Te Tiriti-led and mission-oriented

Assessing Phase 2 of Our Land and Water Toitū te Whenua, Toiora te Wai

NZIER report to Our Land and Water Toitū te Whenua, Toiora te Wai

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Key points

The government created mission-led research programmes, which included partnership with Māori

The Our Land and Water (OLW) Toitū te Whenua, Toiora te Wai National Science Challenge was one of 11 National Science Challenges established between 2014-2016 in order to address major societal challenges in Aotearoa New Zealand (A-NZ).

Established from the start to be 'mission-led', the Science Challenges embraced approaches to research designed to be more collaborative and outcome-focused that would deliver impact to A-NZ.

However, it wasn't until Phase 2 of OLW in 2019 that a commitment was made to embed Te Ao Māori into the heart of the Challenge. The development of Te Taiao conceptual model used te ao Māori framing to guide OLW's thinking about its mission and research planning to achieve the mission.

This study investigated the impact of a commitment to Te Tiriti on the Our Land and Water Challenge

The purpose of the study was to enable the research team to understand and document the experiences of participants involved in the Challenge. In particular, the research sought to understand how the Te Taiao framework, a novel approach for OLW, influenced the mission-led focus.

The multi-method, interdisciplinary research included three main sources of data:

- Interviews with people involved in OLW in governance, management and research, from Phase 1 and Phase 2
- Administrative data from 144 research projects and programmes, which involved over 1,000 researchers, end-users and stakeholders and produced 700 recorded outputs
- A survey of researchers that collected data for a social network analysis of relationships in the Challenge.

The impact in this analysis is the change in research inputs and outputs. We did not assess whether the change in commitment or research processes led to impacts or changes in the food and fibre sector.

Questions around inclusivity, power, decision-making and resources need to be considered from the outset in mission-led research.

The changes for Phase 2 supported different ways of working

We provide evidence to support that deliberately embedding the Te Taiao model helped those involved in OLW, researchers and non-researchers, Māori and non-Māori, conceptualise, legitimise and make credible te ao Māori and what it means to be te Tiriti-led.

Interviewees indicated that the change provided a mechanism for better engagment with communities, including Māori communities. The data analysis and the network analysis both support this view of Phase 2: there was a wider range of people and entities involved in, and being paid from, the Challenge. The network analysis showed circulation of Mātauranga Māori in the network, including between pairs of non-Māori participants.

Through interviews with researchers and those involved in the OLW Directorate and governance, we point to the ways that OLW was able to help empower Māori people, knowledge, and resources and how that differed between Phase 1 and Phase 2 of the Challenge.

- Empowering Māori people was emphasised through the importance of Māori leadership, and the role of bringing people together; the value of building trusted relationships, including valuing the time to do this; and the importance of trusted relationships with and within Māori communities. By contrast, analysis of administrative data found no significant change in the percentage of Māori Programme Leads or full-time equivalents (FTEs).
- Empowering Māori knowledge was expressed by interview participants in the way that metaphors used by Māori had become part of the Challenge. This suggested that broadening the language used can lead to great inclusion and diversity. The use of visual frameworks, such as the Te Taiao model, helps to situate and empower Māori knowledge – in this case providing strategic guidance. A social network analysis provided additional evidence that Māori knowledge was being circulated widely between Māori and non-Māori, and contributing to all parts of the Challenge.
- Empowering Māori resources was characterised by the interviewees suggesting that OLW enabled more involvement from Māori communities in research, thereby providing a mechanism for improving alignment with those communities. They also spoke about a change in the theoretical approach and the mix of people involved, which had implications on the communication about the Challenge and engagement with Māori communities and land stewards. Data analysis and social network analysis provided evidence to support the diversity of people and entities involved in Phase 2 of OLW, and as shown in the network analysis, Māori participants were centrally connected to all parts of the Challenge.

The interviews further suggested that individuals brought social and relationship capital to the Challenge. With Māori stakeholders, the relationships and network they brought were substantial, and the net impact on those networks was positive.

The changes for Phase 2 supported more outputs with an impact focus

We review Challenge data that were generated for administrative purposes – for managing the research and reporting to the Ministry of Business, Innovation and Employment (MBIE).

The data show that there were differences between Phase 1 and Phase 2. In particular, Phase 2 created more outputs that were focused on communicating for impact: more focus on end-users and less focus on peer review. For example, there were more hui to transfer knowledge and more media articles, and more ‘other’ outputs, which included field days, presentations to end-users, webinars and online resources.

The difference in outputs was probably influenced by the research teams. The programmes were shorter in duration – and therefore more focused – and were more likely to involve end-users and community members. Collaborating with end-users shifted the focus from

producing peer-reviewed publications to producing and sharing information that could be immediately useful.

To change research processes, policies also need to change

There is more than one way to 'do' research, and science organisation can make choices about how they engage with communities and stakeholders, and whom they include in their science.

Putting Māori values at the core of the Challenge was good for supporting inclusive, interdisciplinary, collaborative research. This is exactly the sort of research that mission-oriented innovation systems are expected to support, and that are expected to be good for producing science with impact.

Performance indicators should be designed to evaluate the behaviours and results desired. If new methods of doing science have to achieve metrics from older approaches, they will appear deficient. Similarly, if the additional contributions of Māori researchers – the aronga takirua (the second shift) – are not recognised, those researchers will be disadvantaged. The challenge is establishing and accepting new metrics of performance success that are relevant to the outcomes being sought.

Assessment of Phase 2 outputs was incomplete because the data were extracted in August and September 2023, before all research was finished. At the time of the analysis, Phase 2 had fewer outputs of the type that are typically valued by academic organisations: peer-reviewed publications such as journal articles. That is expected to change as Phase 2 programmes mature and finish their work. The Dimensions database of publications that MBIE uses to record Challenge outputs recognises only certain types and only documents with DOI (digital object identifier) numbers. These are the types of outputs measured by bibliometrics typically used by universities and bureaucracies to evaluate performance. However, by the time of the analysis, Phase 2 had already produced more of other things: relationships with communities, co-developped research, research led by rural professional focused on impacts, videos, digital tools, user-friendly maps and many other end-user focused outputs. For science policy-makers, it is important to be clear about the impacts and outputs being sought and to create relevant metrics.

Creating inclusive, interdisciplinary collaborative teams and including wider stakeholder participation requires resources. There must be budget available to pay people to participate and support people to develop the relationships of trust required to do good work. For policy, that means understanding the full cost of the research being requested, including costs to communities.

Private research organisations were an important part of OLW and they were at least as productive as universities and CRI. Science policy should consider the important role of private research organisations, independent researchers, and community-based researchers in the country's science system, particularly if it is to have regard for mātauranga Māori and the communities that preserve that taonga.

Mission-led and mission-oriented science is relatively new in A-NZ as a research approach. The experience of OLW suggests that direction-setting of the mission, and questions around inclusivity, power, decision-making and resource-sharing need to be considered from the beginning. The difference made by embedding te ao Māori within the Challenge at Phase 2 points to the benefits of this approach to develop research that honours te Tiriti, and delivers impactful research for Māori and non-Māori communities.

Glossary

Term	Meaning
Aronga takirua	The Māori term describing the 'double-shift': the experience of Māori researchers of conducting their own work and also providing cultural services to their organisations
Impact	A change in the world that is caused or produced by research. This report is not focused on impacts
Integrative research	A term from Bammer (2013) that covers interdisciplinary, multidisciplinary and transdisciplinary research: *experts from multiple, diverse disciplines working together on complex, real-world problems*
Interdisciplinary	Research that works across traditional boundaries of academic disciplines or subjects, often by taking a problem focus or being mission-led
MBIE	Ministry of Business, Innovation and Employment, the government agency that launched, funds and oversees the National Science Challenges
Mātauranga Māori	Māori knowledge
MLR	Mission-led research, an approach to organising science that focuses on solving important problems, using flexible and collaborative methods
MOIS	Mission-oriented innovation systems, a systemic view of directed, flexible and collaborative MLR science
Multidisciplinary	Research that includes participants from several disciplines
National Science Challenges	A set of 11 large, mission-led initiatives created by the Aotearoa-New Zealand government in 2014-2016 to focus on 'wicked problems', and set to finish in 2024
Our Land and Water, OLW	Our Land and Water is one of 11 National Science Challenges that were established around 2014 and end in 2024. OLW was set up to focus on enhancing the production and productivity of New Zealand's primary sector, while maintaining and improving the quality of the country's land and water for future generations
Output	A publication, meeting, workshop, online tool or other resource that a research programme produces
Rauika Māngai	An assembly of Māori researchers from across the National Science Challenges who are extending the implementation of Vision Mātauranga and providing advice on supporting Māori research and researchers
RSI	Research, science and innovation: the system that connects research to innovations and then to impacts
Te ao Māori	Literally *the Māori world*, it encompasses a Māori worldview from the perspective of Māori culture and values
Te Taiao	Literally *the world*, it encompasses the elements of the world and their relationships
Toitū te Whenua, Toiora te Wai	The te reo Māori name for Our Land and Water
Transdisciplinary	Research that not only works across traditional academic boundaries, seeking to transcend them, but also integrates non-academic participants to involve multiple sources of knowledge and ways of knowing
Vision Mātauranga	The Aotearoa-New Zealand government policy around including Māori research and researchers in publicly-funded research

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1 Project scope and introduction

1.1 Context for the research

The Our Land and Water (OLW) Toitū te Whenua, Toiora te Wai National Science Challenge (NSC or the 'Challenge') has a vision for a future where catchments contain mosaics of land uses that are more resilient, healthy, and prosperous than today. In this future, all New Zealanders can be proud of the state of our land and water and share the economic, environmental, social and cultural value that te Taiao offers.

In 2014 the National Science Challenges (NSCs) were established to address wicked problems in Aotearoa, New Zealand and were mission-led. Mission-led research (MLR) or mission-oriented innovation systems (MOIS) refer to approaches that organise science around solving important problems (Fielke et al., 2023; Larsson, 2022; Mazzucato, 2018, 2022). MLR entails several behaviours or characteristics (Mazzucato, 2016):

- Clear direction-setting from the start
- Portfolio of innovation projects to embrace risks, failures and uncertainties
- Investments across different sectors by different types of actors
- Joined up policymaking (transformative policy mixes) and reflexivity to avoid lock-in scenarios.

More explanation of MLR and MOIS is provided in section 2.3.

As with most Vote-funded research, the expectation was for NSCs to effectively partner with Māori to unlock the potential of Māori people, knowledge, and resources. The Vision Mātauranga Policy was and still is used across all NSCs as the guiding mechanism to achieve that commitment.

In 2020, OLW released a research workplan update entitled *Wai ora, whenua ora, tangata ora: healthy water, healthy land, healthy people*. The workplan grew out of the Challenge's 2019-2024 Strategic Plan, produced after the Ministry's mid-term review of OLW (as with the other Challenges). The workplan and strategic plan set up Phase 2 of the Challenge.

The strategy for Phase 2 of the OLW NSC made a commitment to embed te ao Māori at the heart of the Challenge and honour its obligations as a Tiriti partner, as a means to re-imagine the agri-food and fibre system in ways that are unique to Aotearoa-New Zealand (A-NZ). Subsequently, the leadership team introduced the concept of Te Taiao as the framing that would guide OLW's conceptualisation of its mission and the research planning to achieve the mission. Applying a te ao Māori lens to the development and commissioning of a mission-led, impact-focused research portfolio is new for mainstream research in A-NZ. The OLW Challenge therefore represents an experiment within the NSC experiment. The experience raises questions about the key lessons from the approach.

The OLW vision – a future where catchments contain mosaics of land uses that are more resilient, healthy, and prosperous than today

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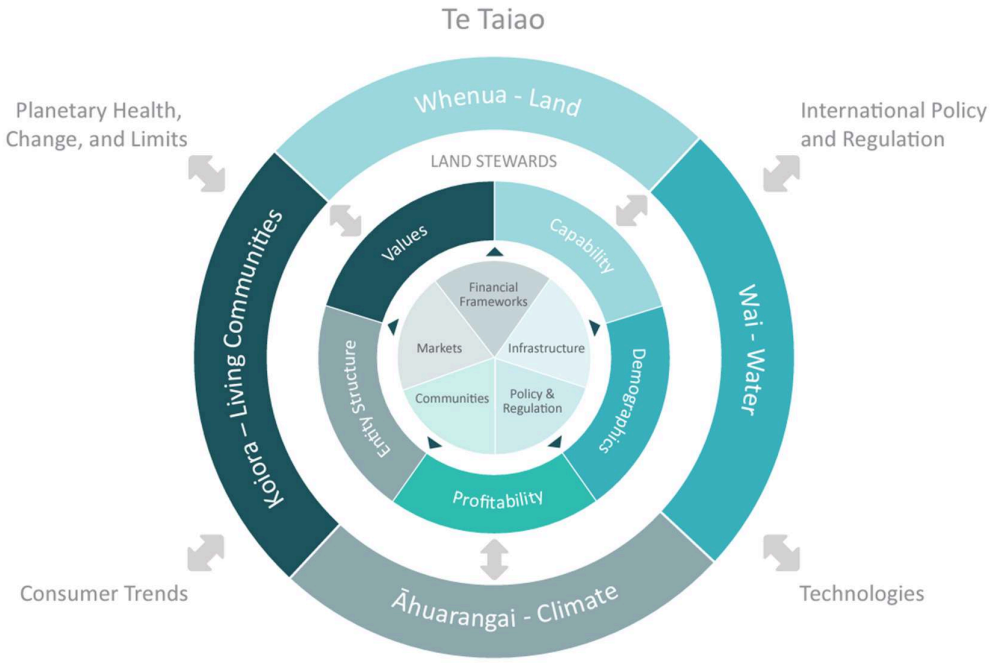
The purpose of the study was to enable the research team to understand and document the experiences of participants involved in the Challenge. In particular, the research sought to understand how the Te Taiao framework, a novel approach for OLW, influenced the mission-led focus. The people and entities of interest included

- Research, Science and Innovation (RSI) institutions
- The Challenge entity itself
- Challenge researchers
- Challenge stakeholders and other participants
- The social, cultural and economic ecosystem in which the Challenge operated.

1.2 Te Taiao model

The overarching framework for the research was the Challenge's own conceptual model, which describes the connectedness and relationships among human and non-human parts of te Taiao. The Te Taiao framework or mental model is shown in Figure 1. The framework is intended to make apparent the many elements that are part of the food and fibres sectors in A-NZ. In the centre are some of the elements that are the social, cultural and economic entities: markets, communities, regulation, etc. The outer ring are the elements that are the foundation on which agriculture and other land-based activities rest, and they draw from a te ao Māori perspective: whenua – land, wai – water, āhuarangai – climate, and koiora – living communities. Negotiating, brokering or managing between the centre and the periphery are the land stewards – farm managers and owners and other land managers or people entrusted with decisions around land uses.

Figure 1 Te Taiao framework for Our Land and Water NSC



Source: Our Land and Water NSC (2020)

From that model followed two interrelated research topics concerning Phase 2 of the Challenge:

1 The extent of the uptake of the conceptual model by, and its impacts on, institutions, research, researchers, and stakeholders.

2 The effect of emphasising relationships in Te Taiao on the outputs produced by the Challenge on the food and fibre sector, that is, the impact of the framework on the Challenge mission.

For question 1, the expectation was that the Challenge was able to make more resources available for research grounded in concepts from te ao Māori and for Māori-led and co-led research. As a result, different types of research have been done, researchers have learned to work in new ways, and there have been changes in attitudes and behaviours. These changes affected the Challenge but may also have spilled over into the wider RSI sector. The Project could record the changes within the Challenge, investigate the changes beyond the Challenge, and evaluate the impacts of the changes.

For question 2, the expectation was that the conceptual model increased the focus of those involved in Challenge programmes on connections and relationships, leading to better co-innovation and collaboration, which in turn produced science with better connections to stakeholders and end-users. Since the adoption of the Te Taiao conceptual model, there should be greater impact from a mission-led perspective.

1.3 Study summary

The study, funded through OLW, used a mixed-method approach using both quantitative and qualitative data to assess the effects that the Challenge had in embedding a te Taiao framework to achieve the mission-oriented outcomes of the Challenge research.

The research team included four members of the Science Leadership Group of OLW: the Kaiarataki and three Theme Leaders. It also included other emerging and established researchers. The project was approved by the AgResearch social research ethics committee, application number 11.22, on 29 November 2022.

The rest of this report is organised along the same lines as the project itself.

- Section 2 discusses the literature review undertaken by the whole research team. The review was organised around two main topics: what it means to be Te Tiriti-led and centred in te ao Māori, and the elements involved in mission-oriented science.
- Section 3 presents data and finding from the key informant interviews. A dozen interviews were conducted by several members of the research team, then coded and analysed collectively and iteratively.
- Section 4 provides an analysis of administrative data collected by the Challenge to manage research programmes and project and report on progress to its funder, the Ministry of Business, Innovation and Employment (MBIE).
- Section 5 presents a social network analysis that used data collected in an online survey, and compares the recent results to those from a similar survey of OLW in 2016.
- Section 6 discusses the results from the different research methods.

2 Literature review

2.1 Introduction to the literature review

The project revolved around two large topics that both have considerable literatures. One was the experience of Māori researchers in A-NZ and their work to design and support an RSI system that was inclusive of Māori and honoured Te Tiriti o Waitangi. The other topic was mission-oriented innovation systems, what they are and how they operate. The review presented here represents only a fraction of the work by the research team to grapple with these literatures. It is intended to provide some context and structure for the primary research presented later, rather than a full treatment of either topic.

2.2 Māori research perspective

2.2.1 A Te Tiriti-based RSI system

This review is a summary of our current knowledge and experience of a Tiriti-led approach to science in A-NZ's RSI system. The purpose of a Tiriti-led approach for RSI is to enable the Crown to fulfil its responsibilities as the partner in Te Tiriti o Waitangi. Article 2 of Te Tiriti and the findings in the Waitangi Tribunal Report, *Ko Aotearoa Tēnei,* recognise rangatiratanga or the authority of Māori to manage and control the use of and access to taonga Māori, including mātauranga Māori (Waitangi Tribunal, 2011). Within the RSI

sector, rangatiratanga over mātauranga Māori (and all other taonga) will ensure that the whakapapa and mauri of our unique and living knowledge system is protected and extended in ways that maintain and extend te ao Māori for the benefit of tangata whenua and tangata tiriti (refer to 'Part A, Essence of the Claim' in Waitangi Tribunal, 2007, pp. 9–10). Around the time of the hearings for the Wai 262 Claim and the Tribunal's findings, two strategic and enabling pieces of work were undertaken; the first was the convening of a Working Group to develop the Matike Mai Aotearoa Report (Mutu & Jackson, 2016). The Terms of Reference given to the Matike Mai Working Group were deliberately broad (Mutu & Jackson, 2016, p. 7):

> *To develop and implement a model for an inclusive Constitution for Aotearoa based on tikanga and kawa, He Whakaputanga o te Rangatiratanga o Niu Tireni of 1835, Te Tiriti o Waitangi of 1840, and other indigenous human rights instruments which enjoy a wide degree of international recognition.*

The constitutional models explored in the report addressed the Tribunal's appeal for co-governance to give effect to the promise of rangatiratanga to Māori. Māori scholars continue to advocate and include some of the models and recommendations from the report to support their research findings and policy recommendations for creating space for rangatiratanga for equitable partnerships and outcomes in RSI and resource management (Bargh & Tapsell, 2021; Kukutai et al., 2021). The second was the development of the Vision Matauranga Policy (VM), intended to unleash the innovation potential of Māori people, knowledge and resources in RSI. The review considers the role of the VM Policy in the implementation of mission-led research in the National Science Challenges (NSCs).

The current settings in the RSI sector are not favourable for Māori trained researchers. Not only is there an under-representation of Māori across the board, but Māori working in the sector also face institutional racism, tokenistic funding approaches and continued under-investment on the whole. Despite Tiriti obligations, Rauika Māngai (2020) reported widespread under-resourcing of Māori involved in projects. Following their recommendations, we have organised the discussion around the three principles of the VM policy:

- Empowering Māori people
- Empowering Māori knowledge
- Empowering Māori resources.

With each principle, we explore the literature describing the potential of empowerment and the barriers experienced in research contexts.

2.2.2 Empowering Māori people

Equitable and authentic partnership in research requires recruiting Māori people with relevant skills, relationships and experience to key roles. Upskilling people along the journey will also contribute to building the capacity and capability of Māori communities. There are a number of indicators that can guide researchers and institutions in their policies and practice.

Leadership and decision-making

Māori leadership and decision-making involves Māori experts and leaders determining kaupapa at the institution level and leading (or co-leading) research projects and programmes. Māori leadership ensures that research is relevant and generates benefits for

Māori communities (Rauika Māngai, 2020). This guidance applies to both the Relational and Rangatiratanga spaces, but is non-negotiable to kaupapa Māori, programmes and projects involving Māori people, resources or taonga, or incorporating Mātauranga Māori. Research of this nature should not proceed where Māori leadership and decision-making is absent (Afoa et al., 2019).

There are examples of success. Marine management legislation enables co-governance arrangements between regional authorities and mana whenua. A collaborative case study by Maxwell, et al. (2020) found that Māori involvement at this level was effective in creating place-based processes and solutions, and that resource management kaupapa, research and decisions are based on a broader balance of community, iwi/hapū knowledge, values and aspirations, as well as government/Crown agendas.

There are also barriers to success. In the review of the RSI sector in relation to Te Tiriti commitments Kukutai, et al.(2021) found that at the decision-making level there are significant challenges with Māori capacity to fill influential leadership positions within science policy and research spaces. Despite the known disparities for Māori and Pacifica within the RSI sector (McAllister et al., 2019), Māori-centred efforts to fill this gap, such as the Pūhoro STEMM Academy, have received little Crown funding. The authors conclude that the current science policy and education systems have failed Māori, thereby failing Te Tiriti commitments (Kukutai et al., 2021).

Co-development and co-design

The collaborative 'relational space' is described in Te Pūtahitanga as the space where genuine partnership, founded on equal power between Māori and the Crown, is used to strive towards shared goals and successes (Kukutai et al., 2021). Simply including Mātauranga Māori into evidence and decision-making is no longer enough (Kukutai et al., 2021).

The collaborative space is becoming increasingly popular. An example of authentic partnership leading to a successful project is the restoration of the Kaiwharawhara Stream Catchment in Wellington, which involved two key organisations, Zealandia Ecosanctuary and Taranaki Whānui ki Te Ūpoko o Te Ika, among others (Michel et al., 2019). The Zealandia manager commented on their commitment to Te Tiriti o Waitangi and a freshwater scientist involved elaborated (Michel et al., 2019, p. 6):

> *it is better to talk at the hapū level and take the time, to actually go and talk to people rather than just getting a tick from the nominated iwi representative via email. […] it made it more legitimate […]. More comprehensive, more authentic, not as in adding an embellishment […]. If there was no iwi involvement, it wouldn't be a good project.*

Barriers to partnership have included a lack of understanding of Mātauranga Māori and Kaupapa Māori research methodologies, a top-down model which fails to incorporate the Māori voice as well as discrimination and racism (Kukutai et al., 2021). Other challenges include different interpretations of Māori values, translating Māori values into policy and identifying and determining pākehā values in society (Maxwell et al., 2020). Reconciling two different world views is difficult and without clear understanding of the foundational values of each knowledge system, it becomes even more problematic. Overcoming these challenges requires commitment from both parties and the formation of a trusting, equal relationship.

