipi (tuatua), snapper**	dried eel (shortfin), aruhe
Autumn	kākā,	ureure	pipi (tuatua)	dried eel (longfin) dried pipi, **kūmara**
Winter	**tuna (eel-shortfin)**	kūkū (kereru), kākā	pipi (tuatua)	dried eel (longfin) dried pipi, kūmara (stored)

Wood et al. (2017, p. 50) goes on to state:

> *"No published figures exist for the scale of the eel resource in the nineteenth century, although it is worth noting that William Fox, when giving evidence to a Native Land Court hearing in Ōtaki, reckoned there were millions of eels within the waterways and swamps of the Rangitikei-Manawatū block alone, and as late as the 1910s, James Wilson observed that it was not difficult to obtain a dray load of eels 'in a very short while' during the seasonal seaward migration."*

As major sources of food those species along with other resources (such as harakeke) were also used for trade and expressions of manaakitanga. The ability to provide local delicacies (such as tuna and īnanga) to visitors was a sign of mana for tangata whenua and marae. The ability to express manaakitanga in this way remains important today although the ability to do so has been drastically affected by the low biodiversity that now exists within fresh water and marine ecosystems.[161]

> *'Talking about how times have changed over the years like cleaning the tuna, Dad and them used to pull all the long grass and clean them down at the back of our place where our grandmother lived. There were heaps of springs all along there, and there were eels and watercress, fresh water crays and stuff like that… and we used to go there and get them. It's a big surprise to go out there now and see it's all dry.'* Sally Petly, Ngāti Wehi Wehi.[162]

Commissioned by the Crown Forestry Rental Trust for the Waitangi Tribunal's Porirua ki Manawatū District Inquiry, p. 46.

[160] Source: Wood et al., (2017), Environmental and Natural Resource Issues Report. A Report Commissioned by the Crown Forestry Rental Trust for the Waitangi Tribunal's Porirua ki Manawatū District Inquiry.

[161] Potter, H., Spinks, A., Joy, M., Baker, M., Poutama, M., Hardy, D. (2017). Porirua Ki Manawatū Inland Waterways Historical Report, 70-71.

[162] Ibid.

'I was born in 1950. The quality of the water, I tell you what we actually use to get buckets of water to take home and we could drink that water - pristine water… Tuna in there, koura – freshwater koura [crayfish], there was īnanga *– whitebait… We always had a kai out of the awa. But I know for over sixty years everything's declined, the water quality has gone backwards. You wouldn't go in there and put your glass in to have a drink of water. No way'* Albert Gardiner, Ngāti Wehiwehi.[163]

'I could go down there now and I'll probably be lucky to get a dozen eels. We could just catch em by hand, but back in the day it was no sweat to walk home with a sack. In an hours time walk home with a sack of tuna that was very sacred to my whānau the Eru's and my dad. The other stream here the Waikawa that is our biggest stream, we got a lot of kai out of there, a lot of whitebait. Our old people used to talk about, how they could catch whitebait, basically it was about knowing then the tides were pushing, they would go out and catch a kerosene tin fill… the habitat is the biggest loss for our kai..." Te Whena Lewis, Ngāti Tukorehe, Ngāti Wehiwehi.[164]

'Tuna and Toheroa were two of our main staple diets. Most people have a story to tell about a tuna somewhere they either saw it or caught it… We utilised the Kuku Awa-iti for mahingakai they used it not just for swimming in, but it was utilised by my mother's whānau for existence… they used the awa-iti for watercress. It grew plentiful in those days very clean not just small bits but lots. Mum and them were always gathering watercress, duck eggs, tuna and Kākahi out of the Kuku awa-iti…' Patrick Seymour, Ngāti Tukorehe[165]

Customary methods associated with the customary take and use of eels, have been widely documented.[166] A range of knowledge, skills and expertise was required to maintain and cultivate fisheries, and to ensure a plentiful sustainable catch. Tuna were important and were not just caught but deliberately cultivated using a range of technologies, including: koumu (eel trenches); hīnaki (eel traps/pots); toi (eel-bobbing without hooks); korapa (hand netting); rapu tuna (feeling with hands and feet and catching in hands); rama tuna (using torch light); patu tuna (eels striking); mata rau (eel spearing); and pa-tuna (eel weirs). Eel weirs were constructed out of branches (such as mānuka and kānuka) and placed in streams for the on-hand supply of live, fresh eels.[167]

Traditionally the daily collecting and preparation of food by whānau was conducted in accordance with local tikanga (cultural practices) and as a collective. The daily practices of whanaungatanga and

[163] Interview with Albert Gardiner, Ngāti Wehi Wehi, at Wehi Wehi Marae, Manakau, 12 April 2016. Poutama, M., Spinks, A., Raumati, L. (2017). Porirua Ki Manawatū Inquiry Inland Waterways Cultural Perspectives Collation of Oral Narrative Report, 49.

[164] Interview with Te Whena Lewis, Ngāti Wehi Wehi, at Waikawa Beach Road, Manakau, 20 May 2016. Poutama, M., Spinks, A., Raumati, L. (2017). Porirua Ki Manawatū Inquiry Inland Waterways Cultural Perspectives Collation of Oral Narrative Report, 117.

[165] Interview with with Yvonne Wehipeihana-Wilson, Patrick Seymour, Zoey Poutama, at Tukorehe Marae, Kuku, 12 June 2016. Porirua Ki Manawatū Inquiry Inland Waterways Cultural Perspectives Collation of Oral Narrative Report, 193.

[166] For example: Best, E. (1929). Fishing methods and devices of the Māori. Dominion Museum Bulletin 12: 1-231; Curtis, C.S. (1964). Notes on eel weirs and Maori fishing methods. *The Journal of the Polynesian Society*, 73(2), 167 – 170. From: http://www.jps.auckland.ac.nz/document//Volume_73_1964/Volume_73%2C_No._2/Notes_on_eel_weirs_and_Maori_fishing_methods%2C_by__C._S._Curtis%2C_p_167_-_170/p1; Downes, T.W. (1918). Notes on eels and eels weirs. Proceedings of the Royal Society of New Zealand 50.

[167] Potter, H., Spinks, A., Joy, M., Baker, M., Poutama, M., Hardy, D. (2017). Porirua Ki Manawatū Inland Waterways Historical Report, 72 & 476.

manaakitanga also included regular sharing out of food and resources to whanaunga (extended family members) and neighbours.[168]

> *'I remember Whetu when he was alive sitting just out there (points to the back of the marae) doing raurekau. They used to do them one at a time on the konga (hot embers of the fire)...*' Bobby Miratana, Ngāti Wehiwehi.[169]
>
> '*My brother Albert used to get us feeds out of the Waikawa, lovely little tuna, they weren't huge – beautifully cooked, fried*.' Diane Taiaora, Ngāti Wehiwehi.[170]
>
> *'Talking about tuna heke I remember going out to the beach, all of Kuku went out, all of Levin and Manakau were there. We were only young but everyone was out there catching tuna, picking up tuna out at Hokio Beach, the whole community went*.' Yvonne Wehipeihana-Wilson, Ngāti Tukorehe.[171]
>
> '*You didn't just have the lone fisherman or group going out getting tuna or flounder or whatever species they wanted on the table at the marae. They went out as groups… so I think there's a lot to be told about whanaungatanga. I'm talking about going out in groups to harvest kai because that's the way most of our people operated around gathering kai for hui, tangi and other things like that*.' Te Kenehi Teira, Ngāti Tukorehe.[172]
>
> '*My kuia Miriama Ngamoana Waitohu Te Wharekaii held these eels in high esteem and she reckoned they were placed there by my koro Ihaka Ngapari. Those eels were shortfin you used to get the long fin as well, my brother owns the Manakau Dairy, behind it is the Mangahuia out of those streams they used to catch flounder and big kokopu the adult white bait, there were plenty in there…we were taken out by our parents… you always got plenty, it wasn't only just for you it was to feed all the old people that lived around here, you could do swapsies with them – swap em for a pawhara tuna or raureka and they would give you rewana*…' Te Whena Lewis, Ngāti Tukorehe, Ngāti Wehiwehi.[173]

According to Wood et al. (2017, p.74)[160], the eel fishery in the outlet streams (Waiwiri Stream and Hōkio Stream respectively) was a particularly attractive feature.

[168] Ibid, 234.
[169] Interview with Sally Petly, Diane Taiaroa, Colleen Harper, Lossy Meaclem, Bobby Miratana, Albert Gardiner, Ngāti Wehi Wehi, at Wehi Wehi Marae, Manakau, 9 September 2016. Ibid, Appendix V, 617.
[170] Interview with Sally Petly, Diane Taiaroa, Colleen Harper, Lossy Meaclem, Bobby Miratana, Albert Gardiner, Ngāti Wehi Wehi, at Wehi Wehi Marae, Manakau, 9 September 2016. Ibid, Appendix V, 617.
[171] Interview with Yvonne Wehipeihana-Wilson, Patrick Seymour, Zoey Poutama, at Tukorehe Marae, Kuku, 12 June 2016. Poutama, M., Spinks, A., Raumati, L. (2017). Porirua Ki Manawatū Inquiry Inland Waterways Cultural Perspectives Collation of Oral Narrative Report, 193.
[172] Interview with Te Kenehi Teira, Ngāti Takihiku, Ngāti Ngārongo, Ngāti Hinemata, Ngāti Tukorehe, Ngāti Kauwhata, at Archives, Wellington, 12 October 2016.). Porirua Ki Manawatū Inquiry Inland Waterways Cultural Perspectives Collation of Oral Narrative Report, Appendix V, 611.
[173] Interview with Te Whena Lewis, Ngāti Wehi Wehi, at Waikawa Beach Road, Manakau, 20 May 2016. Poutama, M., Spinks, A., Raumati, L. (2017). Porirua Ki Manawatū Inquiry Inland Waterways Cultural Perspectives Collation of Oral Narrative Report, 117.

The following photos from the National Library collections show the customary use of īnanga and tuna and their importance to tangata whenua in the Horowhenua region. The photo below depicts an eel weir (pa tuna) named Ruataniwha, on the Hōkio Stream[174].

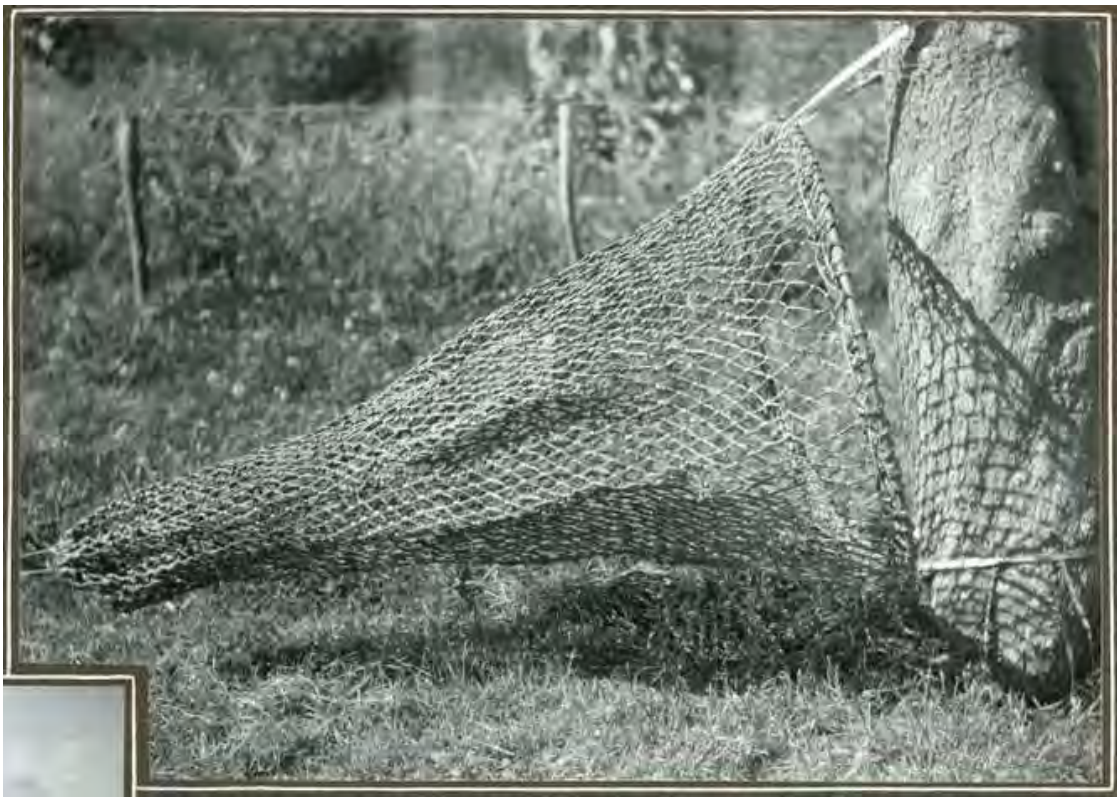
[174] Eel weir on Hokio Stream. Adkin, George Leslie, 1888-1964 :Photographs of New Zealand geology, geography, and the Maori history of Horowhenua. Ref: PA1-q-002-082. Alexander Turnbull Library, Wellington, New Zealand. /records/22517212. Taken 29 November 1925 by G L Adkin. From: https://natlib.govt.nz/records/22517212?search%5Bpath%5D=items&search%5Btext%5D=Horowhenua+eels

The following photos shows a group of cooks with dried eels on a line at Raukawa marae, during the centenary celebrations for Rangiatea church, 18 March 1950[175] (below); and Mrs Henry, of Ōtaki, with eels drying on racks (pataka-tuna), at Raukawa marae during the opening ceremony of Raukawa meeting house[176] (bottom of page)

[175] Cooks with dried eels, Raukawa marae, Ōtaki. Adkin, George Leslie, 1888-1964 :Photographs of New Zealand geology, geography, and the Maori history of Horowhenua. Ref: PA1-f-005-496. Alexander Turnbull Library, Wellington, New Zealand. /records/22299762. From: https://natlib.govt.nz/records/22299762?search%5Bpath%5D=items&search%5Btext%5D=Horowhenua+eels

[176] Dried eels on pataka-tuna, Raukawa marae, Ōtaki. Adkin, George Leslie, 1888-1964 :Photographs of New Zealand geology, geography, and the Maori history of Horowhenua. Ref: PA1-f-005-386. Alexander Turnbull Library, Wellington, New Zealand. /records/22538889. From https://natlib.govt.nz/records/22538889?search%5Bpath%5D=items&search%5Btext%5D=Horowhenua+eels

The following photo depicts a poha, leading net for use with a hinaki or eel trap, made by Arapata te Hiwi of Ngāti Tukorehe hapū, taken on 11 April 1937[177].



The following relevant passages on tuna and īnanga have been selected from the Te Ati Awa, Ngāti Raukawa, Ngāti Toarangatira Fisheries Report collated by the Raukawa Marae Trustees as evidence used for Treaty of Waitangi Fisheries Claims.

NGA MAHINGA TUNA

Eels played a major part in traditional Māori life. It was a source of food for hapū, iwi and whānau. A whole cycle of life revolved around gathering and preparing this commodity of food. It was jealously guarded and maintained as a ready and available source of protein. Each traditional eel pa were named and given tapu status. As these eel pa were well marked and sign-posted, each hapū, whānau and iwi were able to whakapapa to them and they were always held in high regard. Tohunga and Rangatira status were given to those who maintained and looked after these pa. Stealing or destroying of eel pa were thought of as the most heinous of traditional Māori crime, punishable by death in some cases, because of transgression in this area."[178]

[177] Māori fishing net to be used with a hinaki or eel trap. Adkin, George Leslie, 1888-1964: Photographs of New Zealand geology, geography, and the Maori history of Horowhenua. Ref: PA1-f-005-422. Alexander Turnbull Library, Wellington, New Zealand. /records/23139477. From https://natlib.govt.nz/records/23139477?search%5Bpath%5D=items&search%5Btext%5D=Horowhenua+eels

[178] Raukawa Marae Trustees, date unknown, Te Ati Awa, Ngāti Raukawa, Ngāti Toarangatira Fisheries, p. 77.

TUNA/EEL SPECIES – Found between Waimeha Lagoon (Waikanae) and Hōkio Stream (near Levin).

"Hao – Mud eel, large fleshy eel, dark brown in colour.
Pango – Very similar to Hao except it is dark black in colour.
Puhi – Slim eel with tapering head and body. Excellent eating.
Papaka – Yellowish coloured eel found in the Waikawa River.
Paraharahara – Short stocky eel.
Pehipehi – A yellow bellied eel."[179]

Waikawa Area (Informants: Horace Cook and Isobel Ransfield)

"Lake Huritini, Manga Pirau and Manakau Stream are all found on the south side of the Waikawa Stream. These areas were and still are areas of large eel populations. The Ngāti Wehiwehi used this area extensively having many eel pa built along these streams. Manga Pirau Stream was the main eeling stream, it had four large eel pa built along its length. The original Ngāti Wehiwehi Papakainga was also situated on its bank. It supported a very large population. The main eel types caught were Hao, Puhi and Pehipehi from Lake Huritini.

Today, the above areas are still used extensively and eel pa are still used in the Manga Pirau Stream to catch eels during the February/March tuna heke to the sea. The Waikawa was also fished extensively but mainly in the middle reaches and upper reaches where it is known as the Kaitawa (brief history of naming – Waikawa – bitter eater this is because of a greywacke slip in its upper reaches; above this slip the water is sweet). Most eel types caught are of the Hao and Pango variety, although there is a species known as the Papaka which was a yellowish brown colour. It is found only in the lower reaches of the Waikawa. It was found to be unpalatable and never eaten."[180]

Ōhau Area (Informants: Jim Poutama and Gary Wehipeihana Snr)

"Over the past 100 years the Ōhau River has changed its mouth 10 times, and because of this fact, it has left large lagoons on the leeward side of the coastal sand dunes. These, with already present swamps and lakes, have evolved an ideal ecosystem for eels to live in.

The main tribes found in this area were Ngāti Te Rangi and Ngāti Tukorehe, both having strong links with Ngai Te Rangi (Tauranga Moana), Te Atiawa and Ngāti Raukawa.

The main pa were Herehere at the mouth of the Ōhau River and Tirotiro Whetu. Large eel pa were built at the mouths of the different streams leading off from the main Ōhau River. One of the main streams used was Kukutauaki. This stream enters the river 2km from its mouth. Its head waters are found just behind the ridge behind the present Pa of Tukorehe. This stream had many eel pa situated on it. The main eel pa were owned by the chiefs Poutama, Koreniria and Whakaripa. The main vaireties of eels caught are of the Hao variety. Tuna heke pa are still built and used by the Wehipeihana, Patuaka and Poutama families.

The main run for these eels is February/March but there are also small runs of eels during October/November. On the river itself, mainly the upper reaches were used. Here the eels were caught by Ramatuna and by Ripituna. Set nets were not used often on this river. Small runs of Piharau were also caught on the middle reaches (above the stone crusher) during the winter."

[179] Ibid, p. 90.
[180] Ibid, p. 80.

Inanga – by Te Waari Carkeek[181]

"To the Māori, the fish migrating from the sea to rivers were called īnanga at which time all of the sub-species were identical in appearance. On attaining adult form the Māori were able to distinguish the various sub-groups and identify them. The first group were the Mauaiwi (*Galaxias maculatus*), the second were Kaoro (*Galaxias brevipinnis*) and the third group Kokopu of which the three adult appearances are similar except for slight pigmentation changes (*Galaxias fasciatus, Galaxias argenteus,* and *Galaxias postvectis*)….

It is a widely held opinion that whitebait that ascend the rivers at spring is the product of spawning of the previous Autumn… [īnanga] heke down to the tidal estuaries and lay their eggs amon the marsh and grasses near the mouths of streams and rivers. At times of spring tides the eggs are washed out to sea to start their cyclic life. Millions upon millions of eggs are liberated at this time and carried along on coastal and sea currents.

Māori people showed their resourcefulness in designing methods and devices to catch the īnanga. The trap or net for catching the īnanga was termed Kaka. A large opening or gaping mouth with a closed end. Originally these nets were made from Wiwi grass and constructed in a similar way as a Kakahu, the Whatu methods. The smallness of the fish demanded attention to a close weave. Another method was the construction of a water course with a current of water. The īnanga instinctively follow the running water of the course which has a kaka at its top. Inanga that was in excess of immediate needs were dried and stored for later use.

Māori people… can apply to the Māori Land Court to obtain exclusive fishing rights on waterways and lakes (a provision within the Treaty of Waitangi)… At Ōhau [River] access is also restricted to landowners and Pākehā people and other Māori are left to the beach as far up as the high water mark."[182]

A stocktake of freshwater taonga species was prepared for Te Wai Māori Trust, which includes an overview of methods used to assess the health of freshwater species, assessment of their abundance, and commercialisation opportunities for freshwater species.[183] This is a useful source for any groups wishing to embark on inland waterway fisheries restoration.

4.2.2 Hīkoi to Other Fisheries and Aquaculture Operations

Aroha Spinks and Moira Poutama visited and communicated with various New Zealand groups with expertise in this area, as outlined below.

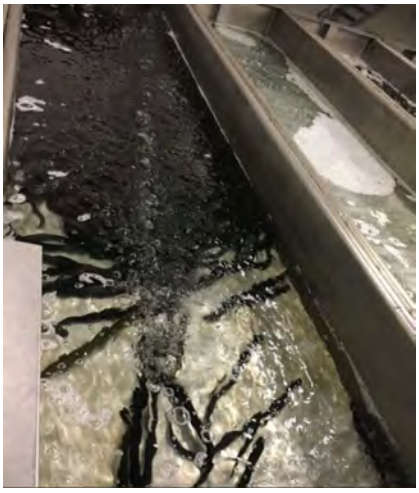
*<u>Levin Eel Trading Company, 28 November 2018</u>

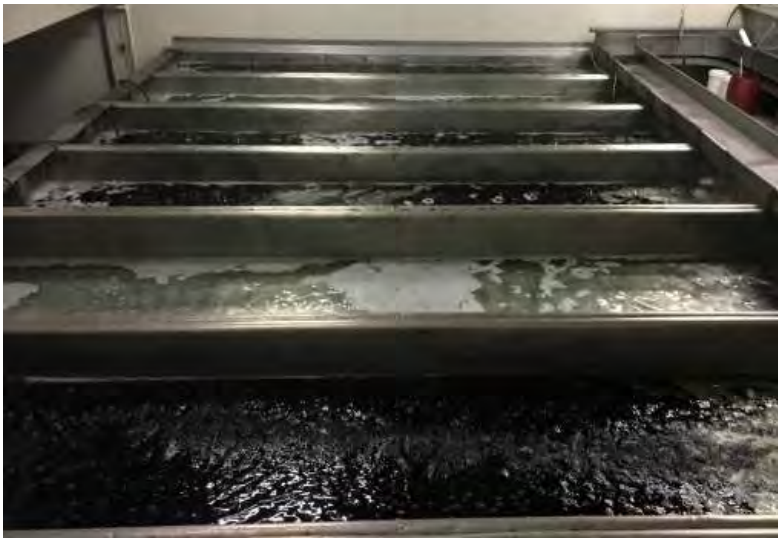
Levin Eel Trading Company[184] is a family-owned eel processing and eel export business based in Levin, Horowhenua region. As stated on their website, they export live and processed eel to various international markets throughout Asia, Europe and North America.

[181] Informants: Maikara Nikora, Hemaima Carkeek, Umakaihau Carkeek, Tui Tahiwi, Rato Royal, Haua Baker, Mahina Royal, Rita White, Ramari Ropata, Hama Johns, Paora Te Hiwi, Ra Rikihana. Ibid, p. 68.
[182] Ibid, pp. 69-75.
[183] Williams, E. et al. (2017). Understanding Taonga Freshwater Fish Populations in Aotearoa-New Zealand. Report prepared for Te Wai Māori Trust. NIWA, Wellington.
http://waimaori.maori.nz/documents/publications/Undertanding_Taonga_Freshwater_Fish_Populations_in_Aotearoa_September_2017.pdf
[184] http://www.levineel.co.nz/

Eric Kuijgen indicated a positive relationship with local whānau landowners who committed to the potential of supplying tuna and īnanga products in the future. They would be able to supply his factory and potentially use his quota or source iwi quota.

Below are photos from Levin Eel Trading Company, showing eel holding tanks and their range of products for sale. These photos were taken by iwi researchers on our team during their visit to the site on 28 November 2018, and are used with permission.





*Raglan Eels / Nitro EELS, Raglan[185]

Box 1: Water Management Systems for Sustainable Fisheries – Raglan-based NitroEELS[186]:

Raglan EELS Ltd[187] is a leading Raglan based Ag research company which has been focused on developing successful, sustainable aquaculture and biological solutions to restore lowland wetland ecosystems, based at a complex of coastal research ponds at Raglan. 'Nitro EELS' have developed a system to create new, highly productive ecosystems, constructed using NZ native plants and animals supercharged by farm nitrate runoff. First developed by Charles Mitchell, and now run by Charlie Young and Jan Mitchell, NitroEELS developed intellectual property to build and manage aquaculture ponds so they replicate prime wetland ecosystem functions for whitebait spawning and EEL rearing habitat (see photo, next page).

NitroEELS state that, "nitrogen-leachate into waterways can be mitigated and reduced using biological processes to create export-quality fish protein. The Nitro EELS system consistently delivers a discharge that is oxygen saturated and biologically stripped of nitrogen. It is intended that this system will become a commercially available solution for legislation requirements as a farm waterway 'clip-on' for nitrogen management plans. It has the potential to deliver multi-tiered ecological and economic benefits for farmers, fishermen, Regional Councils and environmental organisations."[188]

NitroEELS state that their system produces a return on installation investment of 3-5% per annum aquaculture investment income.[188]

"Urban Waste Water and Farm Environmental Incentives Include:
– Capture of Nitrogen Leaching into Waterways
– Continuous Year Round Catchment Monitoring with performance measured by fish growth and survival (canaries in the coal mine).
– Waterway Ecosystem Restoration (over 90% of NZ lowland wetlands have been drained). Benefits from recreating wetlands will return some balance to this lost habitat.
– Increase in wetland wildlife with rodent control.
– Efficient and cost-saving fish harvesting methods based on natural behaviours.
– Reduction of Fishing Pressure on Wild Waterways by filling QUOTA demand for high quality fish.
– Increase in Wild Fish Stocks by releasing larvae and adult spawning stock".[188]

Operations such as NitroEELS diversify their revenue base by operating eco-tourism[189], surf school[190], multiple outdoor education activities[191] including KaiWhenua Organics[192], Rocky Shores Exploration[193], Xtreme Waste[194], Environment Centre[195], Service Projects[196], Leadership and TeamBuilding[197],Kayaking and Coastal Awareness[198], Wahine Moe – the floating classroom[199], and various other affiliated activities.

[185] http://raglaneels.com/
[186] https://raglaneels.com/nitro-eels-system/
[187] https://raglaneels.com/waterways-restoration/
[188] https://raglaneels.com/nitro-eels/nitro-eels-system/
[189] https://raglaneels.com/karioi-lodge/
[190] https://raglaneels.com/raglan-surfing-school/
[191] https://raglaneels.com/school-field-trip/
[192] https://raglaneels.com/school-field-trip/kaiwhenua-organics/
[193] https://raglaneels.com/rocky-shores-exploration/
[194] https://raglaneels.com/school-field-trip/xtreme-waste/
[195] https://raglaneels.com/school-field-trip/environment-centre/
[196] https://raglaneels.com/school-field-trip/service-projects/
[197] https://raglaneels.com/school-field-trip/leadershipteambuilding/
[198] https://raglaneels.com/school-field-trip/leadershipteambuilding/
[199] https://raglaneels.com/school-field-trip/wahine-moe-the-floating-classroom/

It was hoped that our research team could visit Nitro Eels premises in person during the duration of this project; however, at the time of writing this report, that had not yet been possible, but it is hoped that ongoing funding can be secured to enable this to happen. Ongoing communication has occurred with this group, as outlined in Section 3.2.3. The picture below from their website shows the aquaculture pond system at Raglan Eels.

Box 1 and 2 describe operations and research undertaken in New Zealand to enhance inland waterways with a resultant increase in fish species. The learnings from this work are highly relevant to this project, and helped to inform the analyses undertaken in Chapter 6 for the Risk Assessment Tool. Key details are included in the following section, to help guide whānau when considering implementation pathways.

* Fish Habitat Restoration, NIWA

Aroha Spinks liaised with researchers at NIWA who have undertaken projects that aimed to increase fisheries within inland waterways. Key points are summarised in Box 2 below.

Box 2: Process to Restore Habitat for Fisheries, and Rate of In-Stream Fishery Increase: A Research Example[200]

The Hakarimata Streams Riparian Habitat Enhancement Project was undertaken by Kathryn Reeve and Cindy Baker at NIWA. Enhancement work carried out in 1995/96 included the construction of fences to retire the streams from grazing, provision of fish passes at existing culverts (where necessary), and the planting of indigenous species to create shade along the streams to enhance existing habitats.

They constructed 5 bridges, 12km of fences, 12 stock-water troughs to exclude stock from forest and streambed, and over 10,000 trees and shrubs planted along pastoral riparian margins to re-establish a forest corridor (approx. 4m width on each bank) between pastoral sections and the native headwaters. Streams were assessed to ensure that there was unhindered fish passage along the stream length. Fish surveys carried out in 1995, 2003, 2005 and 2016 (1995 survey represented pre-enhancement condition, and latter surveys assessing fish populations after 8, 10 and 20 years of riparian establishment.

Īnanga eggs were not present in this waterway prior to the enhance project. By 2005, the restoration efforts were deemed successful with the total abundance of species associated with forested streams or streams containing good riparian cover (giant kokopu, banded kokopu, and redfin bully all having increased by 50% or more. In addition, lamprey, a culturally important taonga species, and become established in two of the restored streams.

After 20 years, the continued high abundance of banded kokopu and redfin bullies indicated that the riparian restoration works had continued to provide good quality habitat in the lower sections of the streams. Longfin eel abundances had also been maintained or increased compared to previous surveys, which provides further evidence that as the riparian and canopy cover has become self-sustaining it is continuing to support valuable and viable fish communities.

In the study, īnanga declined, as did smelt and common bully; this was thought to be the result of the perched culvert in the lower section of the stream rather than a reduction or loss of suitable habitat. Erosion at the culvert outlet created a barrier to migratory species, limiting access for swimming fish species unable to climb the wetted margins of obstacles.

The absence of giant kokopu in the Forested Stream in the study during 2016 is likely to be because the fish had moved out of the survey reaches in search of more favourable habitat as low summer flows had resulted in a decline of the deep pool habitat preferred by this species.

Lessons learnt: on the small streams restored, the riparian rehabilitation was successful in enhancing fish species that prefer overhead and instream cover. Riparian rehabilitation is likely to reduce water temperatures improve invertebrate food supply and reduce erosion and inputs from fine sediment from the exclusion of livestock and stabilisation of the stream banks.
In order to main diadromous fish populations, access to habitats is just as important as habitat provision itself. This shows that other stressors in the wider catchment can impact on maintaining populations of migratory fish species after the development of self-sustaining riparian vegetation; eg erosion at the outlet of culverts. Careful consideration should be given to site selection as subsequent access problems can prevent the stream maintenance necessary to ensure success of restoration initiatives.

[200] https://www.doc.govt.nz/nature/habitats/freshwater/habitat-restoration/

4.2.3 Fisheries Expansion in this Case Study Rohe

Whānau indicated a strong preference for research into the potential for fisheries expansion as an alternative land use, primarily to restore taonga species in local waterways for customary fisheries purposes, but also with the possibility to generate an alternate income source in the future. This would be undertaken in two phases, as outlined below.

It should be noted that, in a fisheries expansion adaptation option, the purpose of the riparian planting undertaken in Phase 1 is to restore habitat. However, such riparian planting could include harakeke plants, which would also enable expansion of the harakeke production land use, explored in the Section 4.2. Thus, much of the information depicted below for Phase 1 fencing and planting is relevant to that scenario.

Phase 1 – fencing and riparian planting to restore habitat

This is about short term actions that could be started in the next 5 years to minimise ongoing degradation to the waterways, and improve habitat for taonga species.

Riparian planting of streams to build up the habitat in the existing drains, rivers and streams (and wetlands for the eels) to bring back the whitebait and eel populations. This would enhance the habitat for these taonga species and associated cultural value. In the longer term (up to 30 years), as the fisheries populations increase, this could potentially support a future commercial aquaculture activity.

Phase 2 (Between 5-30 years) – fisheries for customary and/or commercial take

With the current scientific predictions of increased rain and seawater levels, the whānau chose to look at the potential of artificial spawning grounds and habitat for tuna and whitebait. The potential for an economic industry is something they want to investigate. The commercial value is not the only reason to do this in the future, but also the cultural value of enhancing and bringing back the taonga species, eg for customary take, for marae etc.

Details about the process, costs and revenue streams estimated to be involved in developing a fisheries operation are described below.

4.2.3.1 Process for Fisheries Scenarios Phase 1

Step 1: Fencing of Waterways (rivers, streams, drains, wetlands)

In the case study rohe, some waterways are already fenced, while others would need to be fenced. Observations by iwi researchers on the team, of the most recent aerial photographs taken by Laurie Cairns in January 2019, showed that:

*For Tahamata, 100% of waterways are fenced (4m wide on average);

*For the non-Tahamata farms, most waterways do not appear to be fenced off in a retired sense. Fences exist along the rivers. Temporary fencing of smaller waterways is used instead. Thus, for the cost purposes of this research, it is assumed that all of these other farms need to be fenced.

A minimum 10m margin on each side of the waterway is required. This is for various reasons including acceptability to landowners. For this study, we are using the preferred margins of 30m strips for each side of rivers and streams, and 10m strips for drains. This is because the wider margin is preferable when water quality and river/stream restoration is the goal.

The river lengths for all case study blocks are detailed below (where the riparian margin is 30 m, as opposed to drains, which have a 10 m riparian margin on each side[201]):

Block name	Water body	length (m)	Width of riparian margin within block
Gardiner	Waikawa Stream	180	30 m on both sides
Te Hatete	Waikawa Stream	100	30 m on one side only
Tahamata	Ōhau River	4936	30 m on one side only
	Ōhau loop	2280	30 m on both sides
	Cut off pond	210	30 m on both sides
Ransfield (if has riparian margin will be drains)			
Peka Peka (no riparian margin)			

There are 30m strips of riparian planting on each side beside the Waikawa Stream and Ōhau River and loop. There are 10m riparian strips beside trains, ie 20m total riparian margin beside drains.
10 m (yes both side 20 m total riparian margin beside drains.

Throughout the analysis, the following distinctions must be noted:

"Riparian planting" refers to planting beside a stream, creek or drain, which will be mainly Harakeke.
"Riparian planting wetland" refers to planting of Wetland species, ie. Raupo harakeke purei.

This distinction is important because in areas where wet lands have expanded, and become a ponded area akin to a wetland, planting will require more than just harakeke; this is often the expected expansion of an existing wetland area. If these areas are not plant4ed, the land type will end up being 'wet or boggy' land.

Cost of Fencing[202]

-Tangatai[203] used GWRC Riparian Management Strategy (2003) to calculate costs in her study[204], as follows:
Fence materials: Permanent fencing *per km* in 2013$ is $18,064.69 for the fencing materials.
Labour: Fencing labour *per km* in 2013$ is $13,256.59 (based on labour cost of $18/hr).

[201] Ngāti Rangi's Iwi Management Plan[201] show that they decided on a 10m riparian margin on all waterways in their region (Ohakune area).

[202] Different companies quoting to install fencing on riparian margins, give widely varying costs. It is important to get different quotes. Costings in Tangatatai et al. (2017) are from a Commercial Fencing Company.The work at Waiorongomai outlined in Spinks (2019) was quoted by a local iwi contractor. We encourage people undertaking this kind of work to get multiple quote before embarking on this work.
[203] Tangatatai, T., Patterson, M.G., Hardy, D.J. (2017). Cost Benefit Analysis of Riparian Planting of Waiwiri Stream, Horowhenua. Manaaki Taha Moana Research Report No. 15. Massey University, Palmerston North.
[204] Ibid., Table 11, p.46.

An alternative study on which to base costings for fencing and planting is Spinks' and Ngā Hapū o Ōtaki restoration of Lake Waiorongomai[205]. The fencing around Lake Waiorongomai was 1.8 km in total length, and that cost $30,000 to fence the entire lake, including materials and labour, in 2013. This was a 7 wire permanent fence. A 2-wire electric fence is cheaper, but requires a power source to the fence, which Waiorongomai did not have. On hīkoi in this case study area that we have been on, the blocks in the case study (with the exception of Pekapeka-Taratoa) appear to be grazing and using electric fences. So the costs could be cheaper. As iwi researchers we would recommend 8 wire permanent fences for waahi tapu areas because of their significant cultural value. Note that Pekapeka-Taratoa have no fencing, thus no costs at this stage have been included for this aspect of the adaptation scenario for their block.

Step 2 Weed (+ Pest) Control

Weed control happens in spring; pest control can occur whenever suit.

Weed Control: This should be conducted prior to planting, otherwise the weeds smother your plants and it is too hard to do it afterwards. Various estimates of these costs are found in the literature:

*In 2013$ *per km*, the cost of weed control for a 10m riparian width, is $10,661[206].

