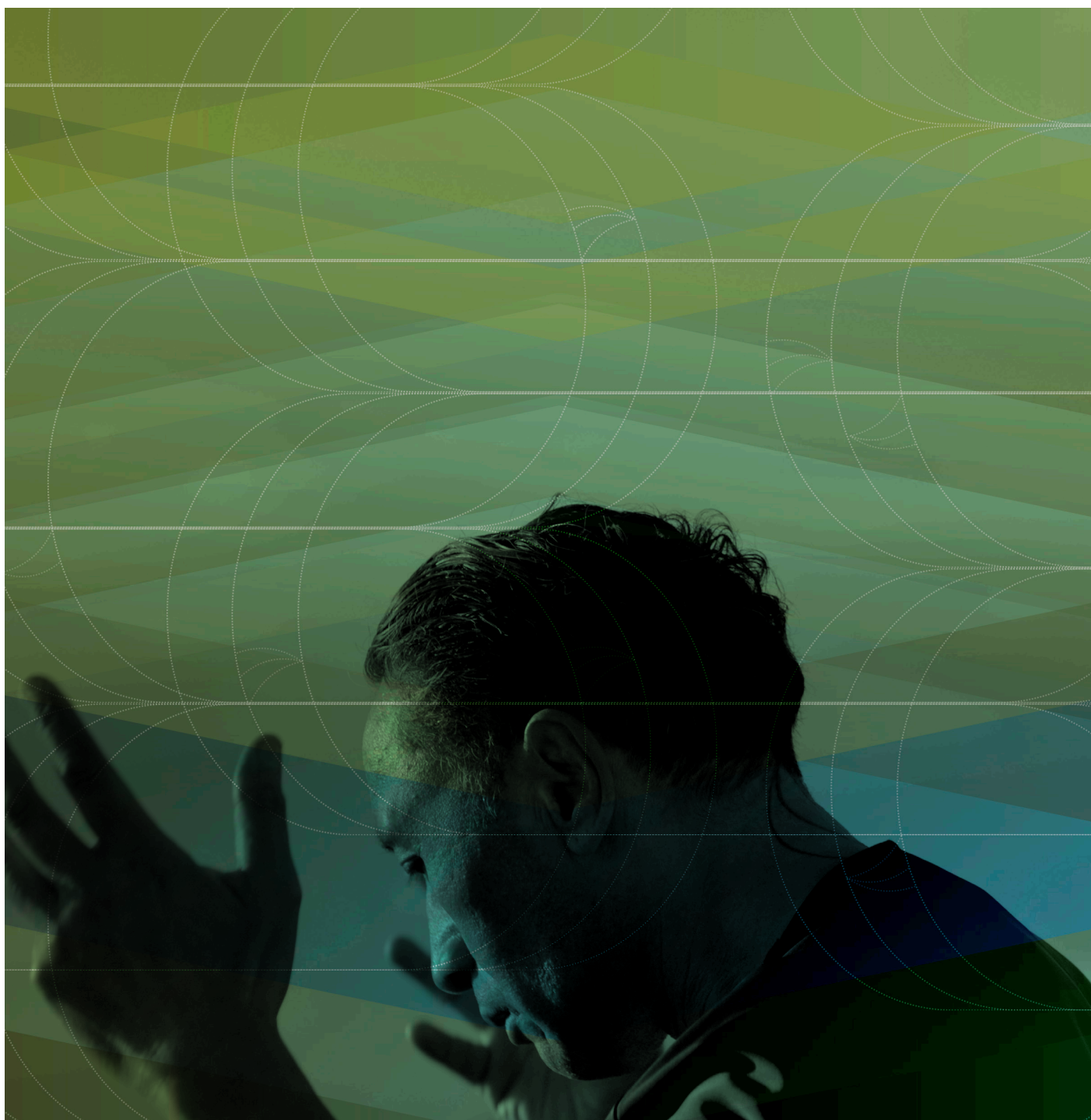# Kaitiaki Intelligence Platforms

John Reid
Matthew Rout

Determining environmental intelligence needs of Māori Agribusiness Collectives (MACs) and iwi to inform the design of a Kaitiaki Intelligence Platform

The Kaitiaki Intelligence Platforms (KIPs) project aims to position Māori at the forefront of cutting-edge remote environmental sensing in Aotearoa.