Role definition and resourcing

Aronga takirua is the Māori term describing the 'double-shift' work role where Māori individuals, employed in the science sector, are called upon to also perform cultural duties above and beyond their non-Māori colleagues (Rauika Māngai, 2020). Māori individuals are expected to act as a consultant for other Māori, technical-cultural interpreter, project-to-Māori relationship manager, Māori leader for welcomes, karakia etc. all while completing their work-related tasks. Additionally, (Rauika Māngai, 2020) commented that individuals performing the 'double-shift' role in research were often not acknowledged through authorship, despite their facilitation of the research in the first place. Acknowledging 'double-shift' roles would enable researchers to meet the scientific and cultural demands of roles without compromising one or the other. Additionally, Māori providing cultural advice should be properly supported by other Māori researchers, colleagues and mentors to ensure they can provide a high quality of work (Rauika Māngai, 2020).

Community resourcing

The majority of discussion in the literature on 'community resourcing' concerns the lack thereof. Resourcing is required for communities to actively contribute to resource management, collaborative research and building their own capacity and capabilities. Enabling communities to contribute to the RSI sector would lead to more positive outcomes for those communities and A-NZ society as a whole (Rauika Māngai, 2020). Māori leadership in Vision Mātauranga projects has empowered some Māori communities to contribute as 'participants' in research rather than just 'subjects', influencing research priorities, questions and methods (Rauika Māngai, 2020).

Other points in the literature were:

- A lack of community resourcing is a barrier to Māori performing their duties as kaitiaki as well as engaging in collaborative work (Maxwell et al., 2020).
- Current resourcing and strategies are directed at colonial, discipline-oriented work which opposes integrative approaches (Moewaka Barnes et al., 2021).
- In order for Māori to participate as equals, time and resources are required to create a trusting and collaborative atmosphere (Moewaka Barnes et al., 2021). Investing time allows both parties to understand new concepts and can lead to the establishment of an effective transdisciplinary team (Afoa et al., 2019).

Deficiencies in capability and capacity in Māori communities can be problematic for proper engagement and collaboration. Resourcing community capability and capacity would enable Māori to contribute as equals. Currently, demands on Māori to provide input can exceed their capacity and often Māori have to provide input above and beyond their daily work (Michel et al., 2019). The capacity of an iwi can depend on when their Treaty Settlement was negotiated, as iwi require time to move on from the impacts of the settlement and grow and develop in the post-settlement stage (Collier-Robinson et al., 2019; Michel et al., 2019). Research projects involving Māori communities therefore should have a focus on building capacity (Moewaka Barnes et al., 2021).

Relationships maturity

Relationship maturity encompasses the ability to create and manage new trusting partnerships with Māori and the willingness and ability to understand the history and

context of the Māori community. A lack of capacity in these areas results in improper engagement with Māori and is a barrier to effective partnership.

In the context of Māori research, cultural competence and cultural safety are paramount to effective engagement and processes within the research (Macfarlane & Macfarlane, 2018). Cultural competence involves, *growing an awareness, knowledge and understanding of the cultural values, beliefs, traditions, and customs of those with whom we work - in this case Māori, the tangata whenua of Aotearoa New Zealand* (Macfarlane & Macfarlane, 2018, p. 71). Cultural safety is an essential element of cultural competence. Cultural safety requires that a researcher knows their cultural identity and any inherent privileges they hold because of that, before engaging in work with another culture (Macfarlane & Macfarlane, 2018). Understanding Vision Mātauranga (VM) and the Te Ao Māori (Māori world view) falls under this category.

Successful partnerships with Māori organisations are based on trust and aim to achieve positive outcomes for Māori and the environment. Ogilvie, et al. (2018) provided an example of a trusting relationship, developed over years, which initiated a successful research partnership. The aim of this research was to improve the cultural and environmental performance of scampi fishing practices and the process was initiated by the Māori-owned Waikawa Fishing Company (WFC) (Ogilvie et al., 2018). Over time, WFC invited scientists from Cawthron to discuss ways to improve their fishing methods and this eventually lead to multiple co-designed projects, including the scampi fishing project (Ogilvie et al., 2018). The research was grounded in the Māori principle of kaitiakitanga and drew upon the specific expertise of Māori along with the research protocols from Western Science to develop new knowledge (Ogilvie et al., 2018).

2.2.3 Empowering Māori knowledge

Rauika Māngai (2020) described empowering Māori knowledge as recognising Mātauranga Māori as legitimate and valuable, resourcing Mātauranga Māori, recognising Māori as Mātauranga Māori and Vision Mātauranga experts and working alongside them and recognising and valuing Māori cultural and scientific expertise. The report suggested that following these recommendations in research would result in projects that are aligned with Vision Mātauranga and get the best out of Mātauranga Māori and Māori researchers. A key concept was knowledge system equity, which involves

- enabling of Mātauranga Māori to contribute to the entire research process in a co-designed project
- using Mātauranga Māori as the main framing for Māori-related projects.

Knowledge system equity was considered essential for driving excellence in the research sector, creating new knowledge that is relevant to all of Aotearoa and generating better outcomes for all communities (Rauika Māngai, 2020).

Mason Durie noted the following differences between the two knowledge systems in A Guide to Vision Mātauranga (Rauika Māngai, 2020) (Table 1). According to Rauika Māngai (2020), these differences can be leveraged to challenge biases, add new perspectives and increase diversity in the RSI sector.

Table 1 Difference between Mātauranga Māori and Western science characteristics – Mason Durie

Mātauranga Māori	Science
Holistic	Analytical
Accepted truths	Skeptical
Based on environmental encounters	Measurement and replication
Centrifugal thinking	Centripetal thinking
Highlights similarities	Highlights differences
Practitioners older	Practitioners younger
Time enhances knowledge	Time ages science
Steadily evolving	Knowledge constantly changing

Source: Rauika Māngai (2020)

Despite the fact that some techniques used to generate Mātauranga Māori are grounded in empirical methodologies and the fact that Mātauranga Māori is evolving and contextual (Moewaka Barnes et al., 2021), Western science has been deemed by society to be more valid due to its objectivity (Kukutai et al., 2021). Mātauranga Māori is generated through systematic observation and experiences, sometimes over generations, and is passed down orally. In Western science, the most objective forms of evidence are ranked at the top of the 'hierarchy of evidence' (Kukutai et al., 2021); therefore, under this protocol, Mātauranaga Māori is not as 'valid' as Western science. A Te Ao Māori, science-policy approach would require a shift to a more holistic approach, with broader concepts of science and recognition of experts outside institutions – such as pūkenga in Māori communities (Kukutai et al., 2021). Kaupapa Māori can be equally valued alongside Western Science if we disregard the 'hierarchy of evidence' which favours the 'most objective' science (Kukutai et al., 2021). The relational space presents an opportunity to create more successful outcomes through co-design and collaboration.

There are many advantages to using Mātauranga to tackle complicated issues in today's society. One benefit of using a Te Ao Māori perspective in the science-policy space is the value of manaakitanga which, in this context, means caring for Māori communities and everyone else (Kukutai et al., 2021). Similarly, the Māori value kaitiakitanga is about 'caring for the environment'. However, if the principle of manaakitanga is not embedded at the policy level, regardless of scientific evidence, it is near impossible to expect widespread behavioural changes to occur without policy directives.

Another benefit of the Māori worldview is the long-term, holistic approach to problems and the recognition that everything is connected through whakapapa. This approach aligns well with a circular economy and examples of Māori leading regenerative agriculture and ecotourism ventures provides evidence that Te Ao Māori can lead us to a more sustainable future (Kukutai et al., 2021). Through whakapapa, all living things are interconnected and this is fundamental to Māori culture. Using a Te Ao Māori lens could identify novel solutions to complex problems for example, a 'water sensitive' approach to urban design, based on Mātauranga Māori and Māori aspirations, has proven to be both economically and environmentally superior (Afoa et al., 2019).

It is useful to have a framework to bring Mātauranga and Western science together in a partnership. Unifying two different worldviews is challenging at best, and trying to squeeze Mātauranga into a Western science framework does not uphold Tiriti obligations, nor does it provide the best platform for collaboration (Maxwell et al., 2020). The He Waka Taurua framework is for *collaborative partnership based on the dual elevation of both Te Ao Māori and western science knowledge systems* (Harcourt et al., 2022, p. 391). The framework recognises values from multiple worldviews and locates these on the hiwi (hulls) of each of the two waka, Waka Māori and Waka Tauiwi (Maxwell et al., 2020). The two waka (canoes) are connected by the papanoho (deck) which symbolises engagement and the space to identify a common purpose (Maxwell et al., 2020). He Waka Taurua represents equality between Mātauranga Māori and western science and this framework was utilised in the case study on Whakatāwai station (a Māori agribusiness) by Harcourt, et al. (2022). In the case study, co-development of knowledge, and subsequent use of that knowledge, led to better decision-making (Harcourt et al., 2022). An alternative model for collaboration is a braided rivers approach (Macfarlane & Macfarlane, 2019). In that model, Western knowledge and Mātauranga Māori are streams in a braided river that have their own defined spaces and flows but are also able to combine into something greater.

2.2.4 Empowering Māori resources.

Communications and engagement

Engagement with Māori is evolving over time from one-off consultation to establishing partnerships for mutual benefit. Communication is a key part of empowering Māori resources and any communication must be timely and easy to comprehend. This section will explore communications and engagement in the context of research processes involving Māori, frameworks for effective collaboration and Iwi/Hapū Management Plans (IMPs/HMPs).

In a specific case of researchers working with genetic data from taonga species, Collier-Robinson, et al. (2019) asserted that it is the responsibility of the researchers to, *move beyond one-off Māori consultation toward building meaningful relationships with relevant Māori communities* (p. 1). Interviewees from this research added that kanohi ki te kanohi (face-to-face) consultation is important in the early stages of the research process in order to establish successful relationships (Collier-Robinson et al., 2019). Incorporating iwi through meeting with hapū and discussing research, makes projects more legitimate, comprehensive and authentic (Michel et al., 2019). Furthermore, conversations at the marae level would add to the depth of the relationship, compared to only engaging at the iwi governance level (Collier-Robinson et al., 2019).

Frameworks can be used as tools to enhance iwi/hapū relationships and improve partnership with Māori (Robb et al., 2015). Examples of frameworks for collaboration are:

- Tikanga-based framework (Robb et al., 2015)
- Values-based frameworks (Moewaka Barnes et al., 2021; Robb et al., 2015)
- Wai Ora Wai Māori (Awatere et al., 2017)
- Te Mana o te Wai from the National Policy Statement for Freshwater Management (NPS-FM) (New Zealand Government, 2024)
- Te Arawa Cultural Values Framework (Te Arawa Lakes Trust & Conroy & Donald Consultants Limited, 2015).

- He Waka Taurua (Maxwell et al., 2020)
- Ngā Puna Aroha (Taylor et al., 2020).

In addition, Kukutai, et al. (2021) argued that Te Tiriti itself offers a framework which supports both the Crown and Māori to work together and independently and that a Tiriti-led approach would enable appropriate responses to the challenges faced by Māori and communities all around the world.

Finally, IMPs/HMPs articulate Māori issues, values, priorities, aspirations and challenges and were generated in response to the Resource Management Act 1991 (Harmsworth et al., 2016). These documents are grounded in Mātauranga Māori and hold important insights into environmental and cultural issues from a Māori perspective. However, these plans are underutilised as staff from government agencies are either unwilling or ignorant as to how to use Māori values (Maxwell et al., 2020). Kaiser & Saunders (2021) found that, of the natural hazard researchers they surveyed, only 22 per cent used IMPs/HMPs in their research. Familiarisation with an iwi or hapū management plan before engagement with the iwi/hapū is just the first-step in partnership (Taylor et al., 2020) and proper relationship building should be pursued subsequently.

Intellectual property, access and benefit sharing

Māori data sovereignty holds that Māori data should be subject to Māori governance (Te Mana Raraunga, n.d.). Te Pūtahitanga states that a Tiriti-led Science-Policy approach would include the development of *Māori-controlled data infrastructure that meets Māori data sovereignty best practice and supports wise decision-making* (Kukutai et al., 2021, p. 6). This would mean that any data collected relating to Māori, including whakapapa and genetic data for people and taonga species, belongs to Māori and is under their control and protection. Ways in which to achieve Māori data sovereignty are as follows (Te Mana Raraunga, n.d.):

- Asserting Māori rights and interests in relation to data
- Ensuring data for and about Māori can be safeguarded and protected
- Requiring the quality and integrity of Māori data and its collection
- Advocating for Māori involvement in the governance of data repositories
- Supporting the development of Māori data infrastructure and security systems
- Supporting the development of sustainable Māori digital businesses and innovations.

Part of empowering Māori resources is ensuring that intellectual property is protected and used appropriately. In cases where it has previously been taken without consent, it is the government's responsibility to provide redress. The most obvious way of ensuring that the use of Māori intellectual property is tika (correct) is to engage with Māori properly and abide with tikanga (Michel et al., 2019). Ataria, et al. (2018) talked about engaging knowledge holders from the start and using 'culturally-safe' practices that protect intellectual property. Overall, when projects are designed and undertaken collaboratively, intellectual property rights must be mutually agreed upon by researchers and iwi/hapū (L. H. Kaiser & Saunders, 2021).

Community Aspiration Alignment

Community aspirations can be realised through suitable policy and collaboration between Western science and Mātauranga Māori. Recent policies which incorporate Māori values regarding the environment, referenced by Harcourt, et al. (2022) are the Resource Management Act 1991 (RMA), the NPS-FM and the Climate Change Response (Zero Carbon) Amendment Act 2019.

The decision to increase the carbon credit price for indigenous trees under the Emissions Trading Scheme, for example, aligns with the community aspiration to reintroduce taonga species into the ecosystem (Harcourt et al., 2022). In the project, Māori researchers collaborated with the Māori agribusiness on Whakatāwai station to co-produce options for land use which were more aligned with their aspirations. Before Harcourt, et al. (2022) began working with the Māori agribusiness, the station was leased for pastoral grazing despite a majority of the land being marginal and erodible. Favouring a European ecosystem management approach resulted in a disconnect between Māori stakeholders and governance and their land, and the farm management was not aligned with Māori aspirations of sustainability and whanaungatanga (relationship, family connection) (Harcourt et al., 2022). Workshops were undertaken to determine aspirations, perspectives and priorities and then co-develop a model for utilising cultural values to inform land management decisions. Collaboration between Western science and Mātauranga Māori produced a selection of alternative land use options for Whakatāwai Station by drawing upon place-based knowledge and technical data in a shared engagement space (Harcourt et al., 2022).

2.3 Mission-oriented innovation systems

2.3.1 Descriptions of mission-led research

Mission-led research (MLR), mission-oriented research and mission-oriented innovation all refer to approaches to organising the funding and doing of science around solving important social or global problems (Fielke et al., 2023; Larsson, 2022; Mazzucato, 2018, 2022). The approach can be contrasted with others. Investigator-led research, for example, is driven by questions developed by research rather than the interests of funders or the impacts targeted (Gluckman, 2015; Penman & Goldson, 2015). Other approaches focus on disciplinary or institutional boundaries to organise scientific research: there is economic research and physics research, or research from a certain university or institute. For example, Gluckman (2015, p. 1) stated that, *Until the mid-1970s, most developed economies were relatively passive about their science systems. In research and development (R&D), there was fairly minimal demand for utilitarian outcomes*. While this description sets up a contrast between science left to its own devices and utilitarian outcomes, it should also be noted that, at the peak of programme spending in the 1960s, over four percent of the United States federal budget was committed to the moon landing project (Mazzucato, 2022). Thus, MLR has existed alongside other approaches in the past.

MLR has also changed over time. Whereas once missions were technology-focused and associated with large scale research and technology initiatives (Janssen et al., 2023), the modern interpretation of mission-led research is more about addressing challenges that are characterised by high uncertainty, complexity and contestation (Mazzucato, 2018) – so-called 'wicked problems' (Ooi & Husted, 2022). The focus on addressing global

challenges is one of the drivers of a more interventionist or directive approach to the science system (Davenport, 2019).

Mission-oriented innovation entails (Mazzucato, 2016):

- **Clear direction-setting from the start** – this direction-setting can be about the desired impacts as well as the process. It is intentionally focused on co-design and collaboration, rather than being researcher-led
- **Portfolio of innovation projects to embrace risks, failures and uncertainties** – the portfolio approach links to the focus on impacts rather than the use of a particular technology or the perspective of a single discipline. Instead, it seeks to find what works and to move resources towards successful approaches and away from failures. Accounts of MLR can be ambivalent on this point: Mazzucato (2020) explained that the one particular way the NASA contracted for work in the 1960s was key to the success of programme, while also praising the diversity of approaches to solving technical problems
- **Investments across different sectors by different types of actors** – the complexity of wicked problems leads to calls for collaboration in MLR, so that many interests and viewpoints are represented in the search for solutions. Investment by different actors across multiple sectors demonstrated that kind of wide involvement. This approach raises themes around co-innovation, transdisciplinary approaches, and different types of roles in the research
- **Joined up policymaking (transformative policy mixes) and reflexivity to avoid lock-in scenarios** – the mission provides a focus for policymaking, which allows different agencies and actors to coordinate their work. However, as much as there is clear direction and coordination, MLR needs to maintain some reflexivity. It needs to be able to evaluate itself and its approaches in order to identify failure (see above) and to respond to changing circumstance and new knowledge.

Fielke, et al. (2023, p. 2) contended that the organisation of mission-led work, which they called mission-oriented innovation system (MOIS), have focused on institutional design to direct investment and activity, but have not produced a set of practices that oriented innovation towards 'socially desirable outcomes'. They pointed to research on responsible innovation (RI) as a supplement to MLR or MOIS. They showed that MOIS literature describes mission orientation as a temporary network of agents and institutions that develop and diffuse solutions to a challenge. RI provides an operational description of the process: it provides both a collection of individual and collective practices that these networks can use and a focus on defining trajectories in an inclusive and ethical way. This work therefore highlighted a gap in MOIS – how to do it – and deployed an older idea from the academic literature to fill the gap.

Ooi & Husted (2022) provided the linkages across MLR, wicked problems, and the practices followed by the NSCs. They found that *a mission-oriented process is more effective in translating wicked challenges into solvable problems, and offers advantages in terms of providing the guidance needed by research groups* (Ooi & Husted, 2022, p. 17). The mission orientation was described as the process followed by one of the NSCs, Science for Technological Innovation (SfTI). It developed a staged process of collaborating with stakeholders on shaping strategic goals, and then actively managing the process of assembling teams to achieve the research objectives. The process had some of the

elements of RI (Fielke et al., 2023), including the collaborative approach to defining trajectories. Ooi & Husted (2022) also scored the NSCs on the wickedness of their challenges, using dimensions gathered from the literature. There were key differences among the NSCs; OLW faced uncertain issues that were interrelated, had multiple interpretations, and appeared to have no right answer. Finally, the NSCs used practices that fit a mission orientation or active management approach: a diverse leadership team, wide engagement with stakeholders, a combination of competitive and commissioned research, focus on knowledge transfer to stakeholders, and flexibility in research aims and teams. The NSCs were seen as using MLR or MOIS practices to address wicked problems.

One of those NSC behaviours that was linked to a MLR orientation was a focus on *converting research outputs into actions that can be implemented by industry and/or society* (Ooi & Husted, 2022, p. 14), that is, having an impact. Governments as funders of research have encouraged this focus on having impact. In earlier years, impact was often framed as economic, and investigator-led research not considered to generate sufficient economic growth (Gluckman, 2015). MLR, instead, involves directing research efforts towards specific goals or impacts, as well as encouraging cooperation between researchers and stakeholders or end-users so that research is relevant and more readily taken up (Davenport, 2019; Foray et al., 2012; Gluckman, 2015; Mazzucato, 2018, 2022; Penman & Goldson, 2015). Impacts and outcomes under MLR are more likely to be environmental, cultural and social as well as economic – thus broadening the previously more narrow conceptualisation of economic impact.

Agriculture and the agri-food system are central to wicked problems. Under the current system, there are levels of waste, environmental degradation, greenhouse gas emissions, and food issues that are socially and politically concerning (Klerkx et al., 2022). The result is calls for transformation of agri-food systems and several suggested options for transition pathways (Klerkx et al., 2022). MOIS is potentially a method for achieving the required transformation, and OLW and the other National Science Challenges are examples of this approach (Klerkx et al., 2022). However, Klerkx, et al. (2022) considered that OLW is too focused on optimising the current agri-food system in New Zealand, rather than developing radical alternatives that would support just transitions to better systems. This situation has arisen from a lack of critical reflection or reflexivity in the Challenges.

2.3.2 Models for innovation

The MLR or MOIS approach draws on prior work that moved away from a focus on science-focused programmes headed up by 'star performers', an approach advocated by Gluckman (2015), and towards research involving multidisciplinary teams engaged with communities and other users of research (Robson-Williams et al., 2018, 2021; Sinner et al., 2022). There are many examples of these other approaches, with overlap in their concerns and processes. Co-innovation and co-design are two approaches to collaboration in which the users of technology work alongside researchers to characterise a problem and design a solution. Action research, similarly, places researchers and communities alongside each other, working collectively to achieve benefits for the community (Sinner et al., 2022). An overall approach is the Integration and Implementation Sciences (I2S) framework (Bammer, 2013; Robson-Williams et al., 2021; Small et al., 2021). The approach has been described by principles and practices, and the effectiveness of those practices has been tested in case studies of co-innovation (Small et al., 2021). Mission-led is distinguished from co-innovation, transdisciplinary, etc. by its scale, directionality and level of ambition. Hall &

Dijkman (2019) describe this as moving from an 'innovation system' to 'systems innovation' that is directional (e.g. towards sustainability). In other words, there can be a co-innovation project that takes a transdisciplinary approach but could be relatively small and not necessarily leading to transformative change. A co-innovative and transdisciplinary approach can lead to change and uptake, and projects that sit within an overall mission-led programme may take this approach.

The similarities with these prior approaches revolve around who participates. First, the approach to selecting the goal or mission is expected to be inclusive. Second, multidisciplinary or transdisciplinary research teams are seen to be more able to achieve success with complex problems or problems that involve a combination of people and technology (M. Kaiser & Gluckman, 2023). The main difference appears to be one of scale. A co-innovation project may focus on solving a particular problem in a single industry; an action research project might focus on the challenges faced by a single community. MLR and MOIS, by contrast, looks to mobilise national governments to solve global problems.

2.3.3 Criticisms of MLR and MOIS

While MLR and MOIS have been promoted as a way to address global, wicked challenges and ensure that science and innovation are targeted toward socially meaningful ends, they have also been criticised. Some criticisms target the way that they have occurred in practice, while other criticisms are more fundamental.

A key problem is defining the mission or challenge to be addressed (Klerkx et al., 2022; Larsson, 2022). The central problem is who gets to choose the mission. Fielke, et al. (2023) used the responsible innovation literature to describe an approach to creating socially beneficial science. Mazzucato (2016) advocated having many different interests and viewpoints involved in to support investments by lots of actors. However, while inclusion seems to be a core value in theory, the literature also seeks to exclude people or actors on one basis or another. Penman & Gluckman (2015, p. 120) suggested that the process of science in New Zealand has been over-managed by *well-meaning people that have never been associated with carrying out scientific research* and noted that *commercial management applicable to retail or manufacturing simply do not work with science*. Mazzucato (2022) advocated for government to take the lead in grappling with problems, but it should be by well-trained people and not small-minded bureaucrats. In an *ex post* assessment of a Dutch mission-led initiative, researchers concluded that establishment of its mission was driven by top-down, expert-led logic rather than a participatory, socially-led process (Begemann & Klerkx, 2022). It appears to be difficult to decide in theory who should decide the mission, and difficult as well to put inclusion into practice.