*For Lake Waiorongomai, KCDC provided $3000 to fund weed removal and control for the 10 hectare property, at the very early stages, prior to planting. The costs of weed control was significantly less on an annual basis from that point on.

Pest Control: this is important for protection of biodiversity (birds, lizards etc). Councils may be approached to provide funding for this. Whānau volunteers currently do this for Waiorongomai. Nga Whenua Rahui DOC worker currently does this for Te Hākari wetland on the Tahamata Farm.

Koha to whānau volunteers, and purchase of traps: For the Lake Waiorongomai restoration project, koha is given to the whānau volunteer for his time and efforts as well as to aid buying the eggs, meat and fuel. Pest control is monthly checks of traps (started with 25, now 12) for the 10 hectare property. What originally took two hours to get around the lake and reset all the traps, now only takes one hour.[207]

DoC 250 traps are used at Lake Waiorongomai and recommended by GWRC Pest Control Department[208].

DoC 250 combo traps cost $59+gst each and shipment[209].

Step 3: Planting of riparian strips

A minimum 10m margin on each side of the waterway is required. This is for various reasons including acceptability to landowners; there is also a precedent for a 10m margin on Māori land, with Ngati Rangi's Iwi Management Plan (Pg 31. Section 3.3.1), showing that they decided on a 10m riparian margin on all waterways in their region (Ohakune area).

[205] Spinks, A. (2018). Restoring the Mauri of Coastal Dune Lake Ecosystems: The case study of Lake Waiorongomai, Ōtaki, Aotearoa/New Zealnad. PhD Thesis, Massey University, Palmerston North.
[206] Tangatatai, T., et al. (2017). Table 12, p.46.
[207] Personal communication by Graham Winterburn with Aroha Spinks, 23 June 2018
[208] https://www.doc.govt.nz/globalassets/documents/conservation/threats-and-impacts/animal-pests/doc250-predator-trap.pdf
[209].Personal communication with Trapinator Sales Representative, 17 April 2019. Also see www.trapinator.com

In this study we have calculated for a 30 m strip either side of streams and rivers, given that a key purpose of riparian planting is to restore the waterways to sufficient quality to enable a flourishing fishery, in which case the wider buffer zone is recommended.

Note that you can only plant in Winter, because that water gets the plant root systems established.

The first thing that need to be done is to find out what has already been planted, what more needs to be done.

*For Tahamata, 100% of waterways are fenced (4m wide on average); and approx. 15% of this is already riparian margin planted. Thus, the remaining 85% would need to be planted.

*For the non-Tahamata farms, most waterways do not appear to be fenced off in a retired sense. Fences exist along rivers but not to the extent that they prevent grazing at all times. Thus, for the purposes of this research, it is assumed that all of the other (non-Tahamata farm/blocks need to be 100% planted.

COST of Plants for Riparian Planting of Streams, Rivers, Drains[210].

There are various estimates of the costs of riparian planting:

*Annualised cost of riparian planting for a 10m riparian width is 12 hectares of land area, annual cost in 2013$ is $991.24[211].

*As outlined in Appendix D, regarding the KCDC costings for riparian planting (1000 plants costs $4000). KCDC supplied $4000 worth of plants each year (which is 1000 plants); Aroha/whānau choose where to plant them and how much area that will take up.

An important consideration when determining the costs of riparian planting on Māori land is that there is often a preference by whānau land owners for this action to be done by whānau, encouraging ūkaipotanga. Thus the labour cost of planting is not factored into costs, and is assumed to be zero. This was the case for the Lake Waironogomai Restoration project (Spinks, 2018), whereas such costs were incorporated into the Tangatatai (2017) study. Active involvement in riparian planting restoration projects is seen by the whānau as an idea opportunity to connect whānau with their whenua. That should be assumed as appropriate for this research and the associated costings, as this has been the case for all our MTM projects.

The Process for Riparian Planting

The process for riparian planting is outlined in Appendix E[212], which provides a checklist template on the preferred restoration methods for planting.

[210] NOTE: In this study, we have included the planting of wetlands in Phase 2 hectare coverage calculations – however, in practice, some initial planting can be conducted in Phase 1 around wetlands if desired, to provide shelter forage for the latter larger trees species to be planted in Phase 2– see pink shaded section of the Enrichment List in Appendix D.

[211] As cited in Tangatatai, T., et al. (2017), page 45. This is based on the Waikato River Independent Scoping Study (NIWA 2010).

[212] Whānau Planting Day, from Spinks (2019), Lake Waiorongomai Lake Restoration project, Table 6.1.1, p.340

Considerations when Planting Riparian Dunes:

There are specific considerations to allow for when planting different coastal areas. This includes specific varieties of plants being planted in different areas. Refer to the planting lists in Appendix D. Note the difference in planting for riparian areas, dunes, and wetlands.[213]

Pekapeka-Taratoa Block is naturally beautiful with native dune plants. With permission from whānau, however, seeds could be collected from this block and used to grow plants by whānau, the marae (Tukorehe and Wehiwehi), local schools (Ōhau School, Manakau School), and/or the Kotahitanga Kohanga Reo at Wehiwehi marae. Pingao is a taonga species that could be planted there again but only if whānau/owners wanted that.

Source: Kāpiti Coast District Council, 2018, Caring for Sand dunes in Kāpiti brochure.

Riparian *dune* planting costs would be very similar to all other riparian planting as, for example, there are no additional costs in preparation etc. The plants are likely to individually cost less, because they are small; however, you would plant more of the smaller dune grasses per square metre. Native tree planting for restoration is not like a market garden, which is planted in neat rows. Native planting tends to be sporadic and 'node planting', ie, planting in groups with space in between the groups etc – refer to the 'Successful dune restoration in Kāpiti' diagram (above), from KCDC[214]. This photo series of Paraparaumu Beach shows how restoration planting has helped damaged dunes move 10 metres closer to the sea over an 8 year period.

[213] Also see Tangatatai, 2017; and GWRC KNE site (see Appendix D & E, sourced from Spinks, 2018)

[214] Other information in the KCDC brochure that whānau might refer explains: sand dune lifecycle, local native dune plants species recommended to plant on the back dune, mid dune and front dune

It is important to protect the dunes in coastal areas because they provide strong natural barriers to the impacts of the ocean and offshore winds. These unique features also have cultural significance to local iwi. Native dune plants are essential to maintaining healthy natural dune morphology. Pīngao (golden sand sedge) and kōwhangatara (spinifex) are native sand-binding plant species that help to build dunes. The plants have evolved to trap sand and thus build resilient, shock-absorbing dunes that recover from storm surges and coastal erosion.[215] Pīngao with its vibrant orange-gold leaves is a taonga species used as a weaving material in tukutuku panels, kete, whāriki, pōtae, pare, belts and raincapes.[216] Pīngao, kōwhangatara and tarakupenga (sand caprosma) provide habitats and food for a range of native insects, lizards and bird species. Pīngao and kōwhangatara are also known to be important in the life cycle of shellfish species such as Tohemanga (also known as Toheroa elsewhere).

4.2.3.2 Process for Fisheries Scenarios Phase 2: Aquaculture

Phase 2 (Between 5-30 years)

With the current scientific predictions of increased rain and seawater levels, the whānau chose to look at the potential of artificial spawning grounds and habitat for tuna and whitebait. The potential for an economic industry is something they want to investigate. The commercial value is not the only reason to do this in the future, but also the cultural value of enhancing and bringing back the taonga species, eg for customary take, for marae etc.

The Vision of this Fisheries Adaptation Option is to restore the following taonga species, for customary take purposes (and potentially also commercial): longfin eels in streams (tuna); shortfin eels in lagoons or lakes); whitebait (īnanga); and mullet.

Of note, a kuia in the case study rohe had a brochure in her records (‘*I have been thinking’* by Henry Perenara), which detailed a potential aquaculture venture on Tahamata Farm. This shows that the potential for such a venture is something that is of interest to stakeholders, and has been considered before.

Step 1 – Riparian plant the whole area within the wetland. Note that some of this has already been planted; e.g., Te Hakari and Ransfields, planted by DOC at no cost to landowners. However, in Phase 2, the additional area surrounding that initial planting area will need to be planted, as the area that is wet expands over time. This will be done over time, starting in the area closest to the existing wetlands, and expanding over the 30-year period of the study as the ground becomes wetter. Based on Waiorongomai costings – they spent $20,000 on plants over 5 years, this was $4000 (1000 plants) per year for 5 years.

Species to Plant – see pink shaded sections in list in Appendix E. See also Box 1 and 2 examples by Nitro EELS and NIWA research, in Section 4.2.2.

Step 2 – Culverts Ensure culverts are accessible and water flow is well established. For this study, we are assuming they are already there. However, if other landowners do need to undertake this step, recently, cost $6500 for 2 culverts to go in and sturdy wooden fencing around it.

Step 3 – Fish friendly floodgates The cost to put these in has been estimated based on associated work conducted on the Ōhau Loop Area during the MTM project. The cost of the fish weir on the

[215] Kāpiti Coast District Council, (2018). ‘Caring for sand dunes in Kāpiti’ brochure.
[216] https://www.landcareresearch.co.nz/science/plants-animals-fungi/plants/ethnobotany/weaving-plants/information-sheets/pingao

Ōhau Loop was $40,000[217]. We assume that we will need to put in 2 fish friendly floodgates, (ie one in, one out) for each newly established aquaculture area. For this study, this is on 2 blocks: Te Hatete and Tahamata. This is a total cost of 4 fish friendly floodgates, ie $120,000 to $140,000.

Below are photos taken recently by Huhana Smith of riparian planting out at the Ōhau loop fish weir site. The last photo shows the cheaper option of a 2-wire electric fence.

[217] Personal communication, Huhana Smith, Feb 22, 2019

Below is a photo of the more expensive 7-wire fence used in the Lake Waiorongomai restoration project, which is better for excluding cows when you don't have electricity available. Taken at Lake Waiorongomai by Aroha Spinks, 10 November 2014

Step 4 – Dig out the Aquaculture Ponds To establish an aquaculture venture, spawning grounds are created at various points along a stream. Figure 4.7 below shows an excavation to create an artificial spawning ground by Charles Mitchell.

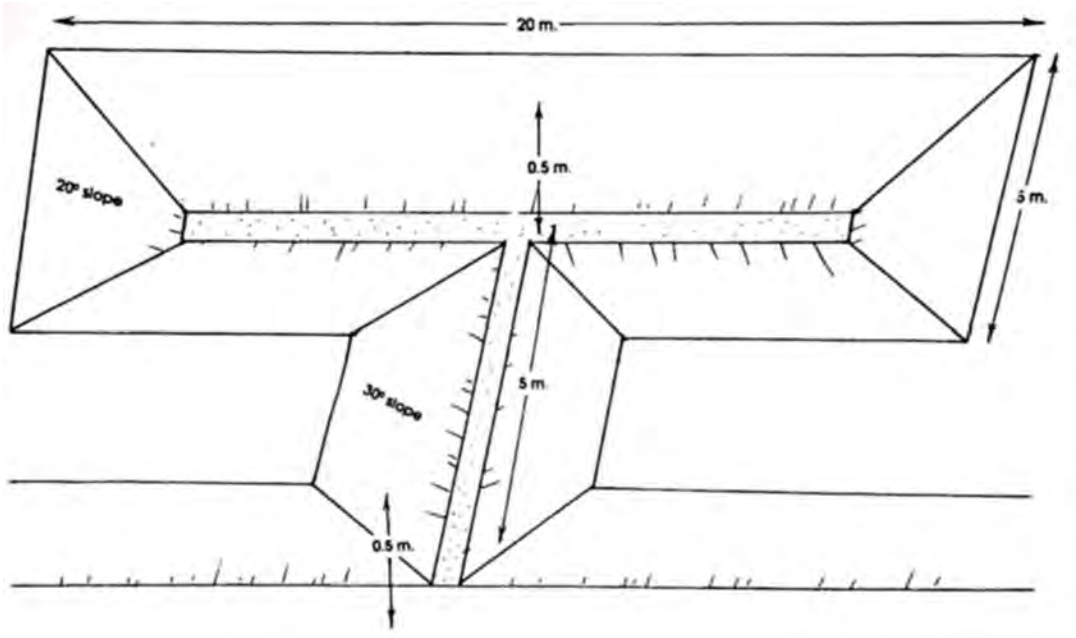


Figure 4.7 Diagram of an excavation to create artificial spawning grounds[218]

[218] Source: Mitchell, C.P. (1994) Whitebait Spawning Ground Management, Science and Research Series, No. 69, DoC, p. 14.

These spawning grounds consist of a 5m wide channel dug out from the stream, connected to a trench running parallel with the stream of approximately 20m long. In this study, the whānau have identified two sites where aquaculture could be located, as seen in the maps for Te Hatete and Tahamata. For Te Hatete, we estimate that three channels will be put in for Phase 2. For Tahamata we estimate that 6 channels will be put in. However, further investigation would be required prior to digging out such channels. Factors to take into consideration include the natural meander of the waterway and the flow of the water, the quality of the water, steepness of stream banks, degree of erosion of the stream bank etc.

The cost of hiring a 16-20 tonne digger and driver to dig out these channels is estimated to be: $1000 a day. Advice from a local contractor is that two channels can be dug in one day, with good conditions in summer. Thus, the cost to get the two spawning grounds at Te Hatete is $2000 (for two days hirage of the digger) and Tahamata is $3000 (for three days hirage of the digger).[219] Patrick Seymour, a Tahamata Board Member and kaitiaki with extensive knowledge of tuna and īnanga, also has digger experience. Ideally if further funding is obtained and this option is explored further then he would be engaged (if willing) in Phase 3.

Step 5 – Create Artificial Spawning Ground Habitat To create a habitat for fish species to spawn and grow in the new aquaculture ponds, artificial habitat is created. This can be done in various ways including hay bales put into the area on the slope, or planting natives such as sedge grasses, as recommended below, from work on the restoration of Lake Waiorongomai. Species to plant to create artificial spawning ground habitat include the following sedges[220]. It is assumed that the cost of planting is as outlined previously.

Scientific name	Māori name	Common name
Carex lessoniana	Rautahi	
Carex Māorica	Makura	
Carex secta	Purei/pukio	
Carex virgate	Pukio	
Cyperus ustulatus	toetoe upoka-tangata	umbrella sedge
Eleocharis acuta	Utuutu	spike sedge
Eleocharis gracilis		slender spike sedge
Ficinia nodosa	Wiwi	club sedge
Isolepis prolifer		
Schoenoplectus tabernaemontani	kapungawha	lake club-rush

Step 6 – Maintenance A recommended annual maintenance cost should be included into industry budgets at 10%; percentage cost is of buildings, equipment, assets etc[221].

[219] Personal communication, Roy Winterburn, 20/02/19.
[220] Spinks (2019), p. 582.
[221] Personal communication, Peter Spinks, 18/10/18. (NOTE: 25 years of experience as a farmer, and 20 years in horticulture.)

Step 7 – Harvest Process + Income/Kg For customary take purposes, no 'cost of harvest' is included. For commercial take purposes, fish stock will be caught in nets (not in hot weather).

Details of Eel Harvesting and Income

The optimum size live catch is at least 600g, and the minimum legal size is 300g (for frozen product); the eels must be caught live and delivered as soon as possible to the buyer[222].

Whānau need a permit to catch eels and whitebait for commercial purposes (price of this permit is at Online Fish Service, for 1, 3 or 5 years). You also need a quota to catch *eels and whitebait* for commercial purposes. Some suppliers may lease you that quote, eg Levin Eels gives 2 options: a price that includes the quota, or a price if you have your own quota. For example, Ngati Raukawa has a quota with a Mandated Iwi Organisation (MIO), and therefore whānau and hapū can negotiate with our own MIO.

COSTS: The only costs associated with harvest of eels to sell to Levin Eels is the cost of the nets, waders, the fisher's time, food safe tubs to transport the live eels in with holes in the lids to allow the eels to breathe but not big enough so they can escape, and transportation costs.
We estimate these costs as follows:
*hinaki (eel fyke nets) can last a long time if looked after but for this analysis we replaced the nets every 3 years for our calculations (even if in good condition we can give to whānau who would appreciate them, good for relationships); they cost $200[223]. We would need 5 nets, initially (more as harvest size increases).
*Waders – range in price from $180-$300. Replacement every 3 years.
*Fisher's time: $18/hr[224]
* Food Tubs to transport īnanga in the truck – 10 x 20l tubs (355mm x 250mm x 215mm) industrial stocking crate can be sourced from Co-Pack). We assume 10 number of such crates would be required to start and used each season. Replace 2 each year.
*Transportation: 75c/km, cost of trip one way Waikawa to Levin is 20 km one way (40 km return) = $30 (each trip to transport a catch to Levin Eel Trading Company).

REVENUE: In 2018, Levin Eel offers their fishermen $4/kg for live eels, using the Levin Eels quota. But if we use Ngati Raukawa's quota, Levin Eels will pay $5.25/kg.

When calculating revenue, one approach could be to utilise the Return on Investment percentage suggested by NitroEELS[225], who state that their system produces a return on installation investment of 3-5% per annum aquaculture investment income.

Phase 2 (in 30 years), it is envisaged that eels will be caught for live sale to Levin Eel Trading Company. Further research is required to gain an accurate assessment of projected catch quantities, once Phase 1 adaptations have been completed. The harvest season for Māori is Spring to Autumn finishing after the tuna heke (eel migration runs). We do, however, also acknowledge that weather, seasons, local environmental conditions and local tikanga as well as kaumatua will influence the eel fishing season.

For this analysis we have assumed eight months approximately running from September through to April. While some commercial enterprises catch eels all year round, in this case study, cultural

[222] As per requirements of Levin Eel Trading Company, 11 Main Rd South, Levin, ph 021 147 9473.
[223] Cost of eel fyke nets taken from The Complete Angler, 22 Feb 2019
[224] From Tangatatai (2017).
[225] https://raglaneels.com/nitro-eels/nitro-eels-system/

consideration about appropriate times of the year to harvest means that it will be limited to certain times of the year, only. Market rates for 2018 have been determined using export amounts listed by SeafoodNZ[226], showing that the average market rate for eels was $11.43/kg.

Details of Whitebait Harvesting and Income

COSTS: The only costs associated with harvest of whitebait to sell to Levin Eels is the cost of the nets, waders, the fisher's time, food safe tubs to transport the whitebait in with holes in the lids to allow them to breathe, and transportation costs. Estimates of costs based on currently available stock at local retailers are as follows:
*Whitebait nets range in price from $170-$220[227]. Replacement every 3 years.
*Landing net (scoop) ranges in price from $15-$45.
*Waders – range in price from $180-$300.
*Fisher's time: $18/hr[228]
*Food Tubs to transport īnanga in the truck – 5 x 18 litre (355mm x 250mm x 215mm) industrial stocking crate can be sourced from Co-Pack)[229]
*Buckets to catch īnanga –20 litre buckets cost $7[230] = estimate 10 required, initially. Total cost = $70. Replacement every 3 years.
(*Note: use a 10% maintenance cost figure per year, which takes account of these types of increases. OR as stock catch increases over time, as water quality increases, the number of buckets and tubs required would increase – so perhaps had another 2 bins every 5 years, so 10 required now, 12 in 5 years time, 14 in 10 years time, and so forth).*
*Transportation: 75c/km, cost of trip one way Waikawa to Levin is 20 km one way (40 km return) = $30 (each trip to transport a catch to Levin Eel Trading Company).

REVENUE: Phase 2 (in 30 years), whitebait will be caught for live sale to Levin Eel Trading Company. Further research is required to gain an accurate assessment of projected catch quantities, once Phase 1 adaptations have been completed.

Seasonal harvest: Like all fishing catch is weather dependant and thus difficult to determine. Catch is spread out as a weekly average catch during the harvest season of 3.5 months. According to DOC[231], on mainland New Zealand the whitebaiting season runs from 15 August until 30 November[232]. Thus, harvest is limited to spring, when the whitebait run.

Potential markets to sell to, and per kg prices:
*In 2011, the current market rate for whitebait was approx. $79/kg[233].
*Market rates for 2018 have been determined using export amounts listed by SeafoodNZ[234], showing that the average market rate for whitebait was $84.51/kg.
*Levin Eel Trading Company purchase whitebait for $60/kg[235].

[226] www.seafoodnewzealand.org.nz/publications/export-information
[227] Prices for Whitebait nets, waders, and landing nets taken from Hunting and Fishing Website, 22 Feb 2019.
[228] From Tangatatai (2017).
[229] 0800 4 Co Pack
[230] www.briscoes.co.nz/shopping/Plastic-Buckets
[231] https://www.doc.govt.nz/news/media-releases/2018/whitebait-season-begins/
[232] Except on the West Coast of the South Island, where it runs from 1 September to 14 November.
[233] According to The Mainland Trader, 2011, cited Allen et al. (2011), p.51
[234] www.seafoodnewzealand.org.nz/publications/export-information
[235] personal communication, Eric Kuijten email to Aroha Spinks 28 Dec 2018

4.3 Land Use Option 3 Explored: Papakāinga, Eco-tourism

The research considered the potential for papakāinga and/or eco-tourism to be implemented alongside other alterntive land uses, such as harakeke and fishers, as land owners work through the stages of the transition action plans. This was an initial exploration of papakāinga options, which should be expanded upon in future research. However, some information about sustainable building constructions that could be utitlise in the rohe is provided in this section, as a starting point for landowners as they work through transition action planning.

4.3.1 Mātauranga of Sustainable Papakāinga

Traditionally, the literal meaning of Papakāinga housing is, 'a nurturing place to return to'[236]. The increasing cost of living has resulted in some Māori moving out of urban areas and returning to their ancestral land and Papakāinga has increasingly become an opportunity for homeownership on Māori Land.

Te Puni Kokori provide guidance to whānau papakāinga housing, and outline process for developing papakāinga housing in three stages with checklists, tips and advice to progress your papakāinga housing development[237]. They state that a papakāinga refers to a group of houses on whenua Māori as a 'community' which may include broader support and occupant involvement.

The Building Better Homes Towns and Cities National Science Challenge has a Kāinga Tahi Kāinga Rua Strategic Research Area[238]. They refer to research about papakāinga which includes a range of development on Māori land, but mainly refers to residential development, referring to a nurturing village or place to return to[239]. Papakāinga have been set up especially for elderly or young families. With return of lands through Treaty settlements the authors envisage an increase of urban papakāinga. Papakāinga are typically higher density with a community focus, the layout and design depending on whānau, hapū or iwi preferences and tikanga, to support a communal way of living desired by papakāinga[239].

Rolleston and Awatere (2009)[240] state that there is a growing desire among Māori to be more active in developing sustainable habitation (papakāinga) within urban environments. To understand contemporary papakāinga, they identify nine key design principles for Māori sustainable development and conclude that conclude that through improved articulation and incorporation of Māori values, concepts and design principles, Māori can change their living environments. Their key design principles for Māori sustainable development are:

*Whānaungatanga: notions of membership and participation within communities; the design of spaces must encourage community participation and membership and not isolate or segregate its members.

[236] https://www.maorimenshealth.co.nz/healthy-lifestyles/papa-kainga/
[237] www.tpk-guide-papak%C4%81inga-housing-2017%20(1).pdf
[238] http://www.buildingbetter.nz/publications/SRA5/Maori_and_indigenous_housing_annotated_biblography.pdf
[239] Burkhardt, L., Swallow, N., & Beckett, H. (2014) Papakāinga Development – Turning Aspiration into Reality. *Resource Management Journal,* (2014): 11. https://www.rmla.org.nz/product/november-2014/
[240] Rolleston, S, Awatere, S. (2009). Ngā hua papakāinga: Habitation design principles. MAI Review, 2, Article 2. http://www.review.mai.ac.nz/MR/article/download/241/241-1461-1-PB.pdf

*Kotahitanga: collective cohesion and collaboration; spaces and environments that are in unison and harmony with their surroundings. The design of physical spaces must link and connect people together but must also connect environments; spaces should be inclusive of people.

*Wairuatanga: in a design context, this draws on the emotional relationships and connections people make with physical and natural spaces – it is an intimate personal bond with an environment.

*Mauritanga: design must take into account the presence of the existing mauri of an environment, but also maintain or enhance the mauri within a community.

*Orangatanga: design can contribute to creating better social, cultural, and environmental interaction for people who occupy or utilise those spaces.

*Manaakitanga: ability of a host community to receive, provide, and welcome visitors and to nurture and protect inhabitants; communities must be places where people feel accepted and safe.

*Kaitiakitanga: sustainable use of the natural environment promotes community awareness of inherent values contained within the environment; innovative design solutions are possible to preserve and protect significant natural assets; design must reflect the role of kaitiaki in the management of communities, recognising the significance of intergenerational equity.

*Rangatiratanga: promoting individual and community aspirations through awareness of fundamental cultural values pertaining to the environment and landscape; access and admission is concerned with encouraging community ownership and responsibility of important natural resources and features found within a community.

*Mātauranga: settlement should reflect an understanding and awareness of local history through design.

These principles are a useful framework that could underpin the design of new community-based housing or educational facilities in the rohe, alongside other land use adaptations that are implemented over time, to adapt to climate change impacts.

4.3.2 Sustainable Papakāinga/Structures Researched

There are numerous frameworks and models for papakāinga development. Examples include:

*Pehiāweri Marae papakāinga: a model for community regeneration in Te Tai Tokerau[241]

*Papakāinga housing at Mangatawa[242]

*Ngā hua papakāinga: Habitation design principles Ngāti Whātua o Ōrakei[243]

*Hastings District Council Papakāinga Development Guide[244]

* Whangarei District Council Planning for Papakāinga Housing[245]

[241] http://hdl.handle.net/10652/3252
[242] http://maorilawreview.co.nz/2012/11/Papakāinga-housing-at-mangatawa/
[243] Rolleston, S., & Awatere, S. (2009). Ngā hua papakāinga: Habitation design principles. *MAI Review,* 2(2), 1-13.
[244] https://www.hastingsdc.govt.nz/assets/Document-Library/Policies/Papakāinga-Guide/Papakāingaguide.pdf See Building Exemplars
[245] http://wdc.govt.nz/CommunitySafetyandSupport/Housing/Documents/Papakāinga-housingbrochure.pdf

*Mangatawa Papakāinga housing project[246] and others in the Bay of Plenty[247].

In this project, the team identified the following types of housing/building constructions, which are affordable and in some cases, transportable, making them suited to the uncertainties associated with a changing coastal landscape such as is the case with climate change. These are described below.

Log homes[248] - these could be constructed for the purposes of hiring them out, thereby providing a rental income.

In the example below, with photos that follow, the cost of a small home is $100,000 + GST; family homes are $300,000; a large Wānanga style structure is $600,000.

Builder: Graeme Mould

Location: Geraldine (Can build anywhere in New Zealand.)

Design: Numerous designs available at varying costs and can be made to your specifications.

Notes: Natural Log Homes Ltd - WINNER Supreme House of the year Mid & South Canterbury 2016.

WINNER sustainability Gold award, Mid & South Canterbury 2016. Log home specialists.

"I have been building log homes for 30 years but have never built two homes the same." - Graeme

Prices: Variable. Tiny homes start at approximately $100k plus gst ex yard.

Contact details: Graeme Mould, 03 6937468 or 0272213812, www.naturalloghomes.co.nz.

[246] http://mangatawa.co.nz/content/Papakāinga
[247] https://www.radionz.co.nz/national/programmes/teahikaa/audio/201822577/Papakāinga-hapu-dream-becomes-a-reality; and
https://www.planning.org.nz/Attachment?Action=Download&Attachment_id=4801
[248] www.naturalloghomes.co.nz; Graeme Mould, 03 6937468

Website photo advertising tiny homes was 112k plus gst ex our yard.

Website photo advertising the family homes; cost is $300,000 + GST ex our yard

The main home that pops up first on their website is a home at Wanaka which had a log shell; the cost is approx. $600, 000 + GST ex our yard.

Mud Brick Housing[249] – homes can be built from $16,000 + GST.

Papakāinga design – Plaster infused with dried Harakeke and Ti Kouka leaves

Builder: Bill Brooker

Location: Wanaka

Design: Open plan lounge and bedroom (to date as this journey continues). Solar powered.

Notes: Bill Brooker is an experienced in building log cabins and mud/brick homes. He is currently retired and very willing to share his knowledge, discuss the process or assist anyone interested in building similar structures.

Cost: $16,000 (to date)

Contact details: wjbrooker@gmail.com

Link for video available: https://vimeo.com/35539256

[249] Bill Brooker, Wanaka – he can use locally sourced mud and harakeke to build the cladding.

Barrel Cabins[250] – these would also be constructed for the purposes of hirage. The example shown here can be purchased from $9,000-$11,000 + GST; they can be moved on an off sites, as required.

Builder: Scott Groombridge

Location: Maraekakaho

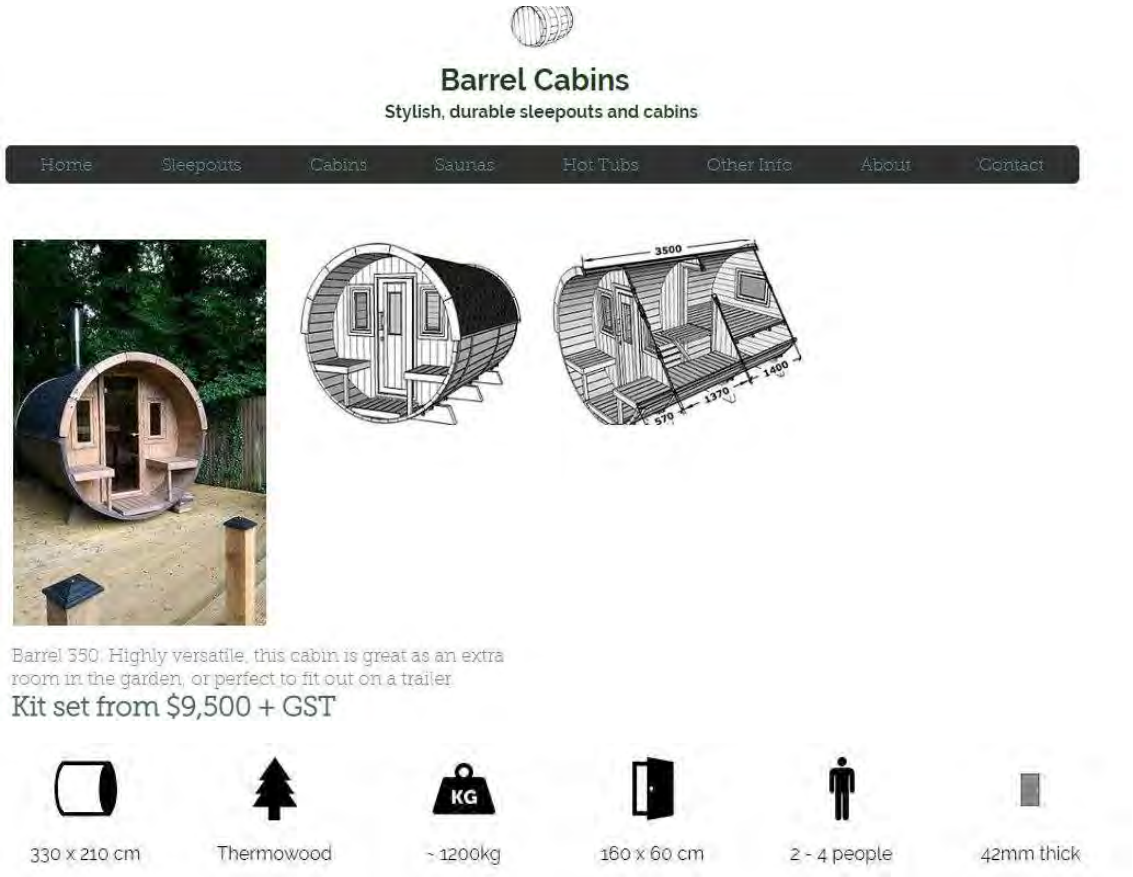
Design: Various cabin designs available including sauna's and hot tubs

Notes: Cabins are just sleepouts – i.e. they don't have toilets, showers, or kitchens. Cabins can however be used in conjunction with a toilet/shower and kitchen blocks, much like a camping ground.

The Barrel 350 design (below) can be transported and put on trailers. They just have to comply with the road rules and sizes that can be towed.

Cost: Variable costs (see website for more details)

Contact details: www.barrelcabins.co.nz



[250] www.barrelcabins.co.nz

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4.3.3 Papakāinga in this Case study Rohe

There are multiple reasons for whānau wanting papakāinga to be explored as an option in the Transition Action Plans developed in this research (see Chapter 5), as summarised below.

A) Cultural Activities:

These structures would be used as temporary seasonal/summer places for people to stay while re-connecting with the whenua and whānau.

To do this, structures such the following have been considered for the case study sites as specified below:

-Te Hatete:
i) barrel cabins,
ii) mud brick homes.

-Te Hakari/Tahamata structures that have been considered include:
i) mud brick homes;
ii) log homes.
-Pekapeka structures to be considered are the mud brick homes (as there is no easy access point for barrel cabins or large log structures).

It must be noted that a communal kitchen/toilet facility would need to be added to the location at an additional cost, including a Resource Consent Process.

B) Commercial Activities:

Eco-Tourism has been considered for Tahamata, in Phase 2 (in 30 years time), as a potential commercial activity. The structures that would be suitable are: log cabins, and barrel cabins.

Barrel Cabins[251] for hirage (these can be purchased from $9000-$11,000 + GST) – they can be moved on an off sites, as required. These would be set up for activities such as those listed below:

*cabins for hire
*running environmental workshops where there is a hirage fee
*possible kura or Wānanga for Reo or bilingual workshops
*potential café with locally produced food
*eco-tourism groups coming through to see the restoration efforts and get involved in learning about cultural history and local cultural practices, learning about kaitiakitanga from a local Māori perspective.

Additional costs would be incurred to establish and run such operations, and additional research is required to investigate the costs and potential revenue streams.

It is recommended that the following process be undertaken:

1) Confirm location of site for papakāinga structure/s.
2) Get any resource consents required.
3) Purchase ready made and/or build the structures.
4) Build communal kitchen/toiletries.
5) Advertise / book people to stay.
6) Ensure appropriate processes in place for maintenance, staffing, and operational matters.

[251] www.barrelcabins.co.nz

5 GEOMORPHOLOGY RESEARCH AND SPATIAL MAPPING TO AID DEVELOPMENT OF TRANSITION ACTION PLANS

5.1 Spatial Mapping of Alternate Land Use Options in the Rohe: Overview

Alongside the exploration of the rohe to identify appropriate places for adaptation options, and the research of other related enterprises in New Zealand that could help inform the transition action planning for this project, geomorphological analysis was undertaken of the physical characteristics of the land. This enabled us to identify areas on the coastal rohe that were a) prone to impacts of climate change, and b) suitable for the three preferred adaptation options.

The process followed to identify potential harakeke sites, and then sites for potential fisheries/aquaculture and papakāinga/ecotourism sites, is outlined below. Spatial maps were produced by Dr Jane Richardson for discussion at hui with whānau and landowners, where they gave feedback as to their preferences, and any relevant Mātauranga Māori about the area that might influence the location of potential adaptations. Thus, the Mātauranga portrayed in the previous chapters was considered in the process of developing the phased adaptations for each case study farm, and the spatial mapping of such adaptations. Multiple iterations of analysis enabled stakeholder considerations and feedback to iteratively be factored into the mapping. Biophysical factors taken into consideration included the soil type, geomorphology, climate change science projections about location and rate of sea level change, flood risk, elevation, and earlier mapping of historical land type categories in the rohe.

Proposed transitions were split into two phases in many cases, with the first phase relating to actions that could be implemented within the next five years, and a second phase for land use changes that were longer term in nature, looking 5-30 years into the future. These spatial maps were the basis for the detailed Transition Action Plans, and integrated assessment of the adaptation options as explored in the latter chapters.

5.2 Data sources and key references

The following data sources and references informed the analysis:

*Data supplied by Horizons Regional Council:
- -Tahamata Incorporation Soil Health Plan
- -Horizons Regional Council Report No. 2011/INT/1401
- -GIS shapefiles
- -LiDAR derived digital elevation map (DEM)

*Land Use Capability (LUC) data, from the New Zealand Land Resource Inventory (NZLI)[252]

*The Tahamata flax proposal, by Malcolm Todd dated 21/07/2014

*Master's Research by Scott (2015) investigating land use change in the rohe[253]

*Aerial imagery (orthophotography) of the rohe[254]

[252] Sourced from https://lris.scinfo.org.nz/layer/48076-nzlri-land-use-capability/
[253] Scott, D. (2015). Old Patterns, New Practice: A thesis in Landscape Architecture (master's thesis). Victoria University of Wellington, School of Architecture & Design, Wellington, New Zealand.
[254] Sourced from the LINZ Data Service and licensed for reuse under the CC BY 4.0.

*Orthophotography for the Manawatū-Whanganui region taken in the flying season (summer period) of 2010-2011.

*Aerial imagery of the rohe taken by Laurie Cairns in October 2017 (as seen in Figure 5.1).