Leveraging the latest and emerging technologies, this project is designing a robust tech platform that will empower iwi to access real-time and precise information about the environmental condition of their rohe (territories). Furthermore, it will equip Māori farming collectives with the essential data to confidently manage their farms in alignment with their kaitiaki principles. Additionally, the platform will facilitate Māori farms in verifying their sustainable production to markets, regulators, and assurance bodies. Simultaneously, it will provide invaluable data to iwi for informed decision-making regarding their environmental management plans and policies.

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Introduction

The purpose of the Kaitiaki Intelligence Platforms (KIPs) project is to position Māori as first movers in environmental intelligence. Environmental sensing technology is advancing rapidly, offering significant opportunities for Māori agribusiness collectives (MACs) and iwi to develop and deploy environmental sensor networks that provide continuous and comprehensive environmental data. Māori have a strong history of rapidly adopting and incorporating new technologies into their culture, whilst still retaining core values. In fact, mātauranga Māori can be used to shape how this technology develops and how it is applied to deliver on core cultural values. As part of this knowledge system, Māori have their own methods and techniques for environmental sensing and monitoring based on long-standing relationships and experiences of place. Furthermore, mātauranga provides a set of Māori environmental ethics, which are being used in Aotearoa New Zealand (A-NZ) to guide Māori commercial agricultural operations and regional land governance through treaty partnerships with regional councils.

Māori farming collectives are continually seeking better quality environmental intelligence to guide their farming operations, while iwi are seeking this intelligence to guide their environmental management plans and respond to resource management demands from councils. The KIPs programme is reviewing the various technologies, and designing a sensor network, that can generate the environmental monitoring and intelligence that these Māori authorities are seeking. However, to appropriately design a sensor network it is necessary to know the types of environmental information Māori authorities desire and how this intelligence should be framed and communicated. The purpose of this report is to bring together the relevant literature to identify the environmental intelligence needs of Māori authorities, which

will inform the design of a sensor network - the Kaitiaki Intelligence Platform.

The report is divided into four sections. The first section provides a brief history regarding the evolution of MACs and iwi authorities to contextualise and explain their current environmental sensing needs. The second section also draws on literature to explicate the underpinning knowledge structure, or ontology, of Māori environmental ethics. It explains how Māori are primarily concerned with maintaining and growing the mauri (life-supporting capacity) and mana (dignity) of various atua (environmental domains). It draws the conclusion that an environmental sensing network should generate information that is organised and processed in a way that can reveal to MACs and iwi the current impacts of land management activity on atua, and whether their mauri and mana is being upheld. The third section reviews a range of Māori environmental frameworks (MEFs) as well as sections of Māori wellbeing frameworks (MWFs) that relate to the environment. This analysis demonstrates how the ontology underpinning Māori environmental ethics, explored in the previous section, is prevalent across MEFs and MWFs, and reveals the indicators and metrics being used in these frameworks, and how they are applied. Based on the review and analysis of the MACs and iwi strategic reporting frameworks, the fourth section identifies the common biophysical metrics used by these authorities to determine and measure environmental health. It needs to be noted that the analysis concentrates on biophysical metrics for which data can be gathered by sensor networks, however discussion on the importance and incorporation of qualitative metrics is also discussed. Finally, this section synthesises all of the analysis to reveal the biophysical environmental data Māori authorities desire, and how this intelligence should be framed and communicated using mātauranga Māori.