A further complication is that there is more than one type of bottom-up approach to research. Co-design and co-innovation involving next or end-users or members of the wider society are participatory approaches. Their effect may be to change the focus of science or produce results that are more immediately useable, as in the responsible innovation approach (Fielke et al., 2023). Investigator-led research can also be considered a bottom up approach (Davenport, 2019) where government leaves researchers to do science without dictating the impacts or results (Gluckman, 2015). However, from a MOIS perspective, investigator-led bottom-up research is unable to achieve the sorts of impacts required to deal with wicked problems (Davenport, 2019; Mazzucato, 2022), whereas participatory and user-led is likely to be more impact-focussed.

The New Zealand NSCs show mixed results in defining, and responding to, the mission. In the case of OLW, Klerkx, et al. (2022) suggested that the focus on optimising current agri-food system limited the opportunities for transformational change. Another NSC, Science for Technological Innovation (SfTI), developed a framework for defining a mission (Davenport, 2019). One part of the process was 'Co-production': industry and Māori leaders worked with researchers to identify high-level missions. A second part was then working with stakeholders to describe the technological opportunity and turn it into a research project, which appeared to be a process of co-design and possibly co-innovation. Thus, within the SfTI Challenge, there was a process for setting the MLR on a trajectory desired by an identified group of stakeholders.

Another difficulty is evaluating the impacts or success of a mission-led research programme (Larsson, 2022). Certainly, it is possible to evaluate the impacts of innovation policies (Janssen et al., 2022). However, MLR can not only fail to achieve a mission that is useful, but also it can end up doing useless or even damaging work (Larsson, 2022). Evaluating success in those conditions is difficult, because it concerns both the successful completion of the research as well as its focus (Janssen et al., 2022). Janssen et al. (2021) note that there are few studies on the completion of missions, with more focus given to the implementation of the mission activity. The value-laden nature of evaluation is apparent in Mazzucato (2022), where the successes of the Apollo programme are lauded, and criticism that it shifted resources away from poverty reduction and social justice are noted but are ultimately given less weight than the moon mission. Many of the recommendations for successful MLR programmes focus on processes or activities: have a diversity of investments, support good communication, encourage multidisciplinary research, engage with users of the technology (Foray et al., 2012; Mazzucato, 2022). These activity-based recommendations do not indicate whether the research is creating improvements in society, the economy or the environment. Further, to the extent that challenges are wicked – poorly structured, complex, uncertain, and subject to multiple interpretations (Ooi & Husted, 2022) – it would be difficult to discern the direct impact of a specific research programme on the challenge. This can be viewed as an especially difficult example of the attribution problem faced in evaluation of scientific research (Greer & Kaye-Blake, 2017).

The difficulties in setting missions and evaluating success led Brown (2021) to conclude that the mission-oriented approach of the Scottish National Investment Bank *constitutes 'fuzzy' policy making which is highly opaque, lacking sufficient detail and fails to align itself properly with the demand conditions within the Scottish innovation system* (p. 739). This criticism of a specific case aligns with more general or theoretical criticisms of the MLR concept (Janssen et al., 2021; Larsson, 2022).

A further criticism of MLR is the focus on the short-term, particularly on short-term funding. Short-term funding and managerialist approaches to research have been shown to be detrimental to establishing long-term relationships with communities, especially low-income or otherwise marginalised communities (Zielke et al., 2023). Longer-term investment cycles are needed to support the evolution of more collaborative innovation cultures across organisations and individuals who have not previously worked together (Davenport, 2019; Fielke et al., 2023). Longer-term investment is also required to develop and retain researchers starting early in their careers to build the science system (Gluckman, 2015; M. Kaiser & Gluckman, 2023). New Zealand public funding of science has already been criticised outside of a MLR context for its incrementalism rather than long-term investment (Gluckman, 2015). The SfTI NSC developed an approach to funding in which

research topics could be rethought or reformulated without researchers losing their funding (Davenport, 2019), an approach that combined flexibility and certainty.

2.3.4 Barriers to change

Regardless of the language used (co-innovation, multidisciplinary, mission-led etc.), there is general agreement that collaborative research programmes with multiple partnerships, that bring together different world views and knowledge sources, are more likely to result in improved uptake and impact of the research (Botha et al., 2014; Mazzucato, 2018, 2022; Sinner et al., 2022; Turner et al., 2016). This is particularly the case when the end-users of the research (for example farmers or policy makers) are embedded within the research throughout the life of the programme. However, such multi-stakeholder partnerships by their nature, involve a range of power dynamics that need to be understood for the group to work effectively together to bring about change (Brouwer & Woodhill, 2016).

Power structures within society, particularly those exerted by the incumbent regime can lead to lock-ins that continue to support the dominant mode of production, in this case within the primary sectors, through technology, organisational or institutional arrangements (Turner et al., 2020). The literature on sustainability transitions, including agri-food system transitions, also highlights the need for an understanding of the diversity of the different actors' roles, visions, missions and agendas, and acknowledges the power dynamics and politics that play out across the different levels explained through the multi-level perspective: landscape, regime and niche, often occurring when strong vested interests within the regime try to maintain the *status quo* (El Bilali, 2019). Another way that power imbalances can play out within a MLR programme is when one or more stakeholder group is not invited or underrepresented, or when they do participate do not have the specialist knowledge or jargon to be able to effectively engage. For example, the language and jargon used by researchers can be a barrier, even between different research disciplines, let alone amongst partners and stakeholders who are not part of the research world.

Power imbalances within mission-led research programmes can cause actors within the incumbent system to actively mobilise resources to stage, or hide, conflicts that either change, or maintain, role perceptions and power relations (Turner et al., 2020). This includes research organisations and researchers, who have established dominant structures and research agendas, and would considers other views as a threat to this. Such dynamics may limit the effectiveness of the research to create transformational impact. *Ex post* assessments of MLR programmes have observed this dynamic of capture by established researchers and reversion to top-down decision-making (Begemann & Klerkx, 2022)

However, as reported in Turner et al. (2020), innovation platforms (which include the multi-stakeholder partnerships that are a feature of mission-led research) can provide a space to bring different actors together, including those from the incumbent regimes. When power imbalances are revealed within an innovation platform, it can potentially reshape perceptions towards power and conflict, which may lead to new role perceptions and new power relations.

The criticism of short-term funding alongside the assessment of power in science suggests that the appropriate balance between short-term and long-term funding, or between temporary arrangements and permanent institutions, is uncertain from a theoretical perspective. That is, both short-term and long-term arrangements have strengths and

weaknesses. The way they play out in a particular science system provides evidence about the best mix for that society, economy or culture, and is likely to interact with other institutions or structures. *Ex post* assessments can answer questions like, *to what extent did this arrangement promote the development of trust among a diverse group of participants?*, or *is this research system renewing its research, management, and leadership capability over time?*

2.4 MOIS in a New Zealand context

MOIS conceptually has been developed overseas, particularly in the US and UK contexts (Mazzucato, 2016, 2018, 2022). The approach has gained traction in New Zealand (Davenport, 2019; Ooi & Husted, 2022; Penman & Goldson, 2015), in particular for its focus on deriving more economic impact from the science system (Gluckman, 2015). MOIS was embraced in New Zealand as a reaction to investigator-led science (Penman & Goldson, 2015) and a science sector seen as underperforming (Gluckman, 2015). The NSCs were created to focus on wicked problems (Ooi & Husted, 2022), and used MLR approaches such clear direction setting, portfolios of projects, participatory planning, short-term and flexible funding to manage their research (Davenport, 2019; Ooi & Husted, 2022). Putting MOIS into the New Zealand science system brought the benefits with the challenges, and also raised questions specific to the country.

The biggest difference between New Zealand and other countries like the US and UK is the Treaty of Waitangi and Te Tiriti o Waitangi, a founding document or founding documents of the country's government. The differences in meaning between the English text and the te reo Māori text are significant enough that they are regarded as two different documents. Regardless, both documents establish New Zealand as a partnership between the British Crown and Māori people. The consequence for the science system is that it, too, should be a partnership (Kukutai et al., 2021; Rauika Māngai, 2020).

The literature on MLR has established that setting the mission and establishing funding arrangements are key parts. Both activities are likely to be different in New Zealand due to the Treaty. Setting the mission should involve a wide range of stakeholders and community participation (Fielke et al., 2023). Nevertheless, in practice, actual mission-led science and innovation have involved a dominant group setting the mission (Begemann & Klerkx, 2022), even despite the protests of significant parts of the population (Mazzucato, 2022). That is, in fact, part of the appeal of MLR: government directs the science system to produce desired outputs (Gluckman, 2015). To the extent that Māori are disempowered in government decision-making and marginalised in communities, they are also excluded from the processes that create the missions that lead the science. Once a MLR programme is under way, funding arrangements can reinforce the exclusion. Working in partnership with Māori communities requires building trust through long-term relationships (Smith, 1999). Building the capacity of participants as co-developers and co-innovators requires time and resources (Davenport, 2019). MLR as short-term funding arrangements to address specific problems (Fielke et al., 2023), while they may promote flexibility and change, are likely to undermine these long-term relationships, as they do with other marginalised communities (Zielke et al., 2023).

In translating mission-led research to an Aotearoa New Zealand context there are common misconceptions around definition and confusion around a technology-focussed 'moonshot' type mission rather than recognising the societal change processes that are inherent in more recent understanding of mission-led approaches (Mazzucato, 2018). The processes

involved in creating change in order to have impact on wicked problems are not simply technological; they are social and cultural as well (M. Kaiser & Gluckman, 2023). Specifically in the agri-food system and for the OLW NSC, Māori approaches to the agri-food system are gaining more prominence (Klerkx, et al., 2022). Collaborative or Māori-led approaches may therefore be appropriate.

The literature on MLR, MOIS and the NSCs raised questions that this project sought to investigate. First was to understand the commitment to embed te ao Māori and the Challenge's Tiriti obligations. As shown above, Te Tiriti, Vision Mātauranga and mātauranga Māori are important context for doing science in Aotearoa New Zealand. A second question was the extent to which OLW adopted MLR practices, which goes to whether the Challenge could or could not be considered an example of MLR. A third question was the perceived impact of these two types of practices on the research: what were the impacts embedding te ao Māori or using MLR approaches, to the extent that those things happened?

3 Interviews with key informants

3.1 Introduction about the interviews

One approach to gathering information for this assessment was semi-structured interviews. Project team members interviewed Challenge governance and leadership past and present as well as researchers (Māori and non-Māori) in the Challenge. The questions (provided in Appendix A) were developed by the project team, to gain insight into how the attitudes and behaviours changed over the life of the Challenge, particularly following embedding of te ao Māori as central to the Challenge at the start of Phase 2 and through the development of the Te Taiao conceptual model. The broader aim of these interviews was to understand the role that OLW played as an enabler in fostering impact and excellence using different approaches to research. Participants were also asked about their understanding of key concepts and approaches that had been introduced at the inception of the Challenge, including transdisciplinarity, co-innovation, collaboration, Vision Mātauranga, and interdisciplinary knowledge exchange as a way of contrasting with an earlier OLW survey that explored the attitudes and behaviours of Challenge participants (Payne & Small, 2016).

3.2 Method for the interviews

3.2.1 Research Design

The study employed a qualitative research design in order to gain a deep understanding of the experiences of researchers within the Our Land & Water research group. By recognising the complexity of human experiences, this approach aimed to uncover detailed insights from the perspectives of the participants, which are often not accessible through more quantitative methods such as surveys (Creswell, 2013).

3.2.2 Participants

A purposive sampling method was used to select twelve interview participants, who represented the researchers, governance and the OLW directorate, and were able to reflect on the earlier and later phases to the Challenge. We specifically included three Māori researchers to ensure we captured an indigenous perspective (Smith, 1999).

3.2.3 Data Collection

Data were collected through semi-structured interviews, which combined the structured nature of predetermined questions with the flexibility for participants to express their thoughts in a more open-ended fashion (DiCicco-Bloom & Crabtree, 2006). This allowed the exploration of specific research themes while also accommodating the emergence of unanticipated insights. The interview guide is provided in Appendix A.

Three different interviewers undertook the interviews, with a Māori researcher conducting the interviews with the Māori participants. Using three interviewers was primarily to share workload but also to mitigate a potential source of bias if only one interviewer was used (Dörnyei, 2007). By having multiple interviewers, the research can potentially capture a broader spectrum of responses (Brinkmann & Kvale, 2018).

3.2.4 Transcription and Data Management

Interviews were transcribed in full, maintaining the integrity of the participants' spoken words. This step was crucial for preparing the data for analysis while ensuring participant confidentiality. NVIVO software was employed to organize and manage the data, which allowed for a thorough and methodical analysis (Bazeley & Jackson, 2013). The use of NVIVO in qualitative research is grounded in its ability to aid in organising, analysing, and finding insights in unstructured or semi-structured data such as interviews.

3.2.5 Data Analysis

The analysis was conducted by a single researcher to maintain coding consistency, adopting a thematic analysis approach as described by Braun and Clarke (2006). Coding in NVIVO is more systematic than manual methods, which increases reliability and assists in maintaining a transparent audit trail. The software enables the coding of data to be easily reviewed and reorganised as the analysis progresses, supporting the iterative nature of qualitative analysis. This is particularly important when refining codes and themes, as it ensures that the development of the coding framework remains grounded in the data (Sinkovics & Alfoldi, 2012).

Initial codes were generated from the data, these were then discussed with the interviewers, and refined based on their feedback. This iterative coding process continued until a robust set of themes were developed, echoing the recursive nature of qualitative data analysis (Braun & Clarke, 2006; Morse, 1994). This collaborative and iterative approach not only provided depth to the analysis but also acted as a check against potential researcher bias (Guba & Lincoln, 1989).

3.3 Interview results

This analysis is structured by grouping themes under the headings set out in the Rauika Māngai document A Guide to Vision Mātuaranga, specifically the three dimensions explained in section two: Empowering Māori Knowledge, Empowering Māori People and Empowering Māori Resources. In addition there is a section that looks specifically at the concept of mission-led and how participants understood this concept in relation to the Challenge.

3.3.1 Empowering Māori People

Māori Leadership

The importance of Māori leadership was discussed and emphasised by all of the Māori participants of this research but only by around a third of the non-Māori participants. The difference in understanding leadership as residing in a person or in a process is notable.

Non-Māori participants often drew attention to the importance of having Māori people in leadership positions in order to communicate with and help educate non-Māori members of the Challenge. This commentary tended to focus on the instrumentality of having Māori leaders in the Challenge, with one participant describing it as 'quite useful':

> *Having a governance board, that's actually now 80 percent Māori, that was quite useful. It meant it wasn't marginalised and was part of day-to-day business.*
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> *I think it has been some very effective Māori leaders in the challenge who are very good at communicating and are very good to work with, and I think a willingness of non-Māori on the board and elsewhere to take this up and not get threatened by it and actually embrace it because they can see that there's value in all sides of our approaches to these problems.*
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> *I think to have the te ao Māori lead in each of the major programmes was the key there really, and the directorate support through te Kaihāpai Māori, and through having a specific person in the science leadership team focused on that as well.*

One Māori participant emphasised the potential transformational impact of leadership in the Challenge by bringing people together from across disciplinary boundaries, interestingly this participant does not specify that leadership as Māori or non-Māori, and does not locate that leadership in an individual person. They then go on to link this leadership process of 'bringing people together' to te ao Māori processes more broadly such as on a marae:

> *Leadership is so central. Having a good leadership that hasn't come out of particular disciplinary confine, and that ability to understand multiple perspectives and synthesize these perspectives, and have some vision. That was the two things. I've seen programmes completely fail because of poor leadership, mostly because they don't have experience and they're very focused in a particular area. But, I have seen the great ones that work and they've got really good leadership people that have broad perspectives, with high empathy and all those sort of things.*
>
> *Anyway, that would be how I would see it. Certainly the sense of te ao Māori perspective, I get to learn a lot from te ao Māori process ways of thinking and how you generate that synthesis or multiple positions, and how you bring them together. If you're on a marae or hui making any decisions that's what it's all about.*

Another Māori participant builds on this to call attention to leadership as a process, as part of the system, and Māori representation as needing to be a core part of this first, before a Māori person might end up as a 'champion':

> *There were at least fifteen people around the table and no Māori… There were quite a few examples like that really early on, where I realised there's a lot of*

systemic things in terms of the way that we normally go about things, that really strongly disadvantage Māori participation and Māori leadership.

We've got to understand how we bring Māori representation into those working groups at an early stage; and we have to find who that champion is going to be, so that we're setting somebody up in a good way to then step into a leadership role around that table that's able to hold that Māori portfolio of work.

Research Timeframes

This theme draws attention to the need to think differently about research processes and timeframes because of the way typical 'Western science' attempts to manage projects. This Māori participant explains how this can disempower Māori researchers and collaborators by undervaluing the mahi that has gone into the building of trust in Māori communities which they estimate takes 50 percent of their time:

What I also found and certainly Challenge recognises it in terms of Selai and Naomi, they know the work that goes into building a trust network like that. It's not done overnight. Sometimes it just taken for granted by researchers. They'll just go, "We can…" They almost feel entitled for them to be able to work with you. They don't actually value that you had to sleep on couches for years, or whether you had to do xyz to build that trust. It's not valued. It's valued by some, but sometimes some researcher's backgrounds are not good. It's certainly often valued in the science system sense. It's all on your publications how much you generate. It's not necessarily on the strength of your relationships and trust building. How do you measure it?

Q: Longevity.

A: Yeah.

Q: History. All of those things they're not part of the system, they're not systemised.

A: No they're not. But, it takes and awful amount of time to maintain them and to build that trust. It takes fifty percent of your time initially, I reckon.

This can also be seen in the way non-Māori participants discuss the impact of properly followed processes and 'correctly' applied models for te ao Māori. This participant for instance explained the importance of creating 'space and time and the resources' to allow researchers to properly carry out their work and then explains how much of a shift this is for non-Māori researchers coming to terms with working in a te ao Māori frame:

I have certainly developed an appreciation of the time and the resources that are needed to understand and apply a te ao Māori model correctly. I guess that has been an important lesson for me is how you create space to do things properly, how do you create the space and time and the resources to make sure that people can work within this model effectively because it's not easy. That's why I think we keep losing – well, we don't keep losing people – but we have lost people. This is a far more difficult way of working than researchers are ever led to believe their careers would involve. It's completely out of the park in terms of what you need to do to be a successful research scientist.

Relationships

This sub-theme is directly related to both Māori leadership and research timelines. With each of those sub-themes also touching on the critical importance of building relationships. We focus here more specifically on the importance of relationships with Māori communities.

> *I see that as the single most useful effective method that we have used is to have Naomi and Selai working in our corner. Those connections in Māoridom are all important, walking into a region as a stranger with no connections into the Māori of that region, it's probably never going to work. But if you've got those connections already then you've got a huge step up to using those connections to work together. I don't think we would have got very far at all without Selai and Naomi on board.*
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> *... there's nothing worse than turning up to Māori communities as a cold caller. It's a total invitation to be beaten up by an aunty. But, if you're already introduced by somebody who's already trusted and vouched for, it takes a lot of that away.*
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> *… it happens with a lot of the Māori researchers is they don't have time themselves to be trying to pull along a bunch of Pākehā researchers on their journey with them because we're slow and they've got stuff to do and responsibilities. There are so few of them.*
>
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> *Because another big challenge that we had is that we had such a small group of Māori researchers who were really interested in this space. It was always the same researchers that were coming with the same relationships; which that's nothing against the researchers, but it did really impact if we think about the national impact that we were trying to achieve, and how we genuinely get a better spread of Māori entities and Māori farmers engaging with what we are doing.*
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> *It's a highly relational process. Māori culture is a highly relational culture. So, figuring that stuff out together.*

3.3.2 Empowering Māori Knowledge

Metaphor or transdisciplinary

It could be argued that the language used around the concepts of 'collaboration' 'co-innovation' 'transdiciplinary' and others do not adequately capture research practice and specifically change to research practices. Participants often had trouble distinguishing between these concepts in terms of describing the intent and contribution, for instance:

> *I don't really see this one as being anything particular to do with the challenge. Interdisciplinary, multi-disciplinary, trans-disciplinary, are all terms that have been used to try and encompass what can be achieved when different disciplines work together. When you combine chemistry and business, when you combine landscape architecture and botany what do you get? This sort of thing. It's just the use of more than one disciplinary field to answer a problem. The difference between inter, multi and trans-disciplinary has kept academics happily chatting for*

a really long time. To me, they can be used interchangeably I'm sure. They have very subtle difference in the new mean. Basically it all comes down to the same thing, usually creating teams of people from different disciplinary backgrounds to try and address problems. Again it's a reflection of this admission that all things are connected, that it is a holistic system and if you want to solve a problem within it you have to involve expertise on more than one side of the system.

Q: Another concept: co-innovation is next on the list. Your understanding, your practice.

A: Co-innovation?

Q: Co-innovation. This is actually a pretty important one for our challenge in particular, because we have made some KPIs built around the theory that co-innovation will lead to better impact.

A: Again it's the same for me around the trans-disciplinary. I don't really see it in a different way. It's about different crews in industry. When I say industry, there are lots of different groups that exist in that as well, coming together to create solutions that work for them. I don't think it's any fancier than that really.

Q: Next concept: collaboration. Your understanding, your practice? You can say it's the same.

A: It is the same. But, again, I guess going back to what I was saying before in terms of 'have to go through it' it's hard. Coming from the commercial sector and working with science or research peeps, it's hard. They've got a whole other way of thinking, being and working. It's a culture.

Te ao Māori concepts of transdisciplinarity are different... deeper and broader – for instance this Māori participant transcends the concepts of 'inter...' and 'co...' with the idea of a metaphor – something that humans use to build a way of understanding. Specifically with regard to te ao Māori metaphor is intrinsically different, not linear, but instead like a koru.

Trans-disciplinarity is often not very well understood. In the literature it is not well defined or explored. Generally what you tend to think is, if you're going to transcend to discipline, what do you transcend it with? What's the knowledge system you use? If you've got multiple knowledge systems that are different disciplines, and you're going to jump outside of that, how do you integrate them? What's the method of integration?

I think what you boil it down to though is metaphors. Metaphors integrate different disciplines. Different cultures have different metaphors. What you find particularly with scientists is they'll come out a machine metaphor, usually thinking of parts and things, and deterministic ways of thinking. If they're more advanced I think the system makes it like a system, otherwise they'll think more deterministic and linear. They need to be made aware of that linear thinking in a trans-disciplinary approach.

They need to be made aware of the metaphors they're using – a machine, metaphors or whatever. Then when you jump into the te ao Māori world all the metaphors shift. They're all familiar. They're not squares. They're often circles,

koru or other shapes and symbols that underpin the knowledge. You're going, "How does a circle and a square fit together?" Or, "How does a koru and a line work together?" Because that's essentially what it is at the core of it.

Mātuaranga Māori / te ao Māori concepts changing research practice

The majority of participants described a shift in reserach practice across the life of the Challenge. Many explained that this change in research practice was due to the improved understanding / recognition / embracing of Mātuaranga Māori / te ao Māori concepts. In the next section we look more specifically at the Te Taiao model and its influence on the research practiced in the Challange, this section captures a more broad recognition of the impact of a growing understanding of te ao Māori and its role in research.

This non-Māori participant talks of the 'ground-breaking' impact of gaining a better understanding of te ao Māori, but also describes this is being a 'very painful... process':

That's when they got to where and basically what the video was telling us about the Tai Ora, and the whole te ao Māori component, not component, but the core of what it does. I think that, in the end, was quite ground breaking, but for me a very painful and quite opaque process to get there.

In a similar vein this non-Maori researcher describes the research practice in the earlier stages of the Challenge as co-design with Māori as part of the research, but not in the crucial idea formation stages. The transition then changed the nature of the relationship to one where Māori formed the ideas as well. The researcher talks of this 'real sharing of power' and the need to 'kind of brace yourself for that'.