5.3 Study sites

The study site consists of five Māori owned blocks of land in Kuku Beach, Horowhenua. This land is located along the coast between the Ōhau River and the Waikawa Stream in the Holocene coastal dune belt that extends from north of the Manawatū River to Paekakariki in the south (Figure 5.1 and 5.2). This part of the coastal plain consists of a sequence of dunes, interdune peat swamps and lakes orientated parallel with the present day coast.[255] Dune sands derived from sediments moved along the coast by waves and carried inland by the prevailing north-westerly wind, have formed a sequence of sand dunes that get progressively younger towards the coast (Figure 5.3). It is a dynamic environment that has been shaped over time by coastal processes and environmental changes, including climate change, earthquakes and tsunami, and human activity.

Figure 5.1 Aerial image of the study site. Source: Laurie Cairns, 28 October 2017

[255] According to Clement et al. (2016), the geomorphology is the result of coastal progradation following the culmination of the Holocene marine transgression and the attainment of present mean seal level; the underlying geology of the area is pre-Holocene sandstone and alluvial gravels. Source: Clement, A.J.H, Whitehouse, P.L., Sloss, C.R. (2016). An examination of spatial variability in the timing and magnitude of Holocene relative sea-level changes in the New Zealand archipelago. *Quaternary Science Reviews*, 131(A), 73-101.

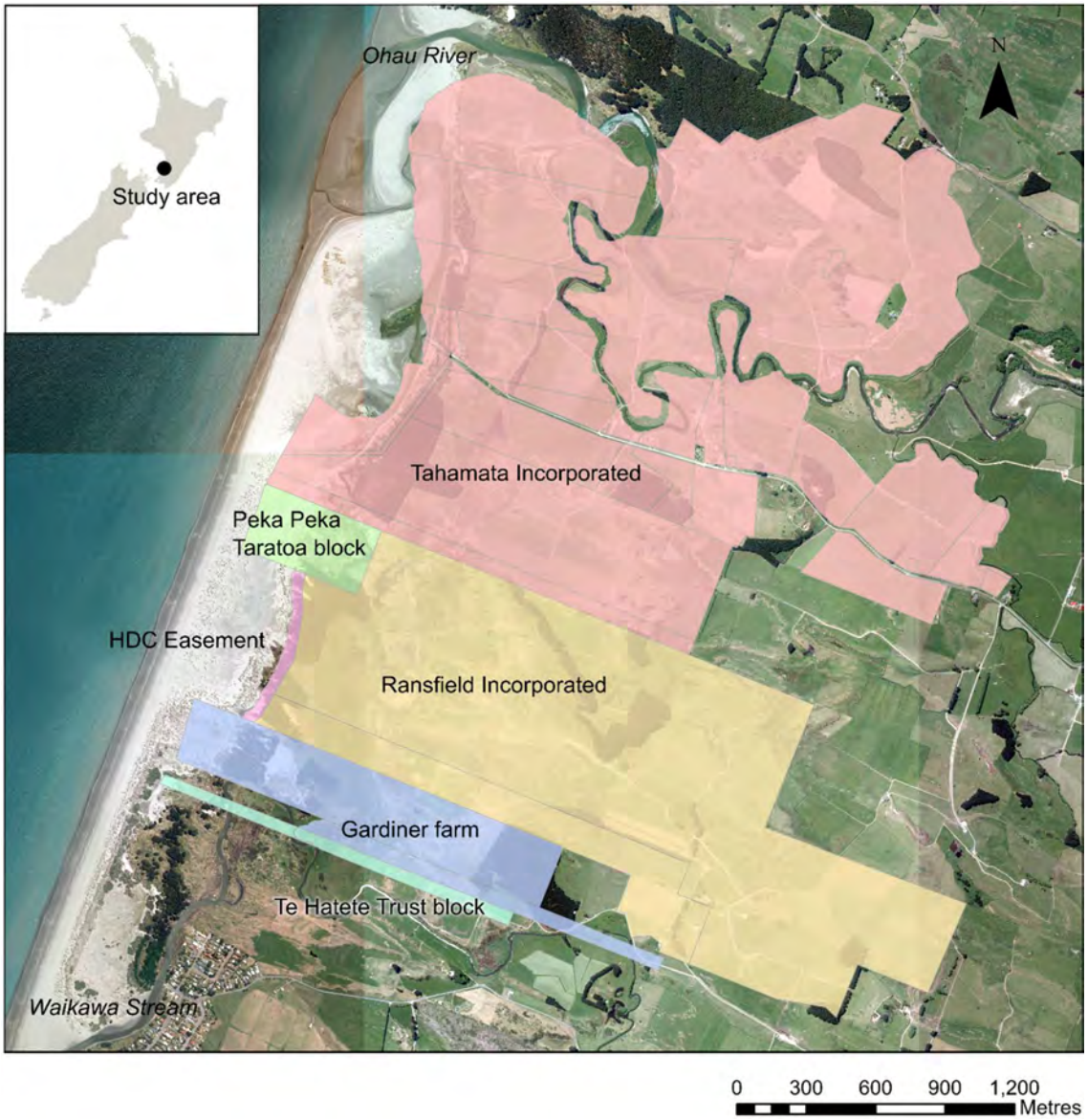

Figure 5.2 Study area, location and ownership of the five land blocks and the Horowhenua District Council Easement

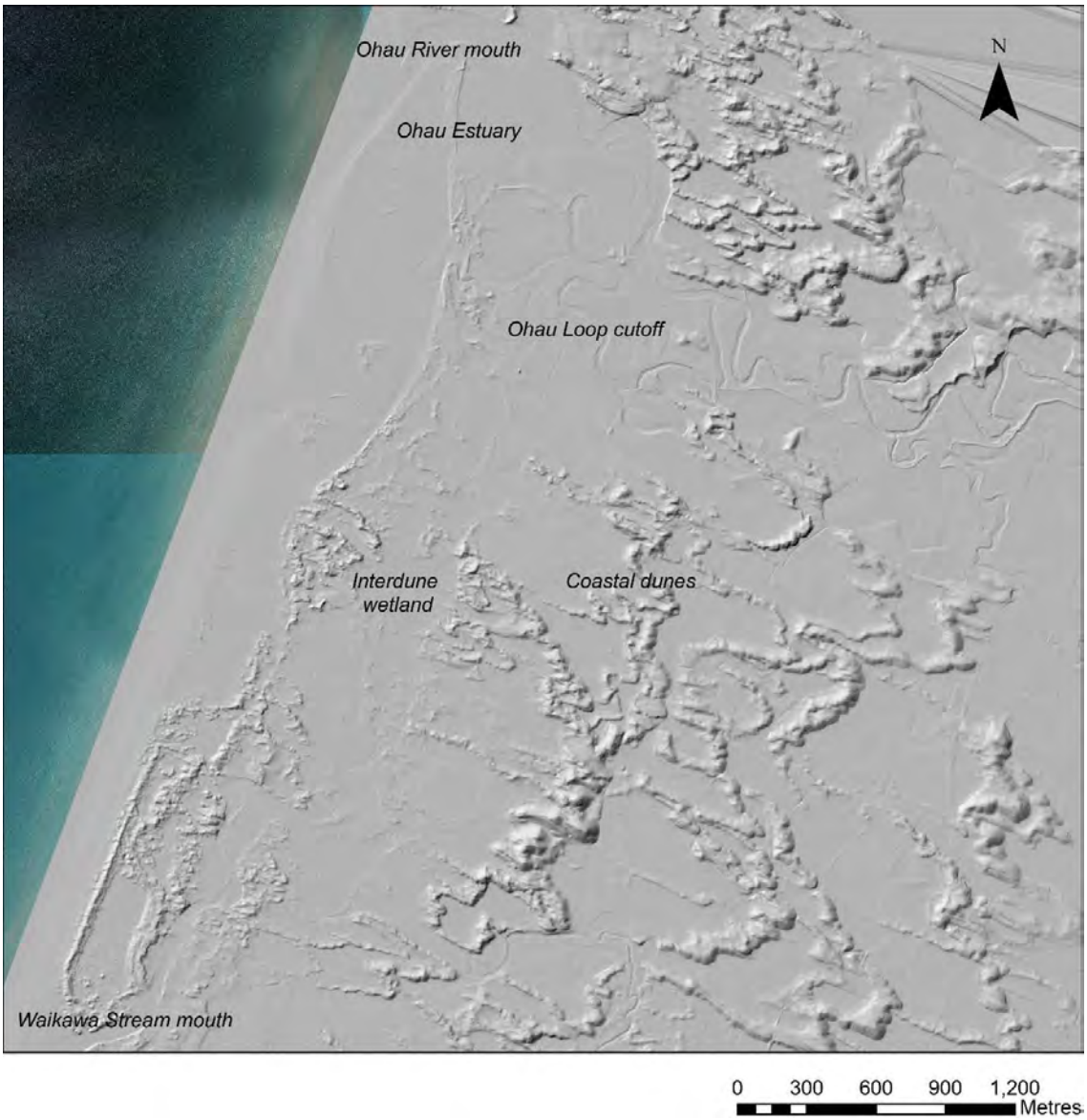

Figure 5.3 LiDAR-derived shaded relief map of the study area showing the major geomorphological units

5.4 Methodology: Identify Climate Change Risks and Vulnerable Land

5.4.1 The Climate Change Risks

Results from previous research and work with landowners, iwi, hapū and community identified a number of different adaption options with the most preferred option being expansion of harakeke planting, riparian planting and potential aquaculture, and papakāinga sites. The first step in developing Transition Action Plans for the individual land blocks was identifying the land most vulnerable to the climate change impacts of sea level rise, flooding and more frequent extreme weather events – area's which will become increasingly unsuitable for current land use practises. The aim was to produce maps and information for discussion at hui with whānau and landowners, where they could be used to co-create transition plans which would incorporate preferences, Mātauranga Māori and local knowledge about the area.The Climate Change Risks

The trend for sea level rise in New Zealand has been around 5 mm/yr over the last 30 years but regional sea level changes of up to 10 mm/yr have occurred recently[256]. There is considerable uncertainty about the pace and magnitude of projected sea level rise[257]. A large number of factors contribute to the difficulty in modelling sea level rise including different future global greenhouse gas emission scenarios, questions about ice sheet stability and the complexity of the climate system. However, for planning purposes a 200 mm/decade sea level rise would be reasonable approach[258]. Based on this assessment, projecting out to 2050 there would be a need to adapt to a 600 mm sea level rise and an ongoing rising sea level beyond that.

This part of the Horowhenua coast has been prograding (building seaward) since sea level reached present day level. Sediment sources for the Horowhenua and Kāpiti coast are primarily from three main fluvial source regions – Whanganui River, Rangitikei River and Mānawatu River and deposited via a longshore southward movement. The historic rate of accretion for the Waikawa shoreline (to the south of the river inlet) has been 3.4 m/yr[259]. The impact of sea level rise on the shoreline is difficult to assess without more data on the coastal sediment dynamics. However, it is reasonable to suggest that the high positive sediment budget on this part of the coast will mean that shoreline recession will be unlikely. Although sea level rise and more frequent storm surges would cause more episodes of wave induced erosion of the foredunes.

The land most at risk from sea level rise is not necessarily the lowest land but the areas where the ground water level is high[260]. The soil survey of the Tahamata farm identifies the wettest areas (poorly drained) and gives an indication of the height of the winter water table through the measurement of the depth to mottles in the soil profile. Mottling occurs as a result fluctuating oxygen availability. A significant proportion of the Tahamata soils have soil-related wetness as the main limitation on their land use (Land Use Capability Subclass 'w') - due to limits on plant growth because of lack of aeration.

An additional consideration for the study area is the impact of increased flooding of the Ōhau River. The onset of climate change is expected to increase flood risk and future floods are likely to be bigger. Modelling work on the Hutt River has indicated the potential for a significant increase in flood frequencies over the 21st century under climate change scenarios[261]. Although the magnitude of the change varied considerably depending on the emissions scenario and climate model used, the authors found that for the Hutt River under a high emissions scenario, flood return periods could reduce to one-fifth of current-day values on average. For the Ōhau River, this could mean that the 1 in 20 year event inundation could become a 1 in 4 year event.

[256] Personal Communication, Professor Martin Manning, 2018.
[257] Le Bars, D. (2018). Uncertainty in sea level rise projections due to the dependence between contributors. *Earth's Future*, 6, 1275–1291.
[258] Personal Communication, Professor Martin Manning, 2018.
[259] Tonkin and Taylor Ltd. (2013). Coastal Hazard Assessment Waikawa to Waitarere, Report prepared for Horizons Regional Council. T&T Ref. 61457.001.
[260] Otago Regional Council (ORC) 2016. The Natural Hazards of South Dunedin, ISBN: 978-0-908324-35-4. See also: Golder Associates (2017). Review of International Case Studies: Protection Options for Managing Rising Groundwater in South Dunedin. For Dunedin City Council and Otago Regional Council. Retrieved: https://teggtalk.files.wordpress.com/2018/11/golder-associates-managing-rising-gw-in-south-dunedin-international-review-final.pdf
[261] Ballinger, J. Jackson, B, Reisinger, A. Stokes, K. (2011). The potential effects of climate change on flood frequency in the Hutt River. Prepared for the New Zealand Climate Change Research Institute Victoria University Wellington.

River management will also play a role in determining the vulnerability of the surrounding land to climate change. A series of Ōhau scheme reviews undertaken by Horizons Regional Council[262] have identified aggradation (sediment build up) trends in the lower reaches and a reduction in channel capacity. A rise in sea level will cause further sedimentation in the already aggrading lower reaches of the river, thereby further reducing channel capacity and exacerbating coastal flooding. The Ōhau River Stopbanks constructed in the 1970's were designed for nominal protection from a 25-year return period flow. However, there has been no major work done on the stopbanks since the 2008 report, which recommended raising the crest height. Increased flooding, along with salinization (and storm surge) near the river mouth would make it difficult to continue current landuse practises.

5.4.2 Identification of Areas Most Vulnerable to Climate Change Impacts

Based on the risks outlined in the section above, the land most vulnerable to the impacts of climate change is the contemporary floodplain of the Ōhau and Waikawa Rivers, the foredunes and the low lying poorly drained land in the interdune environments. It is these areas that should be the initial focus of adaptation efforts.

Earlier work with Tahamata in Phase 1 of this research[263] identified the areas of the farm that were currently grazed but vulnerable to flooding and groundwater rise. Based on the soil drainage data and flood extent mapping, and assuming a max 200 mm/decade sea level rise out to 2046, the farm could expect to lose up to 30 percent of the effective grazing area. This assessment was based on two major assumptions. Firstly, that the areas of the farm where the winter water table is currently less than 30 cm from the surface (Drainage Classes 1 and 1-2) would be surface water. Secondly, that areas of the farm where the winter water table is less than 60 cm, and currently classified imperfectly and poorly drained (Drainage Classes 2 and 3), would be poorly and very poorly drained. It was clear from this work that the farm would need to further investigate some of the adaptation options that the research had presented. Hui with landowners, iwi, hapū and community identified the most preferred adaptation strategies to further investigate in an expanded area of coastal land between the Ōhau and Waikawa Rivers. The most preferred options were riparian planting, wetland expansion, harakeke planting, dune protection, aquaculture and papakāinga. Each block of land is different in terms of its geomorphology, landuse, vulnerability to climate change impacts and the aspirations of the owners. In order to accommodate these differences and to facilitate discussion towards developing plans for transitioning to more climate resilient lands, each of the blocks were mapped separately.

5.5 Development of Climate Change Adaptation Maps for Initial Discussion

In the first step the landform units in the study area were digitised and classified according to elevation and geomorphology type, using the LiDAR derived Digital Elevation Model (DEM), aerial images, onsite observations and the soil data from the Tahamata block. Figure 5.4 is a simplified map of the geomorphology, highlighting the areas of coastal dune, floodplain and interdune environment in the study area between the Ōhau River and Waikawa Stream.

[262] Bell, J. (2012). Ōhau river gravel resource study. Horizons Regional Council Report No: 2012/EXT/1269; and Williams, G. (2008). Ōhau River Muhunoa Bridge to Mouth. Scheme Investigations. Report prepared for Horizons Regional Council by G&E Williams Consultants LTD, Ōtaki.

[263] Smith, H., Allan, P., Bryant, M., Hardy, D., Manning, M., Patterson, M., Poutama, M., Richards, A., Richardson, J., Spinks, A. (2017). *Adaptation Strategies to Address Climate Change Impacts on Coastal Māori Communities in Aotearoa New Zealand: A Case Study of Dairy Farming in the Horowhenua–Kāpiti Coastal Zone*. Massey University, Palmerston North.
Retrieve from: https://www.deepsouthchallenge.co.nz/projects/risk-management-Māori-coastal-assets

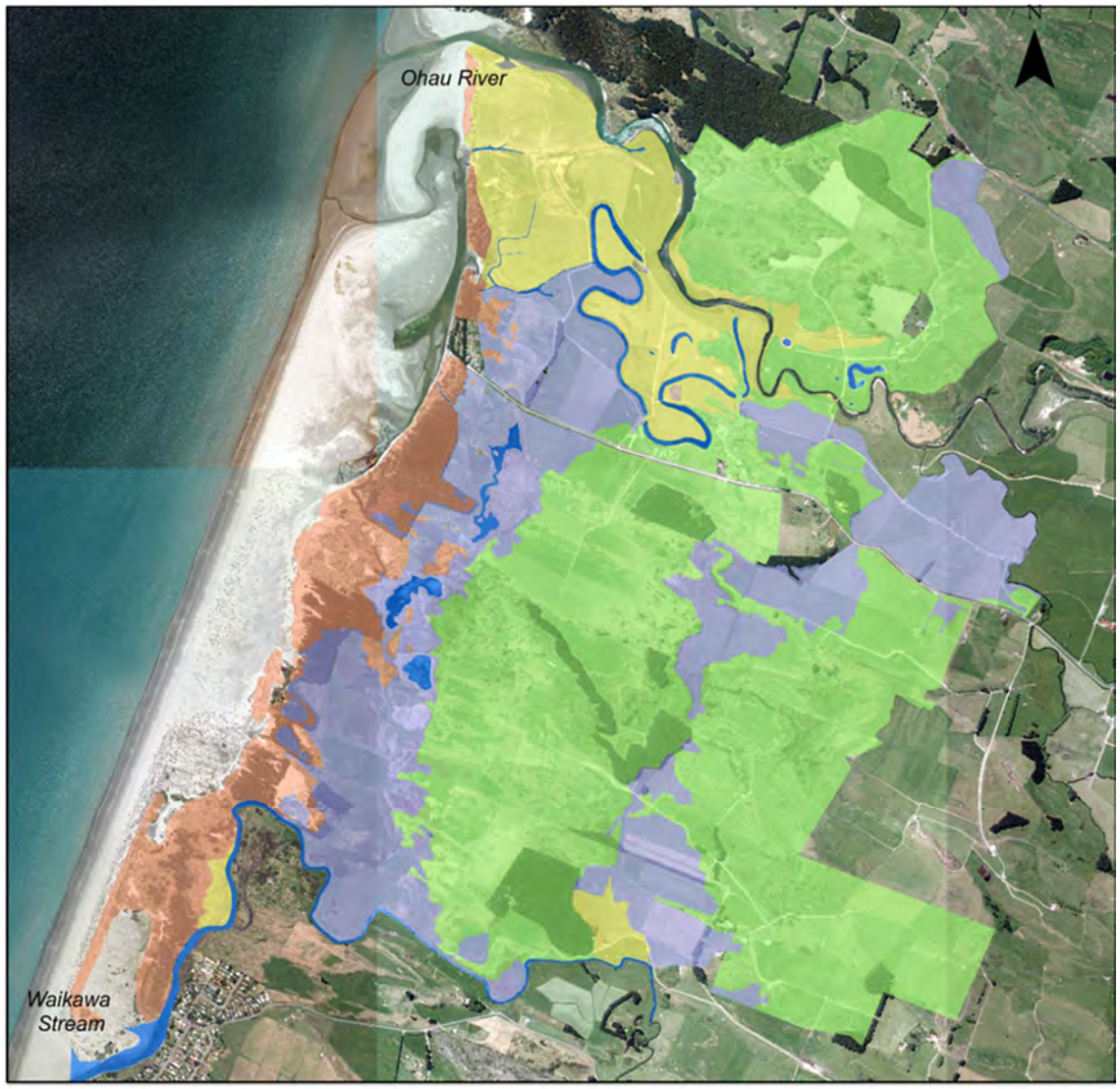

Figure 5.4 Map highlighting the geomorphology of the Kuku Beach study area

The initial map prepared for preliminary hui with landowners incorporated information from a number of sources. The map identified the best areas to plant harakeke based on soil drainage class, flood risk and geomorphology. Malcolm Todd (Horizons Regional Council) recommended that the best place to plant harakeke on Tahamata is on the wettest soils – very poorly drained (drainage class 1 and 1-2) with less than 10 cm depth to the grey anaerobic zone and with most pugging vulnerability. Also suitable were drainage class 5 soils (very vulnerable to pugging) in the river silts and drainage class 4 (vulnerable to pugging) in the sand country. Soil drainage is described as a class

and classes are assessed using criteria of soil depth and duration of water tables inferred from soil colours and mottles. The Drainage classes used here are the same as those used in the NZ Soil Classification (Hewitt 1993). Although soil drainage data was not available for all the land in the study area it was possible to infer soil type and drainage based on the Tahamata soil data. For the farms that do not have detailed soil information the geomorphology will provide broad guidance as to the wettest areas most suitable for harakeke planting. Because of the way the coast has prograded and evolved, with a sequence of dunes and enclosed wetlands/peat swaps parallel to the coast, the geomorphological units and elevation can be used to identify the drainage properties. Comparisons between the Tahamata soils and geomorphology showed that the foredune is well drained (Drainage Class 5), the dunes are moderately well drained and well drained (Drainage Classes 4 and 5) and the interdune environment has the wetlands and poorly drained soils – with wetness limited soils and Drainage Classes 1-3 (less than 60 cm to water table).

Scott (2015)[264] recommended three spatial management strategies for incorporating harakeke into the farm - block plantation planting, connecting corridors, riparian extensions. Information from this work was incorporated into the planting plan for the study area. An additional factor considered was areas at higher risk of flood inundation. Due to the expected increase in flooding the contemporary floodplain of the Ōhau River and Waikawa Stream were also identified as suitable areas to expand harakeke planting.

To summarise, for initial hui with landowners the suggested areas for the expansion of harakeke were based on an assessment of:

1. Land at risk of flooding as determined by 1 in 20 year flood (flow 450m^3/sec) from the Jan 2008 flood extent map.
2. Areas currently where the water table is less than 60 cm from the surface in winter (Drainage classes 1 – 3). The wetlands and interdune environment.
3. Floodplain less than 3m elevation.
4. The Ōhau loop and riparian margins.

Figure 5.5 shows the map compiled for the initial stakeholder engagement Wānanga, during which time landowners discussed the land areas in the maps, shared their own knowledge and specified which areas they preferred to implement the adaptation options being investigated in the research (i.e., harakeke planting, riparian planting, aquaculture, papakāinga).

[264] Scott, D. (2015). Old Patterns, New Practice: A thesis in Landscape Architecture (master's thesis). Victoria University of Wellington, School of Architecture & Design, Wellington, New Zealand.

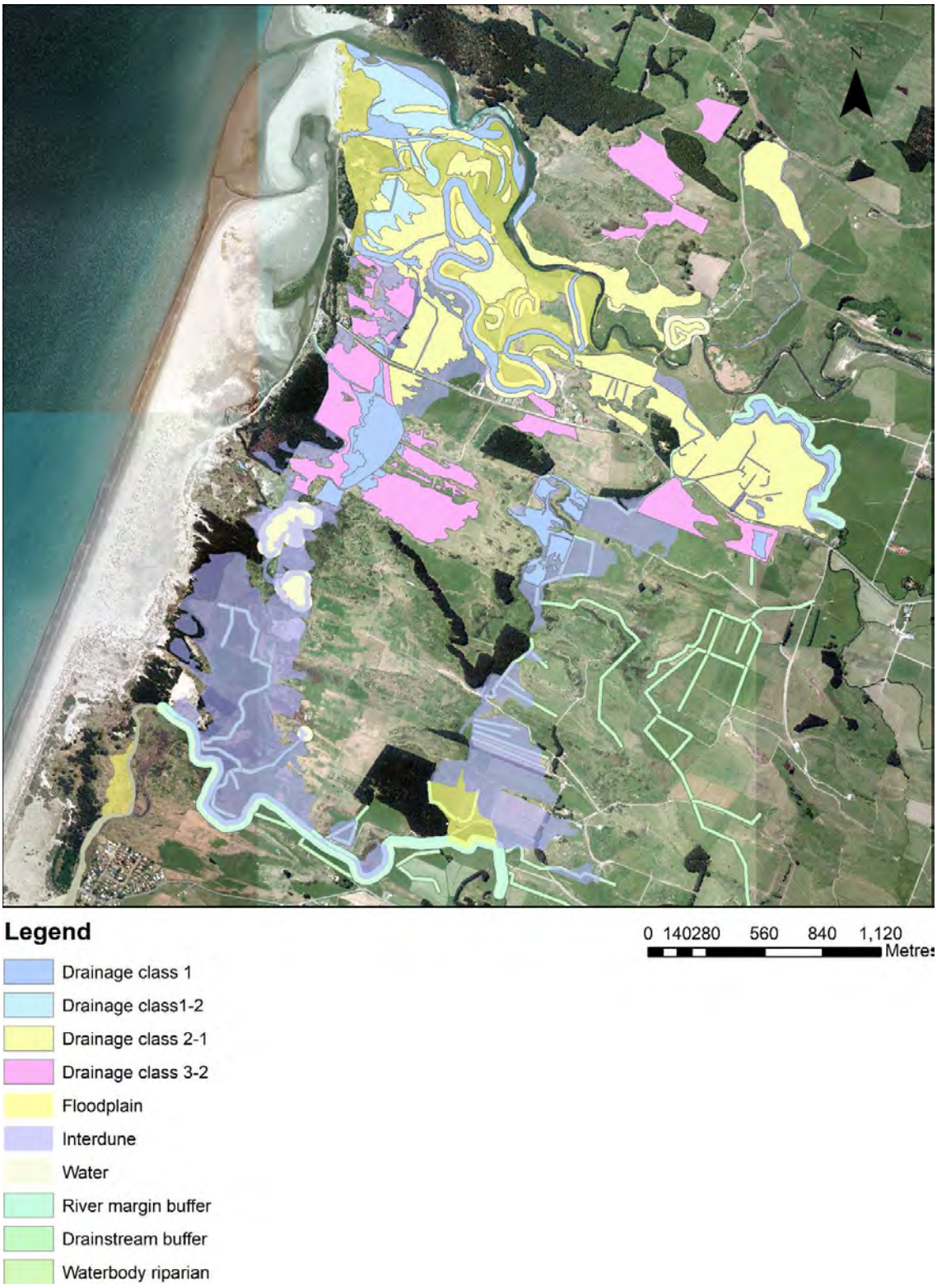

Figure 5.5 Map of the study area showing areas most vulnerable to climate change impacts and suitable for planting harakeke

5.6 Development of GIS Maps for Transition Action Plans

Subsequent to the initial hui (see overview of whānau/land owner engagement in chapter 3.1), a series of formal and informal Wānanga/korero were held with landowners, dependent on their availability, to examine the information presented in the previous section, which highlighted the most vulnerable areas to climate change impacts.

Landowners considered the adaptation options that most aligned with their aspirations and values and identified what stepped changes might be undertaken to transition towards land uses that would be better suited to the changes that climate change will create on the coastal zone.

A series of maps were developed for the five land blocks in the study area – in most case there were two stages identified. The first phase identifies actions that can be taken now and over the next five years to improve the climate resilience of the land. The second phase took a longer term view of adaptation options that could be implemented over the longer ~30 year period as more serious climate impacts occur. The plans reflected in these maps went through various iterations, subject to feedback from landowners and the research team, and formed the basis of the final Transition Action Plans for the case study rohe.

It is recommended that these maps be updated and modified over time, to take best advantage of new research findings, technological advancements that increase the range of alternative land use activities that are possible and viable in these landscapes. Additionally, maps should be updated to take advantage of opportunities provided by institutional and socio-cultural resourcing and capability that develops into the future (see final section of this report, which explores this in more detail).

5.6.1 Te Hatete Trust

Te Hatete Trust owns an 8.4 ha strip of land adjacent to the Waikawa Stream.

Current landuse is dry stock grazing on poor quality pasture leased to Gardiner farm.

Te Hatete landowners expressed their desire to facilitate ecological improvement in their land. Improved waterways for traditional harvest of tuna and whitebait and some expansion of aqualculture were priorities for them. They also identified an area where they would like to establish papakāinga.

Based on these and other aspiration the Transition Plan for Ta Hatete Trust, as displayed in Figure 5.6, comprised the following:

- Aquaculture ponds
- Papakāinga
- Riparian planting 10 m either side of drains
- Harakeke planting – providing a wetland corridor link to Waikawa Steam and plantation for harvest
- Native dune planting

Feedback from representatives of this land block indicated that their preference was for such adaptations to occur as soon as possible, and therefore the plans were not split into phases.

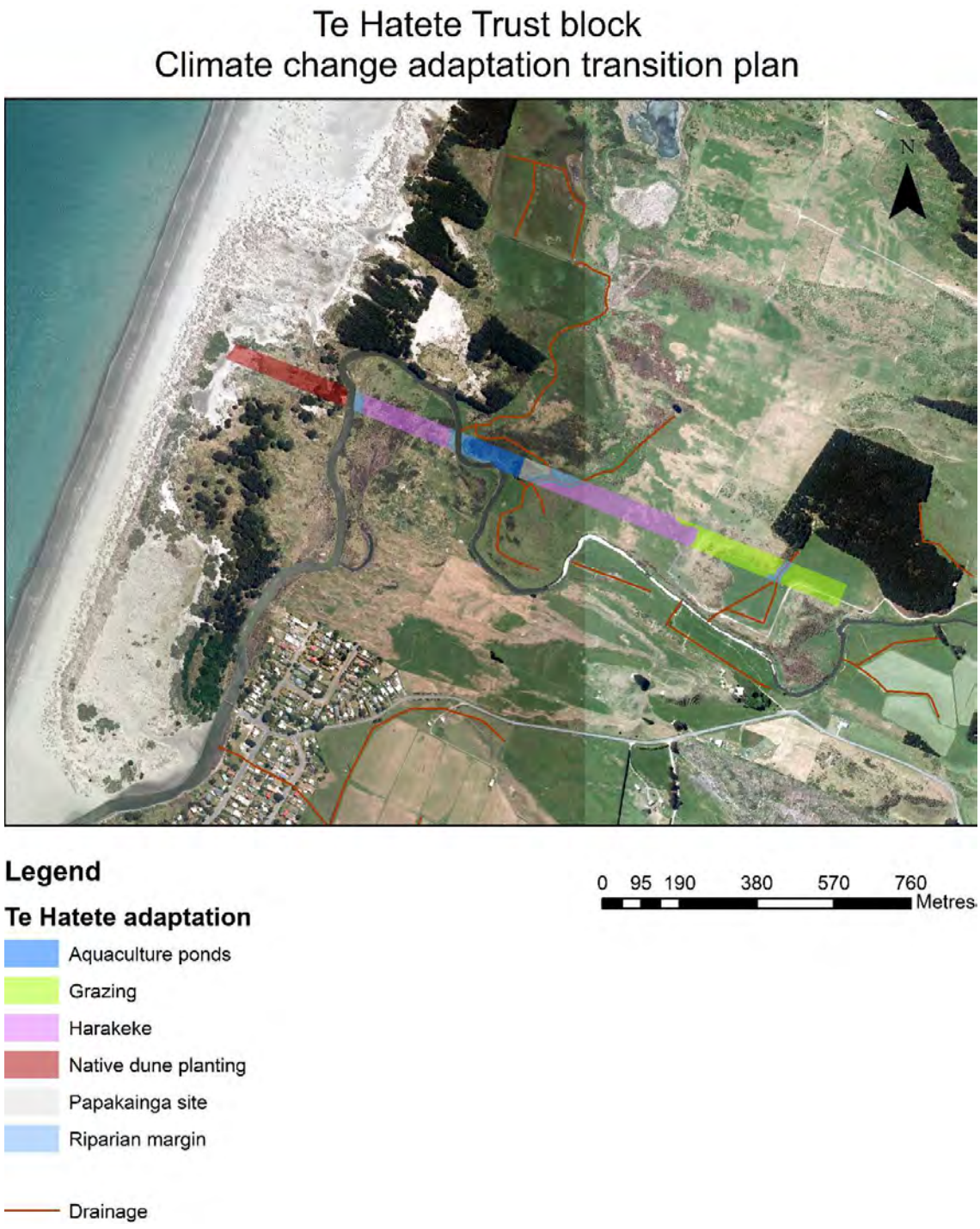

Figure 5.6 Climate change adaptation plan for Te Hatete Trust owned block

5.6.2 Gardiner lease block

The Gardiner lease block has an area of 57.7 ha with the majority used currently for dry stock grazing and forestry.

Given the need to improve resilience to climate change impacts and improve environmental wellness two phases of action have been identified for the Gardiner farm. The first phase (Figure 5.7) are actions that could be undertaken now to improve dune stability and water quality and consist of the following:

- Pingao planting on active sand
- Protect dune with native planting
- Riparian planting 30m beside Waikawa Stream and water body
- Riparian margin beside drains 10 m

Over the next 30 year period, and given projected climate change impacts in the rohe, the second phase is expansion of Harakeke into the interdune environment (Figure 5.8).