1

History of Māori Land Management and Agribusiness

Following the 'protein boom and bust' that characterised the first century of Māori inhabition in A-NZ, Māori recalibrated their land management practices to the new ecosystems in which they lived. Over the next 500 years, Māori managed their land using a relatively sophisticated set of resource user rights that were constrained by an overriding ethic of responsibility for these resources, as well as mechanisms for protecting resources when needed.[1] These user rights and responsibilities were scaled to suit the size of the social grouping, ensuring responsive and effective utilisation and management. Land management was driven by a sense of kinship with the ecosystem the social grouping lived within, it was founded on a belief in the subjecthood of everything within that ecosystem, and it was governed by a comprehensive yet flexible set of rules and behaviours.[2] This institutional framework also ensured that even while individual entrepreneurship was encouraged, redistribution of resources was prioritised, creating a strong safety net.[3] As well as hunting and gathering, Māori utilised horticulture where they could to supplement their needs. Colonisation sent shockwaves through this land management framework and the Māori

means of living off the land, though they were quick to adapt to new practices, species, and technologies.

The 1840s and 1850s were a golden era for the Māori economy in the early colonial period. In the 1840s Māori commerce accounted for roughly 95% of the gross national product of the country, with most of this centred on agribusiness.[4] Māori "were the key producers and suppliers of agricultural produce to the towns that began to spring up. They invested in agricultural implements, flour mills and coastal vessels, and produced, processed and transported produce to markets."[5] For example, in 1857 two iwi with a combined population of 8,000 had:

> [O]ver 3,000 acres in wheat, 3,000 acres in potatoes, nearly 2,000 acres in maize and over 1,000 acres in kūmara (sweet potatoes). Those figures suggest a rate of almost 1.125 acres per head under cultivation, compared with 0.915 acres per head by Europeans in 1870. Those tribes also owned nearly 2,000 horses, 200 head of cattle, 5,000 pigs, four water-powered flourmills, 96 ploughs, 43 ships averaging almost 20 tons each, and over 900 canoes.

Land loss, the Crown's failure to fulfil their obligations in the Sales Deeds, the Land Wars, the growth of the settler population and, consequently, settler economy were key factors in the end of this golden era. The loss of land, the fundamental resource for agribusiness, was particularly impactful. In 1860, Māori still owned about 80% of the North Island (most of the South Island was sold by the 1860s), by the 1890s they had around 40%, by 1910 it was down to 27%, and by 1939 it was reduced to 9%.[7]

The remaining percentage of land did not represent the relevant economic capacity. As Boast explains of the early 20th century, "[e]ven where Maori retained substantial areas of land, as in the East Coast, Hawke's Bay, and in the central North Island, they were hampered everywhere by a lack of access to development credit. Poverty, squalid housing and poor health were widespread."[8] Māori were left with small, often isolated and poor quality, parcels of land. Land held under the various types of Māori land titles, a special category with its own legislation and jurisdiction, was prone to title fragmentation as all children automatically succeeded their parents.[9] By the turn of the century, few Māori owned significant agribusiness endeavours beyond subsistence operations, most were employed as an economic underclass of labourers on their former lands.[10]

Over the 20th century, three collective governance structures specific to Māori land management would emerge. In the 1920s, Māori politician Apirana Ngata "wanted to lift Maori out of what he saw as a threatening rural poverty trap by turning them into modern farmers."[8] He envisioned Māori participating in the export economy while remaining on their land and maintaining their cultural autonomy. His Māori Land Development Scheme, established in 1929, targeted these goals by providing development finance and helping overcome the fragmented property titles that plagued Māori land by encouraging incorporation.[8] Incorporations are structured like a company, with a constitution and a Committee of Management elected by the land-owning shareholders.[11] In 1955, the Māori Trust Board Act was passed, creating another land management structure. Close to 60% of Māori land is now held in a Trust, with shareholders electing trustees to manage the block.[12] Most Māori land incorporations and trusts (MALITs) struggled to develop in the mid to late 20th century.[13] There are a number of reasons for this including: top-heavy governance structures; onerous reporting duties; numerous, diverse, and often distant shareholders; remote, suboptimal land; and trouble accessing finance, often caused

1. Rout, M., Spiller, C., Reid, J., Mika, J., & Haar, J. (2022). *Te Niho o te Taniwha: Exploring Present-Future Pathways for Whānau and Hapū in Māori Economies of Wellbeing*. Ngā Pae o te Māramatanga.