...what we didn't realise, certainly what I didn't realise is that I thought that codesign meant we went along with a fairly broad outline of what it was we wanted to do and said, "Okay co-designers, let's fill in the gaps." What we weren't prepared for I think is for those we were working with to say, "Actually no, we want quite a fundamental shift in what you're doing. In fact we don't even think you've articulated the research objectives in line with our needs. That's a real sharing of power which it would be interesting to know how that's gone actually because if you were going to be true to that way of working you had to kind of brace yourself for that.

This sits in context with the perspective of a Māori participant who talks of the earlier phase of the Challenge seeing Māori as an 'add-on' and the later phase of the Challenge building a 'coherent strategy' with direct particpation by iwi as project owners:

Then you're seeing this evolution and a shift from Māori being kind of an add-on, with a Kahui they kind of engage with, to more of a coherent strategic approach with far more Māori engagement. So, that's when you had more iwi direct participation and ownership of the project.

Clearly this transition had its difficulties, this Māori participant describes the 'whole big learning curve' that has needed to take place at the programme level, particularly with non-Māori 'science leaders' needing to come to terms with a significantly different way of working:

There is also thinking about how Māori knowledge systems influence and inform the design of the programme as a whole. What we have found is that there has been a really big spectrum in terms of how that has played out. A lot of that comes

down to the fact that a lot of our science leaders haven't really done that before, or haven't necessarily done it very well. There's been a whole big learning curve around what it looks like to do that together.

Impact of Te Taiao Model

There is no doubt that the introduction of the Te Taiao model had a meaningful impact on how participants understood their research practice. The holistic nature of the model provided a structured way for participants to think about the entire challenge and also the place of their work within that.

I think it's a fairly fundamental part of encompassing te ao Māori is to understand that philosophy of te taiao and it explains so much of a holistic model. I don't think we've changed it but I think it's changed us hugely. it just spoke so powerfully to how the whole system should really work, you know, that relating back to that whole holistic way of viewing the environment and how we operate within in. For me it was a bit of a watershed moment I guess.

Actually, pretty much all my writing in this area has stemmed from the funding from Our Land & Water. Certainly in terms of personally, and the research teams have worked in, and the writing we have produced together, it led to that evolution and thinking around te taiao, and how fitting te ao Māori perspectives into general environmental views that float around generally, where you have more of a materialistic way of viewing things as an environment, as a service provider to you. That it gives you stuff, as opposed to what your obligations are toward it and how do you have a relationship with it.

In terms of this Māori participant, the introduction of the Te Taiao model provided an institutional touchstone to do the work they were always doing, but without having to do the preparatory and explanatory work that might have previously had to accompany their research approach:

What it gave me was the licence to do what I already do, without banging my head against the wall.

3.3.3 Empowering Māori Resources

This theme explores the issues with institutional forms of research funding that existed before the Challenge was established and continued during the life of the Challenge and how participants saw that as impacting on the deployment of resources, and their impact on Māori.

MBIE and Implementation

A number of participants discussed the existing research funding institutions and government departments and how these institutions interacted with the Challenge. This was primarily discussed in relation to the early part of the Challenge, the establishment of the system.

It was largely a kind of those that already had research money in the field, MBIE money, were very anxious to protect their patch, and UC and others did not currently have funding from the government for agricultural research so they weren't considered to be part of the team so to speak.

So, but then what happened was, between you and me, MBIE got involved, and I'm not trying to knock MBIE here because this is what they do though, and they operationalised it, and when they did they then of course demanded a very expensive sort of elaborate governance structures and very much an MBIE think approach. Whereas, these were, really had the chance to go outside of that and not get bedded down into particularly the formalised structural issues that MBIE demands, and of course they're looking for accountability, but I think once they did that they lost that initial impetus around 'let's find some big issues and go out and try and solve something'. Then what happened over the next two or three year; Land and Water were very slow to get off the ground, and I think they fluffed around too much. We weren't quite sure what we're supposed to do, or how to do it. Once they got going they became then sort of a pseudo-science strategy for MBIE, because MBIE never had a science strategy.

They became quite alarmed because MBIE started to shift some of their big, funded programmes into the challenges, and then the universities or the CRIs realised that a very big part of their funding was going to be decided by the challenge. It's almost as though it became out of their hands, and there was a bit of panic. So there was a bit of a grab by some of the institutions to not only host the challenges but to actually sort of, behind the scenes, to run them, and you can sort of see why.

The issues associated with institutional boundaries at the early stages of the Challenge appear to have been largely put aside by the second stage, allowing a different kind of collaboration. Māori participants particularly talked about this change, noting the ability to take a 'holistic' approach to addressing problems with research. This Māori participant for instance does not believe it would have been possible to do the work without the structure of the Challange:

There is no way you would have got multiple institutions working together, other than through this type of collaborating; transcending the institutional boundaries. You would never have got integrated approaches being developed, whether it was a database or theoretical approach, or multi-disciplinary stuff working in that sort of way, across a broad sway of things. It's that integration and a holistic understanding of the problem from all its angles, rather than confronting one problem here, one problem here, one problem here. It's how they're brought together and how they're interconnected. You would not have developed that without the challenge. I'm really afraid of what's going to happen in the new structure. I've said it half a dozen times, but we're right on the cusp here of getting the institution just right – getting it formed in just the right way after learning after so many years. It comes across to me that it takes a while for institutions to mature.

Yet this Māori participant reminds us that the structure remains a 'colonial construct' and as such 'expressing te ao Māori confidently and safely' is no easy task:

Again I think as Māori we know what that looks and feels like. The question is, when you're bringing that into a space that has for so long been dominated from a colonial construct, it's hard to then be able to sometimes see what is this space? Knowing that we can't just put the whole space to the side and start from scratch,

it's hard to then retrospectively carve out how you can express te ao Māori confidently and safely in those spaces. You're always going to be a square peg trying to fit into a round hole and I hate that. I hate it. That's why the space is often tiring and frustrating. You're always trying to manage different tensions.

Between CRIs and the Challenge

Rather than being seen as an entity in its own right, with its own mission, the Challenge was not easily integrated into existing institutional research structures:

It was just seen as something that we have to do as a compliance thing, and that meant that for a period management saw it as a cost centre, and to be quite blunt, AgResearch over recovered significantly, from the challenge.

3.4 Mission-led approaches to research

Perspectives on mission-led research

It could be argued that concepts of mission-led are confusing or frustrating for the participants. They can be viewed with a level of scepticism, both in terms of the form, but also the function of the research enterprise. For instance:

But I think that there is an element of and I don't know whether it fits into the challenge, but I'd hate to see a science system, and let's face it, a challenge is a sort of science system in its own right, that did not allow curiosity driven research. So that, if everything was so exclusively mission led and hardnosed and pointed towards almost a preordained outcome, then I think you're going to lose out on a hell of a lot of things. I have a little difficulty seeing where this more curiosity led, non-mission led science, which I think the component of that is essential, how it fits in.

This is also the case for this participant who felt that the range of research activities underway were not easily linked to the mission and that there was a tension between the mission and the requirements for more 'foundational science' and for research that supports policy development:

It sometimes can be challenging, and partly that's frustration sometimes, because our mission is so broad and our range of research is broad that sometimes, the line to draw to the mission is not extremely direct.

Is that tension between being mission led, but also having to produce for the Ministries needing some foundational science, and needs specific data for policy support and policy in action.

Another concern was raised by this participant who felt that the concept of mission-led may place too much power in the hands of too few people in positions of governance:

I guess another point, especially given this white paper that's just come out and they keep wanting to do mission-led research. I don't know what the answers are in the sense of how you provide governance for it and how you provide direction, because what you don't want to have in my view having been through the last whatever it is, six years, is you need to be really careful about having one or two people who are driving everything, and everything coming from them. I think you need to be really careful about that.

However this is not shared by all participants with some seeing the mission as critical for understanding how to proceed, and as a framing device to coordinate research work.

> *That's what I think about when I think about that term 'mission led research'; is just to really know the problem that we are trying to solve for, and to make sure that we've got the coordinated approach to addressing different elements or angles of that problem.*

Mission-led vs te ao Māori-led

Some of the interviews discussed the linkages between mission-led and te ao Māori-led perspectives on research.

> *I think the major issue I found was more early on as it was evolving was certainly directors and further up the chain, you would build something and then it would come up and it would have to be reformulated. It might start moving away. The mission of the science challenge might move away from the mission of the communities, or whoever you're working with. That's the only difficulty. But, hey, the science challenge is funded publicly to do particular outcomes, and the community might want to do something else.*
>
> ---
>
> *I think that's one of the beauties about mission-led research; is that you are coming up to that strategic level and you're focusing on those critical intervention points. You're working from there, rather than working from the point of somebody coming to you and saying, "This is what I need," or "This is what we want you to do." Or, from a bunch of researchers sitting in a room saying, "This is what we would like to do."*
>
> *I think that's where the value of that lies. It's problem focused and it's large scale problem focused.*
>
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> *So, to me it's a spectrum, and I think that we should be open to doing our science and investigations in different ways, and if mission led is a term, inhibits some of the things we've been talking about, in terms of te ao Māori or taking Mātauranga Māori approaches to things, or using cultural knowledge and experience then I think it's a negative, and it becomes shown that these sort of terminologies are not helpful.*

3.5 Discussion of interview results

Analysis of the interview data produced themes that related to the main questions of the research. One area for reflection concerned the implementation of the te Taiao framework to guide Phase 2 and the extent to which it supported a Te Tiriti-led approach to research. The observations from Māori and non-Māori suggested that the Challenge did operate differently in Phase 2. There was improvement for all three pou: people, knowledge and resources. Māori participants spoke of the increased number of Māori people in the research programmes and in leadership and governance positions. Non-Māori participants as well noted that increase. Participants also spoke about the empowering of Māori concepts and knowledge, and how they had more impact and were better integrated in Phase 2 of the Challenge. This empowerment was possible in part because of better access

to resources. These observations suggest that the Challenge did act to empower Māori people, knowledge and resources in Phase 2.

Nevertheless, participants also noted issues with achieving a Te Tiriti-led approach. One issue was that the institutions, practices and relationships already defined by and as 'the Challenge' bore the marks of the colonised system that produced them. Māori participants were brought into those structures and had to work with and adapt those structures. Even some of the language was felt to express this inside-outside or othering perspective. That is, some knowledge was being integrated into some other knowledge; or, one set of disciplinary boundaries is correct and taking a different approach entailed being trans, whether that is transdisciplinary or transgressive.

The impacts of the Te Tiriti-led approach were generally portrayed as positive. As one Māori participant explained, it allowed them to work in the way they were comfortable but without the need to explain it. Another participant explained how the Te Tiriti-led approach brought into the Challenge and engaged with a variety of Māori participants from different hapū and iwi. Non-Māori participants also expressed support for the new approach. They reported that it was an appropriate and successful way of working; one even called it *ground-breaking*.

The experience of centring the te Taiao model and working in a more Te Tiriti-led way also provides a perspective from which to reflect on MOIS and mission-led research. The core of MOIS is the mission; it is one of the aspects that separates it from other types of research. The experience of the Māori researchers in the Challenge was that the mission as set by MBIE meant that they were coming into a colonial space. When the Challenge moved toward a more Te Tiriti-led approach, that also meant ceding control of the direction. There were bounds around how much the Challenge could change direction, because it was created from the outset with a mission and purpose. However, the kind of collaboration or co-design expected by Māori stakeholders and actually practiced in Phase 2 did lead to research with different questions, purposes and participants, even within the remit of the Challenge.

The reflections from the participants suggest that the Challenge was able to refine its direction and widen the scope of participation by supporting the three pou. By empowering Māori people, knowledge and resources, the Challenge enabled Māori researchers and stakeholders to determine – to some extent – the content and direction of the research. The new direction could be taken as evidence that the three pou were effectively supported.

4 Analysis of administrative data

4.1 Data on outputs from OLW

Data was provided by OLW from the administrative system used to monitor and record performance of contracted research programmes. Principal investigators, called Research Leads or Programme Leads, were responsible for recording outputs from programmes. All outputs were recorded in a output spreadsheet, and certain outputs – journal articles and books, mainly – were also collected in a second spreadsheet for reporting to the funding ministry. The data were therefore provided in several reports. One report contained all the ministry-reportable publications for the life of the Challenge, again mostly journal articles.

Eleven reports contained the annual outputs from all the programmes that reported outputs in a given year. The platform was a cloud-based spreadsheet tool called Smartsheet. The platform has an export function that can export spreadsheet or report into Microsoft Excel. The Smartsheet reports were exported into Excel for data cleaning, on 01 September 2023 and 04 September 2023 for the data on outputs and publications.

There were several steps in the data cleaning. First, the names of the programmes were standardized. Over time, and because data were reported by several people, the name of a programme might be recorded in several ways. For example, 'Sources and Flows' was also recorded as 'Sources & Flows', and some spelling errors crept into reporting. Second, output names were standardised. The main change was that earlier report had the category 'Conference Paper', while later reporting used 'Conference Paper/proceedings'; these two names were combined into a single category. Third, the data were reviewed to ensure that every reported output had an output type. Most outputs were reported with a type, but some were not. However, other information that was reported, such as the name of a journal or commentary around a workshop, allowed the output type to be inferred. Fourth, the outputs were assessed to determine whether they were reported in more than one year. Several outputs in the period May to August appeared in more than one report. Also, outputs that were in progress or submitted but not accepted were excluded. The inclusions and exclusions by financial year are shown in the table below. The large number of exclusions in 2018 is due to many outputs in progress being reported. A total 196 journal articles plus 504 other outputs were included in the analysis, for a total of 700.

Table 2 Outputs from Our Land and Water included in analysis

Based on programme reporting data

Year	Outputs reported	Outputs excluded	Outputs included in analysis
2017	46	1	45
2018	147	64	83
2019	108	11	97
2020	22	10	12
2021	62	5	57
2022	49	2	47
2023	156	8	148
2024	16	1	15

Source: NZIER

The breakdown of outputs by type in the two phases of the Challenge are shown below.

Table 3 Types of outputs in the two phases

Based on programme reporting data

Type of output	Phase 1	Phase 2
Book	1	1
Book chapter	9	0
Commissioned Report	43	16
Conference Oral presentation	79	86
Conference Paper	24	0
Conference Poster	6	4
Data Set	0	1
Hui to transfer knowledge	25	35
Invited keynote	11	12
Journal Article	115	77
Other	28	58
Published Dataset	6	1
Review	0	2
Media article	0	56
Significant Contribution from Stakeholder	0	4

Source: NZIER

Across the two phases, up to the data of the data export, the Challenge had produced 700 outputs exactly. The final dataset for analysis included 674 outputs, a loss of 3.7 percent. The losses mainly arose from two sources. The input data for FTEs included fewer programmes; data for some more recently commissioned work had not been uploaded into the online system. In addition, some programmes were small projects conducted by the management group, particularly in Phase 1. The FTEs were attributed to the management group while the outputs were attributed to the programme. Programmes with zero FTEs were not included in the final analysis, so their outputs were excluded. The dataset was also cleaned for duplicates. Two main sources of duplication were outputs being entered into two different years, for example when an article was accepted and when it was published, and overlap between the list of published journal articles and the list of all outputs.

After the data analysis was complete, the OLW communications team examined the number of media articles for the Challenge. The data in Table 3 above concern outputs self-reported by research teams and up to a certain date. However, the actual number of media articles was larger. Table 4 provides the results from the communications team on the number of media articles, which shows that there were many more media articles than reported by the research teams. It also reinforces the difference between Phase 1 and Phase 2 already shown in Table 3.

Table 4 Media articles on OLW or its research

Count of articles by year

Challenge year	Media articles (count)
2017-18	14
2018-19	14
Phase 1	**28**
2019-20	57
2020-21	104
2021-22	113
2022-23	218
2023-24*	228
Phase 2	**720**

Source: Our Land and Water (Annabel McAleer, pers. comm., 10 April 2024)
* Partial year

At the outset, this project intended to analyse the authorship of outputs. The aim was to determine whether authorship had changed between phase 1 and phase 2. With greater emphasis on Vision Mātauranga, the Challenge may have produced more outputs with Māori co-authors. The focus on impacts from embedding mission-led principles may have led to a larger percentage of non-academic co-authors, stakeholders or end-users from outside university and CRIs. However, this analysis was not conducted. The data on authors would have required considerable cleaning in order to conduct the analysis. In the raw data, authorship of each output was a single entry. Each entry would have required separation into the individual author names. This disaggregation would have been more complex because the entries used several different formats:

- First Initial then Surname
- Surname, First Initial
- First Name then Surname
- Lists with commas
- Lists with semi-colons
- Authors including titles (Dr, Prof) or positions, sometimes with brackets.

For 700 entries, the total amount of work required to prepare the authorship data for analysis was too great. Therefore, we did not assess the changes in authorship between the two phases.

4.2 FTE data from OLW

The same platform, Smartsheet, was used to record and monitor data on the time the researchers spent on programmes. Time was recorded in terms of full-time equivalents (FTE). Data were provided in two reports, one for each phase of the Challenge. The reports indicates the time in FTEs spent in each programme by each researcher. Again, they were exported to Excel for data cleaning, on 16 August 2023.

Data cleaning included a few steps. First, all names were standardised or corrected. Personal names were entered in different ways for different programmes, such as a person's formal name in one and nickname in another. The differences occurred both with phases and across phases. Some research participants were specified by role or type, such as 'Farmer' or 'Administrator'. These entries were standardised, e.g., 'Farmers' and 'Farmer' were combined into one category. Second, organisation names were also corrected and standardised. For example, one Crown Research Institute was variously entered as 'Plant and Food Research', 'Plant & Food Research', 'Plant & Food', and 'Plant and Food'. Third, researchers were reviewed to ensure that they were correctly classified as identifying as Māori or not. Several researchers were recorded as both Māori and non-Māori, which was corrected. Fourth, one outlier value was removed (20,000 FTEs for one person).

The programme names also required standardisation. The FTE data were exported from the online system as Excel files. The rows (observations) were each person's time by year and programme. They were labelled with the programme name so that programme data could be aggregated. The outputs were exported from other sheets in the online system. Publications were labelled with the programme that produced it, but there was variation in the entries, such as inconsistent spaces and naming. These data, both the FTE and output data, were given standardised names for the programmes.

The programme FTE data was organised by programme-year, but some programme-years contained FTE data for other years. Data cleaning isolated the FTEs by programme-year so they could be aggregated correctly.

The analysis considered the contributions of different types of organisations: universities, Crown Research Institutes, and so on. Most participants were linked to an organisation, and their FTE was labelled with the organisation category. This process had to contend with some grey areas. First, there was a question of whether to connect the type of time to the participant or the organisation. Some participants worked for multiple organisations during the Challenge, such as a university and a private research organisation (e.g., a personal consultancy). Linking the FTEs to the organisation meant that the time was coded correctly. However, missing data meant that some entries noted the participant and not the organisation. In those case, it was sensible to categorise by the person. Also, some organisations have both research roles and industry roles, or they are involved in both research and Māori representation or advocacy. It isn't enough to know the organisation to understand whether the time should be considered research or consider stakeholder engagement. In the end, coding by organisation first and person second produced a complete dataset.

4.3 Data analysis

After cleaning, the data set for analysis included the fields shown in the table below. Data analysis was conducted with Microsoft Excel and RStudio running R version 4.2.3 'Shortstop Beagle'.

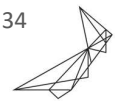


Table 5 Information available on OLW programmes

Data on inputs to research

Project data	FTE data
Years	Total FTEs
Phase 1 or 2	Māori FTEs
Programme Lead	University FTEs
	CRI FTEs
	Non-university, non-CRI FTEs
	Stakeholder/end user/participant FTEs

Source: NZIER

The project had three areas of interest:

- What were the differences between phase 1 to phase 2?
- Did changes provide better support for Māori research and researchers?
- Did changes support MOIS approaches such as directionality, collaboration and end-user participation?

The areas of interest were translated into questions for analysis:

- Is there a different mix of outputs: journal articles vs reports vs other types of outputs?
- Are there more FTEs for Māori researchers and stakeholders?
- Are there more FTEs for Māori-led research?
- Are there more FTEs for stakeholders, end users or industry participants?
- Has the percentage of people or FTEs linked to universities and CRIs changed?

The administrative data provided information on the FTE for each person in each programme. The data also included the person's employer (categorised into university, CRI, private research organisation, government, other (e.g., industry group), and unknown), and whether the person identified as Māori. The person and the employer were used to characterise the FTE according to the type of organisation and Māori/non-Māori.

The main unit of analysis was the programme or project. For each programme, we had the total inputs (in FTE by type) and the total outputs. The analysis tested whether there were differences in the inputs or the outputs per programme. One technique we used was a t-test of means for the phases. Each programme represented an observation of the inputs and outputs for its phase, and we could calculate the mean and variance of the input and output metrics for each phase. We then compared the means using a t-test. The second technique was linear regression. We constructed several equations to test relationships among the variables, including the impact of the phase on the variables of interest. For example, we could test whether Māori FTEs per programme increased with the equation

Māori FTEs = f(Phase, Total FTEs),

where Māori FTEs are a function of the phase and the total FTEs per programme. If the estimated parameter for *Phase* is significant, that suggests that Māori FTEs were different between the two phases.

4.4 Results

A summary of the data is provided below. There were 144 programmes in the initial dataset. The table presents the input and output variables in the dataset, with the mean and the maximum value across all the programmes in both phases.

Table 6 Dataset values across all programmes

Summary of administrative dataset

Metric	Variable name	Mean	Maximum
Input variables			
Paid FTE	Paid.FTE	1.30	24.05
Unpaid FTE	Unpaid.FTE	0.33	13.35
Paid FTE for Māori named participants	Māori.Paid.FTE	0.37	10.34
Unpaid FTE for Māori named participants	Māori.Unpaid.FTE	0.10	3.33
Paid FTE for non-Māori named participants	Non-Māori.Paid.FTE	0.94	13.71
Unpaid FTE for non-Māori named participants	Non-Māori.Unpaid.FTE	0.22	13.35
Paid FTE for named university participants	University.Paid.FTE	0.21	4.28
Unpaid FTE for named university participants	University.Unpaid.FTE	0.14	12.25
Paid FTE for named CRI participants	CRI.Paid.FTE	0.37	14.26
Unpaid FTE for named CRI participants	CRI.Unpaid.FTE	0.03	0.52
Paid FTE for named participants from other research organisations	Private.research.Paid.FTE	0.34	4.98
Unpaid FTE for named participants from other research organisations	Private.research.Unpaid.FTE	0.04	1.30
Paid FTE for named government participants	Government.Paid.FTE	0.00	0.10
Unpaid FTE for named government participants	Government.Unpaid.FTE	0.03	1.00
Paid FTE for named participants from other types of organisations	Other.Paid.FTE	0.36	17.68
Unpaid FTE for named participants from other types of organisations	Other.Unpaid.FTE	0.09	2.04
Paid FTE for named participants from unknown organisations	Unknown.Paid.FTE	0.00	0.14
Unpaid FTE for named participants from unknown organisations	Unknown.Unpaid.FTE	0.00	0.44
Years the programme was active	Programme.years	1.22	4.00
Indicator: whether programme had a Māori programme lead	Māori.Programme.Lead	0.13	1.00
Output variables			
Books published	Allbook	0.01	1.00
Book chapters published	Allchapter	0.06	4.00
Reports published	Allreport	0.33	14.00

Metric	Variable name	Mean	Maximum
Oral conference presentations published	Allconforal	1.20	13.00
Conference papers published	Allconfpaper	0.17	6.00
Conference posters published	Allconfposter	0.07	2.00
Datasets produced	Alldataset	0.01	1.00
Hui held	Allhui	0.40	15.00
Keynote talks given	Allkeynote	0.16	4.00
Journal articles published	Alljournal	1.33	43.00
Other outputs published or presented	Allother	0.59	11.00
Datasets published	Allpubdataset	0.04	4.00
Reviews published	Allreview	0.01	1.00
Media outputs published	Allmedia	0.26	11.00
Stakeholder engagements produced	Allstakeholder	0.03	1.00
Total publications or outputs	Total.publications	4.68	60.00
Total publications or outputs per Paid FTE	Total.publications.per.paid.FTE	6.60	84.51

Source: NZIER

Ten programmes were excluded from further analysis, including the Directorate (which was treated in the dataset as a 'programme' but included the administrative activities of managing the Challenge) and nine programmes with zero FTE (because they were abandoned or had not commenced at the time of data extraction). There were 134 programmes in the final dataset.