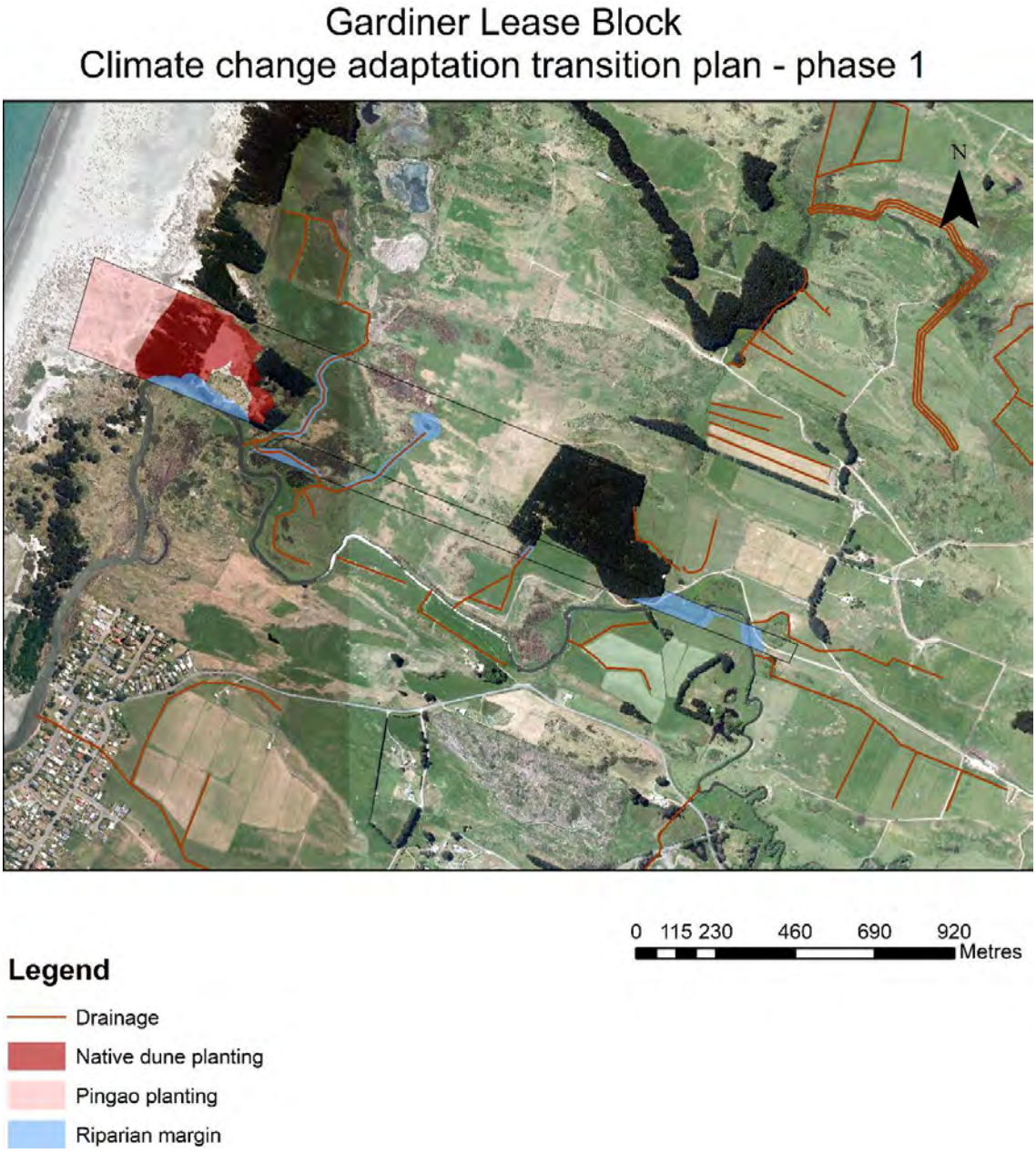

Figure 5.7 Phase 1 climate change adaptation plan for the Gardiner Lease block

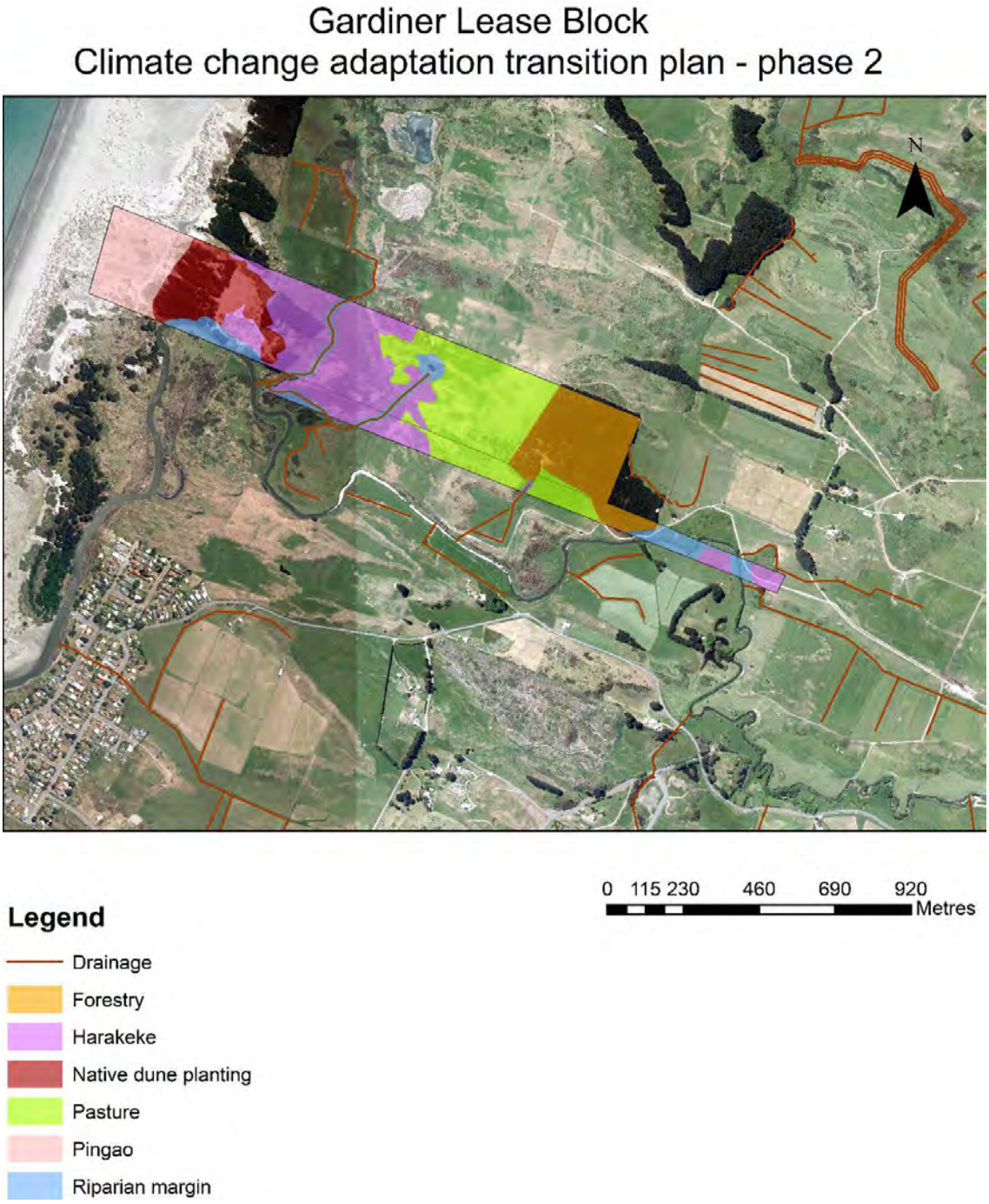

Figure 5.8 Phase 2 climate change adaptation plan for the Gardiner Lease block

5.6.3 Taratoa Pekapeka Block

The Taratoa Pekapeka block is a 16.2 ha block located directly on the coast and primarily on the foredune.

Approximately one-third of the area comprises active sand.

The block is not currently grazed and the vegetation is mainly regenerating dune species and some area of pine forest.

The owners of this block expressed a strong interest in establishing a Pīngao reserve. Pīngao is a rapidly declining native grass found on active sand dunes. It is a highly valued weaving material used for patterning highlights and fine weaving.

The main aspects of the transition for the Taratoa Pekepeka block, as depicted in Figure 5.9, are):

- Papakāinga site
- Pīngao planting on the active sand
- Harakeke expansion in the wetter interdune environment
- Native dune Planting to stabilise the foredune

It is envisaged that these land use changes could occur as soon as the landowners are able to undertaken them, and thus they are not presented as phased steps.

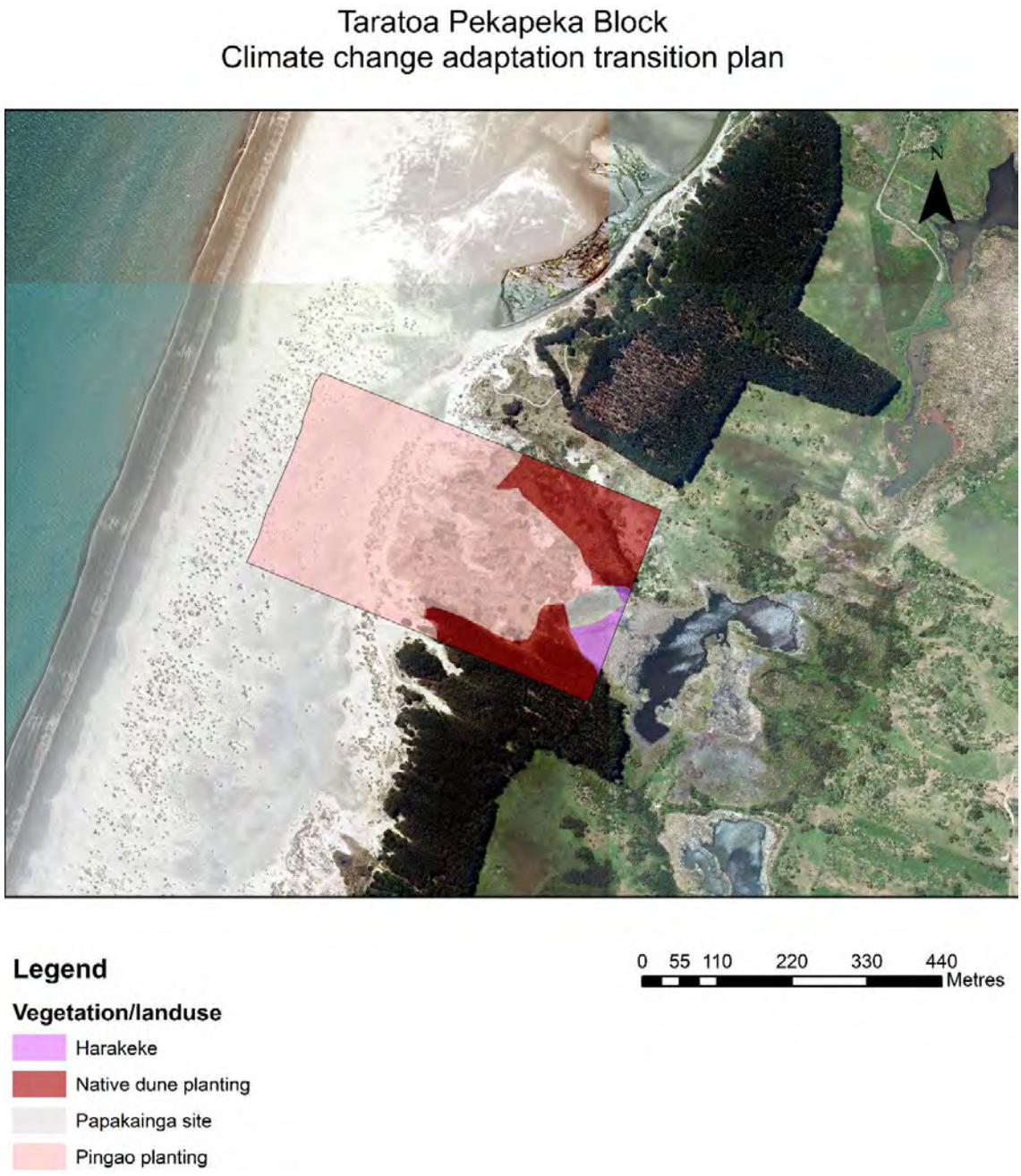

Figure 5.9 Climate change adaptation plan for the Taratoa Pekapeka block

5.6.4 Incorporation of Ransfield's farm

The block owned by Incorporation of Ransfield's has an area of 273 ha and is primarily used for dairy farming. The farm has some area of wetland linked to the Te Hākari dune wetland.

The geography of the Ransfield block makes it less vulnerable to climate change with no major rivers on the property. However, like adjacent blocks, rising sea levels will affect groundwater and cause already poorly drained and puggy paddocks to become wetter.

Two phases of action have been identified for the Ransfields block. The first phase focuses on enhancing dune stability and wetland protection (Figure 5.10). The second phase expands the area of harakeke planting (Figure 5.11).

The main actions associated with the Ransfields Transition Plan are:

- Expansion of Harakeke to most unproductive land adjacent to wetland water body (wetland protection)
- Native dune planting to protect the foredune
- Pīngao planting on active sand
- Harakeke planting to connect wetland corridor to Waikawa Stream
- Harakeke expansion to interdune environment

Figure 5.10 Phase 1 climate change adaptation plan for the Ransfield Incorporated block

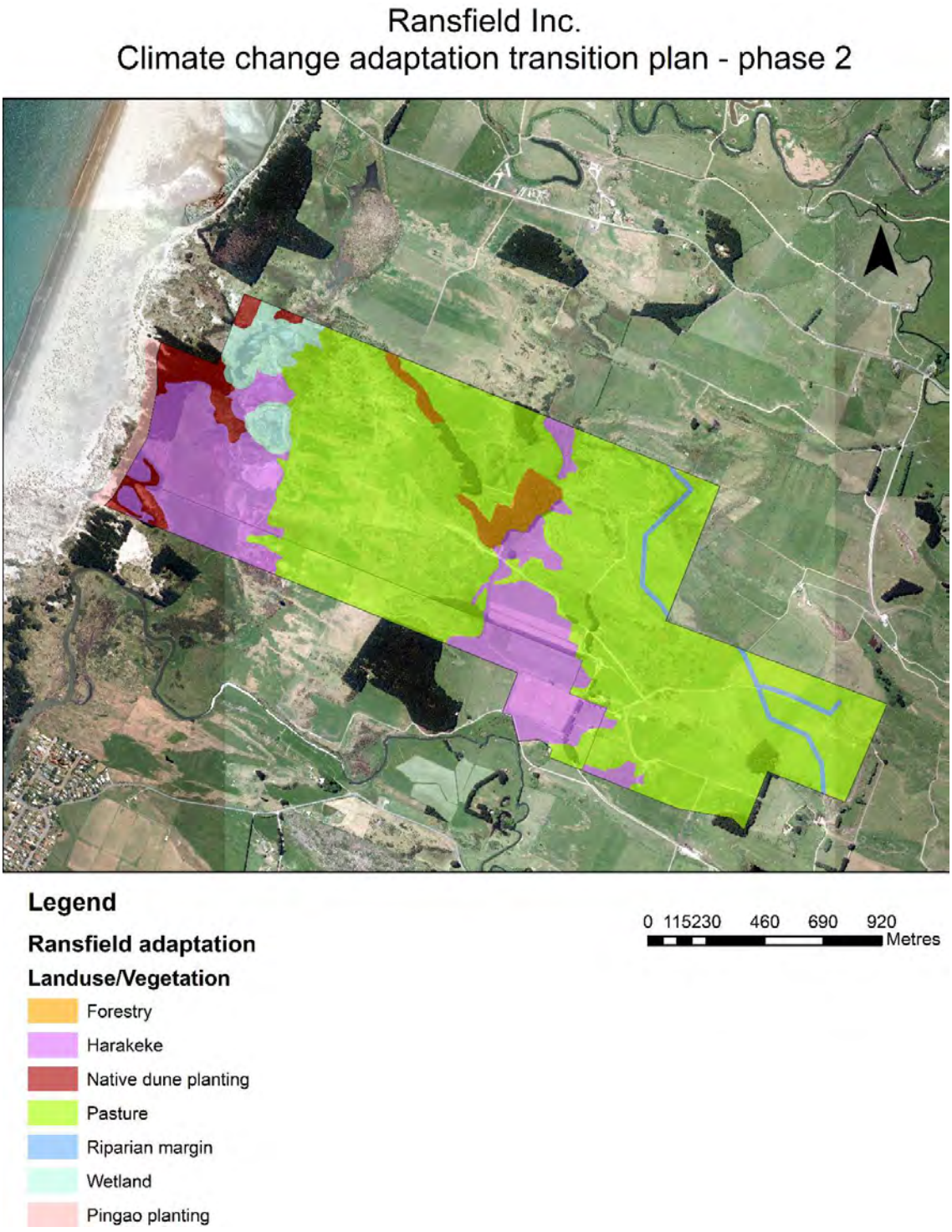

Figure 5.11 Phase 2 climate change adaptation plan for the Ransfield Incorporated block.

5.6.5 Tahamata Incorporation

The Tahamata Incorporation block has an area of 452 ha and is located adjacent to the Ōhau River.

Current landuse is dairy farming – with an effective grazing area of 310 ha.

There are some areas of pine forest on the dunes.

There has been extensive effort to restore the Te Hākari wetland system, which is protected by a kawenata (covenant).

The focus of the Tahamata transition plan are protection and expansion of the wetland, stabilisation of the dunes and improving water quality through riparian planting.

The main aspects, as depicted in Figures 5.12 and 5.13, are:

- Riparian planting 10 m drain and 30 m water body
- Pingao planting on the active sand dune toe
- Native dune planting to stabilise dunes and replace pine plantations
- Expand wetland boundary to the unproductive and wet land
- Harakeke planting expansion to interdune environment.
- Harakeke planting expansion to the Ōhau river floodplain

Figure 5.12 Phase 1 climate change adaptation plan for the Tahamata Incorporated block

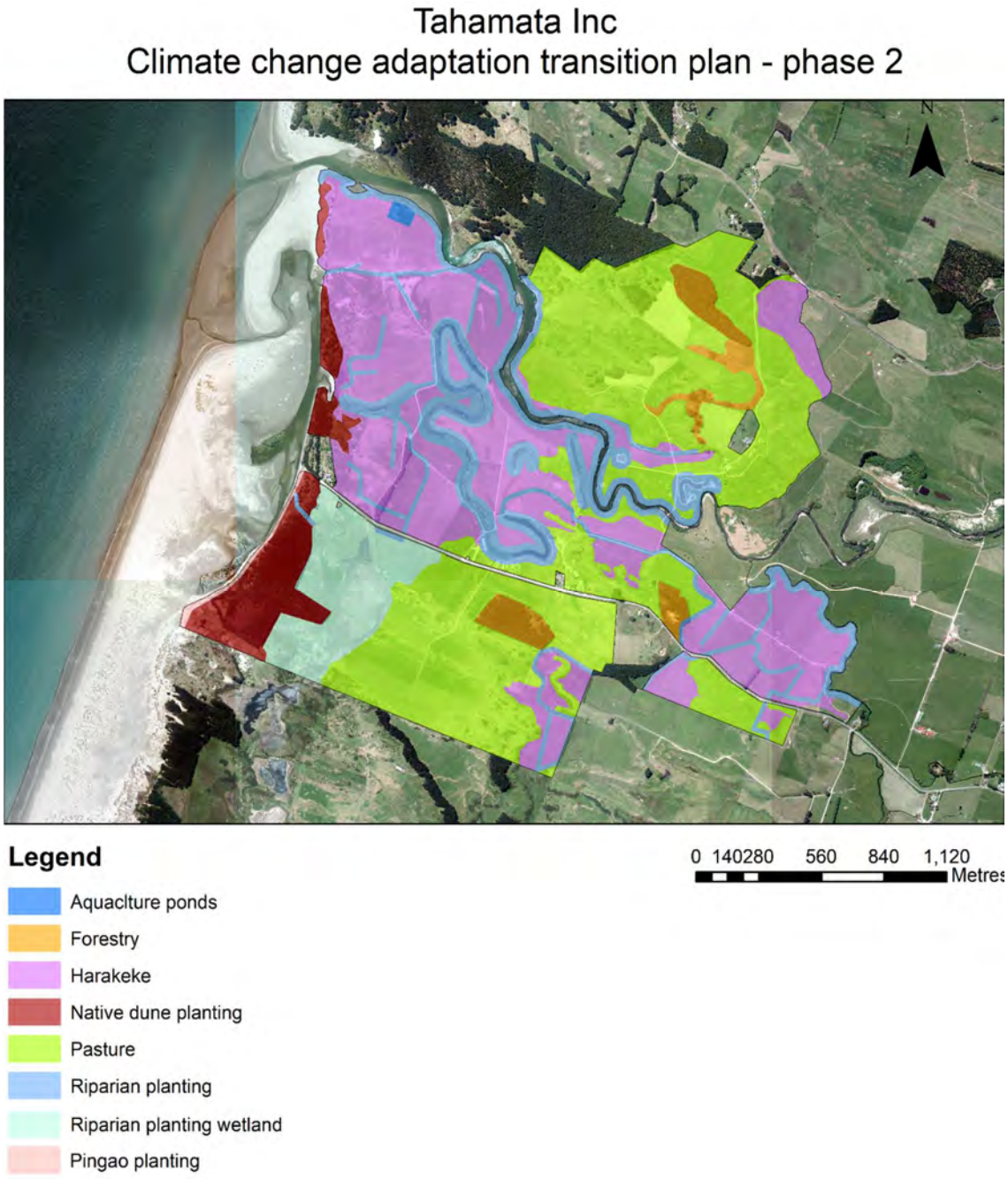

Figure 5.13. Phase 2 climate change adaptation plan for the Tahamata Incorporated block

5.7 Engaging Community – Developing Transition Maps for the Exhibition

Climate change adaptation transition maps were developed alongside landowners of each block (via hui, personal communication with members of the research team, phone calls and so forth), and were designed to meet the aspirations of those particular shareholders. However, the plans also connected to a larger vision of what a climate resilient and ecologically healthy coastal zone would look like. This vision includes concepts of connected waterways and wetland corridors, improved water quality, stable dune systems and valuing indigenous plants. It was seen as an important step to engage with the wider community around how coastal land and communities can adapt to the impacts of climate change. To this end, a series of maps were designed to include in the project's exhibition that distilled the information from each of the land blocks in the study area into one combined adaptation plan for the entire zone between the Ōhau and Waikawa Rivers.

These maps were designed to be aesthetically pleasing and convey information on vulnerability to inundation, flooding and groundwater rise, and the adaptation and landuse change options that could be used to mitigate the impacts for the coastal environment. Jane Richardson and Jo Bailey from Massey University, Wellington worked together to incorporate GIS data and information into images that would be easy to interpret and engaging.

The graphic in Figure 5.14 highlights the areas of low lying land most vulnerable to sea level rise and flooding. The adaption options associated with the first phase of adaptation that focuses on protection and restoring environments in the study area are shown in Figure 5.15.

Finally, a vision for the coast after that focuses on diversifying land use and farming practises as the impacts of sea level rise intensify is communicated in Figure 5.16.

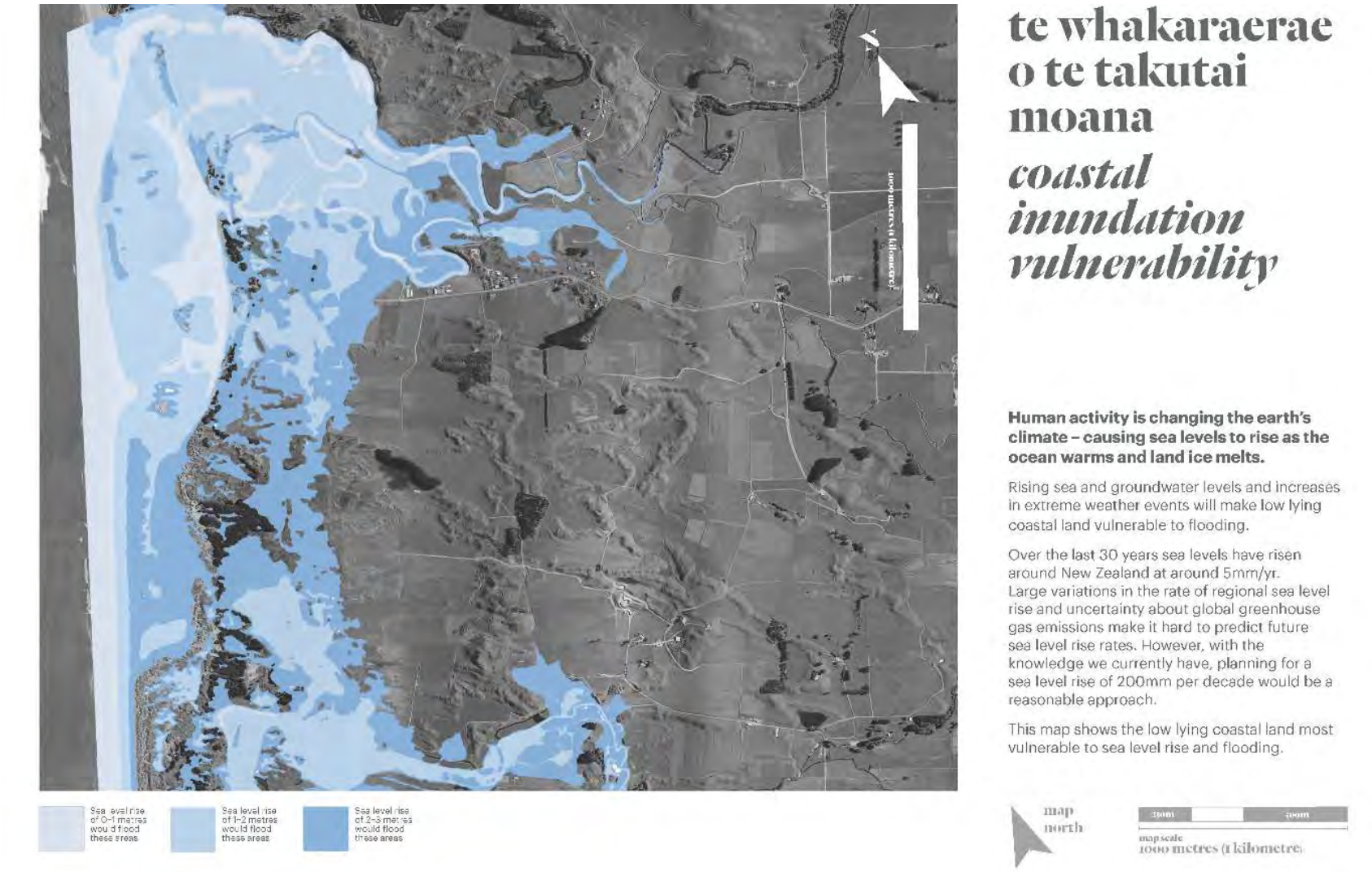

Figure 5.14 Coastal inundation and vulnerability image designed for the exhibition

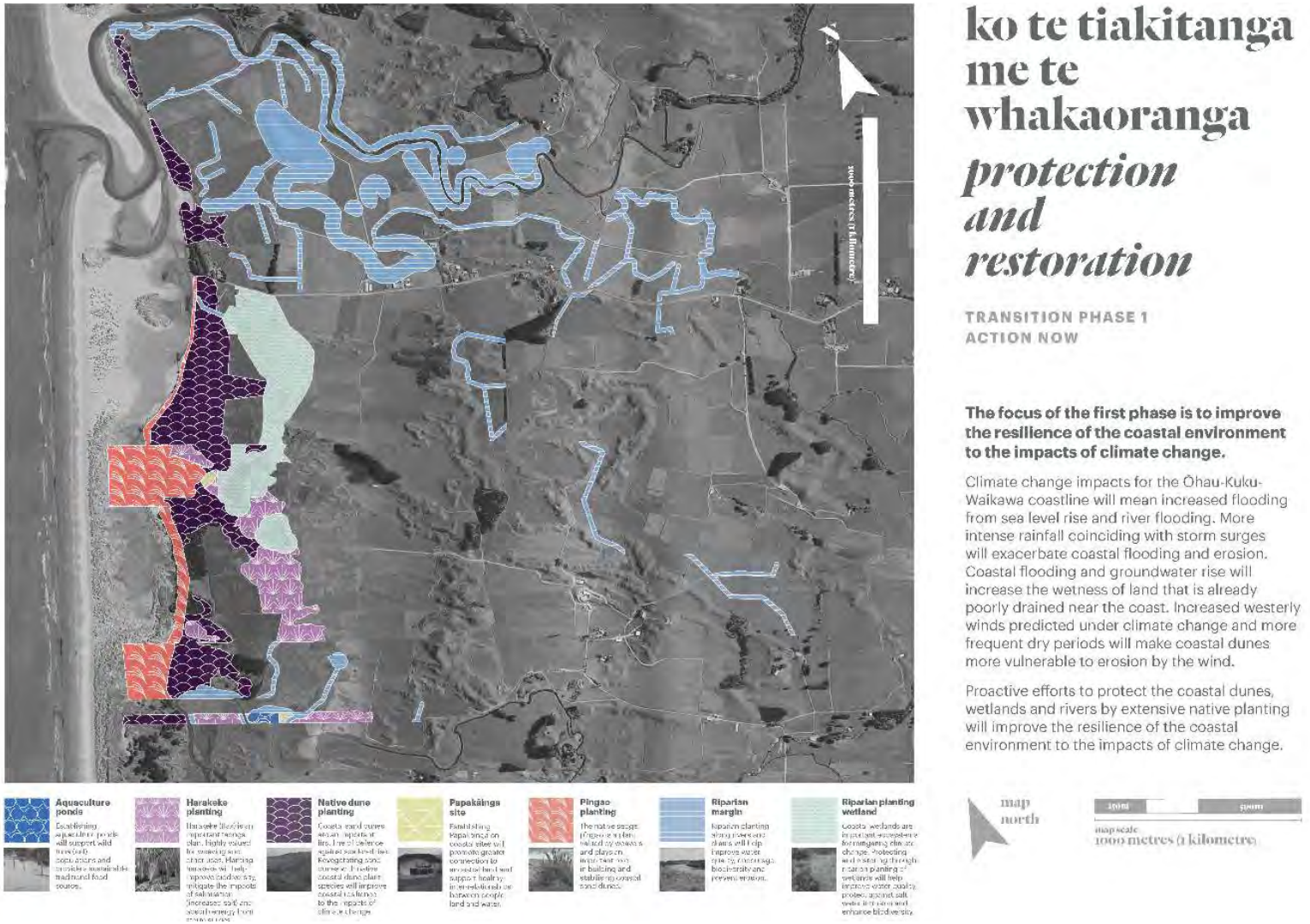

Figure 5.15 Image designed for the exhibition showing Phase 1 adaptation options for the coastal zone

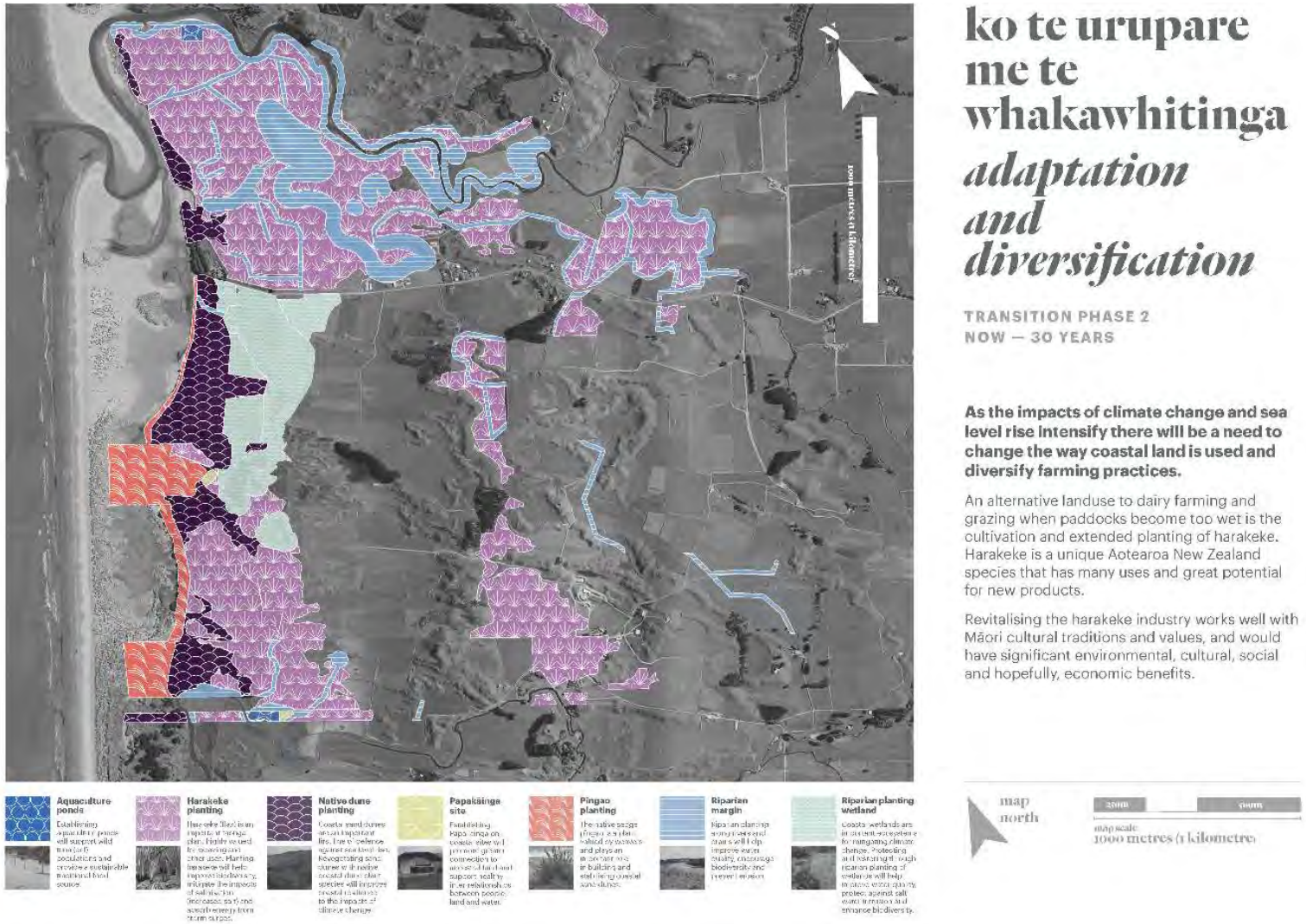

Figure 5.16 Image designed for the exhibition showing Phase 2 adaptation options for the coastal zone

6 ECONOMIC ANALYSIS USING THE RISK ASSESSMENT TOOL

This chapter investigates the economics associated with products and scenarios resulting from land use adaptations to water inundation resulting from climate change. Within this context, specific attention is given to planting harakeke, *Phormium tenax*[265], in areas previously used for pastoral farming. In this regard, a risk assessment tool is developed and applied to analysing the economic benefits across the value chain for the production of high-grade harakeke fibres for high-end clothing products. Such use of the risk assessment tool highlights the uncertainties and risks involved in such ventures, and it is presented as a tool that could be applied in the future to other products apart from high-grade harakeke fibre products.

6.1 Introduction – Land Use Scenarios as Adaptations to Climate Change

One of the adaptations to sea level rise and water inundation on farms in our case study on the Hororwhenua coast is to consider different farming and production options. It is clear that under future scenarios, a significant portion of the land farmed in the Horowhenua coastal zone case study will need to be changed. In particular, intensive agriculture and dairy farming will no longer be a viable proposition in vulnerable areas of the landscape.

In Phase 1 of this project (see Smith et al., 2018)[266] we considered three scenarios for Tahamata farm:
(1) 'no adaptation' to climate change, which meant that the total amount of dairying decreased from 310 ha in the base year (2014/15) to 275 ha in 30 years' time (2045/46);
(2) 'some expansion of wetlands', so that areas inundated by water would now be covered by purposefully constructed wetlands – that is, the area no longer able to be farmed in the first scenario was converted to 56 ha of wetlands;
(3) 'full expansion of wetlands', which meant that all of the land no longer suitable for dairy farming was converted to 193 ha of wetlands.

Our current study detailed here expands that previous scenario analysis to include other farming blocks in our case study area, in addition to the Tahamata Incorporation farm: Te Hatete, Gardiner farm, Taratoa Pekapeka Trust, and Incorporation of Ransfield's.[267] Three scenarios were developed:

Phase 1: This was an initial adaptation to climate change over the first five years, whereby there is very little commercially viable activity, with land use activities focusing on cultural and ecological benefits and objectives.

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[265] Wehi, P.M., Clarkson, B. (2007). Biological Flora of New Zealand 10. Phormium tenax, Harakeke, New Zealand flax. *New Zealand Journal of Botany* 45:4 621-644.

[266] Smith, H., Allan, P., Bryant, M., Hardy, D., Manning, M., Patterson, M., Poutama, M., Richards, A., Richardson, J., Spinks, A. (2017). *Adaptation Strategies to Address Climate Change Impacts on Coastal Māori Communities in Aotearoa New Zealand: A Case Study of Dairy Farming in the Horowhenua–Kāpiti Coastal Zone*. Massey University, Palmerston North. Retrieve from: https://www.deepsouthchallenge.co.nz/projects/risk-management-Māori-coastal-assets

[267] The scenario analysis of the Tahamata farm undertaken in our initial study was significantly more detailed than the more broadbrush analysis presented in this chapter of this report. The earlier study outlined by Patterson et al. (2019), for example, had access to farm budget data, which enabled a more detailed analysis. See Patterson, M.G., Richardson, J., Hardy, D. (2019). *The Real Economics of Adaptation to Climate Change on the Tahamata Dairy Farm – Assessing Future Scenarios From An Integrated Economic Production And Ecosystem Services Valuation Approach*. Massey University, Palmerston North.

Phase 2: This was more widespread adaptation to climate change over a 30 year period, building on the Phase 1 activity. Under this scenario, a number of commercially-orientated projects were postulated and considered.

'**Do nothing':** This scenario was also over 30 years, but there was no deliberate adaptations to climate change. Land unsuitable for traditional pastoral farming was simply retired and became unproductive, or at best marginally productive.

6.1.1 Te Hatete Trust

The Te Hatete Trust block was the smallest landholding studied in this project, consisting of a narrow sliver of 82,000 m² (8.2 hectares). Current land is generally considered to be "poorer quality pasture", which is leased to the Gardiner farm, most of which is used for dry stock grazing. Under both Phase 1 and Phase 2 scenarios, aquaculture ponds (7,205 m²), a papakāinga site (2,577m^2), riparian planting 10 metres either side of drains, some planting to provide a corridor link to the Waikawa stream, and native dune planting (14,104 m^2) would be undertaken. In total, under Phase 2, three hecatres of land would be planted for commercial harakeke production, which is analysed (along with other commercial harakeke plantings in the other farms) by using the risk assessment tool.

6.1.2 Gardiner Lease Block

The Gardiner lease block consists of 57.7 hectares of land currently used for dry stock grazing (34.6 hectares) and forestry (15.2 hectares), with the remainder being in 'unproductive' scrub (14.5 hectares). Phase 1 would involve planting pingao (*Ficinia spiralis*) on active sand dunes, further protection of sand dunes with native plantings, riparian planting of 30 metres beside the Waikawa stream and other water bodies, and riparian margins of 10 metres beside drains. Under Phase 2 (over the next 30 years), there would be an expansion of harakeke planting on the inter-dune environment up to 6 metres above sea level. In total, there would be 16 hectares of planting of harakeke for commercial production, in land that was no longer suitable for livestock farming.

6.1.3 Incorporation of Ransfield's Block

The Ransfield's block is the second largest farm, consisting of 273 hectares of land. Currently most of the land is used for dairy farming (234 hectares), followed by forestry (16 hectares), with the remaining land being either scrub or sand (23 hectares). Phase 1 transitioning (up to 5 years) would involve riparian planting 10 metres either side of drains and 30 metres either side of water bodies. There would also be harakeke planting on most of the unproductive land adjacent to wetland water bodies, as well as some planting of natives on sand. In Phase 2, building on Phase 1, would see significant plantings of harakeke to cover both the inter-dune environment and dune environment, as well as harakeke plantings on the Waikawa floodplain. In total, under Phase 2, 57 hectares of land would be available for commercial harakeke production.