2. Rout, M., Awatere, S., Mika, J. P., Reid, J., & Roskruge, M. (2021). Te ao tūroa, te ao hurihuri, te ao mārama—the old world, a changing world, a world of light: A Māori approach to environmental economics. In *Oxford Encyclopaedia of Environmental Economics*. https://doi.org/10.1093/acrefore/9780199389414.013.715

3. Reid, J., Rout, M., Whitehead, J., and Katene, T.P. (2021). *Tauutuutu: White paper*. Our Land and Water National Science Challenge.

4. McCreanor, T., McManus, A., Moewaka Barnes, A., Rankine, J., Borell, B., and Nairn, R. (2011). Māori business news in mass media. *Sites, 8*(2), 32-56, 33.

5. Keane, B. (2010). Te Māori i te ohanga – Māori in the economy - Māori enterprise, 1840 to 1860. *Te Ara - the Encyclopedia of New Zealand*. http://www.TeAra.govt.nz/en/te-maori-i-te-ohanga-maori-in-the-economy/page-3

6. Petrie, H. (2015). Economic dysfunction or land grab? assaults on the 19th-century Māori economy and their native North American parallels. *AlterNative, 11*(3), 283-298, 286.

7. Ministry for Culture and Heritage. (2021). Māori land loss, 1860-2000. https://nzhistory.govt.nz/media/interactive/maori-land-1860-2000#:~:text=In%201860%20M%C4%81ori%20held%20about,been%20bought%20by%20the%20Crown

8. Boast, R. (2019). Re-Thinking Individualism: Maori Land Development Policy and the Law in the Age of Ngata (1920-1940). *Canterbury L. Rev., 25*, 1.

9. Kingi, T. (2008). Maori landownership and land management in New Zealand. Making Land Work, 2, 129-151.

10. Pool, D. I. (2015). Colonization and development in New Zealand between 1769 and 1900: The seeds of Rangiatea. Springer

11. McHugh, P. G. (1982). The economic development of native land: New Zealand & Canadian law compared. Sask. L. Rev., 47, 119.

12. Kingi, T. (2020). Cultural bastions, farm optimisation and tribal agriculture in Aotearoa (New Zealand). Proceedings of the 22nd International Grassland Congress. Retrieved https://www.grassland.org.nz/publications/nzgrassland_publication_2583.pdf

by collective ownership, low capitalisation, or discrimination.[14] Where MALITs were generally focused at whānau and hapū scale, the third form of collective structure was centred at iwi scale. These began to form in the 1980s after the Waitangi Tribunal's mandate was extended back to 1840, with the Crown preferring to negotiate with 'large natural groupings' – iwi – and requiring iwi to establish post-settlement governance entities (PSGEs) to receive their settlement. Similar to MALITs, PSGEs have both shareholders and an elected rūnanga providing governance, they have two key roles, representing iwi members and managing settlement assets. As well as receiving financial restitution, these PSGEs often received land and assets, including operating agribusinesses as part of their settlements. The PSGEs also re-obtained partial environmental governance rights over their territories in 1991, increasing their influence beyond the returned lands to cover their takiwā or rohe.[15]

MALITs and, in particular, PSGEs have a wide range of responsibilities and assets in a variety of industries, though both still maintain a strong presence in the primary sector, operating what might be termed Māori agribusiness collectives (MACs), which are a primary focus of the KIPs

project. MACs can be understood as the commercial agribusiness operations owned by MALITs and PSGEs on behalf of their collective shareholders. While no single dataset provides insight into the economic performance of MACs, very roughly 10-20% are high-performing, with around 40-50% identified as either underdeveloped or struggling.[16 17 18] Along with legislative changes that have facilitated this development, these high-performing MACs have often successfully:

· Amalgamated land parcels to establish scale;

· Built leadership, governance, and conflict resolution capabilities;

· Developed or accessed management and technical capabilities;

· Accessed processors and supply chains for niche and higher-value products;

· And used the above improvements as a precondition to obtain finance.