4.4.1 Inputs – Participation in OLW

The number of people who participated in OLW is shown in the table below. These were people named in the programme administration documents, so the data excluded 'Student', 'Farmer' and similar entries. If the person was named in documents for the phase, they were considered to have participated; subsequent changes to programme staff were not included. If they were named but not assigned a Paid FTE, they were categorised as Named participant without paid FTE. The data set included both Paid FTE and Unpaid FTE; named participants could have FTE in both categories, or in either or neither.

Table 7 Participants in OLW by phase

Numbers of participants and FTE

Metric	Phase 1	Phase 2	At least one phase	Both phases
Named participants (number)	381	870	1,140	112
Named participants with paid FTE (number)	157	532	625	64
Named participants without paid FTE (number)	224	338	536	26
Paid FTEs, named participants	28.5	149.7		178.3

Source: NZIER

A total of 1,140 people were named as participants in the Challenge. That number included 625 who were allocated Paid FTE sometime during the Challenge. There were 112 people who participated in both phases, of which 64 were allocated Paid FTEs in both phases. Phase 1 involved 381 people (157 paid) and Phase 2 involved 870 people (532 paid). Not only were more participants involved in Phase 2, but a larger portion of participants had some Paid FTE. The χ^2 test for difference in the count of participants with Paid FTE versus not-Paid FTE for the two phases is significant ($\chi^2 = 41.79$, degrees of freedom = 1, p-value = 1.02e-10, using the *chisq.test* function in R).

Using the data, we assessed whether there were differences in the inputs to the research programmes between Phase 1 and Phase 2. There are two parts to the differences. The first part is the overall totals. As shown in Table 8, Phase 2 was larger overall than Phase 1. It involved more FTEs, both Paid and Unpaid, and more Programme years (numbers of years per programme, summed over all programmes). The second part is the difference at the programme level: whether the programmes were observably different in Phase 2 versus Phase 1. For that analysis, we used the programme-level data to calculate averages and models. We used FTE as the key metric of input effort, and investigated whether the FTE per programme changed from one phase to the other. The results are also shown in Table 8.

For both phases, Table 8 indicates the total, mean (average) and standard deviation for each metric. Then, it presents the results of a t-test for the equivalence of the sample means (using the *t.test* function in R). In conducting the t-test, we have not been concerned about the Normality of the data or the equivalence of the variances. In the first place, the t-test was intended to give some guidance about whether the means were different, so the exactness of the statistics was less important. Secondly, these data represented the whole population of programmes in Our Land and Water, so statistics designed for random samples were not actually needed. Finally, if these programmes are viewed as a sample of programmes, or more correctly samples of two different types of programmes, it was not clear what population these samples were drawn from. Thus, we used the t-test for guidance but not as an absolute test of difference between phases.

Table 8 Description of FTE data

FTE variables by phase

Metric	Phase1 total	Phase2 total	Phase 1 mean	Phase 2 mean	Phase 1 st dev	Phase 2 st dev	t-test
Paid.FTE	33.63	154.11	1.77	1.34	1.72	2.91	0.38
Unpaid.FTE	4.74	25.80	0.25	0.22	0.70	0.51	0.88
Māori.Paid.FTE	4.97	47.66	0.26	0.41	0.43	1.27	0.32
Māori.Unpaid.FTE	3.09	10.34	0.16	0.09	0.69	0.38	0.66
Non-Māori.Paid.FTE	28.66	106.44	1.51	0.93	1.71	1.93	0.19
Non-Māori.Unpaid.FTE	1.65	15.46	0.09	0.13	0.11	0.28	0.20
University.Paid.FTE	9.98	19.93	0.53	0.17	0.86	0.48	0.10
University.Unpaid.FTE	3.20	3.53	0.17	0.03	0.69	0.14	0.40
CRI.Paid.FTE	14.80	38.48	0.78	0.33	0.90	1.42	0.08
CRI.Unpaid.FTE	0.52	2.22	0.03	0.02	0.05	0.05	0.49
Private.research.Paid.FTE	4.12	45.35	0.22	0.39	0.32	0.80	0.09
Private.research.Unpaid.FTE	0.15	4.39	0.01	0.04	0.03	0.15	0.05
Government.Paid.FTE	0.00	0.20	0.00	0.00	0.00	0.01	0.16
Government.Unpaid.FTE	0.15	2.83	0.01	0.02	0.02	0.12	0.17
Other.Paid.FTE	1.80	49.82	0.09	0.43	0.20	1.74	0.05
Other.Unpaid.FTE	0.72	12.15	0.04	0.11	0.08	0.32	0.05
Unknown.Paid.FTE	0.00	0.32	0.00	0.00	0.00	0.02	0.08
Unknown.Unpaid.FTE	0.00	0.69	0.00	0.01	0.00	0.04	0.14
Programme.years	30.00	146.00	1.58	1.27	0.61	0.63	0.05
Māori.Programme.Lead	4.00	15.00	0.21	0.13	0.42	0.34	0.44

Source: NZIER
'St dev' = standard deviation

The results in the tables indicate the following:

- There were more total FTEs, Paid and Unpaid, in Phase 2, and more Programme years. The Challenge in Phase 2 was larger and involved more research effort.
- Programmes in Phase 2 were smaller on average but had more variation in size. However, the lack of significance from the statistical tests suggests that the differences at the programme level between the phases were not pronounced.
- There were more FTEs for Māori participants, both Paid and Unpaid, in Phase 2 – nearly ten times the FTEs from Phase 1. Per programme, the Paid FTEs increased but the Unpaid FTEs decreased. There was also a larger variation in Māori participation across the programmes in Phase 2 than in Phase 1. However, the differences at the programme level were not pronounced.
- For non-Māori participants, the total FTEs increased in Phase 2, but the average Paid FTEs per programmed decreased. The variation across the programmes was similar in

the two phases, and the difference in FTEs was within the level of variation seen across the programmes.

- Paid FTEs by university and CRI staff increased in total in Phase 2, but the time per programme declined. The test for significance was positive at the 10 percent level for both types of participant, so this decline appears to be feature of Phase 2.
- The programme FTEs were instead filled by participants from private research organisations and 'Other' organisations, such as iwi entities and private companies. Again, the test for significance is positive at the 10 percent level (and 5 percent for private research organisations), suggesting that Phase 2 did mark a shift away toward these types of participants.
- Another metric was the number of years each programme operated. This was an integer that indicated the number of Challenge financial years in which the programme operated. A programme that ran for six months might be in two financial years, for example. The figures in the table suggest that the variety in the timeframes of programmes was the same in both phases (the have nearly the same standard deviation), but the Phase 2 programmes were on average shorter.
- The final metric in the table is about Māori leadership of programmes. In Phase 2, programmes were asked to fill four leadership roles, including a Māori lead. This metric is different: we looked at whether the Programme Lead for a programme identified as Māori. We believed that this was a comparable metric across the two phases. There were 4 programmes with Māori Programme Leads in Phase 1 and 15 such programmes in Phase 2. More programmes were led by Māori in Phase 2, and the increase appears to be in proportion to the overall growth in programmes from Phase 1 to Phase 2.

4.4.2 FTE for Māori participants

One of the areas of interest was participation by Māori in the research, and what influenced the amount of participation. The administrative data provided some variables to analyse patterns in Māori FTE. Some analysis is presented in the next tables.

We first considered the most basic relationship: whether Māori FTE increased with overall FTE, and whether it changed between the two phases. We started by considering all Māori FTE, both paid and unpaid. As shown in the table below, the simple model (Model A) has good fit, with an adjusted R^2 of 0.716. Programmes with higher amounts of FTE also had higher amounts of FTE for Māori participants. The link between overall FTE and FTE for Māori did not change between the phases: Phase 2 is statistically similar to Phase 1. This finding suggests that increased Māori FTEs overall was the result of the increased size of the Challenge.

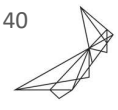


Table 9 Models of all FTE for Māori participants

Linear regression models

Variable	Model A	Model B	Model C
Dependent variable	FTE.Māori.all	FTE.Māori.all	FTE.Māori.all
FTE.all	0.347 (0.0202) ***	0.373 (0.0220) ***	0.325 (0.0180) ***
Phase.indicator	-0.0504 (0.0676)	-0.210 (0.0819) *	-0.136 (0.0645) *
Māori.Programme.Lead		1.01 (0.188) ***	-0.233 (0.199)
FTE.all x Māori.Programme.Lead			0.585 (0.0635) ***
Adjusted R-sq	0.716	0.744	0.844

Source: NZIER

Results are the estimated parameter, the standard error in brackets, and a significance indicator: '***' is $p < 0.001$, '**' is $p < 0.01$, '*' is $p < 0.05$, and '.' is $p < 0.1$.

We next considered whether programmes had more FTE for Māori if they were led by a Māori Programme Lead. Including this additional variable improved the fit of the model (Model B) to the administrative data. Programmes with Māori Programme Leads had on average one additional FTE for Māori participants. The model also showed that, once we controlled for the amount of FTE and Māori Programme Leads, Phase 2 programmes had lower levels of FTE for Māori.

The final model (Model C) in the table considered the interaction between the amount of FTE and Māori programme leadership. This additional variable estimated whether the impact of Māori Programme Leads was larger for programmes with more FTE. The model, which has the best fit of the three, found that with larger programmes, Māori Programme Leads were able to provide proportionally more FTE for Māori participants. With the addition of the interaction term, the parameter for Māori Programme Lead became insignificant. This suggests that it was not simply having a Māori Programme Lead that encouraged Māori participants, but actually providing Leads with a budget for FTE that had the impact.

We also investigated the drivers of Māori paid FTE. For this, we estimated two models as shown in the table below. We used the variables from the best-fitting model in the earlier table to estimate the impact on Māori Paid FTE (Model D). We found similar parameters and standard errors for the paid FTE model as for the model on all FTE. Higher amounts of FTE overall were linked to higher levels of Māori paid FTE. Having a Māori Programme Lead by itself was not statistically significant, but it was significant in combination with greater amounts of paid FTE. Finally, the difference between the phases was marginally significant, with Phase 2 having less Māori paid FTE per programme after controlling for the other variables.

Table 10 Models of paid FTE for Māori participants

Linear regression models

Variable	Model D	Model E
Dependent variable	Māori.Paid.FTE	Māori.Paid.FTE
Paid.FTE	0.319 (0.0175) ***	
Phase.indicator	-0.108 (0.0593) .	0.0598 (0.107)
Māori.Programme.Lead	-0.0158 (0.189)	
Paid.FTE x Māori.Programme.Lead	0.440 (0.0808) ***	
University.Paid.FTE		0.178 (0.152)
CRI.Paid.FTE		0.228 (0.0649) ***
Private.research.Paid.FTE		0.627 (0.119) ***
Adjusted R-sq	0.798	0.343

Source: NZIER

Results are the estimated parameter, the standard error in brackets, and a significance indicator: '***' is $p < 0.001$, '**' is $p < 0.01$, '*' is $p < 0.05$, and '.' is $p < 0.1$.

We also investigated whether there were links between the types of organisations and the amount of paid FTE for Māori participants. This model (Model E) did not explain the data as well as the other models examining Māori FTE. Nevertheless, it found that greater paid FTE for university participants did not link to increased paid FTE for Māori participants. However, both CRIs and private research organisation were associated with greater amounts of paid FTE for Māori participants. For this model, there was no difference between Phase 1 and Phase 2.

4.4.3 Outputs from programmes

We also assessed the outputs from the programmes to look for differences between the phases. The results of the data analysis are shown in the table below. The table provides the total number of each type of output for each phase, and then provides the mean and standard deviation for the outputs from the programmes in each phase. The final column provides a t-test of the significance of the difference between the means. The t-test is provided with the same caveats as expressed above: that it is for guidance rather than a definitive measure of difference.

Table 11 Data on outputs from OLW

Programme-level data for both phases

Metric	Phase1 total	Phase2 total	Phase 1 mean	Phase 2 mean	Phase 1 st dev	Phase 2 st dev	t-test
Allbook	1	1	0.053	0.009	0.229	0.093	0.420
Allchapter	5	0	0.263	0.000	0.806	0.000	0.172
Allreport	33	13	1.737	0.113	3.634	0.574	0.068
Allconforal	83	79	4.368	0.687	4.284	1.962	0.002
Allconfpaper	21	0	1.105	0.000	1.629	0.000	0.008
Allconfposter	6	4	0.316	0.035	0.582	0.184	0.051
Alldataset	0	0	0.000	0.000	0.000	0.000	--
Allhui	26	30	1.368	0.261	3.531	0.859	0.190
Allkeynote	7	12	0.368	0.104	0.761	0.519	0.160
Alljournal	71	31	3.737	0.270	4.433	1.111	0.003
Allother	31	53	1.632	0.461	2.753	1.237	0.084
Allpubdataset	6	0	0.316	0.000	0.946	0.000	0.163
Allreview	1	1	0.053	0.009	0.229	0.093	0.420
Allmedia	1	36	0.053	0.313	0.229	1.231	0.041
Allstakeholder	0	3	0.000	0.026	0.000	0.160	0.083
Total.publications	292	263	15.368	2.287	14.553	4.569	0.001

Source: NZIER
'St dev' = standard deviation

A good place to start is with the final row of the table. The total number of publications was smaller in Phase 2 than in Phase 1, and the average number produced per programme was lower. The difference is statistically significant and thus represents an actual difference between the phases.

The decline was apparent across all outputs that could be considered typical academic outputs: conference posters, papers, and presentations, as well as journal articles and book chapters. The decline in academic outputs per programmes was statistically significant. The number of reports also fell from Phase 1 to Phase 2. However, the programmes reported more hui, more media outputs and more 'other' (miscellaneous and non-standard) outputs. There is potential reporting error, in that media mentions were not tracked early on in the Challenge. Nevertheless, the growth in media and other (e.g., blog posts) suggested more engagement with the public and the popular press.

4.4.4 Production of outputs

The next part of the analysis of the administrative data linked inputs to outputs. The data reported above showed that there were some differences in the inputs per programme, as measured by FTEs, and some differences in the various types of outputs per programme. The next analysis attempted to understand the drivers of the differences. This analysis is limited by the fact that Phase 2 data was incomplete at the time of extraction, and later analysis could repeat this exercise.

We assumed that publications as an output were produced by the labour of participants, measured in FTE. The table below shows the results of three of the models estimated. All three had total publications (per programme) as the dependent variable, with different sets of explanatory variables at the programme level. The first model estimated the contribution of paid FTE to the number of publications, and found a significant positive relationship between the FTE in programme and the number of publications. The second variable in the model, however, showed that publications per FTE were lower in Phase 2 than in Phase 1. There were about six publications per FTE in Phase 1 and one publication per FTE in Phase 2.

Table 12 Production of OLW outputs considering paid FTE

Linear regression models

	Model 1	Model 2	Model 3
Dependent variable	Total.publications	Total.publications	Total.publications
Paid.FTE	6.05 (0.626) ***		
University.Paid.FTE		7.56 (1.02) ***	3.58 (1.79) *
CRI.Paid.FTE		5.87 (0.864) ***	6.49 (1.50) ***
Private.research.Paid.FTE		7.98 (1.19) ***	21.6 (4.26) ***
Government.Paid.FTE		-9.06 (47.8)	
Other.Paid.FTE		5.77 (0.963) ***	
Phase 2 variables			
P2.Paid.FTE	-4.99 (0.655) ***	-5.22 (0.859) ***	
Each programme (Phase 2)			0.47 (0.70)
University.Paid.FTE (Phase 2)			0.0170 (2.19)
CRI.Paid.FTE (Phase 2)			-5.71 (1.56) ***
Private.research.Paid.FTE (Phase 2)			-19.2 (4.33) ***
Adj R-sq	0.475	0.474	0.506

Source: NZIER

Results are the estimated parameter, the standard error in brackets, and a significance indicator: '***' is $p < 0.001$, '**' is $p < 0.01$, '*' is $p < 0.05$, and '.' is $p < 0.1$.

Model 2 examined the contributions of FTE from participants from different types of organisations. The parameters for FTE from universities, CRIs, private research organisations and other entities were all positive and significant. The values were also within the confidence intervals of each other: participants from each type of organisation contributed approximately equally to total publication output per programme. The one difference was government FTE, but the parameter was not significant and the amount of paid FTE was small: none in Phase 1 and 0.2 in Phase 2. On average, paid FTE in Phase 2 produced fewer outputs; the estimated parameter is roughly the same in Model 2 as in Model 1. The model fit for Model 2 as measured by adjusted R^2 was no better that the fit for Model 1.

Model 3 considered the impact of Phase 2, disaggregated to the FTE main types of organisations. For university, CRI and private research organisation FTE, both average publications per FTE and the difference for Phase 2 were estimated. The parameter was lowest for universities, higher for CRIs, and highest for private research organisations. The impact of Phase 2 was similar but opposite: no change in publications per FTE for university FTE (parameter small and not statistically significant), a large drop for CRI FTE, and an even larger drop for private research organisations. Combining the Phase 2 and the average parameters, a university FTE produced 3.6 publications per FTE, a CRI FTE produced 0.78, and a private research organisation produced 2.4. The model fit for Model 3 was better than for the other two models.

The above models focused on the paid FTE. The Challenge also recorded administrative data about the amount of unpaid time expected to be used in each programme. By considering both paid and unpaid FTE, we investigated the impact of uncompensated time on production of total outputs. Three models using total time are provided in the table below.

Table 13 Production of OLW outputs considering all FTE

Linear regression models

	Model 4	Model 5	Model 6
Dependent variable	Total.publications	Total.publications	Total.publications
FTE.all	6.30 (0.503) ***		
FTE.Uni.all		7.72 (0.733) ***	6.18 (1.09) ***
FTE.CRI.all		5.90 (0.707) ***	4.07 (1.26) **
FTE.private.all		7.90 (0.970) ***	19.2 (3.54) ***
FTE.govt.all		4.07 (4.62)	76.7 (60.0)
FTE.other.all		5.87 (0.777) ***	15.7 (5.88) **
Phase 2 variables			
FTE.P2.all	-5.28 (0.527) ***	-5.31 (0.694) ***	
Each programme (Phase 2)			0.304 (0.609)
FTE.Uni.all (Phase 2)			-3.12 (1.44) *
FTE.CRI.all (Phase 2)			-3.41 (1.31) *
FTE.private.all (Phase 2)			-17.1 (3.60) ***
FTE.govt.all (Phase 2)			-79.3 (60.2)
FTE.other.all (Phase 2)			-15.2 (5.89) *
Adj R-sq	0.596	0.604	0.641

Source: NZIER

Results are the estimated parameter, the standard error in brackets, and a significance indicator: '***' is $p < 0.001$, '**' is $p < 0.01$, '*' is $p < 0.05$, and '.' is $p < 0.1$.

Model 4 had the same approach as Model 1, except that it considered both paid and unpaid time. As before, production per FTE was higher in Phase 1 than in Phase 2. In Phase 2,

programmes produced about one publication per total (paid and unpaid) FTE. Model 4 did a better job of explaining the variation in total publications per programme, however (adjusted R^2 of 0.596 versus 0.475), suggesting that accounting for unpaid FTE is important for understanding the productivity of these research programmes.

Model 5 was similar to Model 2, again including both paid and unpaid FTE. The estimated parameters and standard errors were similar between the two models, with the exception of government FTE. Although the parameter was not significant in either model, it was positive in Model 5, suggesting that government participation may increase output of publications. The fit of Model 5 is also better than that of Model 2 (adjusted R^2 of 0.604 versus 0.474).

Model 6 expanded Model 3 in two ways: by including paid and unpaid FTE and by including government and other FTE. Model 6 did estimate a different in the productivity of university FTE by including the unpaid time: the average parameter was 6.18 publications per FTE, with a Phase 2 adjustment of -3.12. The pattern and relative magnitudes for CRI and private research organisation FTE were similar for paid FTE and total FTE. Parameters for government FTE were not significant. However, the parameters for other participants' FTE were significant. They suggest that, although those participants showed a drop in production of outputs in Phase 2 like all the other types of organisations, they contributed about 0.5 of a publication per total FTE in Phase 2.

We then used the parameters in Model 5 to estimate equations for several types of output: conference publications (oral, paper and poster combined), journal articles, reports, hui and other. The other types of outputs either had fewer examples or none in one of the phases. The appropriate modelling would need to account for large numbers of zero observations, such as a hurdle model or Tobit model, which we did not do for this research. The results of the modelling for each type of output are shown in the table below.

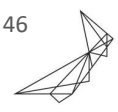


Table 14 Production of several types of OLW outputs considering all FTE

Linear regression models

	Model 7	Model 8	Model 9	Model 10	Model 11
Dependent variable	Allconf	Alljournal	Allreport	Allhui	Allother
FTE.Uni.all	2.55 (0.351) ***	1.59 (0.204) ***	0.710 (0.187) ***	1.26 (0.166) ***	0.693 (0.169) ***
FTE.CRI.all	2.00 (0.338) ***	1.95 (0.197) ***	0.569 (0.180) **	0.500 (0.160) **	0.601 (0.163) ***
FTE.private.all	2.95 (0.464) ***	1.94 (0.270) ***	0.779 (0.247) **	0.637 (0.220) **	1.44 (0.223) ***
FTE.govt.all	1.63 (2.21)	0.837 (1.29)	2.35 (1.18) *	0.385 (1.05)	-0.492 (1.06)
FTE.other.all	1.94 (0.371) ***	1.29 (0.216) ***	0.652 (0.198) **	0.841 (0.176) ***	0.612 (0.179) ***
Phase 2 variables					
FTE.P2.all	-2.01 (0.332) ***	-1.43 (0.193) ***	-0.637 (0.177) ***	-0.601 (0.157) ***	-0.544 (0.160) ***
Adj R-sq	0.390	0.551	0.132	0.350	0.388

Source: NZIER

Results are the estimated parameter, the standard error in brackets, and a significance indicator: '***' is $p < 0.001$, '**' is $p < 0.01$, '*' is $p < 0.05$, and '.' is $p < 0.1$.

The models for the individual types of publications had similar patterns. The total (paid and unpaid) FTE for universities, CRIs and private research organisations were all similar, and fell within the confidence intervals of each other. The only exception to that pattern was for hui, where a university FTE was associated with twice as many hui as a CRI or private research organisation FTE. The parameters for government FTE were statistically zero, except for a weakly significant link to the output of reports. The FTE for other organisations had much the same impact as university and CRIs, although the impact on journal articles was smaller. For all types of outputs, the number per FTE fell in Phase 2. These models had different goodness of fit for their respective dependent variables: the model for journal articles had the highest fit statistic, while that of the report model had the lowest.