6.1.4 Taratoa Pekapeka Trust Block

This is the second smallest block of land, consisting of 16.2 hectares. Most of this land is currently in scrub or sand dunes. Because of the nature of this land, much of it is active sand dunes, it is not considered for harakeke production under Phase 2. Phase 1 transitioning (up to 5 years) would consist of establishing a significant pingao reserve on active sand, consisting of 12 hectares. It is also proposed that a papakāinga site be established, covering 3,534 m².

6.1.5 Tahamata Incorporation Farm

This is the largest farm, consisting of 452 hectares of land, of which 310 hectares is currently in dairy farming, and 16.3 hectares in forestry production. A far more detailed and nuanced set of scenarios for the Tahamata farm was produced by Patterson et al. (2019)[268] in previous research. That said, under the *current analysis*, for Phase 1 for the Tahamata farm, it is assumed that there will be riparian planting 10 metres either side of drains and 30 metres either side of water bodies, pingao planting on active sand dunes as well as planting natives to stabilise dunes.

Phase 2 would see very significant expansion of harakeke plantings, covering the zones of 0 to 3 metres above sea level, and 3 to 6 metres above sea level. These harakeke plantings would be commercially harvested (in total, 135 hectares). This would be on land that would be water inundated or be significantly compromised for dairy farm production from water infiltration due to climate change. The Tahamata farm would therefore contribute 135 hectares of the 210 hectares of harakeke across all farms in this case study.

6.2 Commercial Production and Values for the Proposed Land Use Changes

Elsewhere in this report (Chapter 4), there is additional information on possible customary and commercial production of products and services, from land affected by climate change in our case study area. First, there is a wide variety of potential products that can be produced from harakeke ranging from the use of harakeke in composite products such as, for example, to replace fibreglass, using harakeke in the manufacturing of dartboards, and using harakeke medicinal and skincare products, all of which are outlined in section 4.1.3 of this report.

Second, there are a number of fisheries and aquaculture initiatives, which are incorporated into the scenarios outlined by Table 6.1. Such operations are specifically built into the Phase 1 and Phase 2 scenarios for the Te Hatete block (7,205m^2) and the Tahamata farm (8,248m^2). Already there are examples of eel farming operations in New Zealand, including nearby to this case study area in Levin. Some of these operations can be integrated into our scenarios that involve riparian plantings – this is particularly the case if using harakeke for riparian plantings, which can provide commercial co-benefits such as eel farming and other aquaculture activities. Section 4.2.3.2 of this report provides a seven step process for establishing aquaculture under a Phase 2 scenario, along with some costings and revenue estimates.

Third, the scenarios also provide for developments that may have some commercial benefits in terms of tourism. Specifically, Section 4.3 explores the establishment of papakāinga for cultural purposes, as well as ecotourism benefits. It is, for example, indicated that temporary seasonal accommodation could be available for people to stay at whilst (re)connecting with the whenua and whānau. Possible revenue sources could include hiring cabins, running environmental workshops, kura or Wānanga for reo, café operations and groups coming to view and to participate in ecological restoration activities.

[268] Patterson, M.G,. Richardson, J., Hardy, D.J. (2019). *The Real Economics of Adaptation to Climate Change on the Tahamata Dairy Farm – Assessing Future Scenarios from an Integrated Economic Production and Ecosystem Services Valuation Approach*. Massey University, Palmerston North.

Table 6.1 Land Cover and Land Uses for Three Scenarios on Māori Owned Farming Blocks on the Horowhenua Coastal Zone – from 2019 to 2049

		Do now - 0-5 years scenario		30 years adaptation scenario		Do nothing scenario - after 30 years	
Te Hatete							
Existing landuse (m2)		**Proposed (m2) after Phase 1**		**Proposed (m2) - after phase 2**		**Do nothing**	
Dry stock grazing	67,728	Papakainga site	2,577	Papakainga site	2,577	Dry stock grazing	2,577
Unproductive land (scrub a	14,531	Riparian planting	7,293	Riparian planting	7,293	Wet land (no grazing	7,293
River	2,001	Wet - land (grazing)	29,301	Harakeke	29,301	Wet land (no grazing	29,301
Total area	**84,260**	Dry stock grazing	21,779	Dry stock grazing	21,779	Dry stock grazing	21,779
		Aquaculture ponds	7,205	Aquaculture ponds	7,205	Dry stock grazing	7,205
		River	2,001	River	2,001	River	2,001
		Native dune planting	14,104	Native dune planti	14,104	Dune (no grazing)	14,104
			84,260	**Total**	**84,260**		**84,260**
Gardiner Farm							
Existing landuse (m2)		**Proposed (m2) after Phase 1**		**Proposed (m2) - after phase 2**		**Do nothing**	
Unproductive (scrub and sa	78,777	Pingao planting	60,947	Pingao planting	60,947	Dune (sand and scru	60,947
Forestry	152,009	Native dune planting	67,525	Native dune planti	67,525	Dune (no grazing)	67,525
Grazing dairy	346,582	Riparian margin	52,179	Riparian margin	52,179	wet land (no grazing	52,179
Total area	**577,368**	Grazing dairy	162,456	Harakeke	162,456	wet land (no grazing	162,456
		Grazing dairy	143,320	Grazing dairy	143,320	Grazing dairy	143,320
		Forestry	90,941	Forestry	90,941	Forestry	90,941
			577,368	**Total**	**577,368**		**577,368**
Taratoa Pekapeka Trust							
Existing landuse (m2)		**Proposed (m2) after Phase 1**		**Proposed (m2) - after phase 2**		**Do nothing**	
Srub and sand		Srub and sand	15,721	Harakeke	15,721	Srub and sand	
Total area	**161,995**	Pingao planting	118,047	Pingao planting	118,047	**Total area**	**161,995**
		Papakainga site	3,534	Papakainga site	3,534		
		Native dune planting	24,693	Native dune planti	24,693		
			161,995	**Total**	**161,995**		
Ransfield Inc							
Existing landuse (m2)		**Proposed (m2) after Phase 1**		**Proposed (m2)**		**Do nothing**	
Forestry	155,544	Native dune planting	80,925	Native dune planti	80,925	Dune (sand and scru	80,925
Scrub and sand	234,367	Wetland	103,440	Wetland	103,440	Wet land (no grazing	103,440
Dairy grazing	2,340,540	Dairy grazing	480,357	Harakeke	571,958	Wet land (no grazing	571,958
Total area	**2,730,451**	Forestry	155,544	Forestry	63,943	Forestry	63,943
		Riparian margin	35,794	Riparian margin	35,794	Wet land (no grazing	35,794
		Dairy grazing	1,874,391	Dairy grazing	1,874,391	Dairy grazing	1,874,391
			2,730,451	**Total area**	**2,730,451**		**2,730,451**
Tahamata							
Existing landuse (m2)		**Proposed (m2) after Phase 1**		**Proposed (m2)**		**Do nothing**	
Forestry	163,035	Pingao planting	15,386	Pingao planting	15,386	Dune (sand and scru	15,386
Dairy grazing	3,100,000	Native dune planting	259,051	Native dune planti	259,051	Dune (sand and scru	259,051
Unproductive (scrub and sa	1,046,365	Riparian planting	660,213	Riparian planting	660,213	Wet land (no grazing	660,213
Wetland and water	210,600	Riparian planting wetlan	294,174	Riparian planting w	294,174	Wet land (no grazing	294,174
		Unproductive (scrub and	679,926	Harakeke	1,346,992	Wet land (no grazing	1,346,992
		Forestry	163,035	Forestry	163,035	Forestry	163,035
		Pasture	2,439,787	Pasture	1,773,438	Pasture	1,773,438
		Aquaculture ponds	8,428	Aquaculture ponds	8,428	Pasture	8,428
Total area	**4,520,000**		4,520,000	Total	4,520,717		4,520,717

Due to data and time constraints, only the supply of harakeke leaf for the production of high quality fibre products was assessed for its commercial benefits in the subsequent sections of this chapter (sections 6.3, 6.4 and 6.5). Future research and the ongoing development of the risk assessment tool could, however, focus on other commercial options, which have been outlined in Table 6.1 and other sections of this report, when more definitive data comes to hand.

6.3 Harakeke Value Chain Analysis

Of all of the products considered in Chapter 4 of this report, using harakeke to manufacture high-grade fibres for fabrics and fabric products such as scarves was considered the most profitable and commercially beneficial option. Hence, this option was selected for further analysis and for trialling the use of the risk assessment tool.

6.3.1 Steps in the Harakeke Value Chain – Physical Inputs and Outputs

The value chain for the production and sale of high-grade fibres of harakeke can be quantified in physical terms (tonnes of inputs and outputs into each step), based on the initial production from 1 hectare of land – refer to Figure 6.1.

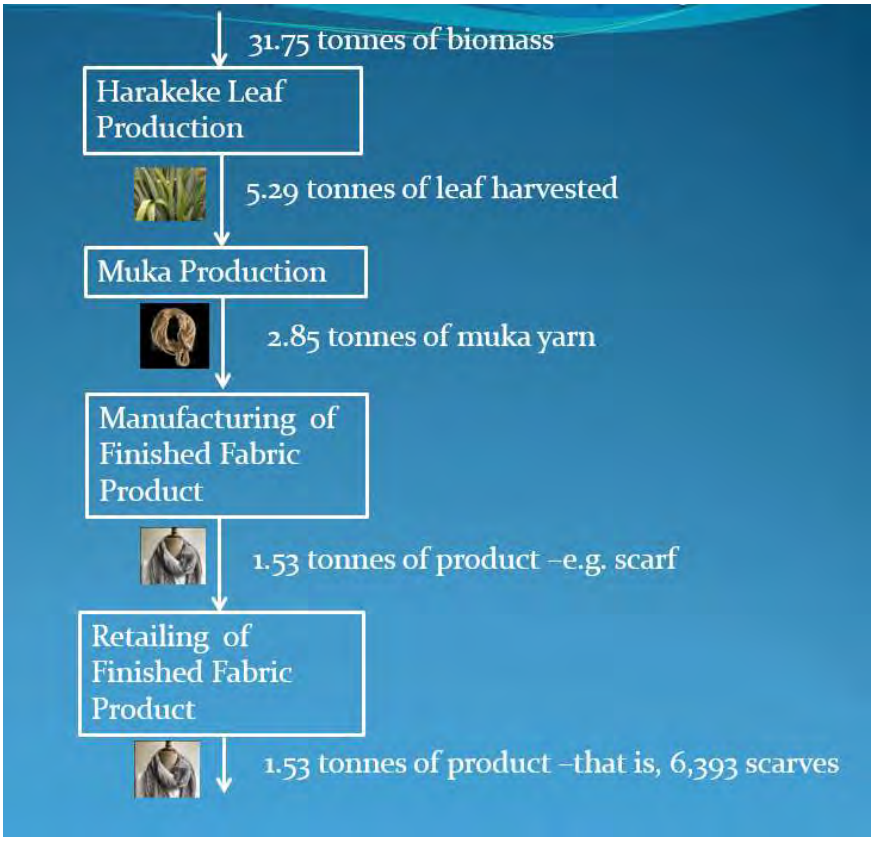


Figure 6.1 Value Chain for Fabric Products from Harakeke, Based on One Hectare of Land

The steps in this harakeke value chain involve:

-Step One: Harakeke Production.[269] As McGruddy (2006)[270] points out, "The calculation of optimal, or even average flax yields from historical data is greatly confounded by use of non-stated assumptions, non-comparable data and various influences of varieties, climate, soils and harvest regimes." Given the range and anecdotal nature of various production data from McGruddy[270], it is difficult if not unwise to even generalise about harakeke yields per hectare. That said, Newman (2006)[271] has suggested working on a conservative value of 25 tonnes per hectare per year of biomass production, which is similar to values based on North American flax production (Agricultural

[269] Another potential way to corroborate these yields, in the absence of commercial production data for harakeke production for fine fibres, is to compare them with the production of other commercial fibre products such as hemp, tencil, jute, sisal and kenaf or even more broadly cash crops such as wheat or barley.
[270] McCruddy, E. 2006. Integrating New Zealand Flax into Land Management Systems. Sustainable farming fund project report. Project 03.153.
[271] Newman,P. 2006. Cited in "McCruddy, E. 2006. Integrating New Zealand Flax into Land Management Systems. Sustainable farming fund project report. Project 03.153.

Marketing Resource Centre, 2019[272]; Flax Council of Canada, 2019[273]). It also needs to be noted that, in terms of its standing biomass, it has been estimated that 80% of harakeke is the 'butt'[274], which is essentially not harvestable as a commercial fine-fibre product, as are the harakeke leaves.

Based on North American guidelines for sustainable harvest, an average number of approximately 5 tonnes per hectare per year is considered to be harvestable (Flax Council of Canada[274]). In contrast, Newman[271] suggests 2.5 tonnes of dry fibre per hectare per year, which represents what Newman considers "a conservative yield of 10%". It also should be noted that, as McGruddy[270] points out, "there is a strong relationship between fine fibre and low yield", and this is an important consideration in our study because we are focussing on the production of finer grade fibre products.

-Step Two: Muka Production. After the harakeke leaf is harvested, it needs to be processed into fine fibre yarn (muka). Traditionally this has been undertaken by Māori by: (1) scraping the outer flesh from the leaves with a shell such as a mussel shell; (2) rolling, soaking and beating the fibre; (3) hand rubbing it several times to soften the threads for weaving. Although there are reports of how muka production can be mechanised, there is no commercially operating mechanised production in muka in New Zealand[275]. Even today when linen is made from flax, it should be noted that the finest linens are still manufactured almost entirely by hand, and even mechanised production of linen requires more handwork than other industrially produced textiles such as cotton. Given the nature of muka production, which requires scraping, rolling, soaking and beating the fibre, and the water content of leaves, and given mass flows for similar production processes, it was assumed that there was a yield of 54% of leaf to muka yarn[276]. Applying this yield of 54%, we determine that 2.85 tonnes of muka yarn is produced per hectare of harakeke plantings (refer to Figure 6.1) – this is very similar to Newman's[271] suggested 2.5 tonnes of dry fibre per hectare per year. The muka yarn can be spun, and potentially sold as a yarn either for commercial use, or non-commercial uses such as the home production of weaved products by hobbyists and recreational users. Various yarns, for example, are available for sale in New Zealand, including those listed on the website "Fibreholics"[277] (ranging from silks, tencil, cashmere, alpaca, merino, possum, linen, cotton to bamboo).

-Step Three: Manufacturing of Finished Fabric Product. This involves producing final clothing products and accessories for sale, such as scarves and shawls. From the raw yarn in the last step, fibre needs to be weaved, and then cut and dyed to achieve patterns on the final fabric product. Based on analysis of mass inputs and outputs of various industries in New Zealand[278], for the

[272] Agricultural Marketing Resource Centre. 2019. National Information Resource for Value-Added Agriculture. https://www.agmrc.org/commodities-products/grains-oilseeds/flax-profile

[273] Flax Council of Canada (2019). Growing Flax. Downloaded from: https://flaxcouncil.ca/growing-flax/chapters/

[274] The butt is the lower third to half of the above-ground harakeke plant. It consists of drier fibrous material, which is not used in fine fibre production.

[275] Rangi Te Kanawa has over the last 15+ years developed a prototype machine to extract muka, instead of using traditional hand extraction methods. Te Kanawa, who comes from a long line of weavers, says muka from her wooden machine can be spun into yarn. Muka forms the base of most Māori cloaks.

[276] Further research is required to investigate the potential for large scale production of Muka using, for example, Rangi Te Kanawa's method of stripping harakeke leaf to muka, and in turn producing fine fibre fabrics from that muka; this would include gaiing a clearer understanding of the yield rates and production costs.

[277] Fibreholics. 2019. Retail Prices of a wide range fibres and fibre products listed under the menu "yarns" and full shawls and scarves under the menu "shop". See http://fibreholics.co.nz/

[278] McDonald, G.W. and Patterson, M.G. 2006. Development of the New Zealand Physical Input Output Table. Written Paper Presented To 2006 Input Output Meeting on Sustainability, Trade and Productivity. Sendai. Japan. Downloaded from:

purposes of this analysis there was assumed to be some wastage, leading to estimates of 1.53 tonnes of fabric product resulting from one hectare of leaf production – refer to Figure 6.1. That is, of the 31.75 tonnes of leaf production per hectare, it was estimated that 1.53 tonnes per hectare ended up in the final fabric products (scarves and shawls as used in this example). Based on a scarf weighing 240 grams, this would result in 6,393 scarves being produced from each hectare each year.

-Step Four: Retailing of the Finished Product. Although there is no currently established retail market for fine fibre clothing products from muka fibres, there are established markets for high-grade fibre products from things such as linen and silk, which have well-established international markets that have developed over many years and in most cases centuries. In New Zealand, there are strong markets for possum, merino and some other agricultural fibre products, as well as fibres such as cotton and silk imported from overseas. In more recent years, there are a number of online retailers who have emerged. It is, however, largely unknown, what the market size and pricing would be for high grade fibre products and garments produced from harakeke, but there may be some price premium available due to the relative 'uniqueness' of the product. It is assumed in the analysis outlined in Figure 6.1, that there is no waste of product in this last step of the value chain.

6.3.2 Prices and Economics of the Harakeke Fibre Value Chain

As no actual markets exist for this harakeke value chain, prices can only be determined by using comparable markets and products, and by understanding the proximate causes of the variation of these prices:

-Step One: Economic Value and Prices for Harakeke Leaf Production. Flax production in the Canadian prairie provinces (Alberta, Saskatchewan and Manitoba), and flax production in North Dakota in the United States, provide the best basis for pricing harakeke leaf production. Comprehensive time series data for the price of flax, indicates that the current market price of flax in Canada is $Can 12 per bushel, which translates into $NZ 519 per tonne. This Canadian price of flax was used in this analysis of flax production on the Horowhenua coast, because it was assumed to have similar cost structures to the Canadian situation, and faces broadly similar market conditions.

In relation to the price of harakeke leaves, it should be noted that:
(1) in order to obtain a premium price for harakeke leaves, it is important that harakeke producers establish a good relationship with down-stream processors of the harakeke flax, and produce a consistently high quality flax suitable for high-end fibre production;
(2) throughout New Zealand, there are a large number of potential competitors for the supply of harakeke, which could exert a significant downward pressure on the price of flax leaves; and
(3) in Canada, flax production competes with other crops such as canola/rapeseed, which helps maintain a favourable price of flax.

Alternatively, the scenario on the Hororwhenua coast is that flax will be planted in areas not suitable for any other productive purpose, therefore there is no upward pressure on the price of flax. In other words, in our Horowhenua case study, there is a low (or no) opportunity cost associated with flax production.

Given that on a per hectare basis 5.9 tonnes of harakeke are produced per year, and the price of harakeke leaf is assumed to be $NZ 519 per tonne, the gross revenue is calculated to be $2,747 per

https://www.researchgate.net/publication/320944145_Development_of_a_New_Zealand_Physical_Input-Output_Table

hectare[279]. Fixed costs, which include costs of machinery, equipment and fencing, are estimated to be $1017 per hectare; and variable costs, which include items such as fertilisers and pesticides, are estimated to be $549 per hectare. Labour costs, also based on the Canadian situation[280] and costs for producing similar products[281], are estimated to be $769 per hectare. When all of these costs are subtracted from the gross revenue, this leaves an estimated profit of $412 per hectare for flax production.

Based on our modelling using the risk assessment tool, this produces annual income estimates (wages/salaries, profit) for each of the farming blocks in our case study:

- Te Hatete Block: Based on 3 hectares of harakeke planting, this generates this block an estimated $2,254 in wages, and $1,208 before tax profit.
- Gardiner farm: Based on 16 ha of harakeke planting, this generates this farm an estimated $12,497 in wages, and $6,695 in before tax profit.
- Ransfield's Inc: Based on 57 ha of harakeke planting, this generates this farm an estimated $43,999 in wages and $23,571 in before tax profit.
- Tahamata farm: Based on 135 ha of harakeke planting, this generates this farm an estimated $103,620 in wages and $55,510 in before tax profit.

The levels of profits, and to some extent wages that can be paid, is highly dependent on the assumed price of harakeke leaves. Based on the assumed price of $NZ 519 per tonne, overall there would be $162,370 in wages and $86,984 before tax profit across all of the land blocks in this study. If the price of harakeke fell to $430 per tonne of leaves, all of the profit across all of the farms would be entirely wiped out; if the price was to drop even further, there would not only be pressure on profit reductions but also on wages paid to employees. The risk assessment tool outlined in Section 6.5, provides a mechanism for generating a number of scenarios and assessing risk, not only related to the reduction in price of harakeke leaves but also other factors that are important in terms of the harakeke leaf production.

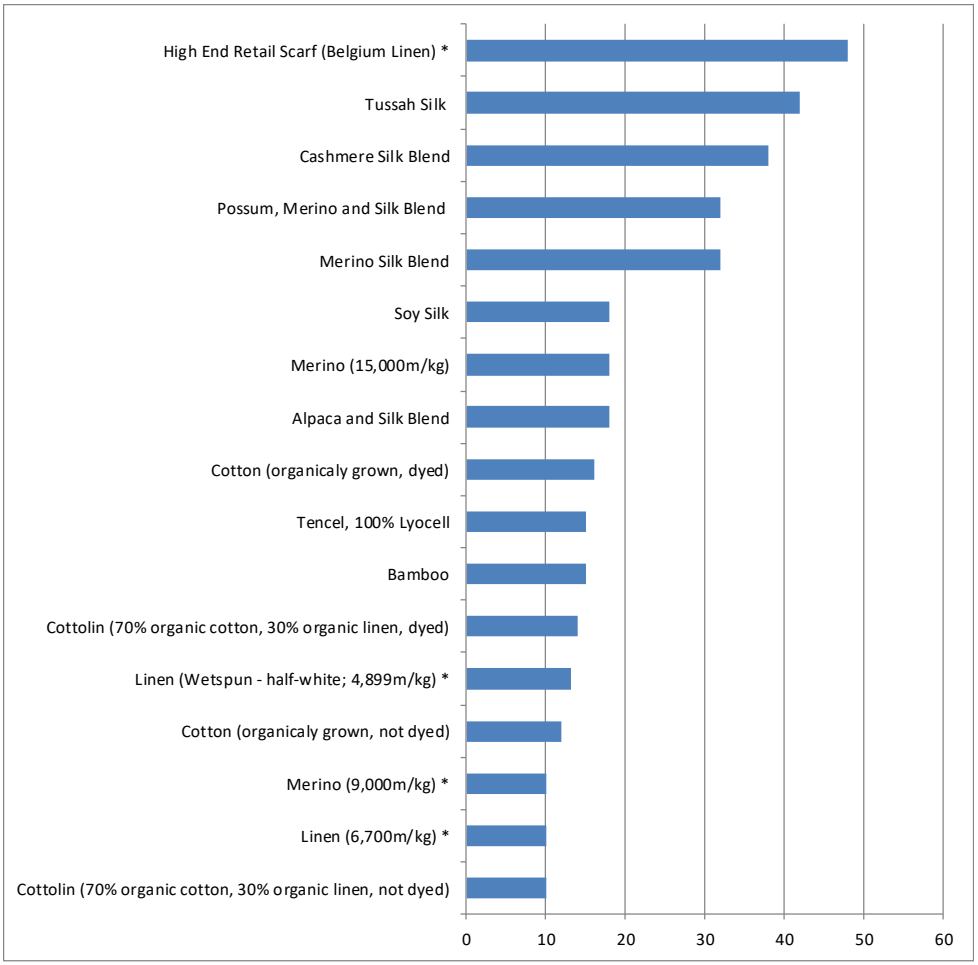
-Step Two: Economic Value and Prices for Muka Production. Estimates for the indicative market price of muka yarn can be obtained by examining the market prices of competitive products in the New Zealand market, which include silk, cashmere, merino, tencel, linen and cotton. These yarns are also often blended together – for example, in the New Zealand market, currently there is a blended possum-merino-silk yarn. Figure 6.2 summarises the market price of yarns based on comprehensive data presented on the Fibreholics website. This Figures 6.2 data, shows that silk (Tussah silk) is the most expensive at $42 per 100 grams, followed by various silk blends including cashmere silk blend at $38 per 100 grams, possum-merino-silk blend at $32 per 100 grams, merino silk blend also at $32 per 100 grams, and finally an alpaca silk blend at $18 per 100 grams. Sitting below silk and silk blends, are the cotton and cotton blend yarns, including cotton (organically grown and dyed) at $16

[279] (5.9 tonnes per hectare) x ($519 tonnes) = $2,747 per hectare

[280] Costs of production for harakeke (fixed costs, variable costs, labour costs) were based on data and information supplied by: Flax Council of Canada (2019). Growing Flax. Downloaded from: https://flaxcouncil.ca/growing-flax/chapters/

[281] The United States Department of Agriculture (2019) provides detailed costings for similar products such as hemp, kenaf, corn, wheat and soya beans. Hemp is considered to be the most comparable to harakeke production in terms of its gross revenue per hectare and its cost structures, and therefore later on its costings were used in this analysis. See: United States Department of Agriculture. 2019. Potential United States Production and Processing: industrial hemp in the United States.

per 100 grams and cotton blend at $14 per 100 grams. Finally, in general terms, the lowest price yarns are linen, for example, with linen (6,700m/kg) having a retail price of $10 per 100 grams.



* For comparative purposes, to show the price of raw yarns in relation to a finished fabric product, Belgium linen is included.

Figure 6.2 New Zealand Retail Price of Yarns ($ per 100 grams)[282]

It is evident from these retail data of yarn that there is a general relationship whereby the 'price of yarn' ($ per 100 grams) increases with the fineness of the thread (metres per kilogram)[283]. Indeed, regression analysis shows that the retail price of yarn is quantitatively related to the fineness of the thread, according to the following equation:

[282] Source: Fibreholics (2019)

[283] There are various ways of measuring the quality of the yarn – for example: NeB cotton numbering system = the number of 840 yd strands per lb; NeL linen numbering system = number of 300 yd strands per lb; Nm = number of metres per gram; YSW Yorkshire Skein weight =256 yd strands per lb; TEX weight in grams per 1000m length; epi = ends per inch. In our analysis, in the regression modelling, we used metres per kilogram as the metric of quality, as this measurement was available for *all of the yarns that we had retail prices for*.

$Y = 5.6895 + 0.001583\ X_1$

Where:

Y = price of the yarn ($ per 100 grams),
5.6895 = constant ($ per 100 grams),
0.001583 = coefficient of '$ per 100 grams', per 'metres per kilogram' (t= 1.73, significant at p=0.11)
X_1 = metres per kilogram

This regression equation can therefore be used to 'predict' the price of muka yarn based solely on the fineness of the muka yarn deemed to be about 6,000 metres per kilogram. By using this approach muka yarn is estimated to have a retail price of $12 per 100 grams[284], and this price was used for the basis of our economic analysis[285] (refer to Figure 6.3).

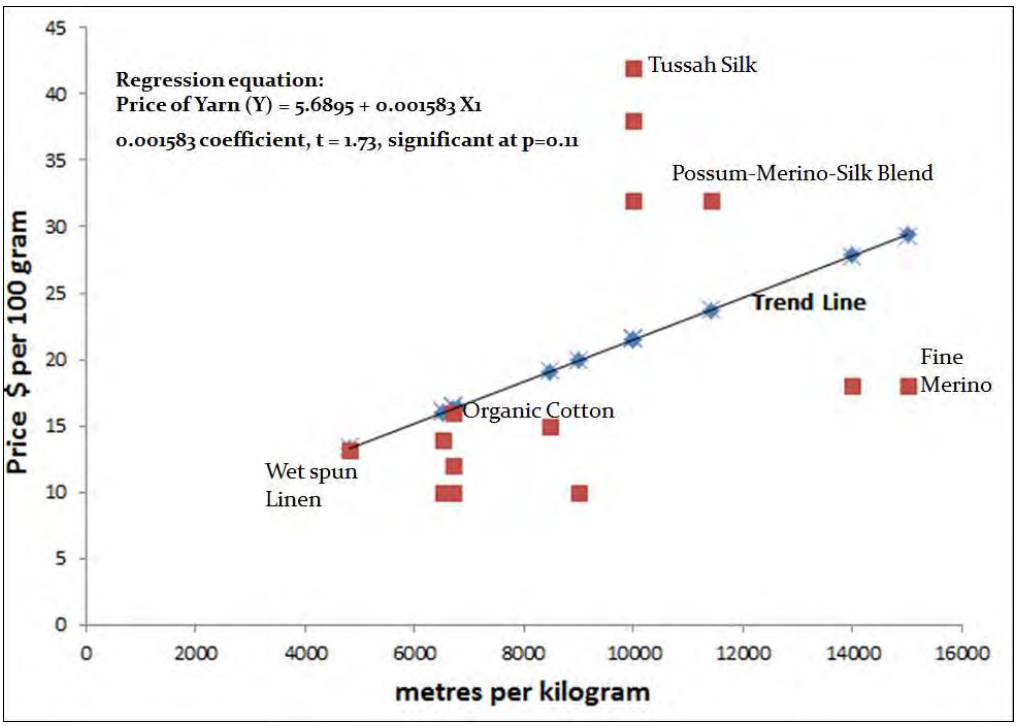


Figure 6.3 Regression Equation: Price of Yarn versus Fineness of the Thread[286]

For each hectare of harakeke production, it is known from Figure 6.1 that this eventually produces 2.85 tonnes of muka yarn. Based on the price of muka yarn estimated from the regression equation, this 2.85 tonnes of muka yarn produced by each hectare, gives rise to a gross revenue of $341,939, which is very considerable, compared with the gross revenue of harakeke leaves of only $2,747 per hectare. Furthermore, if this gross revenue of muka yarn is scaled up to include the entire 211 hectares planted in harakeke in the Hororwhenua coast, this equals a gross revenue for muka yarn of $76

[284] This price of $12 per 100 grams of yarn is identical to the New Zealand retail price of organic cotton yarn. Refer to: http://fibreholics.co.nz/

[285] Although there is some correlation between the market price of yarns and the fineness of the thread, other factors also determine the price of the yarn. For example, for muka it could be argued that there is some price premium, above that predicted by the fineness of the thread, due to the uniqueness of the muka and its cultural heritage.

[286] Data source: New Zealand data from Fibreholics (2019)

million. However, subtracting estimated fixed costs ($13 million), variable costs ($4 million) and wages and salaries ($16 million), the before tax profit is estimated to be $43 million[287].

-**Step Three: Economic Value and Prices for Manufactured Fabric Products.** The next step in the value chain is the production of clothing products and accessories, such as scarves and shawls. There is a diverse retail market for scarves and shawls, in terms of types of fabric, branding and price points. This makes it difficult to definitively determine the market price for scarves and shawls produced from muka yarn. Even a cursory examination of such retail products, indicates that branding and designer reputation are important determinants of the price of the product. For example, a Hermes (French luxury good brand) retail one silk scarf product at $US 670, and there are even examples of luxury silk scarves being retailed for several thousands of dollars. That said, based on our considerations above, it is more likely that a muka fibre scarf has a similar texture to linens produced from flax, would have a similar price point to higher end linen products overseas[288]. Therefore, in our analysis we have assumed that the muka fibre scarf would have the same retail price as a Belgium linen scarf at $NZ 110[289]. To estimate the price obtained by the manufacturer, we have applied a retail margin of 33%, which puts the price of the scarf as sold by the manufacturer at $82.50.

-Step Four: Economic Value and Prices in Retailing of Fabric Products. The final retailing of the muka scarf and shawl products is critical, to not only maximise the value at the retail level, but also if the retail strategy is well perfected, it is likely that this will have positive flow on effects for the value captured in the previous steps of the supply chain. That is, it is critical that the branding and the type of outlets being used attract a premium price, and it is important that there be a good connection between the retailers and the producers of the products in the previous steps in the supply chain. In this regard, It is perhaps worth noting that many scarves are being sold on the basis of being "organic", "sustainable" or being "ethically sourced" usually with no authentication, and therefore it is not surprising that such claims seem to have very little impact on price – the challenge for the muka based product would be to develop a more authentic and unique back story related to iwi/ hapū on the Horowhenua coast, which might attract a higher premium[290].

A factor which is likely to very significantly depress the retail price of muka scarves and similar products is the sheer volume being produced by 211 hectares in our case study area. One hectare is estimated to produce 6,397 shawls per year, which would generate 1,349,394 shawls per year across the 211 hectares of harakeke plantings. Clearly, if these products were flooded onto the New Zealand market, it is more likely that the price per shawl would be similar to that currently obtained from the Glasson's linen shawl product – which means that it is a necessity to develop overseas markets, develop a product range beyond just shawls and scarves, and perhaps even within the shawls and scarves markets develop better product differentiation. To do this, would require very

[287] These are very indicative cost breakdowns, based on national economic accounts for the textile industry. Currently, we only have qualitative descriptions of the muka yarn processing technology, and some of these studies remain commercially sensitive to Rangi Te Kanawa and her colleagues.

[288] Fine Fibre researchers in the College of Creative Arts at Massey University suggested that Belgian linen could be an appropriate fabric to use for comparative purposes when researching marketability of muka-based fine fibre products. For example, see www.couturelin.com; www.libeco.com – these sites sell high quality linen fabric for 11.32 pounds per m2, and/or high end scarves for 65 Euros (at an assumed 160gsm).

[289] At the other end of the market, a Glassons linen scarf is currently being retailed at $24.99.

[290] The closest product we found was a "pohutukawa" silk scarf been retailed online by the Auckland Museum shop at $139.99. The back story for this product makes vague references to "Māori legends" and "New Zealand's Christmas tree", rather than any specific reference to iwi/hapū or place, and clearly the silk is not even a New Zealand product.

significant product development, almost certainly more than was initially anticipated by the proponents of commercial muka production.

6.3.3 *Summary of the Harakeke Fabric Value Chain*

The above step-by-step analysis has revealed the potential for the Harakeke Fabric Value Chain, in terms of producing revenue and adding value. Figure 6.4 shows the positive impact of wages and profits at each step in the value chain, based on 211 hectares of harakeke production in our Horowhenua case study:

- Harakeke production: Estimated before tax profit of $52,190 and wages of $289,946 which would support in the order of 5 to 6 employees
- Muka production: Estimated before tax profit of $43 million, and wages and salaries of $16 million.
- Manufacturing of finished fabric products (eg, shawls and scarves): Estimated before tax profit of $22 million and wages and salaries of $7 million.
- Retailing of the finished fabric products (eg, shawls and scarves): Estimated before tax profit of $22 million and wages and salary of $8 million.

The challenge for the harakeke leaf producers is to position themselves, through supply and franchising agreements, to capture more of the economic value generated in the subsequent steps of the supply chain. Without these agreements safeguarding producers, many of the flow-on benefits will be captured by business operations and employees elsewhere in the value chain, not only within New Zealand, but also overseas as given the sheer bulk of fabric products being manufactured that would necessitate much of it being marketed and sold overseas with overseas businesses and employees capturing some of the added value.

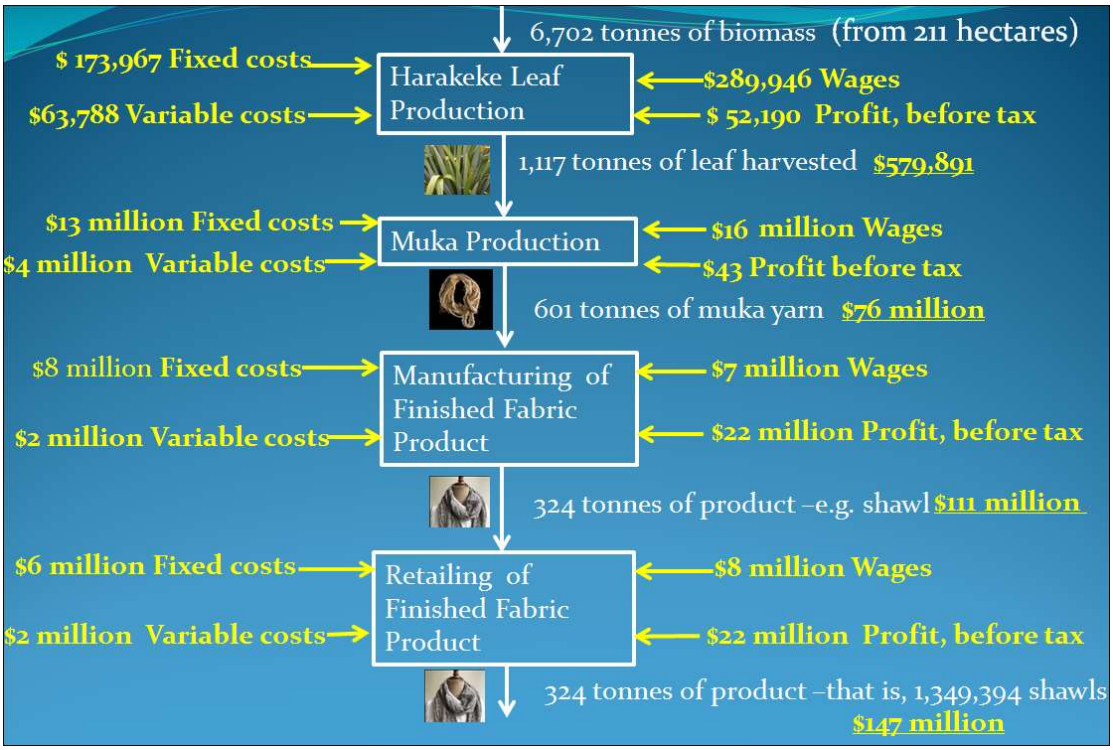


Figure 6.4 Harakeke Value Chain: Variable Costs, Fixed Costs, Wages and Profits, Based on 211 hectares of Leaf Production

6.4 Co-Benefits from Harakeke Plantings

The strategy in planting harakeke for the production of fibre products as outlined above, not only has commercial benefits across the value chain, but also brings significant ecological and cultural benefits in a significant number of cases. Most importantly, the scenarios outlined in section 6.1 (Phase 1 scenario, Phase 2 scenario) involve planting harakeke margins of distances ranging from 10 to 30 metres either side of drains, streams and other water bodies. Such riparian margins will have a number of beneficial ecological impacts and flow-on cultural benefits. Specifically, ecological benefits of riparian margin planting, as summarised by Tangatatai et al. (2017)[291] and Zhang et al. (2012) that can be expected by these plantings of harakeke include:

(1) Zhang et al.'s (2010)[292] meta analysis shows very conclusively how effective riparian margins are in removing sediments, nitrogen, phosphorus and pesticides. Margins of approximately 10 metres will remove 91% of sediments, margins of approximately 15 metres will remove 92% of the nitrogen load, margins of about 20 metres will remove 90% of the phosphorus load, and margins of about 15 metres wiil remove 93% of pesticides.