These high-performing MACs are successful agribusiness operations that are held in acclaim for their profitability, positive social impact, and strong environmental performance.[3,14] The underdeveloped and struggling MACs aspire to deliver economic outcomes but also to match this with social

impact and environmental performance.[18] Due to their collective ownership, MACs are required to operate according to te ao Māori, or the Māori worldview, which in practice sees them operating against a triple bottom line, balancing economic imperatives with social and environmental wellbeing. Because of this requirement, and the shareholders demands to have this verified, most MACs have Māori beliefs, values, and behaviours at the core of their strategic documentation, with a few also reporting on the status of their operations.[3]

Broader co-management and co-governance roles that PSGEs, and to a lesser degree MALITs, have gained across environmental and resource domains at local, regional, and national government scales have given these collectives a degree of responsibility over their takiwā or rohe and have been a key impetus in the development of a range of environmental monitoring frameworks. For example, the 1991 Resource Management Act (RMA) required local authorities and regional councils to consult with iwi, while conversely PSGEs were obligated to develop environmental management plans to guide this engagement and help them exercise their kaitiaki roles and responsibilities. Also, in the late 1990s, the Ministry for the Environment developed a 'three tier approach' regarding Māori input into the national environmental performance indicators.[19] The RMA is currently undergoing reforms that would see Māori roles expanded. Providing MALITs and PSGEs with a tool for broader land

management and monitoring is also a core goal of the KIPs project. MAC strategic decision-making and operations, as well as broader Māori resource management, are guided by te ao Māori and informed by mātauranga to which the report now turns.

> *... MACs are required to operate according to te ao Māori, or the Māori worldview, which in practice sees them operating against a triple bottom line, balancing economic imperatives with social and environmental wellbeing. Because of this requirement, and the shareholders demands to have this verified, most MACs have Māori beliefs, values, and behaviours at the core of their strategic documentation, with a few also reporting on the status of their operations.*

13. Ministry of Primary Industries. (2011). Māori agribusiness in New Zealand: A study of the Māori freehold land resource. Ministry of Agriculture and Forestry. https://www.waikatoregion.govt.nz/assets/WRC/Council/Policy-and-Plans/HR/S32/D/Ministry-of-Agriculture-and-Forestry-2011.-Maori-agribusiness-in-New-Zealand-A-study-of-the-Maori-freehold-land-resource.-Ministry-of-Agriculture-and-Forestry.-Wellington-New-Zealand.pdf

14. Rout, M., Reid, J., & Mika, J. (2020). Maori agribusinesses: The whakapapa network for success. AlterNative : An International Journal of Indigenous Peoples, 16(3), 193-201.

15. Kaiser, L. H., & Saunders, W. S. (2021). Vision Mātauranga research directions: opportunities for iwi and hapū management plans. Kōtuitui: New Zealand Journal of Social Sciences Online, 16(2), 371-383.

16. Ministry of Primary Industries. (2014). Māori agribusiness in New Zealand: A study of the Māori

freehold land resource. Wellington: Ministry of Agriculture and Forestry.

17. Reid, J., Rout, M., Gillies, A., Ruwhiu, D., & Awatere, S. (2018). The development of an indicator framework to measures enablers and constraints on Māori agribusiness. Christchurch: Ngāi Tahu Research Centre.

18. Reid, J., Rout, M., Gillies, A., Ruwhiu, D., & Awatere, S. (2018). Using an indicator matrix to determine correlations and relationships between Māori agribusiness value-drivers. Christchurch: Ngāi Tahu Research Centre.