4.5 Discussion

The results of the analysis shed some light on the Our Land and Water National Science Challenge. They show some changes in the FTE between Phase 1 and Phase 2, a change in the inputs to the Challenge. First, Phase 2 involved much more research time: Paid FTEs in Phase 2 were 4.6 times the Paid FTEs in Phase 1. While the number of FTEs was larger in the latter phase, the growth was concentrated in private research organisations, end-users and stakeholders ('Other') as opposed to participants from universities and CRIs (Table 8). Programmes in Phase 2 tended to be shorter and smaller, with fewer FTEs.

Phase 2 had greater involvement of Māori in research teams, in particular as Paid FTEs rather than Unpaid FTEs. Māori Paid FTEs also grew at a higher rate than overall Paid FTEs (9.6 times versus 4.6 times). At the programme level, Māori participated in programmes at the same rate in the two phases. We did find that participation by Māori was greater when there were Māori Programme Leads with greater amounts of FTEs in their programmes.

The outputs also changed from Phase 1 to Phase 2. Phase 2 had fewer outputs recorded in the administrative records, and fewer of most types of outputs. However, data were extracted in September 2023 before all Phase 2 programmes and their publications were complete. There were some outputs that increased: hui, media communications, and 'other' outputs. The change likely reflected a move away from academic outputs toward outputs that would reach or engage with end-users and stakeholders.

When we investigated the relationships between inputs in terms of FTE and outputs as collected in the records, we found a clear relationship between FTE and output: giving participants more time tended to produce more outputs. However, the relationship was different for Phase 2 than Phase 1: the second phase of the Challenge had produced fewer outputs per FTE at the time of the analysis. In general, participation from universities, CRIs and private research organisation tended to produce relatively similar levels of output per FTE. This was the case both with all outputs and with several specific types of outputs, such as journal articles, conference publications and reports.

Participation from different types of organisations were, however, affected differently by the change to Phase 2. One major initiative in Phase 2 was the Rural Professionals Fund, which accounted for many but smaller projects. These projects were intended to include private researchers, end-users and stakeholders, and were impact-oriented and focused on producing non-academic outputs. The initiative thus focused on different participants (inputs) and different outputs. It may have been an important cause of the differences between the phases.

We also found that including unpaid FTE in the analysis improved its explanatory power. This result suggests that both paid and unpaid time are important inputs to the research process.

A final point concerns the use of administrative data. The data were originally inputted into the computerised records system by several different people over many years. The data were therefore inconsistent in several ways. Errors were also identified, for example, whether an individual identified as Māori. Data cleaning – harmonising the names of people, organisation and programmes and correcting errors – was a significant effort. One caveat to the analysis is that the dataset could still contain errors.

The results have further limitations:

- One aim had been to understand how research changed from Phase 1 to Phase 2, both in how it was conducted and in the range of impacts it had. The administrative data, however, provided limited information on questions of process and on non-traditional research outputs. The data indicated who worked how much, but not what they did. The quarterly report from programmes would provide narrative about research processes – especially about the impact of Covid on research practices such as in-person workshops. Interrogating those reports would require other, qualitative and text-based research techniques. In addition, those reports were not standardised, so the level of detail varied by programme and by person.
- As for non-peer-reviewed outputs, the administrative data did include hui, media reports and other outputs. However, we do not know how well these types of outputs were reported. In particular, we understand that the Dimensions database of publications that MBIE uses to record Challenge outputs recognises only certain types and only documents with DOI (digital object identifier) numbers. That focus on peer-reviewed publications by MBIE could bias reporting efforts by research leads. By contrast, the reporting on journal articles was good, clear and comprehensive.
- As noted previously, data were extracted for analysis before the programmes in Phase 2 were finished, so the record of outputs is incomplete.

5 Social network analysis of OLW

5.1 Context for the SNA

Social network analysis (SNA) investigates the connections among researchers in order to describe how well connected they are and whether there are patterns to those connections. In its first phase, OLW commissioned a SNA (Payne & Small, 2016). It found that there was a single central person in the network, the Chief Scientist, and several people who served a key conduits between project groups and the overall Challenge. The network was generally strong, but one major programme was linked through only one or two connections.

We repeated the SNA for this project to help assess the impacts of changes between Phase 1 and Phase 2. The use of SNA to investigate changes in researcher networks has been done before. For example, Smart, et al. (2013) analysed the performance of seven Centres of Research Excellence in New Zealand. Among other findings, co-authorship network analysis found that collaboration between researchers had increased. For our analysis, we were

interested in whether there were changes in the network that represented key researchers and participants in OLW. The approach in Phase 2 prioritised collaboration and participatory approaches, which may have influenced the membership and structure of the network.

5.2 Method for the SNA

To aid in drawing longitudinal conclusions, we closely replicated the network analysis method of the earlier report (Payne & Small, 2016). When we undertook our work, neither author was still at the same institution as when their research was undertaken, so we did not have access to files, list or tools from it. However, the written method in the report was sufficient to replicate the research, and we were able to check our understanding informally with one of the researchers.

We conducted an online survey of participants involved in OLW research. The survey was administered by NZIER using the website SurveyMonkey. The survey concerned only the questions relating to the SNA. As with the prior work, we used a combination of reputational and positional sampling. From the administrative data discussed in section 4, we identified one or two members of every Phase 2 programme or projects. This was usually the Programme Lead, a position established in each programme contract. However, one gap in the administrative data set was the the name of the Progamme Lead, so we also looked for the first person or the person with substantial FTE. We added the the Science Leadership Team to the list. The list was then circulated to the Challenge Directorate for feedback and finalised. The final list included 108 individuals who were researchers, Challenge managers and collaborators.

To gather more information about the network itself, we replicated a question from the earlier research. We presented respondents with the entire list we had developed and asked them to identify those people with whom they communicated at least once every three months.

We then asked respondents about three topics.

- Collaboration – as with Payne & Small (2016), we asked respondents to rate *the degree of collaboration [they] have had with each selected person, on a scale of 1 (no collaboration) to 7 (a lot of collaboration)*.
- Interdisciplinary exchange – again replicating the earlier method, we asked respondents to rate *the frequency of interdisciplinary knowledge exchange [they] have had with each selected person, on a scale of 1 (no exchange) to 7 (a lot of exchange)*.
- Vision Mātauranga – we added to this survey a question about Vision mātauranga: *how much did [their] communication with each selected person consider Vision Mātauranga or mātauranga Māori, on a scale of 1 (no consideration) to 7 (a lot of consideration)*.

Responses from these three questions used a 7-point scale, and they were recoded into three levels: 1 and 2 were coded as ‘low’, 3 to 5 were coded as ‘moderate’, and 6 and 7 were coded as ‘high’. These recodings were as the same as Payne & Small (2016), and aid the interpretability of the network graphs.

Table 15 Recoding of responses from 7-point scale to three levels

Following Payne & Small (2016)

Original scale, collaboration	1	2	3	4	5	6	7
Original scale, interdisciplinary knowledge exchange	1	2	3	4	5	6	7
Original scale, Vision Mātauranga	1	2	3	4	5	6	7
Recoded levels	Low		Moderate			High	

Source: NZIER

In this survey, respondents rated other people. The edges in the network – the relationships between two nodes or vertices – are 'directed'. They have a directionality, because respondent A rated individual B. The network maps therefore have arrows that indicate directionality. Where two individuals have rated each other, the edge has arrowheads at both ends. There is also an impact on the colours in the graphs. Where two people have rated each other and given the same rating, the edge and both arrowheads all have the same colour. Where the ratings are different, this is not the case.

Network design and analysis were conducted with NodeXL (version 1.0.1.448), a template for Microsoft Excel from the Social Media Research Foundation in California.

5.3 Data and results of the SNA

5.3.1 Demographics

We invited the 108 people from our list to participate in the online survey. Each person needed to be identified in order to construct the network work, so individualised survey links were used. We received 46 responses for a response rate of 42.6 percent. With the responses, the resulting network included 79 people from the list of 108, and 254 relationships or edges in the network were identified.

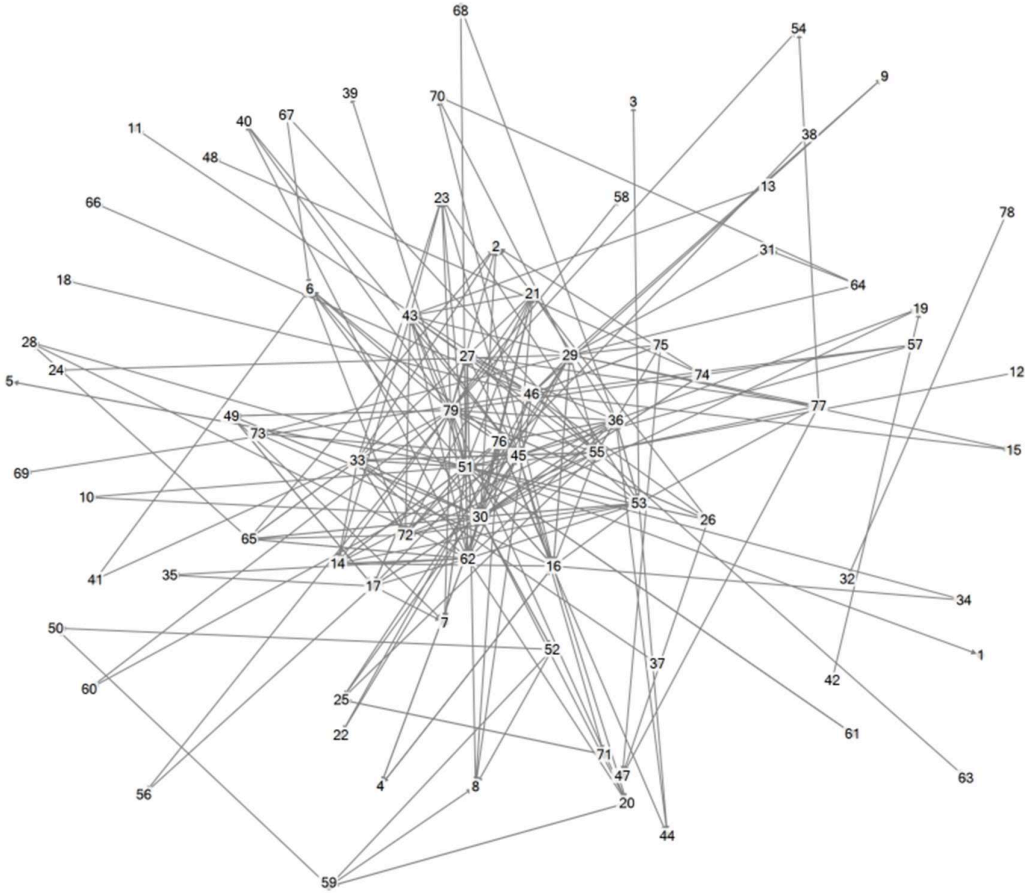
For comparison, Payne & Small (2016) had 39 respondents from a sample of 73 individuals, a response rate of 53.4 percent. The rating network included all 73 people and had 438 relational connections or edges.

Figure 2 presents the network graph of the responses. It is a directional graph (respondents indicate that they talk with other Challenge participants). The layout used was Fruchterman-Reinhold, the default layout for NodeXL. A circular network layout did not provide the same positional information as Fruchterman-Reinhold. For Figure 2 and subsequent graphs, identities of people have been anonymised with numbers, and the same number assignment has been used throughout. Numbers were assigned to people in a random order (not alphabetical or by strength of results).

The base network graph shows a centrally-organised network in which people in the centre have more connections and people at the periphery have fewer. There do not appear to be any definite clusters, which would indicate sub-networks. While most connections are between the centre and periphery, which is how the network layout algorithm works, there

is evidence of connections between people at the periphery, for example, 33 to 4 in Figure 2.

Figure 2 Base network map of Our Land and Water



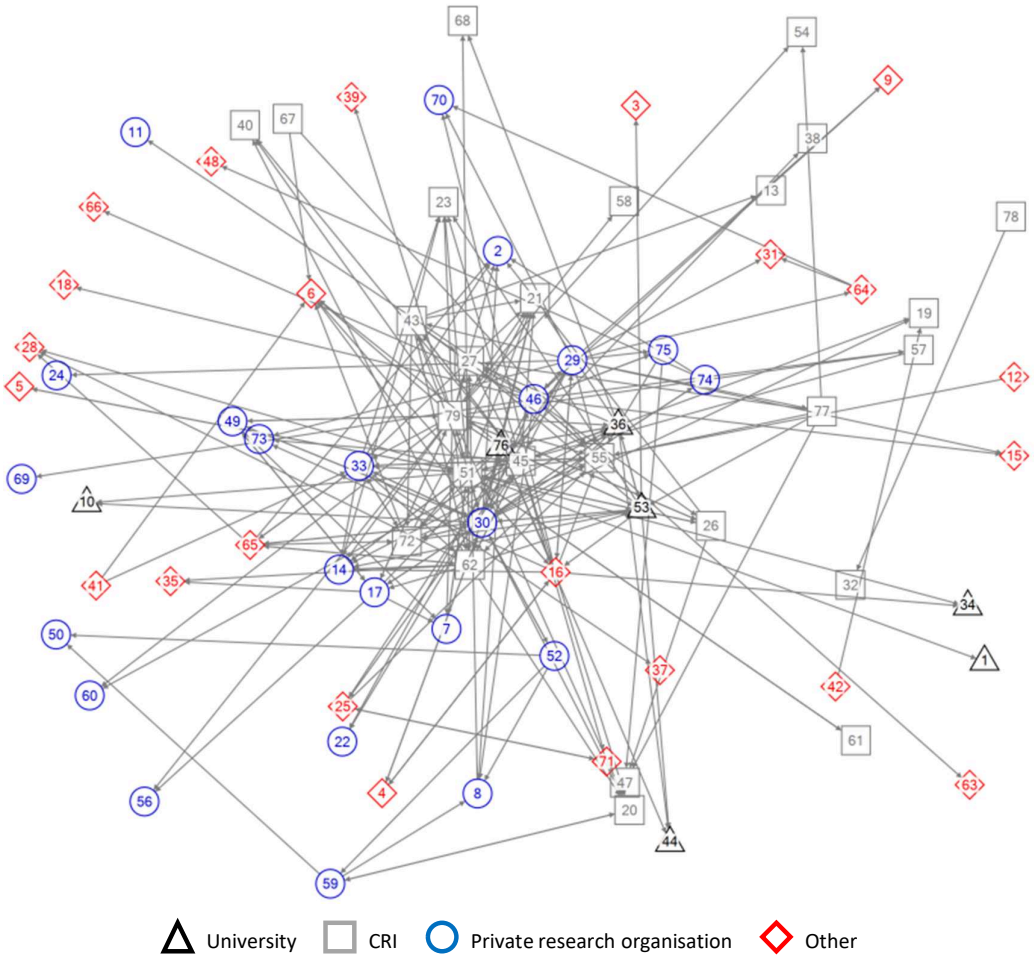
Source: NZIER

Figure 3 presents the same network with the type of entity or organisation identified. We had this information from the administrative data set. For the network graph, the categories were university, CRI, private research organisation and other, with the last category including industry and iwi organisations. The network included the following:

- University (black triangle) – 7 participants, 8.9 percent
- CRI (gray square) – 26 participants, 32.9 percent
- Private research organisation (blue circle) – 23 participants, 29.1 percent
- Other (red diamond) – 23 participants. 29.1 percent.

The composition of the network from Phase 2 is different from that of Phase 1. The earlier research found that 67.1 percent of network were from CRIs and 26.3 percent were from universities. Private research companies comprised 5.5 percent of network members.

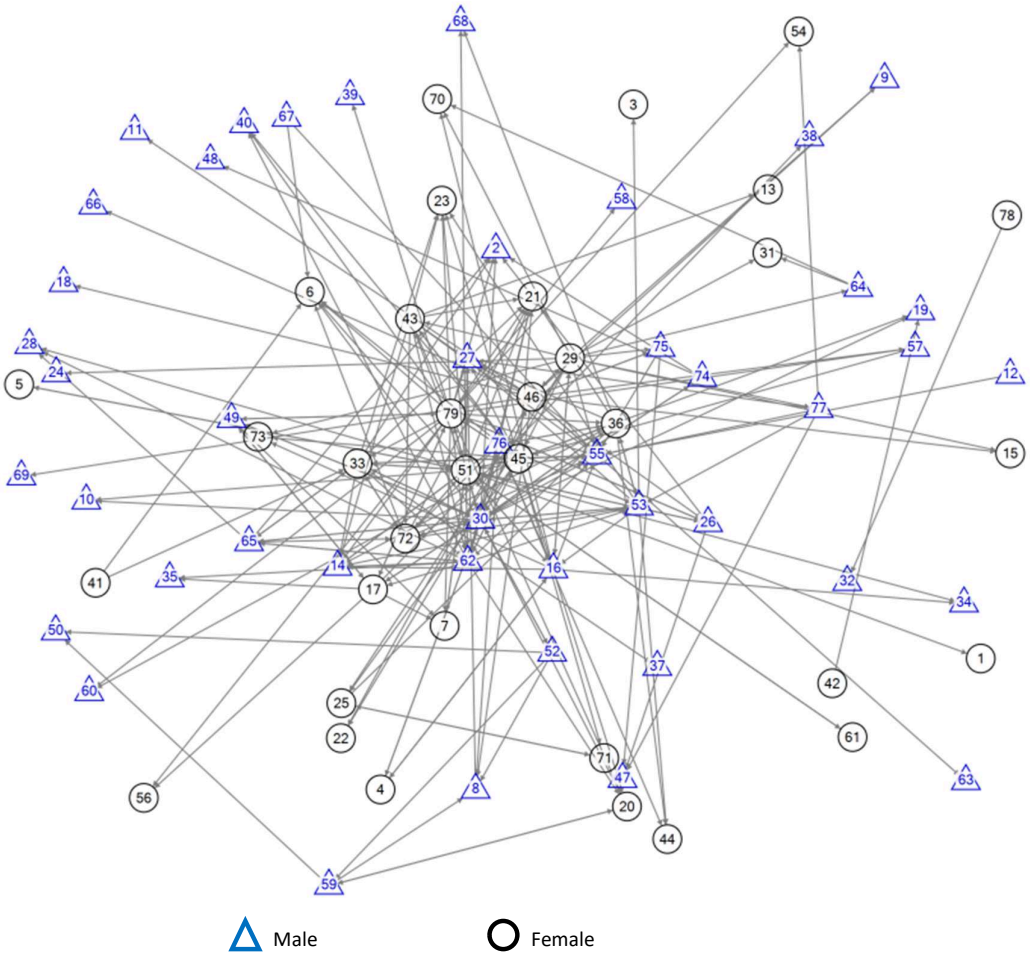
Figure 3 Type of entity or organisation for OLW network members



Source: NZIER

Figure 4 provides a network graph indicating the genders of the network members. Females are indicated by black circles and males by blue triangles. The survey was answered by 46 respondents, who provided relationship information that included 79 people in total. The survey asked respondents their gender identity. There were 18 females (51.4 percent), 17 males (48.6 percent) and no gender diverse respondents. We did not have self-declared gender identities for the remaining network members. They were assigned gender identities by the research team based on a) typical gender identity of their first names and b) web searches to determine the pronouns used to refer to them. The result was 34 females and 45 males, a ratio of 43:57. The core of the network graph includes several females and males, and both of those genders are apparent at all distances from the centre of the graph. There appear to be more males than females in the outside ring, noting of course that there are also more males than females overall in the network. In the prior research, the ratio was 30:70 female to male network members.

Figure 4 Gender for OLW network members

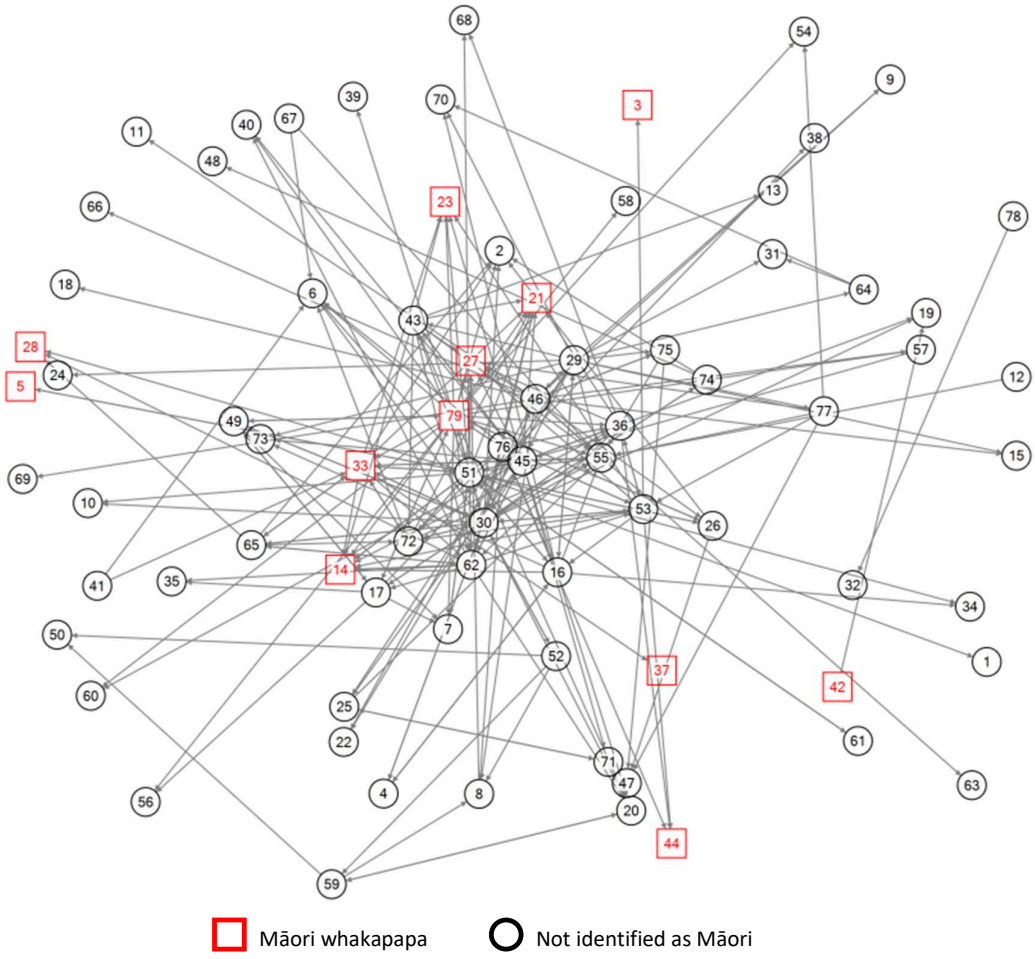


Source: NZIER

In the online survey, we asked respondents to indicate whether they identified as Māori. As with the gender responses, the responses provided data for respondents but not other network members. As part of creating a dataset for analysis from the administrative data, we determined whether each OLW participant identified as Māori or had Māori whakapapa. We used those data to complete the SNA dataset.

Figure 5 provides the results for the network members. People who are known to have Māori whakapapa are shown as red squares, and people who do not are shown as black circles. In the network, there are 12 people (15.2 percent) who identify as Māori and 67 (84.8 percent) who do not. Māori network members are spread throughout the graph: they are in the core and the periphery, and they are not clustered anywhere on the periphery. This suggests that they are involved in the Challenge in various roles, and that they are networked with Māori and non-Māori throughout the Challenge. On the other hand, it may also indicate that some Māori participants may not have strong networks with other Māori and be isolated in their workplaces, a known issue facing Māori researchers (Smith, 2012).