(2) This removal of pollutants and nutrients is beneficial to the instream ecology and biology. For example, there is an increase in abundance and diversity of stream invertebrates (e.g., mayfly, stonefly, caddisfly) which carry out a number of important ecological functions such as processing instream and terrestrial organic carbon. The removal of nutrients will also reduce the amount of slime (periphyton) and the risk of nuisance growth blooms that are often observed over the summer period.

(3) Tangatatai et al. (2017) provides evidence on how riparian plantings result in improvements of the habitats of key species of cultural importance to iwi/hapū – for example, eels (*Anguilla genus*), and īnanga and giant kokopu (both of the Galaxias genus).

6.5 Risk Assessment Tool – For Harakeke High Quality Fibre Production

There is a great deal of uncertainty concerning the potential for producing not only the harakeke products, but also uncertainties concerning other new commercial activities such as tuna and īnanga aquaculture, all of which are being considering as alternatives to farming land that will be affected by sea level rise and water inundation caused by climate change. There is uncertainty from a number of different sources across a number of different levels and scales. First, there is inherent uncertainty about the impact of climate change in our case study area. Although the broad magnitude and nature of climate change is now beyond dispute, there is a wide range of plausible ways that it could play out on the Horowhenua coast. In our Phase 1 report[293] it was shown that it is possible to project sea level rise in the case study area for the year 2100, but this should not be seen

[291] Tangatatai, T., Patterson, M.G., Hardy, D.J. 2017. *Cost Benefit Analysis of Riparian Planting of Waiwiri Stream, Horowhenua*. Manaaki Taha Moana Research Report No. 15. Massey University, Palmerston North.

[292] Zhang, X., X. Liu, M. Zhang, R. A. Dahlgren, and M. Eitzel. 2010. A Review of Vegetated Buffers and a Meta-analysis of Their Mitigation Efficacy in Reducing Nonpoint Source Pollution. *Journal of Environmental Quality*. 39: 76-84.

[293] Smith, H., Allan, P., Bryant, M., Hardy, D., Manning, M., Patterson, M., Poutama, M., Richards, A., Richardson,J., Spinks, A. (2017). *Adaptation Strategies to Address Climate Change Impacts on Coastal Māori Communities in Aotearoa New Zealand: A Case Study of Dairy Farming in the Horowhenua–Kāpiti Coastal Zone*. Massey University, Palmerston North.

as a definitive prediction, rather a plausible end result of the application of our best knowledge of the situation at this time.

Second, there are a host of factors to do with farm production and markets, which are very difficult to predict in this case study, as in many cases the markets and value chains don't exist or are poorly developed. Therefore, we need to rely on information for comparable markets and products assuming factors such as price signals will play out in a similar manner. The risk assessment tool developed in this case study cannot predict future price and market trends, and cannot even quantify the degree of uncertainty and risk. However, it can be used as a reliable platform to assess various 'what if' scenarios such as, for example, 'what if' the price of harakeke leaves falls from 52 cents a kilogram to 32 cents a kilogram?

Third, there are a number of uncertainties with factors associated with the technologies and engineering aspects of harakeke production. In this regard, in our modelling and analysis in the foregoing sections, we needed to make a number of assumptions about yields and input costs for the technologies, in the absence of specific data about these technologies. For the on-farm production of harakeke, we assume, for example, that there would be similar input costs to products like hemp production, and in the manufacturing sector we used data from national economic accounting and physical input output tables.

The risk assessment tool, specifically developed for harakeke fibre production is schematically outlined by Figure 6.5.

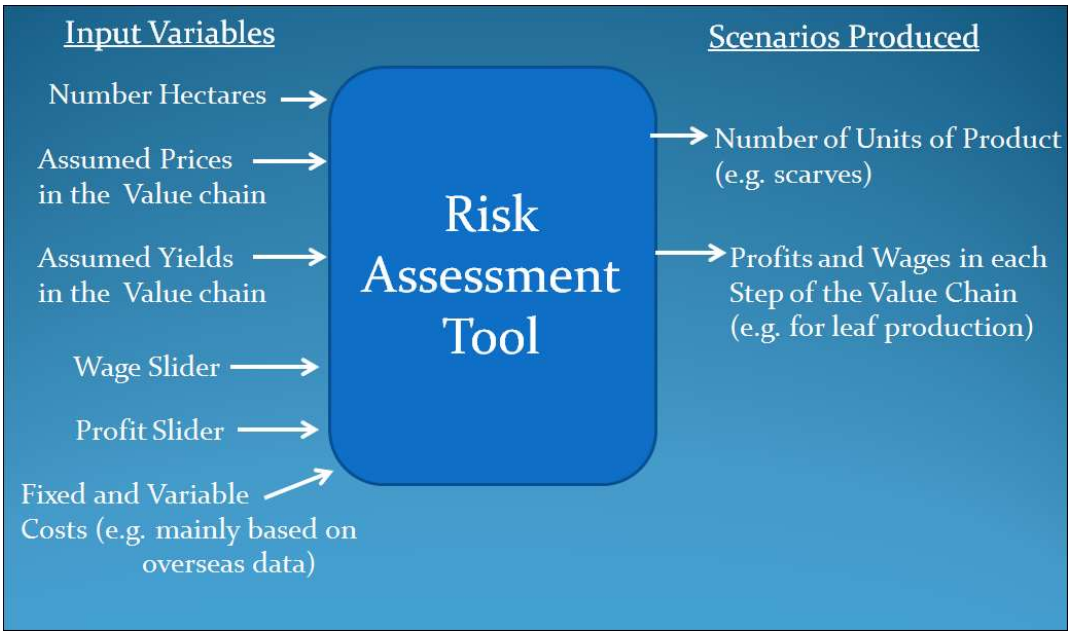


Figure 6.5 Risk Assessment Tool for Harakeke Fibre Production

This risk assessment tool has a number of input factors that can be varied or altered:

(1) Number of hectares in production – the default setting is 211 hectares, but, for example, fewer hectares in harakeke production may be evaluated, particularly if it is seen to be important to have lower levels of production in order to develop more 'niche products' rather than having a 'mass-produced' product.

(2) Prices in the value chain – the default settings are often comparable products in each step in the value chain. For example, linen products are considered to be comparable to muka products, but it could be argued that muka will attract a price premium.

(3) Yields in each step of the value chains. These yields are very difficult to precisely estimate, until actual processes have been developed, and therefore the risk assessment tool could be used to undertake a sensitivity analysis of different yields, by altering the input values for the yields.

(4) Wage and profit sliders. There is always some trade-off between the level of wages and the level of profits, and the impact of this can be evaluated by the risk assessment tool.

(5) Fixed and variable costs. The default setting for these costs are set at comparable technologies – for example, the fixed and variable costs of harakeke production is set at the costs for hemp production as determined for the United States. One possibility, is to use fixed and variable cost data from Lincoln University's (2011, 2016) technical and financial budget manual for New Zealand based agricultural and cropping activities[294].

6.6 Summary

In this study, the risk assessment tool was developed and applied to analysing the economic benefits across the value chain for the production of high-grade harakeke fibres for high-end clothing products. Such use of the risk assessment tool highlights the uncertainties and risks involved in such ventures, and it is presented as a tool that could be applied in the future to other products apart from high-grade harakeke fibre products. Future research and the ongoing development of the risk assessment tool could is recommended, to focus on other commercial options, when more definitive data comes to hand. This is further explored in the final chapter of this report.

[294] Lincoln University. (2011). Farm Technical Manual. Lincoln University, Christchurch. Editors: G. Trafford and S. Trafford; and Lincoln University. (2016). Financial Budget Manual. Lincoln University, Christchurch. Editors: D. Askin and V. Askin.

7 WAI-O-PAPA WATERLANDS EXHIBITION AND RECONNECTION HĪKOI

7.1 7.1 Overview

An important aspect of the research design underpinning this project was the use of visual and other artistic forms to communicate complex science and culturally important knowledge relevant to climate change transitions for Māori coastal communities; and to facilitate meaningful engagement with stakeholders through the use of public exhibition. Accordingly, this chapter includes a wide selection of photos of the presentations, exhibits, displays and activities included in the exhibition hosted by the research team from 22-26 January 2019 at Māoriland Hub in the main street of Ōtaki township. The purpose of this exhibition was to communicate key issues surrounding climate change, and its likely impacts on the Horowhenua coastal zone into the future. It also explored the culturally appropriate and community-preferred adaptation strategies examined in this research.

Below are posters advertising the exhibition, which were displayed on large sandwich boards on the footpath outside Māorilands during the exhibition.

The exhibition was publicised in the media[295], where it was described as including "a striking set of maps that draw on Māori knowledge systems of whakapapa (genealogy), hīkoi (walking) and kōrero tuku iho (ancestral knowledge) in combination with scientific data and intuitive design, to show what the local landscape will look like 30 and 100 years from now". In the article, Huhana Smith explained

[295] https://www.stuff.co.nz/environment/climate-news/110587713/climate-change-scientists-look-to-maori-and-other-indigenous-people-for-answers

that “climate change is not being communicated in a way that relates to the Māori communities who are most at risk from its impacts. This has a knock-on effect on national vulnerability, so her project seeks to forge a new way of sharing knowledge about climate change, based on "mātauranga"”.

The Māoriland Hub venue in Ōtaki was selected as a vital place that regularly hosts culturally relevant topics, including the annual Māori Film Festival, and is well known in the local community. Likewise, Ōtaki is the nearest town to the case study rohe, which made it easier for locals to access the exhibition, than hosting it in a city further afield, such as Wellington. The exhibition included visual, physical and artistic representations of the issues explored in both Phase 1 and 2 of this research. This followed on from the Phase 1 research exhibition, which was held in dis-used cow sheds on Tahamata Farm (see Appendix A).

Aroha Spinks was key Concept Developer for the exhibition. She led the visioning and organisation, with assistance by Moira Poutama, Huhana Smith and key contributions from rest of the research team. Tyler Harlen (Victoria Unviersity Masters Student working with the team) was supported by Huhana Smith and Moira Poutama during his research project, with Huhana as key transporter, and later carrier of his materials and exhibition materials from Wellington to Hub site. Members of the research team were present throughout each day of the exhibition and were able to show people through the exhibits and personally talk to them about the information depicted, where this was welcomed (e.g., see photos below).

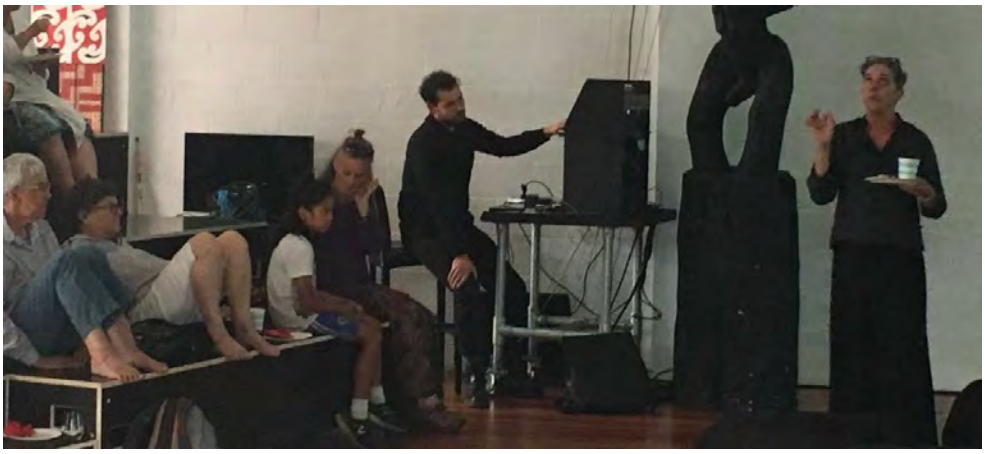
Exhibits were separated into two groups: a) exhibits about the current Phase 2 research and selected exhibits from previous research, and b) artistic and physical displays or performances by whānau from the case study rohe, related to the research. A short survey was available for people to complete, seeking feedback about the exhibition.

Approximately 400 people attended the exhibition; this included around 100 people on opening night, around 100 people on the closing day, and close to 200 throughout the week. Attendees included local landowners both from the case study rohe and others not participating in the research, Māori from other areas throughout New Zealand, Department of Conservation, New Zealand Defence Force, Science Communicators Association of New Zealand (SCANZ), Track Zero, other researchers and academics from universities including Massey and Victoria Universities, local kaitiaki and whānau, as well as leaders from the National Science Challenge that funded the research.

Surveys were available at the exhibition for attendees to voluntarily complete, seeking feedback about the exhibition, as well as the Māorilands Visitors book in which attendees also left comments.

The photos below and over are from the Opening Night of the Exhibition.

Mr Stephens doing the introduction on Opening Night of the Exhibition



Professor Huhana Smith introducing the Exhibition on Opening Night


MAORILAND

The following photos were from the last day of the exhibition, and during the closing event.

The photo below is from the Closing Night of the Exhibition, and shows Huhana Smith addressing the attendees, followed by a kai (over).

7.2 Current research project – 2017-2019

7.2.1 Current Climate Change Science

Professor Martin Manning summarised the latest climate change science, as at 21 January 2019, and related it to the Horowhenua coastal zone, which is the case study rohe for this research. This 3-page summary was displayed in the exhibition, and handouts printed for people to take away (see Section 2.1). This "science summary" underpinned the need to change, according to the latest IPCC projections.

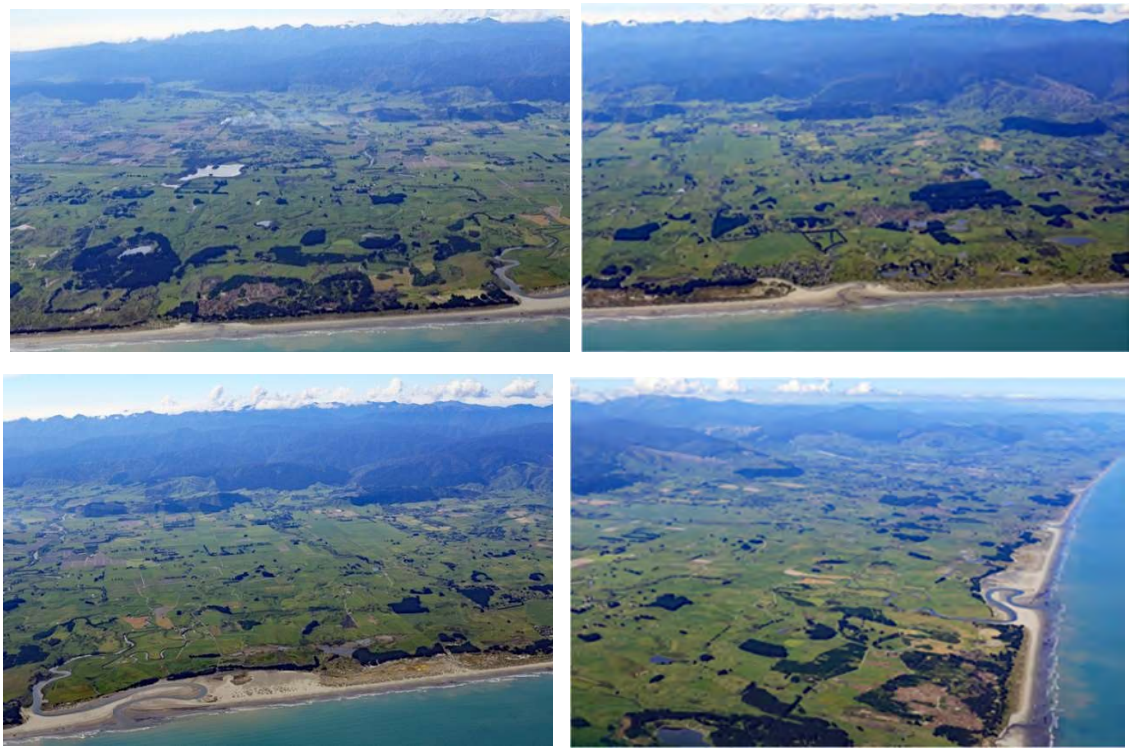
7.2.2 Adaptations on Coastal Māori Land to address the impacts of Climate Change

The following posters were created by Dr Jane Richardson and Jo Bailey, from Massey University. For more detail, please refer to Section 5.7, Figures 4.14-5.16.

The first poster highlighted the areas of low lying land most vulnerable to inundation from sea level rise and flooding. The next poster depicted the Phase 1 adaptation options in the case study rohe that focus on protection and restoring environments. The final poster showed Phase 2 adaptation options for the coastal zone in the research rohe.

7.2.3 Visual images of the coastal zone

Aerial pictures of the coastal zone in the case study rohe were taken on 28 October 2017 by Laurie Cairns (see below). These images depict the current state of the case study rohe, and very clearly depict the state of the sand dunes, coastal rivers and streams, wetlands, pasture, cleared land for development, and so forth. They very powerfully allowed attendees at the exhibition to see the current state of the land and waterways, and to identify where various possible future adaptations could be situated. Recent images are from the 2018-2019 period.



7.2.4 Impacts of Climate Change on Coasts

Alongside this, were photos depicting climate change impacts that have already been felt in the coastal zone rohe, and will continue into the future, thus necessitating the need to adapt. That is, increased flooding of coastal waterways, higher underground water levels and increased, standing water in paddocks, coastal erosion and inundation of the ocean, failures of species (see below).

7.2.5 Harakeke and Stakeholder Engagement

As explored in Section 4.1, harakeke was a focal point of this research, as both a key component of riparian planting of waterways to improve water quality and habitat for taonga species such as tuna and īnanga, but also as a potential new niche industry, or larger scale industry further down the track. The use of harakeke fibre in sustainable cladding for new builds was one of the papakāinga examples.

Physical displays were set up containing harakeke fibre produced at Riverton Flaxmill (see below), as well as photos depicting the process of plantation planting of harakeke for large-scale milling, and the milling process.

Other photos showed the various species of harakeke at Manaaki Whenua, harakeke weavers at various local events with physical examples of their kete on display. There were also photos of children from the local kura walking the rohe alongside members of our research team as part of this Phase 2 research enagagement phase (see Chapter 3 for more detail about the stakeholder engagement in this research).

7.2.6 Muka Fine Fibre, by Rangi te Kanawa

The potential to utilise muka from harakeke to produce fine fibre was explored in this research, building upon various research and experimentation conducted by people outside this research team. Rangi Te Kanawa has spent decades investigating and perfecting a process to extract a very high quality muka from harakeke, with the vision of it being processed into high quality top end fine fibre products. While this process is not yet at the stage of being market-ready, it is useful to explore the potential for harakeke to be utilised for marketable products, thereby providing employment and incomes for Māori coastal landowners whose coastal land will become increasingly boggy and/or wet.

Rangi Te Kanawa attended the exhibition and displayed some of her Muka products on the opening night (see photos above).

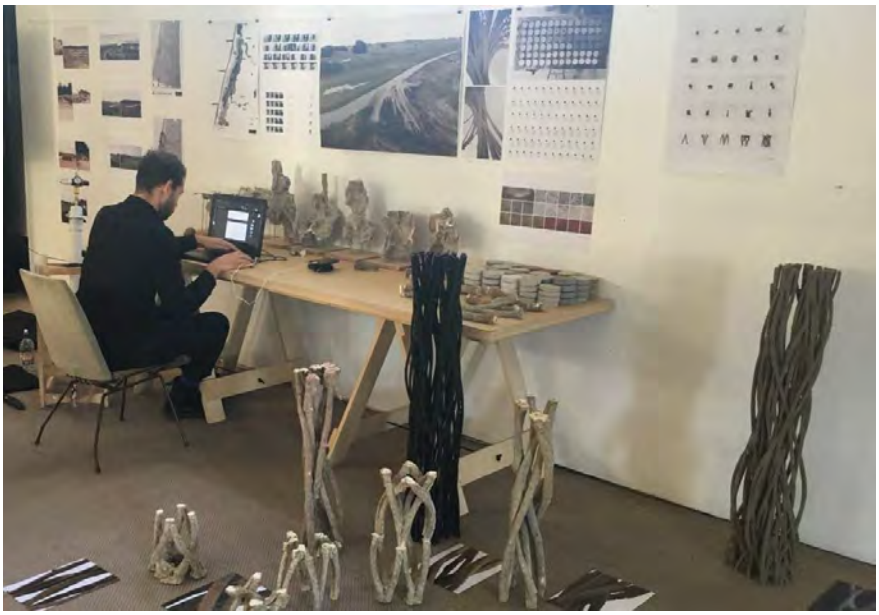
7.2.7 Papakāinga Designs

As discussed in section 4.3, papakāinga was explored in this research, as a means to adapt to the changed condition of the coastal zone by having sustainable, affordable and potentially transportable built structures positioned in higher locations along the coast. This could be used for multiple and varied purposes including permanent or temporary housing, for Wānanga and education purposes, eco-tourism, or as structures alongside new industries along the coast. Examples of such structures that members of the research team have studied were exhibited (see below), including mud and harakeke cladding, log cabins, and barrel cabins.

7.2.8 Coastal Erosion Mitigation

The exhibition also displayed the installation of Tyler Harlen, final year Masters student from Victoria University, who developed innovative site-sourced coastal erosion mitigation devices, which were made by high-pressure forced injections into sand moulds (see photos on the next page).

Tyler's associated digital computations and coastal erosion prototypes (that looked like tree root systems) emulated the concept of Māori 'rootedness' to their whenua or lands. These were well received by the whānau group. Tyler took inspiration from the land, whakapapa and connectivity to create root-like sculptures using a natural concrete made from locally-sourced sand, clay and soil. His idea to inject sand, clay and soil composite into local sand dunes and therefore to stabilise them from the inside, is to prevent them from collapsing under the increasing force of the rising sea.



7.3 Previous relevant research

Key displays, posters or reports from previous related research were included in the exhibition, to maximise the "reach" of these studies. These included reports from the Manaaki Taha Moana (MTM) MBIE-funded research programme[296], and related research conducted with MTM by Victoria University Landscape Architecture Students on Potential Land Use Adaptations for Tahamata Farm to adapt to climate change impacts, in 25, 50 75 and 100 years' time. Other displays included large scape imagery utilised in previous exhibitions to portray the impacts of flooding and related climate change events. Further imagery from earlier exhibitions are in Appendix A.

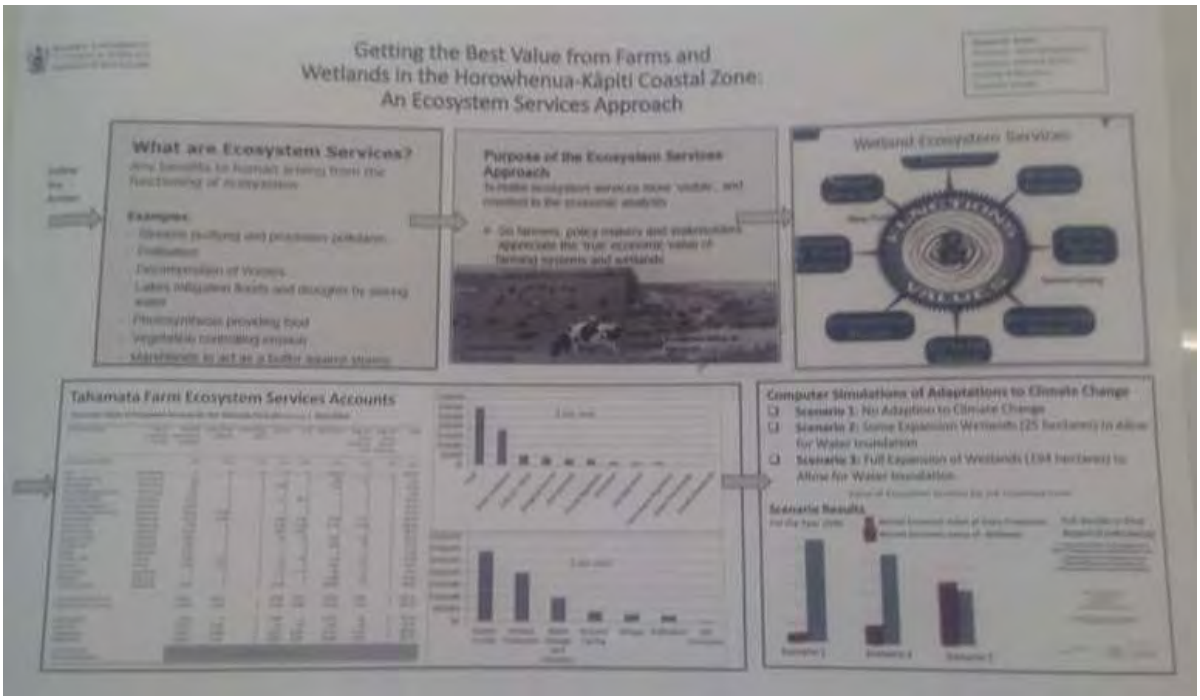
7.3.1 Current vs. Future Coastline with Sea Level Rise

These images very powerfully depict the current coastal zone in the rohe, and the likely inundation of the ocean into the coastal zone due to a 3m sea level rise. These images were displayed on either side of the entranceway into the Exhibition of the Current Research, thus powerfully portraying the reason why research such as this is required, and the need for coastal communities to work together to co-develop Transition Plans towards preferred future land uses that are better suited to changed environmental conditions.

[296] See www.mtm.ac.nz

7.3.2 *Maximising the Value of Wetlands in the Horowhenua-Kapiti Coastal Zone: An Ecosystem Services Approach*

A poster was displayed (see below), showing the key findings of work conducted in Phase 1 and built upon in this Phase 2 study, by Ecological Economist, Professor Murray Patterson and others from Massey University. Handouts were available for people to take away, as well as a report by Tene Tangatatai[297], with a cost-benefit analysis of riparian planting of a waterway in the rohe. The information from that study was utilised in the current Phase 2 research about riparian planting with harakeke for restoration of waterways to enable improved habitat and water quality for fish species, as well as harakeke-based industry (see section 4.1.4, and chapter 6).



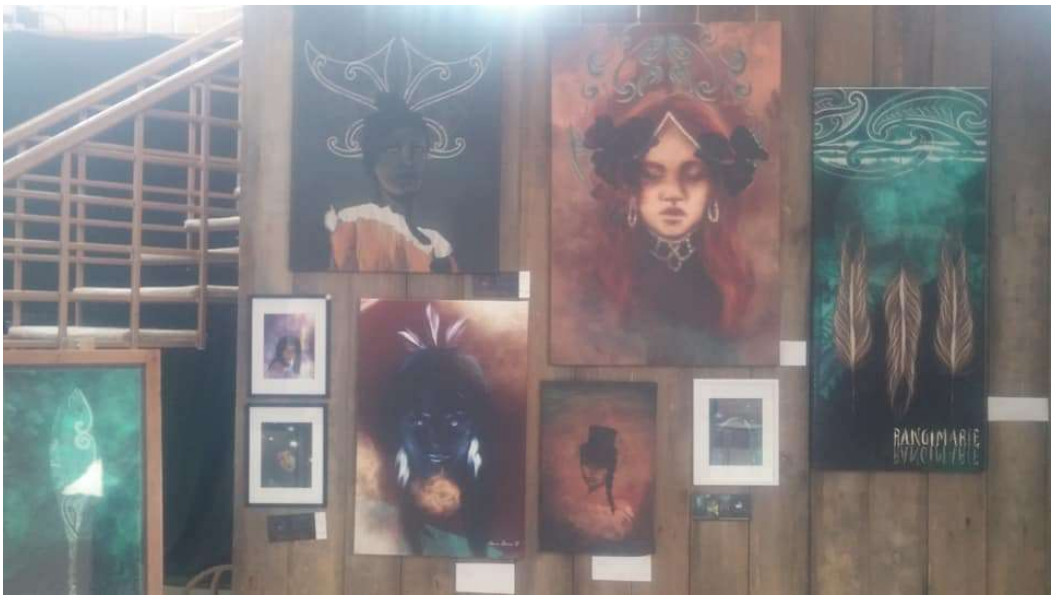
7.3.3 *Large scale imagery of flooded coastline + Reports from previous research*

Visible from the street entrance to Māorilands was a table with reports from our previous Manaaki Taha Moana MBIE-funded research, and the Phase 1 climate change adaptation research funded by the Deep South National Science Challenge. Behind the table, was a large scale photo printed onto fabric of a coastal beach in the rohe after a major flood a few years ago, which was taken by Professor Martin Manning. This was also displayed in prior exhibitions as a stark reminder of how our coastal zones will be impacted by flooding events that will increase in frequency and severity.

[297] Tangatatai, T., Patterson, M.G., Hardy, D.J. (2017). *Cost Benefit Analysis of Riparian Planting of Waiwiri Stream, Horowhenua.* Manaaki Taha Moana Research Report No. 15. Massey University, Palmerston North. Retrieve from: https://www.mtm.ac.nz/wp-content/uploads/2017/12/FINAL-PUBLISHED-REPORT-WAIWIRI-CBA-cover.pdf

7.4 Cultural and Artistic Displays or Performances by Local Māori Artists

A number of local artists and performers were invited to contribute to the exhibition (see below). These local people showcased art forms that related to the land use adaptations of focus in this Phase 2 research, and were purposefully included in the exhibition to emphasise the importance of culture and community connections to engage people in meaningful korero about the critical issues facing coastal communities. In addition to those depicted below, Rangi Te Kawana displayed her Muka Products (see Section 7.2.7).

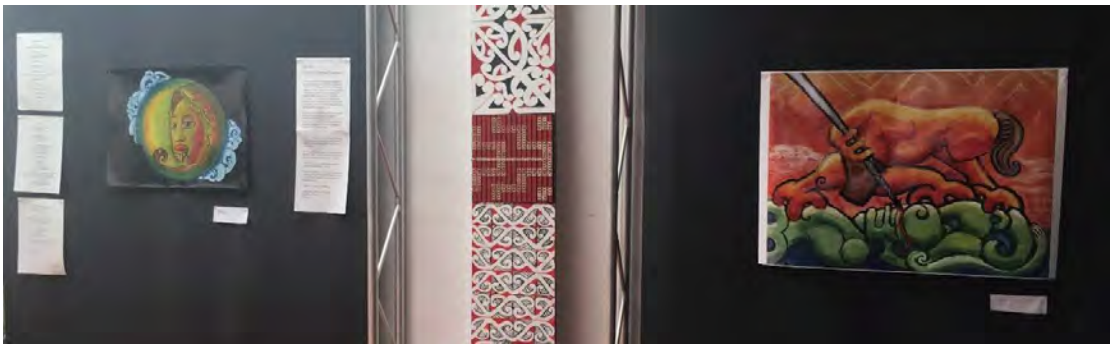


Art works for sale, by Lorna Tawhiti, Ngai Te Rangi/ Tainui: Tapu-ā-rangi – Sky Tohunga; Wakahoe; Makawe ō Ahi; Matariki-Māmā o ngā Whetu – Star Mother; Rangimarie[298]

Art works by Ursula Osborne-Keswick, Ngāti Raukawa/ Ngāti Motai, from left to right Kaitiaki; He nōhanga mokomoko; He tohu

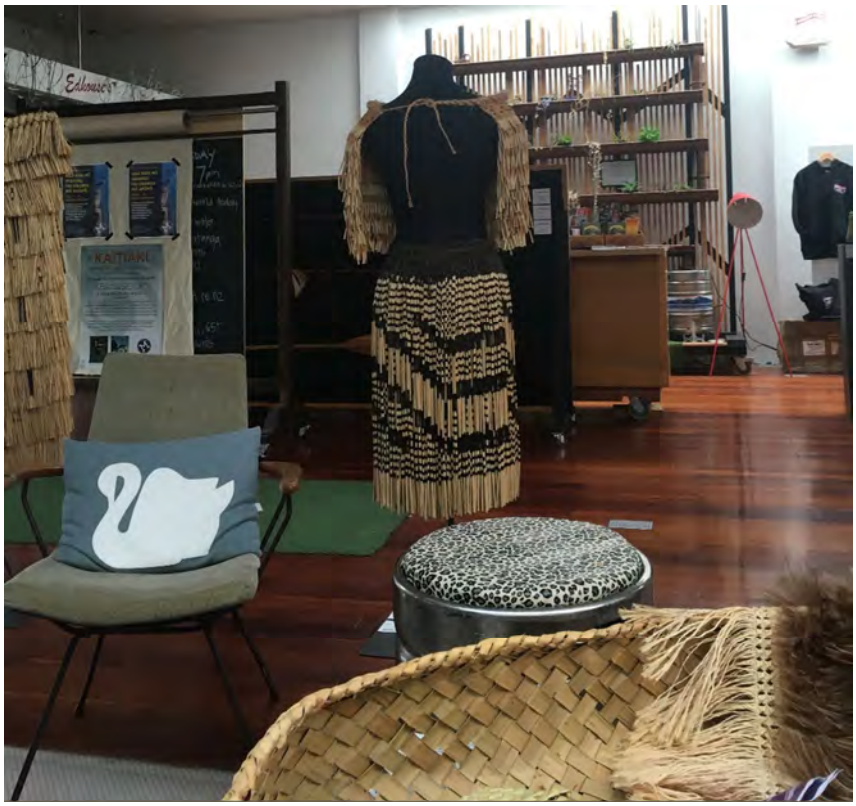
[298] https://www.may15tattoo.com/shop

Early works that featured responses and concerns for water health and pending climate change issues for Tahamata Incorporation and the case study region, featured in *Rae ki te Rae*, 2013, oil on linen (above) and *Musings from the Top Lodge*, 2014, Oil on linen (below) by Huhana Smith, Ngāti Raukawa/Ngāti Tukorehe



Riparian/tuna/ īnanga poetry by Sean Ogden, Ngāti Tukorehe
Kaitiakitanga and Climate Change Graphic Prints by Sean Ogden, Ngāti Tukorehe

Te Wānanga o Raukawa staff onsite demonstration, from right to left: weavers Pip Devonshire (Ngāti Te Au) and Hinepuororangi Tahuparae (Ngāti Pareraukawa); and carver Chris Gerretzen (Te Āti Awa). Woven taonga that were displayed during the exhibition are below and on the next two pages



Storm surge images by Kevin Cartwright from dairy shed exhibition at Māoriland Hub exhibition within the whatu raranga lounge, January 2019

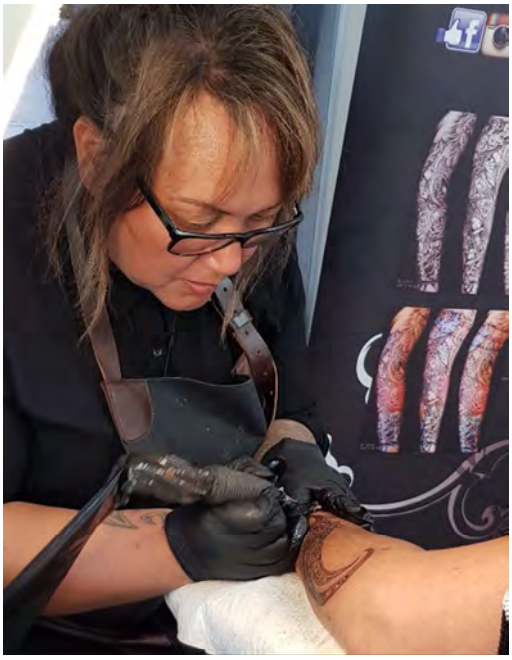
Students from Ōtaki Primary School also created a harakeke artistic piece for display in the exhibition. Due to unforeseen circumstances the piece was unavailable so photos were displayed.

Ōtaki Primary School student, Āwhina Osborne, Ngāti Raukawa /Ngāti Motai, created some graphic art pieces: Papatūānuku, Hineahuone, Hinepūkohurangi and Huia Te Taiao (see below and over).

The photo above is of Kiinui and Āwhina Osborne, viewing art works produced by Āwhina (daughter of Aroha Spinks, research team member).