19. Harmsworth, G.R., & Tipa, G. (2006). Māori environmental monitoring in New Zealand: Progress, concepts, and future direction. Landcare Research.
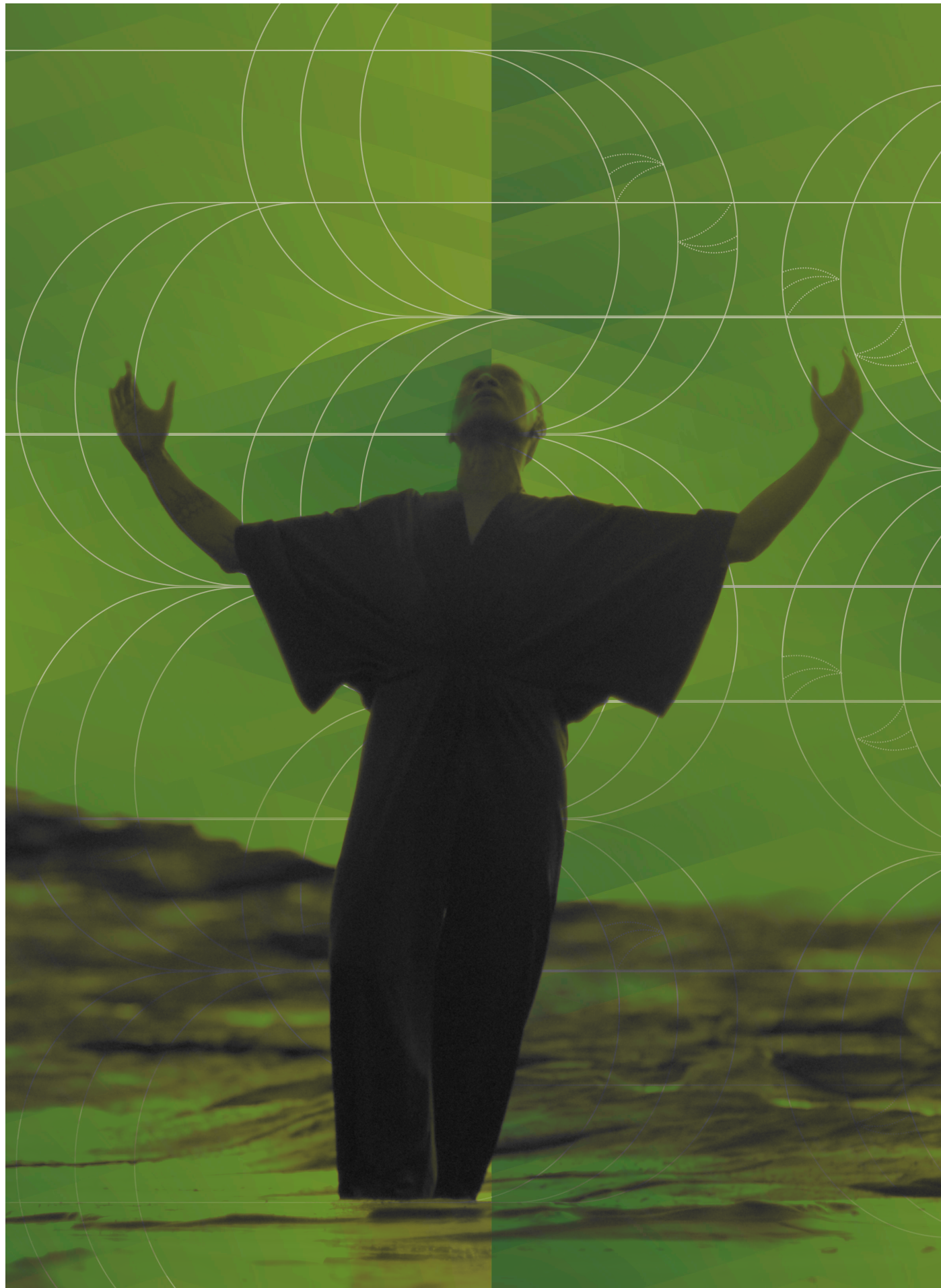
2

The mātauranga axioms of environmental ethics and monitoring

The underpinning mātauranga axioms that underpin Māori approaches to environmental ethics and monitoring are explored in this section. While there are many core concepts that could be explored, emphasis here has been placed on five core axioms: whakapapa and atua; utu, mauri, mana, and tapu.