Figure 5 Māori whakapapa for OLW network members



Source: NZIER

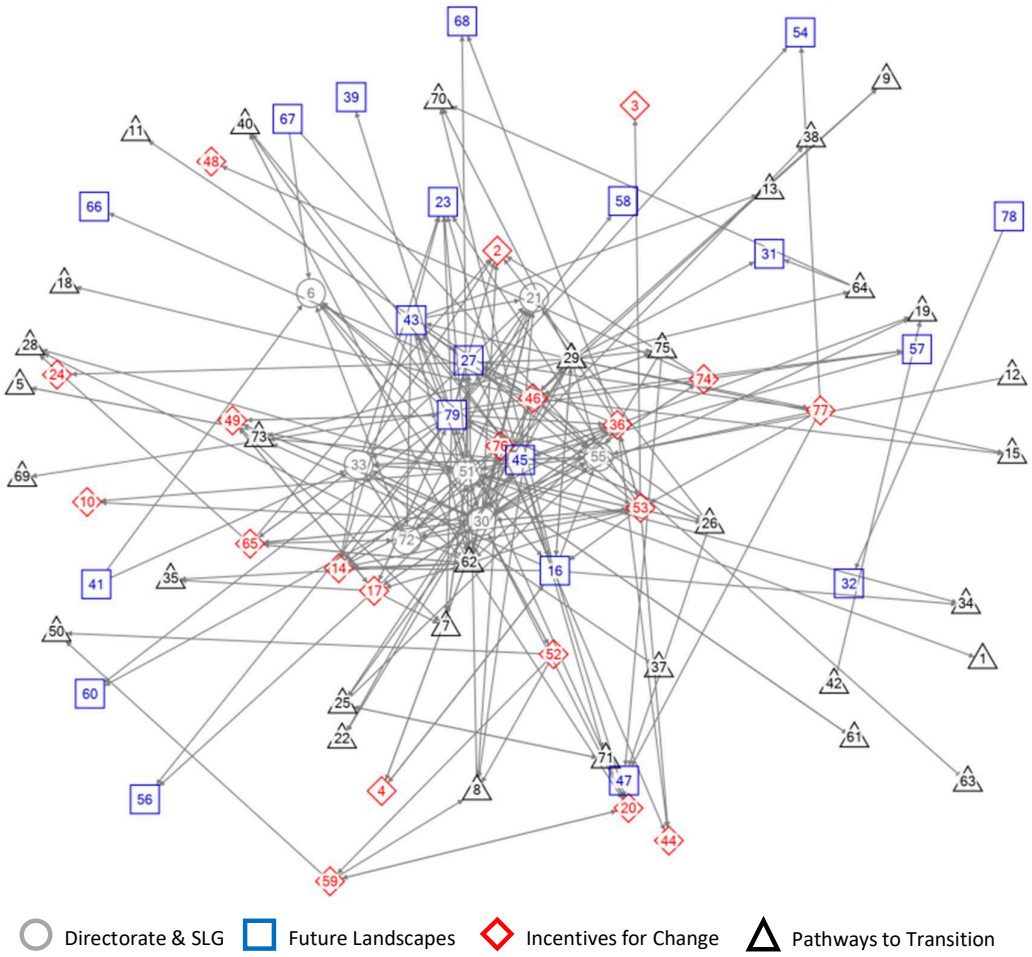
5.3.2 OLW Theme structure

In Phase 2, OLW was organised around three Themes, each with a Theme Leader: Future Landscapes, Incentives for Change and Pathways to Transition. Research programmes and projects were managed under a specific theme, as was budgeting. Theme Leaders had responsibility for maintaining contact with programmes, helping where necessary with research and logistical questions, ensuring that research was making sufficient progress, and communicating with the Directorate about individual programmes.

Figure 6 shows the network with members identified by the Theme in which they principally worked. Members of the Directorate and Science Leadership Group (SLG), including Theme Leaders, are shown as grey circles. They are, unsurprisingly, clustered toward the centre of the graph. Members from Future Landscapes are shown as blue squares; Incentives for Change, as red diamonds; and Pathways to Transition, as black triangles. There are similar numbers of members from all three Themes in the network graph. There are no obvious clusters of a single theme; all Themes have members spread throughout the network. There is also no obvious choke-point where members of a Theme go through a particular person. There are also edges connecting members of different

Themes, not just edges connecting the Directorate and Science Leadership Team (grey circles) outward to other shapes. Diamonds are connected to squares, triangles to diamonds, and so forth. This network graph suggests that the organisation of the Challenge, while it used Themes to allocate budget and workload, did not end up producing research or communication silos.

Figure 6 OLW Theme for network members



Source: NZIER

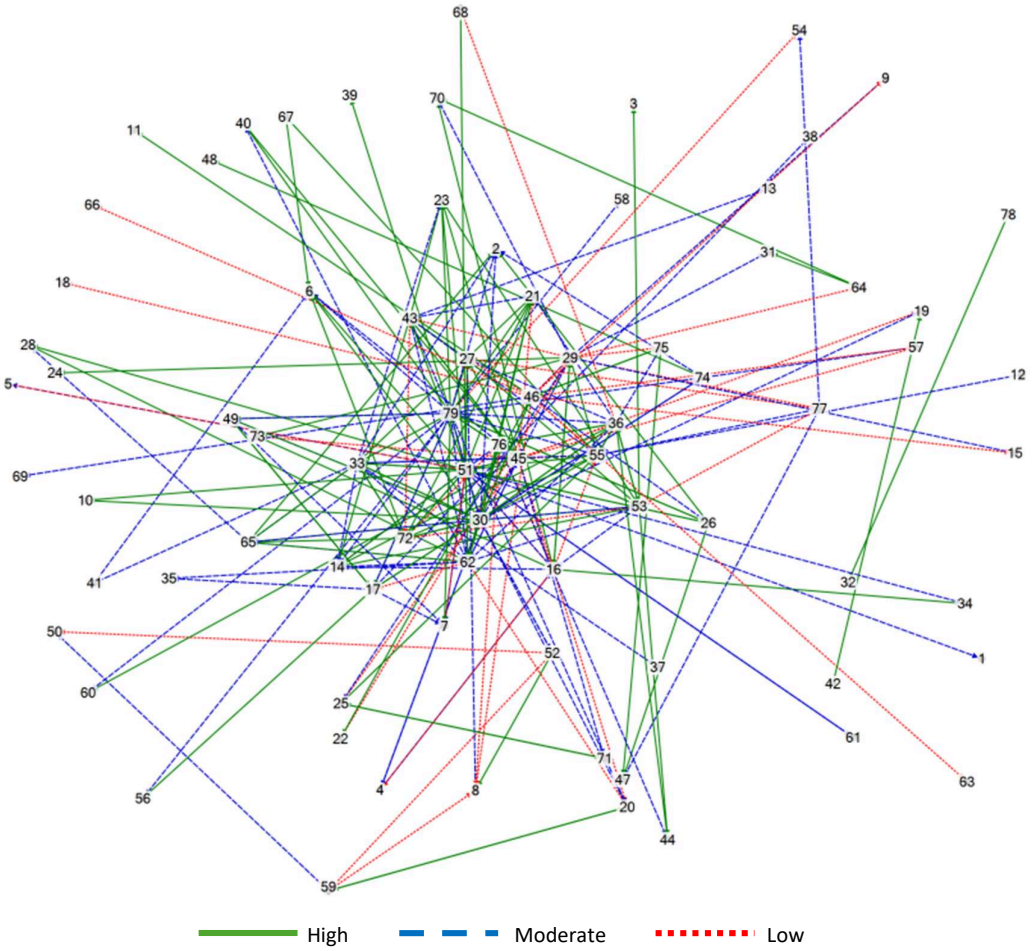
5.3.3 Respondents' subjective ratings of other participants

Figure 7 presents the subjective ratings that respondents provided regarding the degree of collaboration they have with other network members. The ratings concerned those members with whom respondents communicated at least once every three months. Nearly half of all ratings were high (48.0 percent) and most of the rest with 'moderate' (35.4 percent), with only 16.5 percent rated as 'low'. These are similar to results from the 2016 research (Payne & Small, 2016), although for that exercise only 5.9 percent of connections were rated as 'low' for collaboration. In Figure 7, the distribution of high, moderate and low

collaboration, shown by green solid, blue dashed and red dotted lines, are evenly distributed throughout the network. There are all three levels of collaboration in core and in the periphery. The interpretation is that some people who are not highly connected within this OLW network nevertheless have very collaborative relationships with one or a few people. Conversely, some members who are highly connected have a variety of relationships, some more collaborative and some less.

It is difficult to draw firm conclusions from the data available. The earlier research suggested that members toward the core had to maintain larger numbers of relationships, so their relationships tended to be moderately rather than highly collaborative (Payne & Small, 2016). This network graph suggests that some connected people near the core do maintain moderately and high collaborative relationships, such as nodes 23, 26, 14 and 33. Referring to Figure 6, we can see that those four nodes represent all the parts of the Challenge, including the Directorate & SLG. Thus, there may be other drivers of collaborative behaviours as well, such as personal choices or approaches to their work by individuals, or something about the nature of their work.

Figure 7 Degree of collaboration with OLW network members

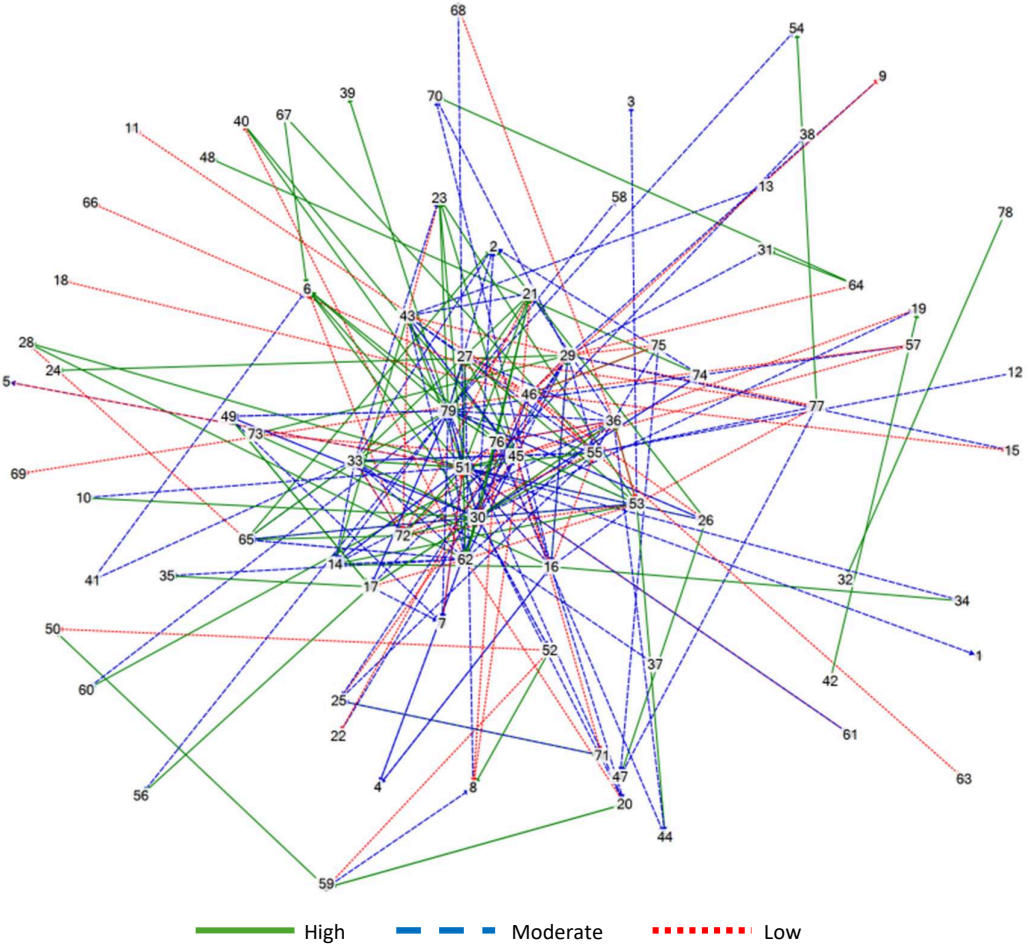


Source: NZIER

Figure 8 provides the results from a second set of ratings from survey respondents: the degree of interdisciplinary knowledge exchange. In this graph, the connections are 32.3 percent high, 44.9 percent moderate, and 22.8 percent low. The different levels of exchange appear to be fairly evenly distributed throughout the network, with both core and periphery connections of all three levels. Among those members with multiple connections, many have a combination of levels of interdisciplinary exchange. This would tend to indicate a person who works with people both in their own discipline and in other disciplines. Thus, they are neither isolated as the only member of their discipline amongst their connections nor are they confined to their own discipline.

This network graph has some similarities and differences with the corresponding graph from Payne & Small (2016). One similarity is that collaboration and interdisciplinary exchange in both cases tended to be fairly similar in extent and patterns across the networks. However, the earlier graph had more pronounced patterns for the different levels of exchange: more highly interdisciplinary exchange at the periphery and more moderate exchange at the core, and less low interdisciplinary exchange overall. They suggested that this could indicate that some peripheral members were recruited to provide specialist knowledge.

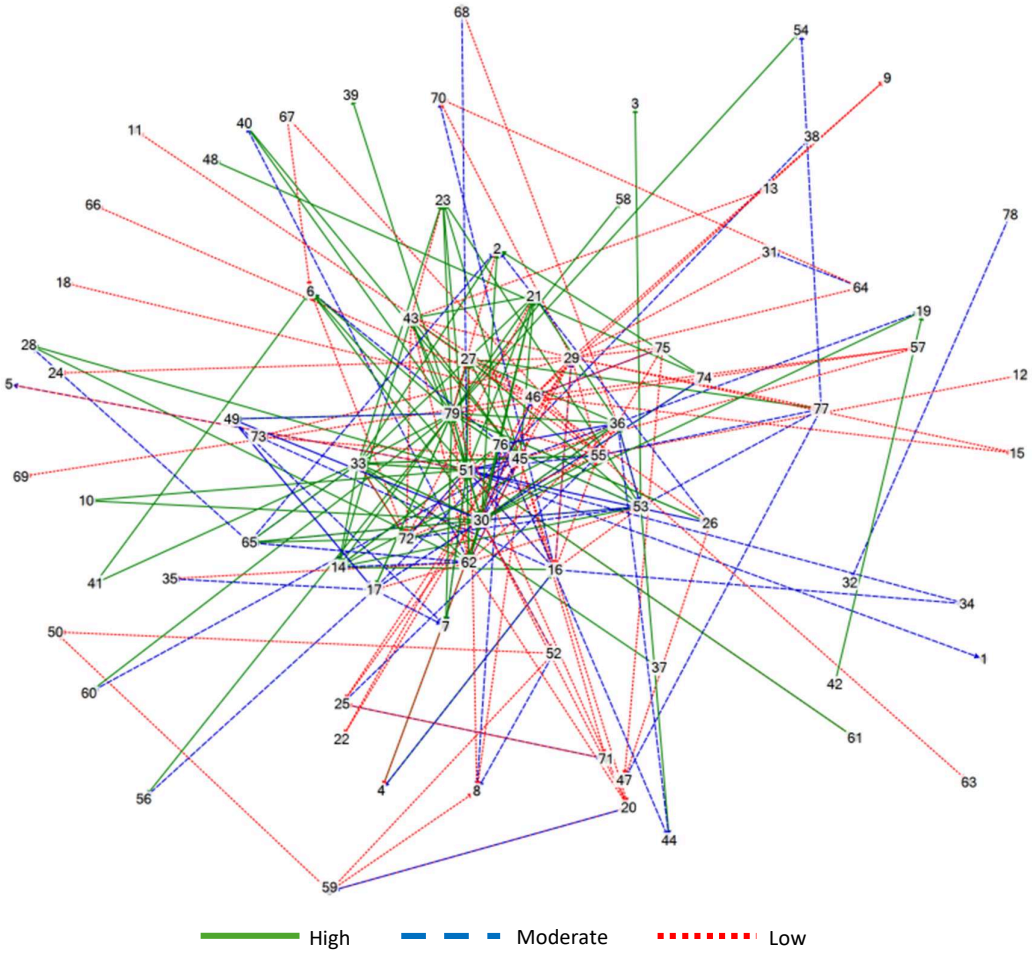
Figure 8 Degree of interdisciplinary knowledge exchange with members



Source: NZIER

The third set of ratings, shown in Figure 9, was new for this survey. Respondents were asked to indicate how much their discussions considered Vision Mātauranga or mātauranga Māori. The graph tends to suggest that the amount of consideration is higher toward the core of the network and lower toward the periphery. There are all three levels of consideration – high, moderate and low – through the graph. However, the green lines indicating high consideration are mostly in the core, while most (but not all) of the lines connecting to nodes on the periphery are blue (moderate) and red (low). Overall, the share of ratings at the three levels was nearly even: high, 38.2 percent; moderate, 27.6 percent; and low, 34.3 percent.

Figure 9 Extent of Vision Mātauranga consideration with members

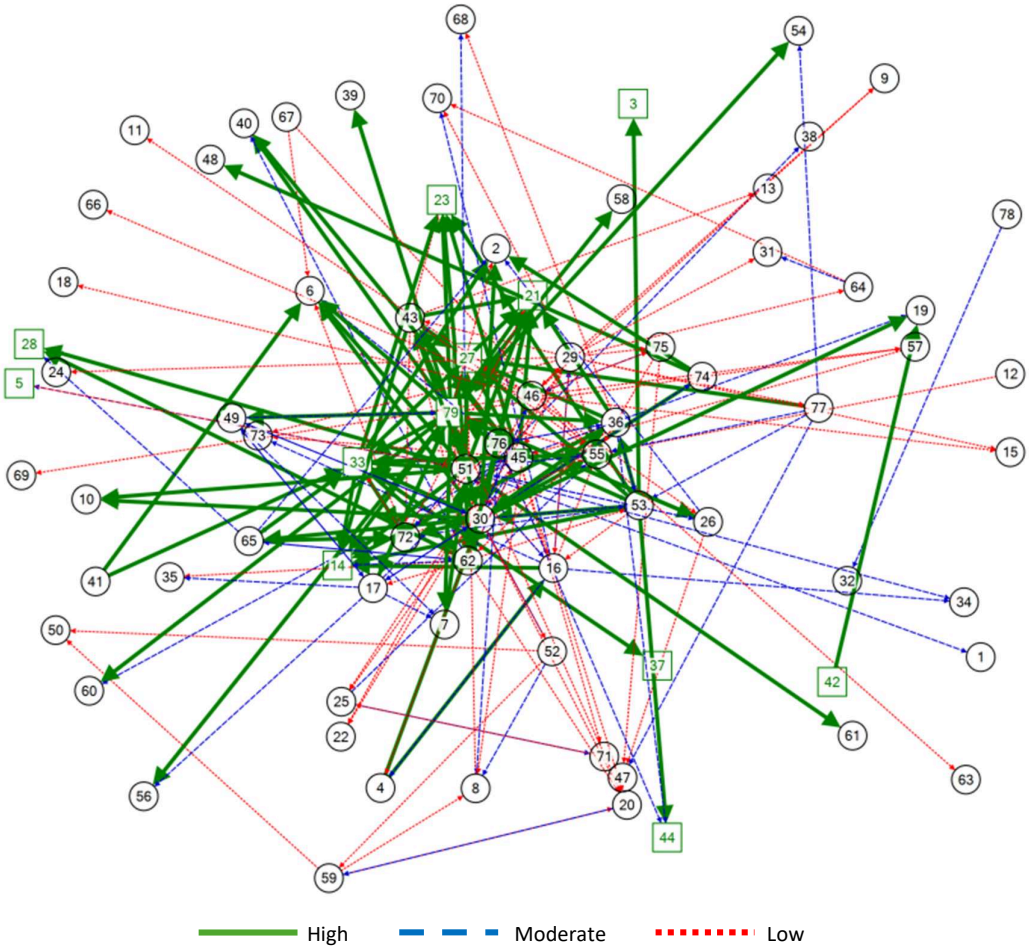


Source: NZIER

Figure 10 adds an additional layer to the analysis of data on considerations of Vision Mātauranga. It has the same connections between the nodes as Figure 9, but now the nodes indicate whether the person identifies as Māori or has Māori whakapapa. In addition, the green lines indicating a high degree of consideration have been enlarged to highlight them. This presentation shows that Māori network members are highly engaged with Vision Mātauranga, such as nodes 28, 23 and 33. In addition, many of the lines indicating high consideration of Vision Mātauranga occur between non-Māori network

members. This result would tend to suggest that discussions about Vision Mātauranga are happening throughout the OLW network and not just with Māori participants.

Figure 10 Vision Mātauranga and Māori whakapapa



Source: NZIER

5.3.4 Centrality of network members

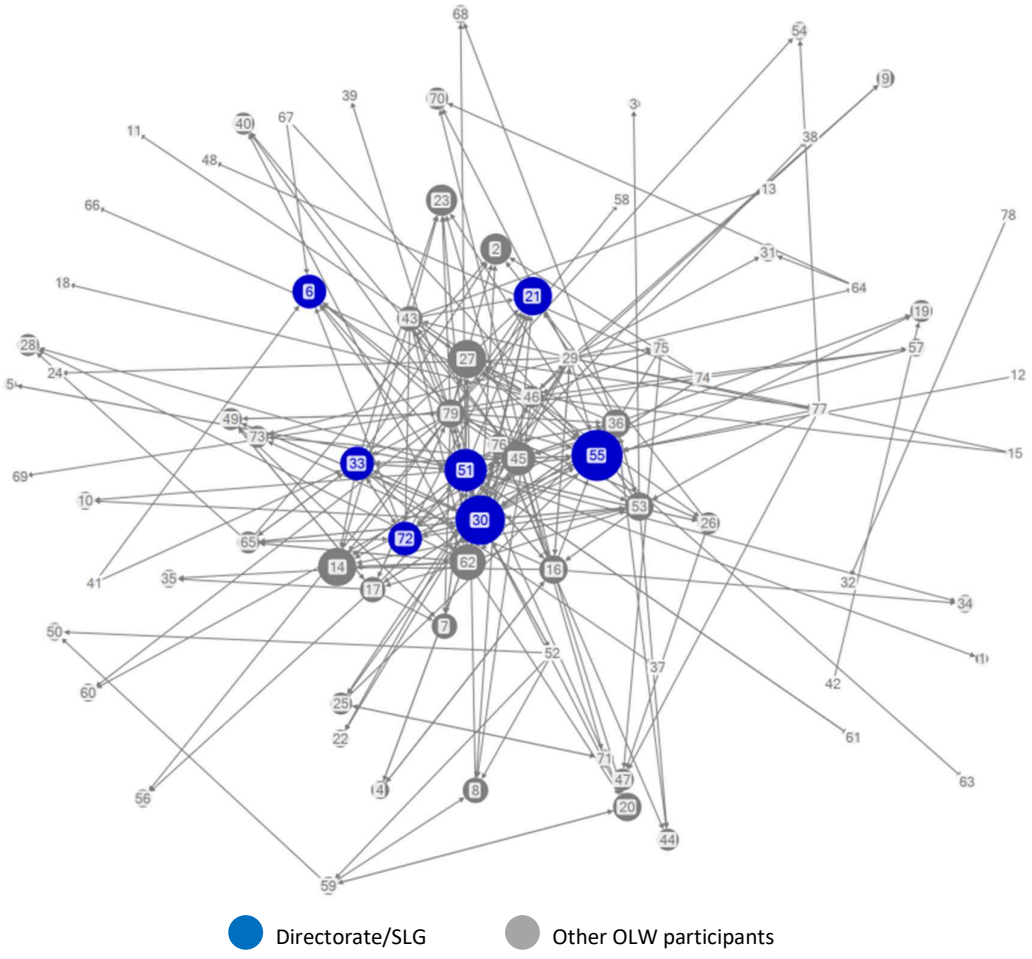
One metric produced by network analysis is centrality, which indicates the degree of connectedness of a person in a social network. The layout algorithm used here positions nodes according to their centrality, but centrality can also be measured by the number of connections that a node has. The network described here is a directed network, so there are both in-degrees and out-degrees of connectedness. As Payne & Small (2016, p. 33) explained:

> *In-degrees are* the number of network members that report communicating with a given member*, that is, in-coming connections. Out-degrees are* the number of network members that a given member reports communicating with*, that is, out-going connections.*

Figure 11 displays the in-degrees of the 79 members of the network we have been analysing. These are the number of times that respondents to the survey indicated a relationship with that person or node. In Figure 11, members who are part of the Directorate & SLG are shown as blue disks, and other members are shown as grey disks. The disks sizes have been scaled to the numbers of in-degrees, providing a visual indication of the centrality of members. Two details are apparent. First, not all of the largest disks belong to the Directorate & SLG. Some large disks – indicating relatively central members – are members of programme teams. Examples are nodes 27, 45 and 14. Second, there are multiple large disks, both for the Directorate & SLG and for other members. This result suggests a network that is not organised around a single centre, but instead has a more distributed character.