Ōtaki Primary School student, Parearohi Edgington, Ngāti Maniapoto, created a graphic art print of Hinemoana and Tō ana te rā ki tua O Kāpiti (below).

Lorna Tawhiti, Ngai Te Rangi/Tainui also did on onsite tattoo demonstration[299] on the final day of the exhibition – see below (Moira Poutama, with Aroha Spinks getting tā moko).



[299] See https://www.may15tattoo.com/shop

Choreographer and dancer Dolina Wehipeihana presented a performance work in development KAITIAKI at the Exhibition (see below). The advertisement for her performance, was displayed in the front window of Māorilands throughout the exhibition.

Drawing on the artforms of Māori contemporary dance, waiata, taonga puoro, electronic music and vocal soundscape, KAITIAKI was a performance work that explored concepts of whakapapa, turangawaewae, and kōrero tuku iho in relation to the themes in the exhibition - climate change, adaptation, and matauranga Māori. Dolina collaborated with leading Māori choreographer, Louise Potiki Bryant (Kai Tahu), Māori kaiwaiata and vocal artist, Waimihi Hotere (Ngāti Maniapoto, Te Aupouri), and electronic musician, Paddy Free.

The creative development process investigated the interconnections between people, land and waterways, and the concept of being on a threshold. The creative team considered questions of how to respond now to plan for the future, drawing on matauranga Māori concepts from the past.

The concepts of whakapapa and reclamation of ancestral knowledge were also strong sub-themes of the work, as Dolina was returning to the whenua to present the work, having grown up in the Waikato and a practicing artist in Tamaki Makaurau. The outcome of the choreographic development was a 25 minute performance work based on the concept of Tides. There were five sections to the work:

1. Prologue
   The performance space was marked by kohatu in a circle. These were a combination of kohatu owned by the chorographer from the Nelson river, and kohatu borrowed from the Ōtaki awa for the performance (and subsequently returned). The prologue consisted of the dancer walking in slow-motion tracing the shape of the performance circle. The dancer played *tumutumu* as she walked and created pulling motions with her arms into her centre, as if pulling on giant umbilical cord or controlling the tides like Rona-whakamau-tai.

2. Impending Tide
   The dancer embodied ancient taonga as played in the sound-score, the performance of this section consisting of slow-motion rolling upstage to a standing position. Enacting through the body a sense of whakapapa and history, nature readying itself and the tide drawing itself back ready to change again. The dancer's focus was internal, the body responding to the sound of the taonga puoro in the sound-score.

3. Destroyer Tide
   This section the dancer embodied the idea of a building tide, a lyrical dance that flowed from one side of the stage to another, evoking the ebb and flow of the tide. Using the costume of a long flowing skirt as part of the movement material the choreography built in energy in tandem with the sound-score.

4. Reflection
   This section of the performance was a waiata by *Nga Tae* performed by Waimihi Hotere. Entitled Matarangi, this waiata evoked how we can reflect after the tides come in. The sea rises and the people rise to meet it – our people have always been able to adapt to change and new environments. The lyrics of this waiata include the first line from a proverb said by Ngati Tuwharetoa ancestor Ngoitoroirangi when he arrived in his new homeland:

   Ka Ū ki Matanuku
   Ka Ū ki Matarangi
   Ka Ū kit e Whenua Hei Whenua
   I arrive where an unknown earth is under my feet
   I arrive where a new sky is above me
   I arrive at this land, a resting place for me

This whakaaro is key to the work of the research project – working with local iwi and hapū to plan and adapt to the effects of climate change.

5. Regeneration

   The final section of the work explored the concept of regeneration. The dancer performed a solo based on an atua wahine (female deity.) This section evoked the concepts of bringing back the birds, as well as whānau, hapū and iwi.

   The choreography built to a large movement piece performed to the *Nga Tae* waiata *He Moemoea* performed by Waimihi Hotere. This waiata refers to the seeds being handed down to us by our ancestors, their spirit flowing through us. The energy of this section was uplifting – to hold onto our dreams and our matauranga and treasures passed down to us through our ancestors to help us plan for the future.

The next stage of development for this work is to further develop the performance work. Next steps in the process will be to return to Wānanga in Kuku. The purpose of this further Wānanga will be to develop the next stage of the work with interface with Kuku and its community, and further research. Dolina anticipates this will be a longer process and include gathering and creation of material (movement, AV and sound) in site-specific places, and informed by local knowledge and aspirations.

A local band, Light Entertainment[300], closed the evening celebrations.

[300] https://www.facebook.com/lightentertainmentnz/

7.5 Attendance and Feedback about the Exhibition

Approximately 400 people attended the exhibition. A short survey (see Appendix B) was available for people to complete, seeking feedback about the exhibition[301]. People were also invited to add their contact details to the Māorilands Visitors Book and to provide comments about the exhibition. During face to face korero between members of the research team hosting the exhibition and people attending the exhibition, rich feedback was also given. These various forms of feedback are explored below.

7.5.1 Survey Feedback

There were 18 completed surveys (of which 2 Part A survey responses were excluded from the analysis as they were considered to be completed erroneously). Given so few people who attended the exhibition completed these voluntary and anonymous surveys, these results should be interpreted cautiously. However, they do give some interesting insight into the impact of the exhibition. These results back up anecdotal feedback received by the research team when conversing with exhibition attendees during the event (see previous section).

Part A – tick the box questions (5 point scale, strongly disagree to strongly agree)

Question 1 - 88% of responders Moderately or Strongly Agreed with this statement:
"This experience has made me want to find out more about the impacts of climate change".

Question 2 - 94% of responders Moderately or Strongly Agreed with this statement:
"The exhibition reflected our reality in a culturally appropriate way". (The person who neither agreed or disagreed was not from NZ).

Question 3 - 94% of responders Moderately or Strongly Agreed with this statement:
"An exhibition is a good way to bring our community together to resolve common problems".

Question 4 - 75% of responders Moderately or Strongly Agreed with this statement:
"I feel more confident talking about climate change to my family and friends after this experience".

Question 5 - 75% of responders Moderately or Strongly Agreed with this statement:
"I now feel more confident that our community can do something together about climate change".

Question 6 - 100% of responders Moderately or Strongly Agreed with this statement:
"This experience made me want to get more involved in efforts to help my community be better prepared for climate change".

[301] The survey questions were developed by Dr JT Thakar from Massey University's School of Journalism and Communication and Derrylea Hardy of Massey's School of People Environment and Planning (also a member of the research team for this study).

Part B – Open ended questions and demographic questions

Responses to Question 1 -
What were the most memorable things in this exhibition for you?:
All of it (x2)
Always excited about the work put into this event by our very own people, the passion shines thru, Nga mihi koutou!
Artwork, houses
Loved everything
The talk given by Derrylea
Poems by Sean Ogden
Photographic maps of Kuku/Takutai moana
Te Kaupapa o kaitiakitanga mo te Ao
The passion these people have for this kaupapa
The architecture; Imagination and possibilities
I love living in the coast - the info part of the exhibition prompt me to be more involved and proactive
Tyler and his mahi, Huhana amazing korero, everyone and everything
One to one personal talk
One on one explanation
Presenters first night - diverse speakers and topics, Love Harakeke Kataha
The areal (sic) shots (for beauty) and estimated flood areas (for state)

Responses to Question 2 -
What three words would you use to describe climate change?:
Scary, confronting, uncomfortable
"An approaching Heatball!" (Gathering speed)
Confusing; frustrating
Inevitable; awareness; hope
A bigger change than civilisation has ever seen
Horo a Nuku, Horo a Rangi, Titaka
Polar shifts coming
Bloody scary unstoppable
Scary, difficult, kiha
Here now, what next?
Awareness needed, alarming
Just go away
Fantastic opportunity for positive natural change
Change, wet, uncertain Preventable (Immediate Action Required)
Threatening, destructive, unpredictable

Responses to Question 3 -

How have your views about climate change changed (if at all) after experiencing this event?:

Increased worry
They haven't changed, but made it more confronting when thinking of the moko in years to come
Understand the relevancy to take more action in our daily lives
Yes (x 2)
More power to the little people - local restorations by locals forges cultural change and community
Thoroughly enjoyed the cultural kaupapa
Reinforced by feelings that as a country we are not prepared
A little more hope
Reawakened the need to creatively communicate possibilities
From awareness to action on what can be done; an informed community is an empowered community
A little
More informed
Slightly Gentle reminders of impacts
I notice the worry/trouble in my mind more

Responses to Question 4 -

If we were to do such an exhibition again, what would you suggest we do differently next time?:

Practical ways households can help
"Māoriland" is an excellent venue; however the council could host this event as well, say in 6 months time.
Coastal inundation vulnerability map for Ōtaki Beach (would be great to see).
More of the same.
Whatever Aroha says / Te Aho
Exhibition is well done! More advertising to a wider community, schools, kuras, community organisations
Keep doing it
A clearer journey, flow.
The art and info goes well; to have staff talk art it helps.
Nothing, superb
Great venue, advertise earlier.
No
I was interested in the weaving
Longer presentations on first night or spread out one speaker per night

Responses to Question 5 -
Where would you prefer displays from the exhibition to be kept in the future?:
Local marae = suggested by 9 people
Local council = 7 people
Dedicated website = 6 people
Other ideas suggested: Community and kura; wānanga Library; DOC may wish to borrow if possible; libraries, Parks, Right here [ie Māorilands]; Love the street; Te Papa
-Don't know = 3 people

My Gender:
Female/Wahine = 13 people
Male = 4 people

My Ethnicity:
Māori = 9 people
Māori-Danish = 1 person
English = 1 person
European = 1 person
1 Aussie = 1 person
1 Asian = 1 person
3 Pakeha/NZ Pakeha = 3 people
1 German = 1 person

My Age:
26-35 years = 2 people
36-45 years = 3 people
46-55 years = 6 people
56-65 years = 4 people
Over 65 years = 3 people

Other comments:
Suggestion: would you consider doing something for the children in the holidays - craft - story telling
Nga mihi kia koutou nga kai mahi

7.5.2 Māorilands Visitor Book Feedback

Comments written in the Māorilands Visitors book included:
Miharo!
Tino pai rawa atu
Kia ora! Great work
Thank you! Amazing mahi!
Kei te pai
Ataahua Tenei
Aroha – amazeballs
Awesome!!!
Absolutely Amazing
Please send me copies of all the booklets (multiple requests)
Absolutely amazing
Loved and amazing
Beautiful exhibition
Ataahua Rawa!
Kia ora!
Awesome!
Pai rawa
Pai ana!
Ka mau wehi
Kia ora – great show!
Rawell
Love your work!
Very interesting
Good luck

7.5.3 Received in Person during the Exhibition

Effort was made by the research team members who hosted the exhibition each day, to interact with attendees where this was welcomed, and to "walk them through" the exhibition and answer questions about the exhibits. This korero elicited comment and feedback from attendees, which was overwhelmingly positive. Such feedback received in person from attendees included:
*that the event, and engaging in action research projects such as this, is a great way for Māori who feel disconnected from their iwi/hapū to reconnect in a positive way, again (and not only at tangi).
*very interesting research and requested copies of reports of current and previous research.
*interested in speaking with research team about sustainable energy options and research.

From conversations with people during the exhibition, and notes in the "Visitors Book" at Māorilands, it was evident that a wide variety of people from different iwi/hapū, countries and organisations had attended the exhibition, including: pakeha and local iwi and hapū members from the case study rohe; Māori from the other regions including Auckland, Bay of Plenty, Whanganui, Kapiti/Wellington regions; visiting tourists from countries such as Australia; Department of Conservation; New Zealand Defence Force; Organic Farming.

7.6 Hīkoi Reconnect

The day after the exhibition, there was a hīkoi associated with the dance performance for whānau who live out of town but who had returned for the exhibition. Photos from this hīkoi are below:

8 TRANSITION ACTION PLANNING: CONCLUSIONS, RECOMMENDATIONS & FUTURE RESEARCH

8.1 DEVELOPING TRANSITION ACTION PLANS FOR COASTAL CLIMATE CHANGE ADAPTATION: OVERVIEW

The final phase of the research was to work alongside landowners to consider the findings of this research and co-develop Transition Action Plans. We consider Transition Action Plans as living documents that can be adapted, built upon and developed in more detail as more information is gained and government policy adapts to meet the needs of coastal communities in the face of climate change.

An initial Transition Action Plan framework was developed by firstly considering the land use adaptation options that were preferred by landowners; i.e., harakeke, fisheries and papakāinga. Spatial mapping was undertaken, based on geomorphology, soils and other physical conditions in the landscape, of what stepped changes could be made to the case study land blocks, to address inundation from sea level rise, flooding, and other climate change impacts. Spatial maps were created specifically for each land block, but also to portray a larger vision of what a climate resilient and ecologically healthy coastal zone would look like. This vison includes concepts of connected waterways and wetland corridors, improved water quality, stable dune systems and valuing indigenous plants.

A risk assessment tool was developed to allow landowners to consider various risks associated with land use adaptation options, which was applied to the production of fine fibre from harakeke in this project, as outlined in the previous chapter.

Specific Transaction Action Plans were then finalised for each case study farm, and as they contain commercially sensitive information, they are not shared here. However, the final maps depicting the adaptation options researched in this study, are found in Chapter 5.

8.2 Factors to be Considered when Developing Transition Action Plans:

This research identified issues that Māori land owners in our case study rohe should consider when planning for the likely impacts from climate change over the next 30+ years. These learnings may also be helpful to other coastal communities grappling with the same issues. These key issues are outlined below. What follows is intended to assist local communities to consider the broad areas that we had to take into consideration when developing Transition Action Plans in this project. It should be noted that the specific issues faced by individual communities or land owners may include additional factors that are less relevant to the communities in this project, and it is thus necessary for local conditions to be analysed and incorporated in Transition Action Plans developed elsewhere. The following factors need to be assessed when developing Transition Action Plans for Māori coastal communities facing impacts from climate change.

8.2.1 Ecological and Environmental Considerations:

The specific climate change issues for each region, and for each land block, will vary depending on factors such as the soil type, land elevation, stability of sand dunes and land, quality of waterways, geomorphology, hydrology and drainage. It is critical that a Transition Action Plan include an assessment of such factors for the specific area under consideration. An overview of what was investigated for the case study farms in this project is found in Chapter 5 and we recommend that

these steps be undertaken for any other group investigating adaptation for climate change on coastal land.

Questions to consider:

**what climate change impacts are projected for your region*?

There are extensive reports available in the public domain that outline the projected impacts from Climate Change, including the IPCC reports, central and local government reports, research reports from projects such as those conducted in the Deep South NSC, and so forth. Coastal communities should review these sources, and identify information of relevance to their rohe, especially with regards to the particular climate change impacts expected to incur in specific regions, given that the impacts of climate change will not be experienced in the same way in different locations. In this study, a summary of such climate change science, impacts for the case study rohe and related research are outlined in Chapter 2.

**what are the site-specific physical geography/environmental characteristics of my land/region?*

Not all areas are equally exposed to the impacts of climate change due differences in the physical characteristics of the land and climate variables. Coastal low lying land and areas where the water table is high are more sensitive to changes in sea level, storm surge and coastal erosion. Land adjacent to rivers and stream will be vulnerable to flooding and erosion if climate change increases the occurrence of flood events. Spatial mapping should be used to help identify the areas most at risk from the impacts of climate change. An elevation digital map of the area will highlight the low lying areas most vulnerable to sea level rise and/or flooding. Additional environmental data and an assessment of the most likely geomorphological response to climate change can be used to provide extra information to ensure the most vulnerable areas are identified. Soil mapping can identify areas where the soil may be vulnerable to drought or increased precipitation. For example, sandy soils dry out quickly and can be vulnerable to wind erosion in times of drought, while soil wetness can be a major limiting factor in landuse. Also, understanding the sediment budget and hydrological regime of rivers will help to determine the sensitivity of floodplain environments to climate change.

8.2.2 Socio-Cultural Considerations:

**Social Capital:*

Leadership and committed "people power" is required to drive climate change adaptation plans. Whānau should identify "champions" to lead the change process, and empower them with the support and resourcing required to implement Transition Action Plans. Furthermore, a stock take of the "social capital" networks should be undertaken to identify the people and groups that are available to support and aid in adaptations. For example, volunteers to help plant riparian strips, coastal buffers and expanded wetland plantings; drawing together experts with specialist knowledge in fields such as business case development, experts in the type of land uses being considered, people with cultural knowledge for Wānanga or eco-tourism type ventures, or whatever the specific adaptations may be.

* *Readiness to Change*:

Transition Action Planning will be of little use if the motivation to implement the plan does not exist within communities/whānau groups. People's readiness to accept the need for change, and to embrace the possibilities, is an important consideration. Land owners and their communities who acknowledge the issues facing them and show a readiness to invest funds, time and energy into

exploring options and taking steps to implement Transition Action Plans will be much better prepared once the impacts of climate change reach irreversible tipping points, than those who keep "putting off" action.

It may be that additional information is required to help people understand the need for change, with an expanded ongoing process of land owner engagement. Varying modes of communication might help this process, as with the Exhibition conducted during this research, to help communicate the likely impacts of climate change on the rohe, and the various transitions that were possible, in order to be better prepared for such impacts.

**Need for Ongoing Education, Training and Research*:

Whānau involved in this project have been able to access specialist expertise in various fields including climate change science and geomorphology, ecological economics, and so forth, to help inform their Transition Action Plans. However, not all coastal land owners have ready access to such expertise, and there may therefore be a need for land owners to source information, whether that be through engagement with research providers, local Councils, consultants, or even undertaking education/training in areas where knowledge gaps exist. This will be the case in areas where the preferred alternate land uses are in areas where land owners do not currently have a great deal of expertise, and need to either upskill in various areas, or employ people who do have the requisite skills and knowledge.

**Whānau Aspirations and Cultural Appropriateness of Land Uses*:

The tikanga associated with using taonga species for customary and commercial purposes in any given rohe must be taken into consideration. For example, some whānau may not wish to harvest taonga species for commercial gain, preferring instead to restore and live on the land in ways that promote sustainability and cultural wellbeing. Other whānau may choose to employ land use options that can provide optimal economic return, while at the same time promoting opportunities for cultural revitalization and employment. It is critical that the values and aspirations of whānu/hapū/iwi are clearly outlined, and climate change adaptation options weighed up alongside such criteria, accordingly. What is optimal for one whānau may not be desirable for another.

**Reinvigorating the Adaptive Capacity of Communities*:

Archaeology and oral histories have shown that Māori had a strong capacity to adapt to environmental change prior to European settlement. For example, the archeological record of the study area shows that around the time of first Polynesian settlement 600 years ago, occupation sites were located close to the coast. However, the focus of settlement moved inland following an earthquake, which caused subsidence and a shift from dry to a wetter environment. Huhana Smith states that 'our marae in the Ōhau region for Tukorehe Iwi and associated hapū moved five times back from the coast to where it is now, next to State Highway 1 (approximately 7 kms from the coast)'. Actions that support and value matauranga Māori in adaptation will be vital in creating climate resilient communities.

8.2.3 Economic and Financial Considerations:

**Economics vs Cultural Considerations:*

The degree to which economic profit should determine the merit of various land use adaptation options in this case study was a point of considerable discussion. Research by Mika (2016a)[302] addressed the conundrum of how indigenous entrepreneurs balance commercial and cultural imperatives in ways consistent with their values, aspirations, traditions and circumstances. Studies by Mika et al.[303], and Wood and Mika[304], found that Māori entrepreneurs' attitudes to thinking about managing money and wealth are culturally and socially mediated. This means cultural identity (self and collective) and socialisation (upbringing and status) as Māori are material considerations in how entrepreneurs view money, its use and efficacy. They also found that growth in Māori economies requires Māori entrepreneurs who have access to resources, working inside a supportive entrepreneurial ecosystem and markets that value indigenous offerings. They found that Māori entrepreneurs viewed money as transactional and wealth as transformative, manifesting in multidimensions of social, cultural, economic and spiritual value. Money and wealth were regarded as enabling Māori to uphold tikanga (culture and values) and contribute toward to whānau and community wellbeing. In other words, money and wealth, and enterprise and economic growth, should not involve compromising tikanga, identity and wellbeing, but rather enhance these characteristics of culture and identity[304].

Cultural considerations were pertinent in this study, and underpinned the necessity of evaluating land use options through a cultural lens. In some cases, land uses that enabled the passing down of tikanga and the preservation of taonga species were as important, if not more so, than making a profit off the land, albeit recognising the need for productive land uses to enable payment of minimum mandatory costs such as rates, and so forth. For example, it is important to note the important ecological and cultural factors that would be enhanced through riparian planting of harakeke, not least by contributing to the restoration of important taonga species in coastal waterways and buffering the coastal areas behind the dunes from unexpected storm surges or flooding.

**Debt Levels of Current Trust/Company*:

The debt levels of coastal farms vary from one farm to the next, which impacts on what adaptations are feasible. Māori owned land often has hundreds if not thousands of owners. Thus, the imperative for economic return to individual owners is not as relevant as it would be for an individual who owns coastal land and farms the land themselves as their primary source of income to live on. Owners of whānau/hapū coastal land blocks may prioritise more culturally-valued forms of land use, for which economic return on investment is of lesser importance than ensuring the waterways are rich with taonga species, the land offers opportunity for inter-generational cultural experiences.

[302] Mika, J. P. (2016). The indigenous entrepreneur's dilemma: Balancing cultural and commercial imperatives in business. Paper presented at the Exploring cultural perceptions of money and wealth conference, 10-11 October 2016, Westpac Centre, Takutai Square, Auckland, New Zealand.

[303] Mika, J. P., Warren, L., Foley, D., & Palmer, F. R. (2018). Perspectives on indigenous entrepreneurship, innovation and enterprise. Journal of Management & Organization, 23(6), 767-773. DOI:10.1017/jmo.2018.4

[304] Wood, P., and Mika, J.P. (2018). TE MANU KA RERE: FOSTERING MÄORI ENTERPRISE FINANCIAL CAPABILITY. A joint research report of the Westpac Massey Financial Education Centre and
Te Au Rangahau Mäori Business & Leadership Research Centre, Massey Business School, Wellington.

Suitability/Adaptability of Current Infrastructure:

Much of New Zealand's storm- and waste-water infrastructure was not designed for the challenges climate change will bring. Section 2.2.1 details the significant impact that climate change is projected to have on infrastructure. As discussed below, there are varying levels of responsibility from central and local government to business and the private sector, with respect to how such threats to infrastructure should be managed. At the individual farm level, there are important considerations that land owners should address, to ensure that they are as best prepared as possible for potential threats in the future. For example, ensuring that infrastructure is located in areas least likely to be negatively impacted by flooding, erosion, storm surges and suchlike; locating new construction in higher areas, and utilising technologies that protect from climate change impacts as much as possible. This is particularly important, given that funds spent now, set in place things that are difficult if not impossible to change. With limited resources, decisions about what infrastructure is invested in, where it is located, and the adaptability of buildings and other infrastructure, will have a bearing on the degree to which landowners can be resilient and agile when faced with uncertainties and changes in the future.

8.2.4 Institutional/Government Supports

Insurance-Sector and Government Policy Initiatives:

It is critical that government incentives at the central, regional and local level work together to provide incentives that collectively encourage transformative changes for resilience. This is imperative because, as the effects of these changes become more frequent through flooding, coastal inundation and drought, we'll have less time to recover and there will be cumulative consequences. The resources available to coastal communities to transition to more resilient land uses in the future will also be heavily influenced by public and private sector supports, incentives and resourcing. Local Government New Zealand has sought legislative change to let it act on climate change adaptation. The Government's Climate Change Commission is expected to look into mechanisms to incentivize carbon zero initiatives, which should provide platforms that will facilitate transitions required by coastal communities. Likewise, attention is increasingly focussed on the influence that the insurance sector plays in the readiness and urgency of climate change adaptations.

Research by Ellis[305] examined how the costs of sea level rise should be shared, recommending that "the most important, immediate step New Zealand can take towards an ethically robust sea-level rise policy is to bring certainty and consistency into the legislative framework, ending the collective action problems and risk transfers associated with legal "gappiness."Central government should also resource adaptation nationwide, so that community resilience does not vary with ratepayer capacity. At the local level, deliberately inclusive and robust community engagement (such as citizen jury processes) should be used to engage the public as early and as deeply as possible." [306]

The most common method of managing flood risk in New Zealand is through flood mitigation schemes, in which flood-related infrastructure is funded via targeted property rates and government budget. Many of these schemes were implemented last century, with mounting evidence that land use and population changes mean they're insufficient for future risk. Thus, coastal landowners need to recognise that externally funded flood protection schemes that have been relied upon in the past, may not be as readily available into the future as "100-year floods" occur much more frequently.

[305] https://www.deepsouthchallenge.co.nz/projects/how-should-risks-sea-level-rise-be-shared
[306] https://interactives.stuff.co.nz/2018/11/beach-road/

"Managed Retreat" whereby coastal houses are moved inland, needs to be considered in regions identified as prone to climate change impacts, albeit while recognising the significant social upheaval inherent in moving one's entire home, and possibly also one's livelihood. Other initiatives include the establishment of inter-generational funds set up now to support future adaptations over the next 10 to 20 years, such as that being done in Hawkes Bay. Likewise, a regional natural hazard strategy such as that being undertaken in the Hawkes Bay, could be positively implemented in the Kapiti/Horowhenua/ Manawatū. In embarking upon such steps, Councils and other agencies must ensure they follow a culturally-appropriate process to engage local communities in a way that people feel empowered and part of the process rather than feeling like something is being done to them by an outside agency.

* *Resourcing and Decision Making Tools to Implement Transition Action Plans*:

There are costs involved in implementing substantial changes in land use, and the feasibility of implementing a particular potential future land use may be dependent on the availability of funding, for example. There are also plethora of grants, funding streams, government incentives, scholarships and the like to help with many of the activities associated with adaptation for climate change; for example, see section 8.4.

Various decision making tools are outlined in Section 2.2.4, to help land owners and communities make decisions about adaptation to climate change. It is recommended that these be investigated and where appropriate, utilised as part of the "toolbox" available to communities to help raise knowledge of climate change impacts and options to address them. We also recommend that landowners utilize the DairyNZ Riparian Planner tool[307] to guide the in the budgeting and planning for land use adaptations that include riparian margins of waterways, such as in this project.

8.3 Summary of Key Steps in Coastal Transition Action Planning (TAP):

1. Protect the coastal strip: reinforce dunes, consider planting suited to salt water intrusion, consider if/when to retire some pastures.

2. Identify and plan for vulnerable land: Climate change has the potential to drastically affect the viability of land for use in agriculture and other primary industries. Low lying areas, flood plains, erosion-prone land, areas where water tables are high and soils are poorly drained will likely be more prone to the climate change impacts of sea level rise, flooding and more frequent extreme weather events. Such areas will therefore become increasingly unsuitable for current land use practises and adaptation plans should be developed first for these areas.

3. Plan for phased transitions: Set out a clear, measurable plan for what activities will be prioritised to adapt to climate change impacts (Now, Then, Later), including who will be responsible for their implementation with set deadlines. This may include identification of 'tipping points' to indicate when subsequent steps in the Transition Action Plan need to be implemented.

4. Anticipate and plan for flood events: consider adequacy of storm and waste water systems; determine when and where stock removal is warranted; identify areas where protection of housing, transportation routes, and critical infrastructure will be necessary, and plan for ways to do this – for example, Managed Retreat.

[307] https://www.dairynz.co.nz/environment/waterways/riparian-planner/

5. Plan for higher temperatures and potential drought: for example, riparian margin planting for stock cover and enhancement of waterways.

6. Protect water supplies: consider how to better manage and store freshwater supplies for personal consumption, as well as plant/stock needs.

7. Resource and Equip People: who will lead the TAP implementation? What resourcing or training do they require, and how will that be provided?

8. Plan for insurance, debt servicing, future investment requirements: Plans must be developed for the future possibility that land, and buildings on that land, may become uninsurable in areas that are classified as prone to flooding and other damage as a result of climate change. This could impact on the availability of finance, and suchlike. Financial investments undertaken now, may create 'lock in' situations that limit future options; these potential future financial factors must be taken into consideration. Prudent decision making for the future would ensure that decisions made now don't increase risk in the future; e.g. location of land developments carefully selected for areas least prone to impacts of climate change.

9. Consider business options derived from mātauranga Māori to realise core values and aspirations of Māori landowners – for example, in addition to the adaptation options explored in this project, other options that could be considered are alternative forestry (mānuka, kānuka, tōtara, mataī, puriri, harakeke and kawakawa), horticulture (including honey, olives and olive oil, lemons and hemp. Reforesting the land – particularly with indigenous species – reduces the risk of soil erosion, thereby.

10. Consider co-benefits: Explore land uses that have the potential for multiple income streams and/or the meeting of cultural, ecological and economic goals. A multi-pronged approach may be required, where various new initiatives are trialed or implemented alongside each other, to reduce the risks associated with new business. For example, harakeke can produce muka for fine fibre, but the potential for other products to be made from the seeds and other parts of the plant could also be explored. Likewise, harakeke planting along waterways provides shade for stock, as well as contributing to the restoration of water quality and abundance of fisheries, which enhances cultural values. Alongside such adaptations, eco-tourism or educational programmes could be offered, to supplement income as well as fostering community awareness of initiatives.

11. Readiness to make use of new opportunities: Undertake the planning now, and resource the best people, so that your whānau/community are better able to take advantage of new opportunities that become available as the public and private sectors develop new incentives and funding streams to aid New Zealanders in carbon neutrality initiatives and climate change adaptation.

12. Develop partnerships: Networking and collaborating with other groups may be a powerful means of effecting positive change in the wider community, including in liaison with local, regional and central government. Neighbouring farm/coastal land areas may be able to implement adaptations more effectively if they work together rather than in isolation. For example, research of benefit to all landowners in a coastal strip, as in this project, could be conducted in a joint approach, for the benefit of all.

13. Make use of decision making tools: there are a plethora of guides and tools being produced to assist communities in the necessary changes resulting from climate change (e.g., see Section 2.2.4), that can increase knowledge required to make sound decisions.

8.4 Ongoing Development of Transition Action Plans in this Case Study Rohe

8.4.1 Draft Transition Action Plan Presented to Whānau at Final Wānanga

At the final whānau wānanga, the research team presented each component of the research that was conducted in this Phase 2 research, with culturally appropriate processes around the order of presentations, location of the wananga, and opportunities for stakeholders to participate and provide feedback (see Appendix F, for the Final Whānau Hui agenda).

This research has identified areas where additional information would enable land owners to make better informed decisions about which adaptation strategies are more or less preferable, given local conditions, values and aspirations. The spatial maps depicted in Chapter 5 show the phased Transition Action Plans developed in this research. However, there are many additional factors that influence which land use changes may be undertaken in any given land block, and the timing of such changes, as outlined in the previous section. The key factors outlined in the previous section were presented to whānau representatives at the final stakeholder hui on 12 April 2019, and it was recommended that land owners consider the following issues, before finalising Transition Action Plans (see Appendix F, for discussion templates):

**Phased Transitions*:

As recommended in Phase 1 of this research, stepped changes can be implemented as the impacts of climate change are felt over time. Whānau were again presented with the 3-pronged approach recommended in Phase 1; i.e., Protect, Adapt/Anticipate, Retreat (see Appendix B). The adaptations recommended in this report align with that framework, in that over the next five years the proposed changes relate to stabilization of the dunes and planting of riparian margins, with more significant changes and modifications of commercial land use implemented over time as the impacts of climate change are more prominently experienced. Longer-term planning should consider commercially-viable alternatives to current land uses in areas where changes will be required due to high risk of flooding, erosion and other impacts from climate change. In this project, income-generation from harakeke and fisheries was explored, alongside papakāinga design options that both complement and promote sustainable integrative wellbeing for whānau and hapū, as well as for the environment, while supporting business ventures such as eco-tourism, Wānanga and so forth. Recognising the co-benefits of various adaptation options is also important; for example, planting of natives along riparian corridors alongside waterways is one way to provide such stock cover, which is critical during times of high temperatures and drought, and also protects the integrity of waterways and taonga species that live in them.

**Ongoing Culture of Adaptation*:

It should be noted that the analysis conducted in this study considered the likely impacts of climate change over the next 30 years, with spatial mapping and ecological analysis of preferred adaptations also undertaken over a 30 year period. However, the impacts of climate change will continue to impact upon the landscape well beyond that time, and coastal communities will need to continue to plan for adaptation for the 30-100+ year period and beyond.

In this case study, Phase 2 planting of harakeke has been suggested for the wettest areas in the rohe. However, over time, these 'wet' areas will expand, pooling in greater areas and effectively creating wetland lakes. Harakeke cannot survive in areas where they are largely submerged in water; thus, plans out to 100 years+ would need to account for a continuing transition landwards. Sea levels will continue to rise even if global emissions stabilise (or even reduce) because of the lags in the system, requiring continual adaptation/landuse change. Developing a culture of adaptation needs to be part of any Transition Action Plan. This culture of adaptation is something Māori have been good at in the past – shown by the adaptations they made on that part of the coast in response to environmental change (Bruce McFadgen, pers comm.).

Furthermore, new developments are being explored rapidly; e.g., the use of harakeke for batteries in a recently funded MBIE Smart Ideas project. A Transition Action Plan should keep abreast of technological changes related to the adaptations under consideration. Thus, adaptations that facilitate the progression of multiple goals should be sought, for example the planting of harakeke along riparian margins of waterways in order to a) pilot harakeke-based income generation, and b) improve water quality, stream/river health and the resultant increased abundance of taonga species.

Research funding is being sought to investigate the viability and production of taking muka (from harakeke) to a thread, via the research proposal, *He Aho Tapu Hou – A New Sacred Thread: Taking Muka to Fine Fabric.*[308]

**Tipping Points:*

Given the ongoing nature of climate change impacts, it is critical that landowners and communities are regularly observing the landscape and noting changes, which indicate additional actions are required. It is helpful to identify "tipping points" that signifying when next steps in the TAP need to be implemented; ie NOW, NEXT, LATER? For example, see Figure 5.14 which depicts the increases in inundation over time as sea level rise increases. As areas further away from the coast become wetter, that signifies the necessity for implementing additional adaptation measures in the TAP, or Phase 2 land use adaptations outlined in this report.

**Individual versus Collective/Regional Approaches*:

This research has identified transition pathways for individual land blocks. However, coastal regions will be impacted by climate change, irrespective of where ownership boundaries lay. Thus, it may be prudent for collectives of land owners in coastal strips to work together to determine which, if any, aspects of Transition Action Plans can be implemented in a collaborative fashion. For example, the feasibility of establishing a large wetland area to be used for fishery/aquaculture as well as eco-tourism may be enhanced if it was done across multiple land holdings. Likewise, initiatives such as that by Hawkes Bay Regional Council whereby regional funds are established to support regional climate change adaptations should be considered in this region.

Likewise, it is important to note that maximising economic return is not necessarily the primary consideration when assessing alternative land uses for Māori coastal land, and cultural and

[308] This possible project aims to develop the technology and processes to take muka (harakeke/NZ flax) fibre to a machine spun yarn (or thread). Rangi Te Kanawa (Ngāti Maniapoto) and Massey University researchers will work in partnership with AgResearch towards this aim. If funding is secured, the team will develop new knowledge to adapt current wool processing infrastructure in order to process muka fibre into yarn for sustainable industrial manufacture of high quality textiles, whilst incorporating first principles embedded in traditional muka processing.

ecological considerations can in some cases be of equal or greater importance. This understanding must be taken into account when 'trade-offs' are required in land use decision. Thus, Transition Action Plans for adaptation to climate change must be holistic and sensitive to fact that cultural and economic needs of whānau will vary and a "one size fits all" approach is inadequate.

* *Risks/Barriers to TAP implementation – and how can these be mitigated or addressed*?

As outlined in Chapter 2, research and experience show that increasingly severe and frequent flooding events significantly impact on people's homes, livelihoods and primary income sources; floods are already noted as the most frequent economically damaging natural hazard in New Zealand, and they are projected to increase with climate change and sea level rise. Thus, it is imperative that coastal land owners incorporate this risk into their planning. Over time, the land use practices of many coastal farms will need to adapt, accordingly.

It is critical that careful analysis of each stepped change is undertaken, to ensure that what is done now, does not remove important options into the future, or lock people into a trajectory that they may not have intended. This can eventuate when, eg, substantial finances are invested in infrastructure developments today, that remove the possibility of future financial investments because debt levels are too high, or future insurance is jeopardized.

To minimise risks, it may be prudent to diversity land uses during the transition phase, so that "all the eggs are not in one basket". Multiple adaptation options may need to be implemented in parallel, with the co-benefits of each supporting the viability of the system, overall.

Some of the adaptation options preferred by whānau may not yet be at the stage of being commercially viable, and may require ongoing research or technological advancements. There are various ways in which the adaptation options outlined in this report could be implemented, including through small scale trials and pilot studies in the short term. For example, trialing growth of harakeke (and other natives) for riparian margins AND block plantings in designated areas, and then measuring rate of improvement in water quality, habitat improvement for taonga species, and increase in quantity of taonga species kaimoana etc. Additionally, investigating co-benefits of using the harakeke/plants to grow Māori business enterprise as well as papakāinga, may be possible with funding from the Provincial Growth Fund, and this should be investigated further.