It is difficult to compare this graph with the result from Payne & Small (2016), due to the way the roles of members were displayed. However, by inspection there appears to be somewhat less focus on the Directorate & SLG and somewhat more centrality by other members. The distribution of the size of centrality scores is relatively similar.

Figure 11 In-degrees of OLW network members

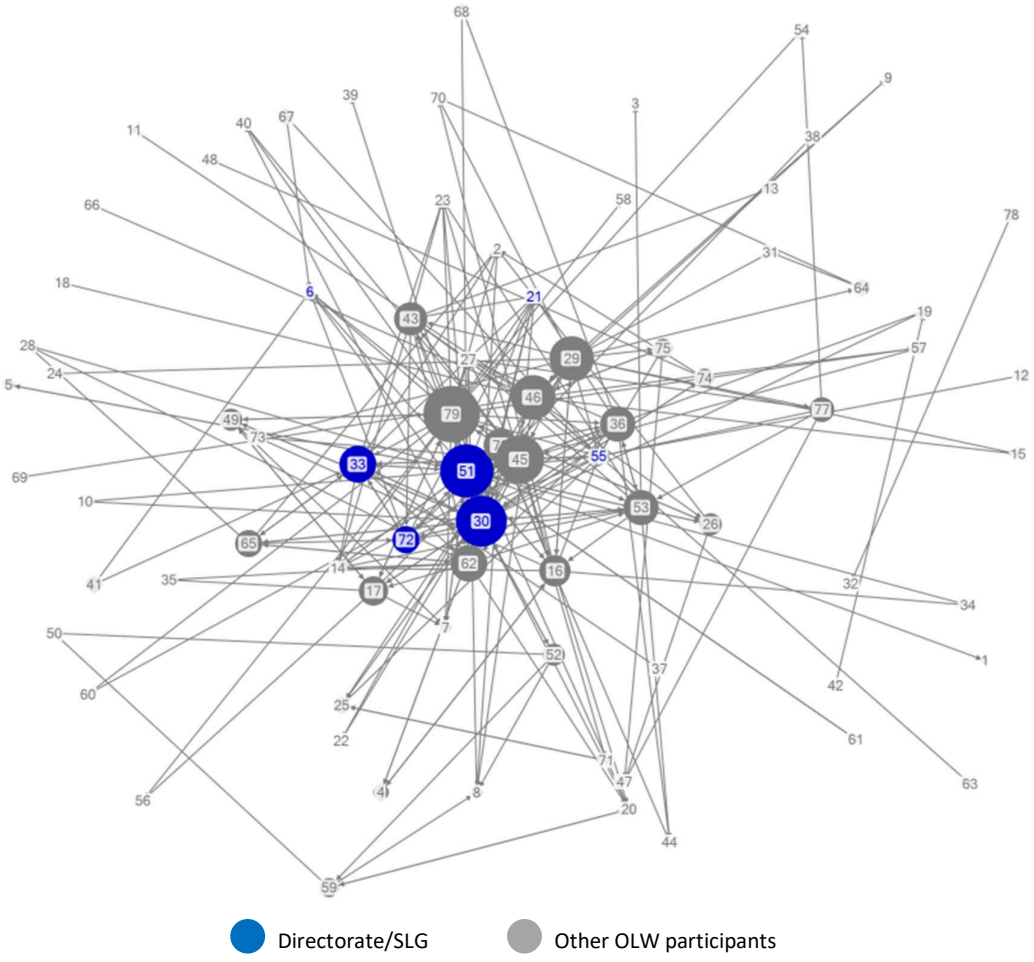


Source: NZIER

Figure 12 presents the results of an assessment of out-degrees for members in the network. Out-degrees indicate the number of members with whom respondents indicated a regular connection. **Importantly, if a network member did not complete the survey, they do not have out-degrees in the network graph.**

The network graph is somewhat similar to Figure 11. Out-degrees are clustered at the core and nearly absent at the periphery. In general, in-degrees and out-degrees correlate for those members who have both types of connections; the correlation coefficient is 0.693, which is highly significant. The same observations apply to the out-degree graph as the in-degree graph. There are multiple people with large numbers of connections, and those people are both in the Directorate & SLG and in the wider network of OLW participants.

Figure 12 Out-degrees of OLW network members



Source: NZIER

5.3.5 Network metrics

Network graphs generate several metrics. A few of them are presented here for the OLW network graph. As noted by Payne & Small (2016), these metrics are most interesting as an indicator of how OLW has changed over time. The metrics suggest that the OLW network has become less concentrated and dense between Phase 1 and Phase 2:

- The average number of connections for each member has decreased from 12 to 6.4.
- The total connections per member has decreased from 438 to 254.
- The average path length has increased from 2.2 to 2.6, so members are farther from each other in the network.
- The graph density has decreased from 0.083 to 0.041, so network members are less connected.

Table 16 Key SNA metrics for OLW network graphs

Including comparison to prior results

Metric	Description	2016 report	2024 report
Average degree	The average number of nodes/vertices to which a node/vertex is connected	12	6.4
Nodes/vertices	The number of members of a network	73	79
Edges/connections	The number of links between nodes	438	254
Network diameter	The longest distance between two nodes, measured in number of connections	5	5
Average path length/distance	The average number of connections between any two nodes	2.2	2.6
Graph density	The actual number of connections divided by the possible number of connections in a network	0.083	0.041

Source: NZIER, Payne & Small (2016)

5.3.6 Key network members

The local centrality of network members can be measured by the number of degrees for each node, where the number of degrees is the sum of in-degrees and out-degrees. Table 17 provides some information about the network members with the highest local centrality. A key caveat is that one of these members did not record any out-degrees, which has the effect of understating the overall centrality. The results suggest once again that there are several members with high centrality (and several members with moderate centrality), and that these network members are both from the Directorate & SLG and from other parts of the Challenge. Two of the twelve members in Table 17 identify as Māori, which is approximately proportional to the entire network. There are more females than males – a ratio of 8:4 – which is marginally significantly different to the overall composition of the network.[1]

[1] The network contains 34 females and 45 males and the 12 members with the highest centrality include 8 females and 4 males. The expected ratio for 12 people is 5.2:6.8. $\chi^2 = 2.73$, df = 1, pr = 0.0983.

Table 17 Centrality of selected network members

Members with highest degree counts

Node/vertex number	Degree (local centrality)	Theme/role	Māori whakapapa	Gender
30	36	Directorate/SLG	No	M
51	34	Directorate/SLG	No	F
79	31	Future Landscapes	Yes	F
45	26	Future Landscapes	No	F
46	19	Incentives for Change	No	F
62	19	Pathways to Transition	No	M
29	18	Pathways to Transition	No	F
33	18	Directorate/SLG	Yes	F
55*	16	Directorate/SLG	No	M
36	15	Incentives for Change	No	F
53	15	Incentives for Change	No	M
72	13	Directorate/SLG	No	F

Source: NZIER

* Network member who did not participate in the SNA survey.

5.4 Discussion of the SNA

The OLW network developed here appears to be good in several respects:

- There is a single network and not a collection of subnetworks. For each aspect of the network examined, the results indicated that the attribute or rating was distributed throughout the network. The Challenge in Phase 2 does not appear to have created silos; quite the opposite, it has developed linkages across programmes and Themes.
- The key nodes in the networks have two main strengths. There are several members at each level of connectedness, including among the most connected. This result indicates a network that is not organised around a central node and is not subject to key person risk. In addition, the well-connected nodes are both inside the formal central organisation of the Challenge – the Directorate & SLG – and in the wider Challenge programmes and projects. This result suggests, again, that the Challenge is not centrally or hierarchically organised but has supported the development of multiple connections of connections. It may also suggest that the Challenge has developed capability in the wider group of participants, which would bode well for future research.
- The approach of the Challenge in Phase 2 emphasised interdisciplinarity and support for Māori research and researchers. The network graphs suggest that many interdisciplinary connections have been made and that they are generally considered strong by network members. The analysis also suggests that discussions about Vision Mātauranga and mātauranga Māori are happening through the Challenge, and they are not just happening with Māori researchers and other participants.

The analysis suggests some differences from the prior work. Although the two network graphs have nearly the same number of members or nodes, the more recent network has fewer connections and the network is less dense. One likely reason for that result is that the total number of participants in the Challenge grew greatly from Phase 1 to Phase 2. The 79 members in the current network represent a smaller proportion of the overall Challenge participation, so they are likely to be less well connected. The less-dense network could be considered an indicator that the Challenge did open up to more people and wider participation.

The other significant differences is in the entity or organisation for the network members. In the Phase 1 network, nearly everyone was from a CRI or university. In the Phase 2 network, there is a large proportion of researchers from private research organisations, and there is more participation by people from stakeholder groups such as industry and iwi. The results suggest, again, that the Challenge opened up to wider participation in Phase 2. As part of that opening up, the Challenge also appears to have gone through a sort of renewal of its network. The data are confidential, but we can share that of the 73 members of the 2016 network and 79 members of the 2024 network, there are only 14 people in common. Despite this considerable change in the people involved, the Phase 2 network still showed considerable connectedness and the same network diameter as the earlier network.

There are limitations to this analysis. First, the network was partly dictated by the research team when it selected the 108 potential members. Respondents did not have the opportunity to suggest other names for the network, so this network may not represent their perspectives of their networks. Second, the responses did not generate connections for all 108 potential members, but only for 79. As a result, the size of the 2024 network was the same as the 2016 network, but it was less complete. Third, a few key people (members with high in-degrees) did not complete the survey. The analysis therefore did not have their out-degrees or their perspectives on the network and the issues covered here.

These limitations aside, the analysis provides some evidence that the Challenge was successful in what it set out to do in Phase 2: it created strong relationships among researchers and other participants in the Challenge, where people shared interdisciplinary knowledge and gave consideration to mātauranga Māori. It opened to a wider group of participants and included them in its network.

6 Discussion of the assessment results

6.1 Introduction to the discussion

This assessment project was an opportunity to explore Phase 2 of Our Land and Water and reflect on the changes made in the Challenge. The project focused on two interrelated research topics concerning Phase 2:

1 The extent of the uptake of the te Taiao conceptual model by, and its impacts on, institutions, research, researchers, and stakeholders.

2 The effect of emphasising relationships in Te Taiao on the impacts produced by the Challenge on the food and fibre sector, that is, the impact of the framework on the Challenge mission.

We investigated these topics with three approaches:

- Interviews with key informants, analysed as qualitative data
- Administrative data from both phases, analysed with quantitative techniques
- Responses to a survey of key people in the Challenge, assessed with social network analysis tools.

To explore the results, we adopt the same four themes as above: empowering Māori people, knowledge and resources, and the connection with mission-oriented innovation systems.

6.2 Empowering Māori people

The literature on empowering Māori people discussed several key topics: leadership and decision-making, co-development, aronga takirua (the second shift) and community resourcing. We found evidence related to these themes.

The interviews provided evidence that respondents found that the Challenge had increased the amount of Māori leadership and that this increase was important for Phase 2. Both Māori and non-Māori drew attention to the importance of having Māori people in ledership positions in the Challenge. There was even the idea that Māori leadership could be transformational for the Challenge and its science. The analysis of administrative data found that Māori participation in Challenge research increased from Phase 1 to Phase 2, which seemed to be driven more by the overall amount of research conducted rather than changes to research teams at the programme level. In another finding, having a Māori lead was associated with having more FTE for Māori researchers and other programme participants. Finally, the network analysis suggested that Māori were involved throughout the core of the Challenge in Phase 2, whereas the Phase 1 work suggested that one Māori-led programme was related to its own cluster within the wider network.

Māori leadership was seen as potentially transformational for the Challenge and its science

Empowering Māori people is also about empowering the communities they come from and that support them. In the interview, we heard how building a trust network is long-term work and requires time and other resources. The administrative data from Phase 2 showed that the Challenge did have more people involved with more FTE, including Māori from private research organisations and other entities. These results suggest a shift toward providing resources for Māori communities as part of their participation in the research. The network analysis provided a similar picture to the administrative data: Māori people from different types of entities as part of the Challenge network.

6.3 Empowering Māori knowledge

Empowering Māori knowledge includes ensuring that Mātauranga Māori contributes to the entire research process, from conceptions through research work to communication. Importantly, projects related to Māori should be framed mainly through Māori knowledge.

One theme in the interviews was about Māori knowledge and metaphors. The idea was that the metaphors used in Mātauranga Māori and Western science are different. The informants reported that the metaphors used by Māori had become part of the Challenge. The results suggest a broadening of the language used in the Challenge, suggesting greater inclusion and diversity. In particular, the Te Taiao model was used to direct the Challenge and did serve as a guide for research planning.

The network analysis suggests that Māori knowledge was being circulated widely in the Challenge. We asked about whether people discussed Mātauranga Māori and to what extent. The network results showed that there was a considerable circulation of Mātauranga Māori in the pairs of people making up the network. In addition, these pairs included only Māori, only non-Māori, and mixed pairs of Challenge participants. This result suggests that ideas of Māori knowledge were contributing to all parts of the Challenges.

6.4 Empowering Māori resources

Empowering Māori resources has several elements: communications and engagement, intellectual property and benefit sharing from research, and alignment with community aspirations. The interviews suggested that OLW did shift resources in the Challenges toward empowering Māori resources. Informants spoke of the change in the people involved to include more from Māori communities, thereby providing a mechanism for improving alignment with those communities. They also talked about a change in the theoretical approach and the mix of people involved, which had implication on the communication about the Challenge and engagement with Māori communities and land stewards.

The data analysis and the network analysis both support this view of Phase 2. There is a wider range of people and entities involved in, and being paid from, the Challenge. This had the effect of channeling more resources into Māori entities and to Māori participants, supporting communication and engagement with them. Their participation throughout the Challenge – shown in the network analysis – also indicates that Māori participants were in a position to ensure that benefits were directed to their communities in a way that aligned with their aspirations.

6.5 Implications for MOIS

One of the distinguishing features of mission-led or mission-oriented science is the mission. It provides direction to the research and researchers and a rationale for supporting certain projects. The interviews recorded both support for the way Phase 2 developed but also concern. There was support for increasing Māori leadership and using the Te Taiao model as an organising framework, and these actions were seen as improving the ability of the Challenge to move in a direction that benefited a wide range of stakeholders. However, the question of who makes decisions was still raised – researchers, communities, funders, end-users? This disquiet is also notable because the Challenge did broader participation per the administrative date and did create more diverse groups per the network analysis. Fielke, et al. (2023) raised the issue of how to achieve socially desirable outcomes, and the interviews suggested that Phase 2 achieved them to some extent. However, the question still appeared to be contested in the interviews. This lack of resolution is important, because a key problem in MOIS is defining the mission (Klerkx et al., 2022; Larsson, 2022).

Another feature of large MOIS is multiple and varied investments including interdisciplinary research teams, so that research is not confined to silos but instead considers many options

for achieving the mission (Mazzucato, 2022). A MOIS is part of a trend in research toward integrative research (Bammer, 2013) engaged with communities and other users of research (Robson-Williams et al., 2018, 2021; Sinner et al., 2022). The administrative data and the network analysis both show clear changes in that direction from Phase 1 to Phase 2. There is a lower proportion of participants from traditional research organisations such as universities and CRIs, and more participants from other types of entities, including private research organisation, iwi entities, and other stakeholders and end-users. These collaborative research programmes with multiple partnerships are expected to produce greater uptake and impact of the research (Botha et al., 2014; Mazzucato, 2018, 2022; Sinner et al., 2022; Turner et al., 2016).

This assessment also gives an idea of the cost of large, diverse, multi-disciplinary, multi-stakeholder research teams. Just in dollar terms, the amount spent on the research programmes in Phase 2 was larger than Phase 1. In addition, Phase 2 had produced fewer of the standard research outputs per FTE and per dollar than Phase 1 as of the time of the analysis. The reasons have not been fully explored in this research, but interview evidence suggested that building relationships and networks among the teams and with communities and end-users required significant time. In addition, in Phase 2 there was more focus on working in interdisciplinary teams and with end-users, as opposed to producing journal articles. This finding raises an important question about the performance indicators used to evaluate research. To the extent that new methods of doing science still have to meet metrics from older approaches, they will appear deficient. At a system level, this is the same problem that Māori researchers encounter on an individual level: aronga takirua (the second shift). The challenge is establishing and accepting new metrics of performance success that are relevant to the outcomes being sought. In particular, we found that the metrics recorded in the administrative data were largely held over from Phase 1, and did not match the aspirations of the Te Taiao model or Phase 2.

A final point about MOIS is the discussion over short-term versus long-term funding. Short-term funding allows for greater flexibility and adaptation, and even just a larger number of projects with potentially more participants and more inclusion. At the mission level, it allows for better fast-failure and thereby more risk-taking. Long-term funding can be about supporting science teams to focus on difficult problems, and providing scientists with career pathways. It is also about supporting the relationships with the wider community so that MOIS stays connected to the communities it is supposed to benefit. Community resourcing is required to empower Māori people, and requires a trust network built up over time. At the level of individual, it allows for greater risk-taking by researchers (and others) because funding is less tied to showing immediate proof of success. Both types of funding have their benefits. One approach in another Challenge was to pair long-term funding for researchers with short-term changes in research topics (Davenport, 2019), providing both support and flexibility. This assessment project did find a shift from Phase 1 to Phase 2: the administrative data found that projects were on average shorter, and the network analysis found a wider variety of people from more types of entities. However, what the network analysis did not investigate was the amount of social and relationship capital that individuals brought to the Challenge, and whether that capital was enhanced or depleted by their work in OLW. The interviews suggested that, at least with Māori stakeholders, the relationships and network they brought were substantial, and the net impact on those networks was positive.

6.6 Policy implications

The research results suggest several implications for policy:

- First, the intentional shift in Phase 2 towards co-development with a more diverse group of stakeholders, organised according to a framework from te ao Māori, did work. The Challenge was more diverse, did support a wider range of people and research, did incorporate more community members, industry representatives, iwi members, and other stakeholders. This finding suggests that there is more than one way to 'do' research, and science organisation can make choices about how they engage with communities and stakeholders, and whom they include in their science.
- Mātauranga Māori was more widely distributed throughout the Challenge and became part of the discussions among researchers, including among non-Māori researchers. The changes provided more space in the Challenge for Māori researchers to do more of the work they wanted to do. From a policy perspective, putting Māori values at the core of the Challenge was good for supporting inclusive, interdisciplinary, collaborative research. This is exactly the sort of research that mission-oriented innovation systems are expected to support, and that are expected to be good for producing science with impact.
- Phase 2 had fewer outputs of the type that are typically valued by academic organisations and measured by bibliometrics typically used by bureaucracies. It was less efficient at producing journal articles, conference papers and reports. These types of academic publications are considered less important as indicators of project quality for transdisciplinary research (M. Kaiser & Gluckman, 2023). Phase 2 produced more of other things: relationships with communities, co-developped research, and research led by rural professional focused on impacts. However, these other things were not measured because there was no requirement to do so. For science policy-makers, it will be important in the future to be clear about the impacts and outputs being sought, and to create metrics and gather data that pertain to those impacts and ouputs.

Science policy-makers must be clear about the impacts and outputs they seek, and support metrics relevant to those impacts and ouputs.

- The comparison of Phase 1 and Phase 2 also showed that creating inclusive, interdisciplinary collaborative teams and including wider stakeholder participation requires resources. There must be budget available to pay people to participate and support people to develop the relationships of trust required to do good work. For policy, that means understanding the full cost of the research being requested, including costs to communities.
- Particularly in Phase 2, private research organisations were an important part of OLW and they were at least as productive as universities and CRI. The 2022 white paper on the refresh of the New Zealand science system (Ministry of Business, Innovation & Employment, 2022) focused on universities and CRIs and did not provide much guidance on the future role of private research organisations. Policy will need to consider the important role of private research organisations, independent

researchers, and community-based researchers in the country's science system, particularly if it is to have regard for mātauranga Māori and the communities that preserve that taonga.

- Mission-led and mission-oriented science and research can be both flexible and goal-oriented. This research suggests that the people involved, especially the decisions made by the leaders of the Challenge, can make the difference in how questions of inclusivity, power, decision-making and resource-sharing are resolved. These are questions that do not appear to be answered in the literature, nor has the experience of Our Land and Water permanently resolved them. Instead, they are addressed collectively over time with trust and aroha among people who are focused on supporting science and mātauranga.
- The next step would be to assess whether the impacts on inputs, outputs and the research process had follow-on impacts on the food and fibre sectors – whether the changes in the Challenge helped it better achieve its vision for a future where catchments contain mosaics of land uses that are more resilient, healthy, and prosperous than today.

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Appendix A Interview questions

A.1 Changes over time (individual journey and reflections)

1 Referring to the Our Land and Water Timeline, tell me about your own role or participation in Our Land and Water during the different phases of the Challenge?

2 Again using the Timeline as a guide, talk through your experience of being involved in the Challenge – highlights, low lights, frustrations, and anything you've learnt.

3 I'm going to mention some key concepts associated with the Challenge, and I'd like you to reflect on your understanding and practice related these concepts, and how this might have changed over the time period of the Challenge:

- Transdisciplinarity
- Co-innovation
- Collaboration
- Interdisciplinary Knowledge Exchange
- Vision Mātauranga
- Mission-led research
- Te Taiao
- Tiriti-led Partnership
- Te Ao Māori

A.2 Te Taiao Model

4 In 2020 the Challenge introduced the Te Taiao conceptual model and new ways of working with Māori (refer to the model https://ourlandandwater.nz/news/why-te-taiao-matters-and-the-supporting-role-of-our-research/

a Please talk through how the concepts in this model and the commitment to effectively partner with Māori may have influenced your practice (research, leadership, governance) and outcomes/outputs of research that you have been involved in.
[Prompts: relationships (transactional versus relational); approaches to working]

b What's different about this from business as usual? If there is none or very little difference can you explain why?

c What has been the role of Te Taiao framework (and Our Land and Water?) in influencing thinking amongst you and your team?

d How has the OLW Te Taiao Conceptual Model helped or hindered you to work with Māori people, knowledge and resources in your project(s)?

A.3 Impact of the Challenge

5 Reflecting on your own experiences how has research from the Challenge led to different types of outputs, outcomes, and impacts than might have otherwise been the case? What are some of the factors that you think have enabled (or disabled) this?

6 Thinking about the Challenge as a whole, and some of the concepts that we've discussed, what do you think are some of the changes that have occurred in how research is conducted?

7 Thinking about the Challenge as a whole, what aspects of the Challenge [tools, policies and processes, roles and capabilities, etc.] enabled you to effectively partner with Māori, and/or deliver outcomes that were identified as useful for Māori and equally, what aspects created barriers to working with Māori?