Landowners could also plant other species alongside harakeke in riparian margins; e.g., returning Manuka to dune systems, and other medicinal species to create future health products. Alongside, could also investigate ways to do these new enterprises in low carbon ways to meet Paris Agreement Climate Change goals... could include scholarships or some kind of fund to help develop research and business capability in these areas (i.e., human infrastructure to facilitate transitions required to move into new sustainable economies). The very useful Riparian Planning Tool[309] could assist in this regard.

It is also important to consider other products that could be developed from harakeke planting, alongside the fibre. For example, seeds can be supplied to nutrimetics companies, for health shakes, salad toppings, nut seed mixes, etc. Another option is that once you have larger paddocks planted, you could supply nurseries with small flax bushes, or groups undertaking restoration projects.

In this case study rohe, the use of eco-tourism that is marketed to emphasise the cultural and ecological "journey" of transitioning to a resilient future in the face of climate change, could be part

[309] https://www.dairynz.co.nz/environment/waterways/riparian-planner/

of a Transition Action Plan that includes the use of harakeke and other species to stablise the foredunes, restore the quality of coastal waterways and increase the abundance of taonga species such as īnanga and tuna. In time, fisheries stocks could increase to the level that commercial activity is warranted, perhaps with the inclusion of purposeful aquaculture ponds. Sustainable papakāinga structures could be built in elevated areas, to support Wānanga and cultural activities, as well as sustainable tourism or income generation. Various uses of harakeke could be explored, first as a small niche market, with a view towards expansion into areas that prove economically viable over time.

Risk Assessment Tool: this research recognises that there is a great deal of uncertainty concerning the potential for producing not only the harakeke products, but also uncertainties concerning other new commercial activities such as tuna and īnanga aquaculture, all of which are being considering as alternatives to farming land that will be affected by sea level rise and water inundation caused by climate change. There is uncertainty from a number of different sources across a number of different levels and scales. The risk assessment tool produced in this research includes input factors that can be varied or altered, to show the impact that changing conditions would have on the value chain of alternate commercial products to be produced from the land – ie., the number of hectares in production; prices in the value chain; yields in each step of the value chains; wage and profit sliders; and fixed and variable costs. Future research could expand the variables considered in this decision making tool, and it could be applied to other potential products.

**People to lead the work*:

Without champions to lead change, it is unlikely to happen. It is recommended that landowners consider mandating and resourcing suitably experienced people to advance this work, and liaise with the local community to implement the Transition Action Plans, and adapt them as more information comes to hand, and tipping points are reached. Such people could also be responsible for sourcing funding, scholarships, assistance from government etc, to facilitate implementation of Phase 1 activities, and to set in place mechanisms to ensure progress is continued beyond the life of this research. Noting the feedback received during the exhibition about where those displays could be housed in the future, it would be beneficial to include research findings on a dedicated website and to work with local marae, Councils and other community groups regarding the possibility of posters and other exhibits being shared in these locales.

8.4.2 Next Steps for Whānau – Final Transition Action Plan:

In addition to the points identified in the previous section, at the final Research Hui the following key issues are identified as areas requiring consideration in any Transition Action Plan. Landowners will need to meet with their respective Trusts, boards and/or whānau groupings to investigate options over time, and to implement aspects of the alternate land use options explored in this research.

-What are our values and aspirations for our land and whānau?

-What are the important cultural features of our land that we want to protect, utilize, expand?

-What other matauranga or resources do we have, that can guide us in adapting to climate change impacts in our rohe?

-What areas do we need help with, to make decisions – and where can we access that information?

-Do we have the 'people power' with the right knowledge and skills to make these changes? If not, how can we get them?

-What is the state of our current infrastructure, buildings etc, and how well will it cope with climate change impacts?

-How important is it to make money off our land? Debt levels?

-What economic or financial risks might we face as a result of impacts from climate change on our land? eg access to finance, insurance? Loss of current income? New costs incurred?

-Which sources of funding/support/new income should we pursue – eg support and korero with local/regional council; Trusts etc.

8.4.3 Whānau Feedback:

Feedback received from attendees at and in the days after the final whānau wānanga was very positive and reflected a desire to continue research on transition planning and implementation in the rohe. Ongoing funding is required to undertake the research and planning requested by these and other stakeholders, and we are currently investigating options to enable this to happen. The research process itself has fostered discussion and kōrero between land owners who may not have previously had opportunity to discuss issues related to future impacts on their whenua, and is generating increased motivation and enthusiasm for doing so. A summary of feedback from landowners who attended the whānau wānanga is below.

During the wānanga, there was much kōrero between the research team and whānau regarding the draft Transition Action Plan. When asked whether they liked the idea of an integrated plan that could be implemented with multiple land blocks working together, one participant stated:

> "I love it. We love it. Where our hapū is, is about that distance again on the other side of the Ōhau River (north). We are still on the coastal margin as well. And so our Marae is just outside that coastal area but a lot of land is still owned in that area and so this research is still relevant. So it is not only enriching us to be part of this project but also our hapū [Ngāti Pareraukawa]."

When asked by a member of the research team whether what the landowners' preferences were on how the ideas proposed in the draft Transition Action Plans could be implemented, for example by leading it themselves, or with an environmental manager, or as a coordinated group, the response from one attendee was:

> "as people we would be doing a small part of the whole project it would be silly to do it in isolation... in the past we did try to do some replanting on the block. I'm not sure how successful it was but indications are that it wasn't very successful. My nanny took me there 35 years ago and she was on sticks and we had to go up the dune hills. And I remember her standing on the sand hills there and saying 'that little lake there that is us' and that is the last time I was there. And so the lake is no longer there now so it is really sad. But yeah this whole time the access has not been there for us. To go in and look down on the lake… I think the old people used to regard the actual lake as a real puna. Kai could be taken and harvested. And now the lake is gone is sad."

In this research, three land use adaptation options were researched (due to funding and time limitations) but there are many other possibilities that whānau may wish to consider. The research team suggested an example of how this area used to be wetlands and it may well be that whānau want to help grow it back into a wetland. Response from one attendee was that they would love to do that.

It was also noted that there may well be further hapū all up along the coast who are likely to be interested in the work being conducted in this project, over and above the 5 land blocks included here.

Other feedback received was that "we love the idea of harakeke but not just as a textile. A local wānanga a place for people to go learn. That would be lovely to see on our [Pekapeka Taratoa] block. Be part of that educational kaupapa. Clay whare."

Another participant noted the inevitability of other big storms coming in the future, stating:

> "I've seen the big flooding in the past. Well it should also be considered what is happening inland – up river! Plant up here [indicated further inland on the map] as well… up there affects down here [indicating on the map]. Mountains to the sea. I'm a whitebaiter I know what is happening on the Ōhau River."

Kōrero noted by the research team during the wananga in relation to Pekepeka block is as follows: Support Phase 3 research progressing adaptation on the ground, in situ, subject to funding, and looking into expansion of adaptations further north. Interested in dune stabilisation options, as well as wetland enhancement for increasing inanga. Have kura/wananga to encourage learning and enable people to see the revitalisation as it progresses. Further development of the Transition Action Plan should consider mountains to sea, not just the coastal strip; ie adaptations for climate change, but also all the other changes that need to be implemented for freshwater regulations eg Fonterra dairy pick up regulations and Horizons nutrient limits. Would like ongoing adaptation research to consider carbon sequestration as a mitigation, and denitrification, plus possible tax breaks.

Kōrero noted by the research team during the wananga in relation to Gardiner farm is as follows: The dairy farm is inland, with runoff by the coast. They want to weigh up options for the use of that land, that are economically sound as they don't want to waste/lose money. Decision making can be difficult as there are multiple owners (7 whanau). They want the best Return on Investment. They have an AGM once a year, where big decisions are made. They are already doing riparian margins; they can get spinifex etc for margin planting. They would like to firstly plant the dunes to stabilise them, using pingao/natives/harakeke – some parts could be planted or turned into a wetland, this is still to be decided. In any ongoing Phase 4 research, they would like more information on the feasibility of harakeke uses such as those outlined in the report; ie the economics of other aspects of harakeke (not just for production of fine fibre) to make growing it a viable economic venture, including looking at the co-benefits of multiple uses for multiple income streams, eg as stock feed (noting that American flax is eaten by cows – can we find out if harakeke can be used as a stock feed, also), seed/pharmaceutical, for leaching/nitrate mitigation. One attendee stated that the research had given them "more passion to get our act together".

Representatives from ngā uri ō Nepia Taratoa whānau stated that access to their small block was the biggest issue for them, and gaining access would be awesome, whether that be through a walkable track through Te Hākari, or beach access:

> "To be able to stand on the whenua and appreciate the kōrero about it and to get a sense of how the whānau may like to see it used would be a lovely first step. There are a few of us who would really appreciate an organised hīkoi and I have heard that some of our Parewahawaha whānau would be keen too… We loved the idea of maybe a small whare – shelter. Some kind of distinctive feature to aim for. A place to walk to and appreciate the

larger project 'tiaki whenua' which is something we have always aspired to and began 25(?) years ago when Peter Hapeta and others did some planting out on the block. I don't know if any of that planting has survived. Your plan showed pingao planting could be one of the preferred options for the raised areas with harakeke in the lower areas. I would personally love to see a little more diversity with plants like tī and some mānuka – but that could be a second step. And if we could access the block we could then look after it…
"Tungia te ururua kia tupu whakaritorito te tupu o te harakeke"
Ngā mihi ki a koutou e whakahaere ana I tēnei mahi rangatira!
Nāku iti nei, nā"

Further to the request for a hikoi for these whānau to visit the whenua, dates are currently being put forward for this to occur, in liaison with the broader whanau.

A representative from Tahamata Board who attended the final whānau wānanga contacted the research team a few days after the wānanga with the following update:

"Last night we had a Board meeting and I presented a short summary of the work that you have been doing. It was very well received by those Board members present and I would like to congratulate everyone for such a wonderful resource document that you have created. Please pass this on to the rest of the team from Tahamata Board. The Board is very interested in pursuing an environmental plan for the farm, based on your findings in the report… The Board sees that the above [information which has been deleted or obscured in this public report] will need to be project managed and seek your advice as to how we could move these things forward.
Look forward to hearing from you.
Nga mihi"

We will continue to seek funding to facilitate such ongoing work with Tahamata.

Feedback from whanau attendees from Ransfield Inc, Gardiner Farm MK2 B8 and Te Hatete Trust included that they are all supportive of the transitions plans as outlined in the Maps produced and are encouraged by the potential of a Phase 3 project.

8.5 Potential Sources of Support and Funding for Adaptation Plans:

The following is a list of potential sources of funding to assist with environmental projects such as riparian planting, restoration of waterways, fisheries and aquaculture, forestry and food or fibre related projects, such as those explored in this research. Coastal communities and landowners working on strategies to ensure they are more resilient to the impacts of climate change are encouraged to explore these sources of funding, and apply for assistance where appropriate. Guides[310] for the process and maintenance of riparian strips on waterways are also available.
*Nature Space[311] – provides a list of potential sources of advice on funding and a sample of national and regional funds that are available for community groups who are carrying out restoration on public, private and covenanted land.

*Generosity NZ[312] – this portal provides a comprehensive list of funding bodies and funds. This is available on a subscription basis, or can be accessed for free at many local libraries and council offices.

*Envirolink funding[313] – funds Crown research institutes, universities and private research organisations to provide regional councils with advice and research on environmental projects.

*Horizons Regional Council[314] – the Freshwater, Land and Biodiversity teams all have a variety grants that the public are able to apply for when looking to improve our Region's environment, from fencing and planting, to rejuvenating wetlands or helping to control erosive hill country.

*Dairy NZ[315] – funding for planting of waterways. Their website also advises on the right plants and techniques that will help maximise the success of riparian planting and value for money. Planting fenced riparian areas adds further benefit to the environment as plants function like a sieve, helping to filter out sediment and nutrients before they enter waterways. Stabilising riparian plants help prevent land erosion and increase the habitat for native wildlife.

*Greater Wellington Regional Council – funding of up to $15,000 towards the cost of fencing, planting and pest control of waterways[316]. They also have a Wetlands enhancement programme[317], where landowners with significant and outstanding natural wetlands are eligible for up to 50% of the cost of fencing to prevent stock access. In some circumstances, they can also provide funding for pest plant control, pest animal control and eco-sourced native wetland plants to assist in restoring these wetlands.

[310] https://www.mpi.govt.nz/growing-and-harvesting/land-care-and-farm-management/farm-management-for-healthy-waterways/;
https://www.doc.govt.nz/globalassets/documents/science-and-technical/riparianzones1.pdf
[311] https://www.naturespace.org.nz/resource-centre/funding-your-projects
[312] https://generosity.org.nz/
[313] https://www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/envirolink-scheme/
[314] http://www.horizons.govt.nz/about-our-region-and-council/grants-and-sponsorship/combined-environmental-grants
[315] https://www.dairynz.co.nz/environment/waterways/planting-waterways/
[316] http://www.gw.govt.nz/healthy-waterways/
[317] http://www.gw.govt.nz/wetland-programme-2/

*Tax Breaks for costs of riparian planting – the Income Tax Act 2007 allows deductions for plantings to prevent or mitigate discharges into water courses or water bodies[318].

*Crowd Funding – increasingly, crowd funded has enabled initiatives such as those explored in this study; for example, the Million Metres Streams Project[319].

* The Provincial Growth Fund[320] - its priorities are to: enhance economic development opportunities; create sustainable jobs; enable Māori to reach their full potential; increase social inclusion and participation; build resilient communities; help meet New Zealand's climate change targets.

* Green Investment Fund – while not currently available, this is a potential future fund supported by the government to invest in assets that reduce carbon emissions.

* Māori Climate Change Commission[321] – provides independent Māori-focused research and advice that will contribute to Aotearoa meeting its obligations under the 2015 Paris Agreement; to facilitate opportunities for Māori to learn about climate change, and programmes that will help Māori play their part in Aotearoa's campaign to clean up the world.

* The Government's 1 Billion Trees initiative[322] – for forestry related initiatives.

* The Emissions Trading Scheme[323] – all sectors interested in land uses that reduce emissions should investigate whether there is potential within the ETS.

* The Ministry for Primary Industries (MPI) – they have various funds that could help implement adaptations. For example, forestry-based erosion control initiatives[324]; Sustainable Land Management and Climate Change (SLMACC) Research Programme to help the agriculture and forestry sectors with the challenges arising from climate change[325], with the following funding: Hill Country Erosion Fund, an Afforestation Grant Scheme, and a Permanent Forest Sink.

* MPI also works with tangata whenua to help them maximise their natural resources and assets, with a focus in Agribusiness[326] and the research of Customary Fisheries[327]. Their Customary Fisheries Research Fund[328] assists tangata whenua to manage their customary fisheries by providing financial assistance to undertake fisheries research.

* MPI also support innovative projects to grow New Zealand's Food and Fibre industries sustainably[329].

[318] http://www.stuff.co.nz/auckland/local-news/rodney-times/8929472/Tax-breaks-encourage-more-riparian-planting
[319] https://millionmetres.org.nz/open-project/2018-maraetotara-river-planting/; http://www.maraetotaratreetrust.co.nz/
[320] https://www.mpi.govt.nz/funding-and-programmes/other-programmes/regional-economic-development/
[321] http://www.maoriclimatecommission.co.nz/purpose/climate-change/
[322] https://www.teururakau.govt.nz/funding-and-programmes/forestry/planting-one-billion-trees/
[323] https://www.teururakau.govt.nz/funding-and-programmes/forestry/emissions-trading-scheme/
[324] https://www.mpi.govt.nz/funding-and-programmes/forestry/erosion-control-funding-programme/
[325] https://www.mpi.govt.nz/funding-and-programmes/forestry/sustainable-land-management-and-climate-change-research-programme/
[326] https://www.mpi.govt.nz/funding-and-programmes/maori-in-the-primary-industries/maori-agribusiness/
[327] https://www.mpi.govt.nz/funding-and-programmes/maori-in-the-primary-industries/
[328] https://www.fisheries.govt.nz/funding-and-programmes/maori-in-the-primary-industries/customary-fisheries-research-fund/
[329] https://www.mpi.govt.nz/funding-and-programmes/sustainable-food-and-fibre-futures/

*The Ministry for the Environment (MfE)[330] – they have various sources of funding including:
the Freshwater Improvement Fund[331];
Te Mana o Te Wai Fund[332];
Community Environment Fund – for projects that strengthen environmental partnerships, raise environmental awareness and encourage participation in environmental initiatives in the community; and
Environmental Legal Assistance Fund[333] to engage in Environment Court cases.

*The Department of Conservation (DOC) have various funds including:
Ngā Whenua Rāhui Fund[334] supports conservation projects by tangata whenua groups;
DOC Community Fund - Pūtea Tautiaki Hapori is designed to inspire and enable community-led conservation work doing practical on-the-ground projects[335];
Nature Heritage Fund[336] for projects that protect ecosystems of high ecological value on private land either by direct purchase or covenant.

*Pacific Development and Conservation Trust Grants[337] fund a range of conservation, development, cultural heritage and goodwill projects in the Pacific.

*Lottery Grants, including:
Community Grants[338] – to help improve the quality of people's lives in their communities;
Environment and Heritage[339] – for plans, reports and one-off projects that will protect, conserve and promote New Zealand's natural, cultural and physical heritage;
Lottery Community Facilities[340] – to improve or build new facilities for communities;
Feasibility Studies[341] – to find out if a community facility (or conservation plan for cultural heritage projects) is needed and can be achieved.

* The Ministry for Culture and Heritage website[342] provides a good overview of various funds and which projects are most applicable, for the following areas: Arts, Culture and Heritage[343] funding for heritage protection[344]; Internal Affairs; and Tourism. This includes many of the Lottery Community Grants.

*Te Puni Kokori[345] – they have a guide to papakāinga housing[346], and various funding:
Whenua Māori Fund[347] supports Māori land owners to explore different uses of land and ways of

[330] http://www.mfe.govt.nz/more/funding
[331] http://www.mfe.govt.nz/more/funding/funding-fresh-water/freshwater-improvement-fund
[332] http://www.mfe.govt.nz/more/funding/te-mana-o-te-wai-fund
[333] http://www.mfe.govt.nz/more/funding/environmental-legal-assistance-fund
[334] https://www.doc.govt.nz/ngawhenuarahui
[335] https://www.doc.govt.nz/doc-community-fund
[336] https://www.doc.govt.nz/get-involved/funding/nature-heritage-fund/
[337] https://www.communitymatters.govt.nz/pacific-development-and-conservation-trust-2/
[338] https://www.communitymatters.govt.nz/lottery-community/
[339] https://www.communitymatters.govt.nz/lottery-environment-and-heritage/
[340] https://www.communitymatters.govt.nz/lottery-community-facilities/
[341] https://www.communitymatters.govt.nz/feasibility-studies/
[342] https://mch.govt.nz/sites/default/files/Table%20NZ%20Govt%20ACH%20related%20funds%20%28D-0720121%29.PDF
[343] https://mch.govt.nz/funding-sources
[344] http://www.heritage.org.nz/protecting-heritage/funding-for-heritage-protection
[345] https://www.tpk.govt.nz/en
[346] https://www.tpk.govt.nz/documents/.../3201/tpk-guide-papakāinga-housing-2017.pdf
[347] https://www.tpk.govt.nz/en/whakamahia/land-and-environment/whenua-maori-fund

boosting its productivity;
Kāinga Whenua Infrastructure grants for infrastructure development on housing on Māori land;
Māori Housing Network[348] for planning, funding and implementing successful housing initiatives;
Ka Hao: Māori Digital Technology Development Fund[349].

*To Ohu Kaimoana[350] – work to advance Māori interests in the marine environment, including customary fisheries, commercial fisheries and aquaculture as well as providing policy and fisheries management advice to iwi and the wider Māori community.

*Kiwibank Kāinga Whenua — Home Ownership on Māori land [351] – the Kāinga Whenua loan scheme is an initiative between Kiwibank and Housing New Zealand to help Māori achieve home ownership on papakāinga. Kāinga Whenua supports ahikaa and haukāinga to help address whānau papakāinga housing aspirations and can be used to build, buy, renovate or relocate a house on to your whenua Māori.

*Papakāinga Solutions Ltd[352] – can assist with the planning and implementation of individual or collective Papakāinga housing, including traversing the various legal, cultural, political and financial issues involved.

*Collaborative Government Funding for Papakāinga – there are various examples[353] of funding from a variety of sources being used together to build Papakāinga, eg Ministry of Housing and Urban Development, and Te Puni Kokori, which should be explored. This can also include
Housing New Zealand Kāinga Whenua Loans for individuals[354];
Kiwisaver working with Housing NZ[355], KiwiSaver Home Start Grant[356], and Kiwisaver first home withdrawal[357].

*Iwi/Hapū Funding – Various funds exist to support the activities, education and wellbeing of iwi, hapū and whānau throughout the country. In this case study rohe, such as Ōtaki Porirua Māori Trust Board; Mandated Iwi Authority for Fisheries (MIO) and others.

[348] https://www.tpk.govt.nz/en/whakamahia/maori-housing-network
[349] https://www.tpk.govt.nz/en/whakamahia/it-and-innovation/ka-hao-maori-digital-technology-development-fund
[350] https://teohu.maori.nz/
[351] https://www.kiwibank.co.nz/personal-banking/home-loans/rates-and-options/kainga-whenua/
[352] http://www.psladvisory.co.nz/papakainga-housing-and-housing-on-maori-land.html
[353] http://www.scoop.co.nz/stories/AK1902/S00052/otangarei-papakainga-funding-approved.htm
[354] https://www.hnzc.co.nz/ways-we-can-help-you-to-own-a-home/kainga-whenua/kainga-whenua-loans-for-individuals/
[355] https://www.hnzc.co.nz/ways-we-can-help-you-to-own-a-home/housing-new-zealand-working-with-kiwisaver/
[356] https://www.hnzc.co.nz/ways-we-can-help-you-to-own-a-home/kiwisaver-homestart-grant/
[357] https://www.hnzc.co.nz/ways-we-can-help-you-to-own-a-home/kiwisaver-first-home-withdrawal/

8.6 Key Findings and Recommendations for Researchers Conducting Climate Change Adaptation Research with Māori Communities

The aim of our research was to investigate alternative land use options and aspirations identified and prioritised by the landowners. Our research has identified the following factors as being important to successful research with Māori communities who are grappling with the impacts of climate change, and attempting to work through the relevant issues and make sound and evidence-based decisions about appropriate adaptations. These points are not considered to be a comprehensive assessment of how to conduct research with Māori, but are learnings that have come from our research and things that we found helpful and that we hope will help other transdisciplinary bicultural researcher–community teams who are collaborating to address complex issues.

8.6.1 Culturally-Appropriate Engagement Processes

Both phases of this cross-cultural, inter-disciplinary, collaborative, participatory action research project were designed around wānanga (workshops), hui (meetings), hīkoi (walking and talking on the land) with local kohanga reo, kura, wānanga and university students, which encouraged pukengatanga (sharing of knowledge). This approach was designed to bring together whānau land owners (stakeholders) and the research team, as a way of co-producing new knowledge and capability to identify, respond and adapt to potential climate change impacts. This engagement process (see Chapter 4) was initiated well before the application for funding was submitted to the funder, and continued throughout the research process as priorities were identified for detailed investigation, through to the final development of transition action plans and preferences for ongoing funding.

As kairangahau-Iwi/hapū researchers Moira and Aroha coordinated and led this local engagement with whānau. In these important roles, amongst other things, they ensured the rangatiratanga (self determination) of their whānau and whānaunga was given mana. Our research gave the whānau-land owners the freedom to express and maintain the self determination of their futures.

The process of people engaging in wānanga and hīkoi together, gives opportunity for stronger connections between the diverse groups engaging in collaborative research, and builds stronger joint vision and commitment to the research. Hīkoi, whereby the research team and other participants in the research walked over the physical case study rohe (for example, see section 7.6), were also utilised as a means of physical/cultural/spiritual reconnection with the ancestral landscape - ūkaipotanga. Joint understanding of the key kaitiakitanga issues is improved during hīkoi as it fosters face-to-face communication and knowledge sharing on the rohe of investigation. It also offers opportunity for whānau to reconnect to the land, to be leading their vision for the future, and to identify ways to contribute to the achievement of whānau determined kaupapa (cultural values) and aspirations. It is critical that such culturally appropriate engagement processes and local tikanga are employed in any research involving Māori Communities, or in research where Māori Communities will be impacted. Engagement needs to occur during all stages of the research design, visioning, operations and communication of the research.

Likewise, ensuring that the local community has opportunity to engage in all aspects of the research, if they so wish, is important. As an example, whānau members of the land blocks attended the Deep South National Science Challenge annual conference in May 2019, alongside the research team, and participated in workshops and other engagement processes at that forum.

Researchers, environmental planners and policy makers working in the field of climate change could follow a similar community engagement process as in our project.

A summary of the main steps is as follows:

1) Project Leaders engage an inter-disciplinary research team, including whānau/hapū researchers, and designs the research in consultation and collaboration with potential end users/whānau/local communities.

2) The research team investigates the likely local climate change impacts, and with whānau/local communities then explores potential ideas for adaptation, resilience and protection (brief outline of concepts only).

> Outputs: local maps of climate change impacts and adaptation scenarios, brochures/posters of mitigation option ideas. Slide presentation.

3) Workshop/presentation by the research team to whānau and the local community, who can feed into preferred adaptation options, providing new ideas or scenarios. This step increases awareness of climate change impacts and adaptation options, but also provides the opportunity for whānau/local communities to be engaged in their environmental planning and rangatiratanga (self-determination).

4) The research team then further investigates a number of key preferred adaptation options, identified by the local community. The findings are then built into the spatial mapping of land use adaptations and economic analysis of these land use changes, so that the financial costs and benefits associated with the options are understood.

> Outputs: adaptation option maps, cost-benefit analysis and risk assessment on preferred options.

5) Workshops and exhibition/s are held, to communicate research results to end users/whānau/local communities in innovative and interactive ways. The community thus has another opportunity to consider the options, consider the costs and benefits and provide feedback.

6) The community feedback is presented to local council planner.

> Outputs: final report, final maps, local newsarticle, slide presentation.

8.6.2 Enhancement of Kaitiakitanga, Pūkengatanga, Ūkaipotanga, Wairuatanga and other Māori values

The aim of this research was to contribute to an integrated framework for resilience in coastal Māori farming communities by identifying culturally-informed climate change adaptation strategies, and to build Māori capacity to proactively and productively adapt to climate change, leading to new processes of effective social engagement for dealing with this issue. Our research team ensures that local mātauranga, tikanga and kaupapa are given mana at all times. We strongly recommend keep up the communication. Face to face is best. In our experience, when collaborative research teams are successful in working alongside and supporting local communities, the total effect is more than the sum of the individual parts – synergistic outcomes can be produced.

The feedback received from whānau and landowners at and after the final wānanga evidenced the value they perceived from this research, and the contribution that it made to their environmental and cultural planning for the future (see section 8.3). With such strong buy-in shown from hapū and whānau representatives, particulaly with positive repsonses to final wānanga, this research shows

clearly that the scaffolded effort over years of projects has now coalesced into a positive transformation in attitude, coupled with a strong desire to make changes grounded in a mātauranga perspective.

The draft transition action maps (5 years and 30 years) were included in an exhibition we held in January and discussed again recently with the whānau at our final Wānanga – at which time a draft of this report was preseented. Two opportunities were thus given for the whānau to adjust and make changes. Representatives took the information back to their whānau and trusts to discuss further. It is important to give them sufficient time to do this. We find this process is mana enhancing and again supports rangatiratanga. In our opinion, it is a key to ensuring support, success and safety for all involved within this research space.

8.6.3 The Effectiveness of Exhibitions as a Means of Communicating Complex Information

As is evident from feedback received from attendees of our exhibition (see section 7.5), exhibitions are our research team's effective way of communicating complex information and research, in culturally appropriate ways.

In developing our kete or toolkit of methods in this expansive research endeavour further, our team continued to use exhibitions as research methods and powerful means to disseminate knowledge. Consolidated geological or cultural data research for all our climate change projects was translated into the series of Wai o Papa exhibitions we have staged 2016-2019.

In all iterations, we combined design, scientific and art elements to share these complex findings and explore new perspectives and possibilities. From the research findings on the case study of Tahamata Incorporation in Kuku, Horowhenua at the dairy shed site, we later communicated this via the expanded climate change art and design exhibition in the Dowse Art Museum in Lower Hutt, Wellington. Based on this 2017 work, we developed the summer iteration in January 2019 in Ōtaki. We had well-designed transition action plans in place, hanging alongside practical and innovative opportunities for new erosion control materials, harakeke, papakāinga and tuna and īnanga fisheries. Each area was further anchored by the mauri of tā moko, whakairo and whatu raranga demonstrations, alongside contemporary paintings and photography.

In total, these culturally-determined and trans-disciplinary research exhibitions (finished of with funded performances of dance and music) became the innovative means to coalesce Māori worldviews with scientific knowledge, and from which to disseminate our research findings visually, performatively and audibly to our key communities.

As climate change is a global crisis impacting severely across the world and particularly in our Pacific rohe, another chapter entitled "Collaborative Strategies for Re-Enhancing Hapū Connections to Lands and Making Changes with Our Climate" was written by Huhana Smith for an international publication, *The Contemporary Pacific,* Ludwig Maximillian University, Munich, Germany. This is also the final proceeedings chapter for the conference attended in June 2017.

Currently Huhana Smith is working with the Drawing Open International Research Collaborative, indigenous and non-indigenous contemporary artists who have instigated the Te Waituhi ā Nuku-Drawing Ecologies project. From our first wānanga in Kuku in February 2019, we aim to bring contemporary art deeper into our design-led exhibitions. For our next iteration, we aim to have a large scale international cross cultural art/design exhibition grounded in indigenous knowledges, as led by the growing indigenous artistic compliment. This project will also likely link in with Local Time-

Tikapa and Victoria College of the Arts wānanga to be held in mid January 2020 wereby indigenous possum skin cloak makers/artists from Australia are coming to work with hapū in the Tikapa, a remote East coast region. The development of more cross-indigenous engagements is growing to ground future research exhibitions and effort.

8.7 Next Steps and Future Research

While this project has allowed us to investigate various alternate land uses that are economically, culturally and ecologically appropriate for the conditions likely to be evident in this case study rohe in the coming decades, questions remain about the economic viability of specific industries that could be built around such new land uses. Further research is recommended, as outlined below:

*Uptake of Climate Change Adaptation Knowledge by Local Communities: Given the time it takes time to build awareness and engagement in climate change research with local communities, it is recommended that the investment to date be built upon through expanded ongoing research in the rohe, expanding it further to the north and south of the areas covered in Phase 1-2. This is important and timely, given that there is now a significant interest by landowners to engage in such research (see Sections 7.5 and 8.3.3), who are are now interested in looking at multiple different options in Phase 3 research, as laid out below. Ongoing research should examine which factors help foster meaningful engagement in climate change research, and further explore communication methods to facilitate understanding and co-production of knowledge.

*Quality of Harakeke Product: In order to obtain a premium price for harakeke leaves, it is important that harakeke producers produce a consistently high quality flax suitable for high-end fibre production. Ongoing pilot testing and development is required to ensure such high quality leaf can consistently be harvested. It is highly recommended that future research be conducted to explore the process of cultivating, processing muka for producing a high quality spinnable thread for fine fabric.

*Harakeke Yields and Production Costs: Further research is required to investigate the potential for large scale production of Muka using, for example, Rangi Te Kanawa's method of stripping harakeke leaf to muka, and in turn producing fine fibre fabrics from that muka; this would include gaining a clearer understanding of the yield rates and production costs.

*Harakeke Market Research and Development: Currently, it is largely unknown what the market size and pricing would be for high grade fibre products and garments produced from harakeke. Very careful branding and market development is required to ensure that muka-based fine fibre products can gain a premium price in the national and international market. Furthermore, it is important to develop a product range beyond just shawls and scarves, and perhaps even within the shawls and scarves markets develop better product differentiation.

The challenge for the harakeke leaf producers is to position themselves, through supply and franchising agreements, to capture more of the economic value generated in the subsequent steps of the supply chain. Without these agreements safeguarding producers, many of the flow-on benefits will be captured by business operations and employees elsewhere in the value chain. It is critical that harakeke producers establish a good relationship with down-stream processors of the harakeke flax, and even look at partnership or ownership agreements at all levels of the value chain.

Likewise, further research of the business case feasibility of co-products from harakeke production should be explored; for example, harakeke extracts for cosmetics, phyto-medical extracts, oils and so forth. The economic viability of harakeke production may well be dependent on land owners

developing multiple products from the various parts of the harakeke plant, and not just focussing on the muka, alone.

It is highly recommended that future research be conducted to explore the potential for other products from harakeke, before significant funds are invested in widespread planting of harakeke for financial return. Such research should also assess the optimal strategy for marketing harakeke-based products, given that there will be a high premium for the value associated with harakeke as a sustainable product being utilised to promote cultural and environmental wellbeing, as an adaptation to coastal climate change.

*Associated Income Streams: The use of harakeke in riparian margins along coastal inland waterways could both allow for harakeke-based commercial enterprises to be piloted, while at the same time contributing to the restoration of waterways and the resultant increase in freshwater taonga species. Generating additional income streams in associated areas could also improve the viability of such land uses as explored in this study. For example, eco-tourism ventures based on sharing knowledge about tangata efforts to diversify land uses as they adapt to climate change. Similarly, wānanga-based activities situation in the rohe help reconnect whānau and whenua, and this research has posed the possibility of utilising papakāianga to help achieve this. Also, utilising harakeke planting on riparian margins all has the positive impact of enhancing the habitat for culturally-valued taonga species, improving water quality and restoring the integrity of the waterways, which may also increase fishery production in local waterways. Further research is recommended to pilot such activities.

*Tuna and īnanga Aquaculture: the viability of tuna and īnanga aquaculture should be piloted through ongoing collaborative research, irrespective of harakeke production. While the risk assessment tool has thus far only been applied to harakeke fine fibre produts, ongoing research is recommended to utilise the tool for tuna and īnanga aquaculture.

*Papakāianga: In this project we have explored low cost options for movable structures that could serve multiple purposes as standalone dwellings and/or to support eco-tourism, wānanga and other related ventures. Likewise, innovative mechanisms to reinforce the coastal dune areas for more potentially stable foundations on which to build structures were investigated. Options for papakāianga-based land uses as adaptation strategies that enabled coastal communities to be more resilient in the face of likely climate change impacts warrants ongoing investigation.

*Ongoing Development of Risk Assessment Tool: In this study, the risk assessment tool was developed and applied to analysing the economic benefits across the value chain for the production of high-grade harakeke fibres for high-end clothing products. Such use of the risk assessment tool highlights the uncertainties and risks involved in such ventures, and it is presented as a tool that could be applied in the future to other products apart from high-grade harakeke fibre products. Future research and the ongoing development of the risk assessment tool could, however, could focus on other commercial options, when more definitive data comes to hand.

*Researching Additional Climate Change Adaptation Options: This research could also be extended to examine ways in which Māori communities could transition to a carbon zero economy, with a focus on energy transitions through things such as ‘off the grid’ papakāinga.

Furthermore, ongoing research should be conducted to explore additional land use adaptations to climate change, other than the three in this project such as the value and potential of wetlands, forestry and other culturally-focussed sustainable land uses.

The research rohe could be expanded to include whānau and hapū further up and down the coast who are also facing the impacts of climate change, but who may have different aspirations and land use preferences.

*Impact of Groundwater on Climate Change Adaptation Options: We need more data on groundwater; research in Dunedin showed that the land most prone to impacts of climate change is not necessarily the lowest land; groundwater movement under the ground is having a significant impact eg cycles relating to rainfall. We have used soil wetness as an indicator of 'most prone land' in our Phase 1-2 research, but the impact of how long soil takes to drain is important, including the impact of rainfall from mountains as well as the sea. This total water content of the soil warrants investigation in this case study region, blending available data on soils, hydrology etc.

*Designated Champions to Implement Plans: It is recommended that designated persons be supported to champion this work, including the development of funding proposals to research funders as well as groups who resource climate change adaptation initiatives and environmental-related work, as outlined above. Futhermore, without visionary champions to take research findings and lead a process whereby they can be implemented on the ground, much of the learnings generated in projects such as this are often lost. Landowners could work collectively to foster such a cooperative working group that builds on the findings of this research over time, and works on assessing and implementing the steps in Transition Action Plans outlined in this report.

*Ongoing Research Funding: Ongoing research funding from the Deep South National Science Challenge, and elsewhere, should be sought to pilot some of the Phase 1 adaptation strategies outlined in this report.

Stable ongoing resourcing is critical to enable the ongoing capability development of transdisciplinary collaborative bicultural research teams such as in this project. Stable funding will also maintain the momentum and knowledge advancement generated by such research teams, and ensure the skillsets of Kaupapa Māori community-based researchers in this area are utilised, and the capability developed in this research is utilised into the future.

Momentum gained from collaborative action research projects such as this should be built upon by ensuring that funding streams are stable and ongoing. This enables the knowledge and findings from such research to be shared as widely as possible.