Whakapapa and atua

Whakapapa is the key organising principle of te ao Māori – it is the "Māori view of reality." Whakapapa provides a genealogy that "links all animate and inanimate, known and unknown phenomena in the terrestrial and spiritual worlds." Whakapapa looks forward, binding an individual to future generations, both human and non-human, as well as past ones. This shared ancestry is traced back to the atua who are "the progenitors and personifications of all known phenomena, both living and non-living." These 'departmental gods' are super/natural primary ancestors who personify particular environmental domains. Māori do not see this 'cosmological family' in an undifferentiated way, akin to a human family. Rather, whakapapa is a complex genealogical narrative that identifies and classifies everything across creation and time.[20] It has been referred to by Māori academics as a 'mental/philosophical construct' and a 'taxonomic framework' because of this capacity to identify and classify.[21,22,23] Similarly, the atua "act as both spiritual and spatially defined signposts of the environmental realm or territory within which the information coded in the whakapapa is located."[24] As a taxonomic framework whakapapa provides information on the relational dynamics amongst people and it also contains insights about the natural world.[23] However, it also has a motivational component. Because Māori trace their ancestry to atua, and through them to the rest of the natural world, Māori also have a responsibility to care for these domains as well.

Utu

The understanding that all of reality is interconnected means that relationships are viewed as fundamental. The term utu refers to 'relationship balance' between different entities, and maintaining balance is a core principle of te ao Māori.[25] However, Māori also understand that life is an ongoing series of interactions and processes that means balance is never fully achieved but rather only

20. Te Rito, J. S. (2007). Whakapapa: A framework for understanding identity. *MAI Review LW, 1*(3), 10.

21. Taonui, R. (2011). Whakapapa – genealogy - What is whakapapa? *Te Ara - the Encyclopedia of New Zealand*, http://www.TeAra.govt.nz/en/whakapapa-genealogy/page-1

22. (Roberts et al. 2004, 3)

23. Te Rito (2007).

24. Roberts et al. 2004; Taonui, R. (2011); Roberts, M. (2013). Ways of seeing: Whakapapa. *Sites: a journal of social anthropology and cultural studies, 10*(1), 93-120.

25. Harmsworth, G. R., & Awatere, S. (2013). Indigenous Māori knowledge and perspectives of ecosystems. *Ecosystem services in New Zealand—conditions and trends* (pp. 274–286). Lincoln: Manaaki Whenua Press, 274.

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temporarily acquired. Acquiring balance is critical in all exchanges even if it is fleeting. The understanding then is that while balance is ideal, in the complex array of relationships – such as on a farm – the best that can be achieved is a positive trending dynamic imbalance.

Tauutuutu

Tauutuutu is the fundamental framework that guides Māori exchange. While it can be described as an 'economic' framework, the holistic nature of te ao Māori and the consequent intertwined spiritual, political, social, environmental, and economic domains means its scope is far broader than any Western understanding of economics. Tauutuutu informs all transactions amongst humans, and between humans and nature, and focuses on both instrumental and intrinsic value, making it the foundational guide for land management. It encourages an ongoing cycle of mutually beneficial reciprocal exchanges between humans, and between humans and the environment. All exchanges in te ao Māori carry an obligation to provide a return of equal or greater value with the aim of creating dynamic equilibrium, or an ongoing state of 'positive' imbalance – this positive imbalance within a network of relationships is tauutuutu in action. The framework of tauutuutu, can be outlined as escalating reciprocal exchanges that create and maintain social and environmental obligations and dynamic equilibrium. The way this works can be best understood by explaining the three core cosmic forces in te ao Māori.

Cosmic forces

There are three key atua-derived 'cosmic forces' that animate, empower, and consecrate reality, respectively: mauri, mana, and tapu. These provide the key 'unit of measure' for the indicators.

Mauri

When the actors in an exchange include the natural world, the main unit is mauri. Mauri animates all of reality, it is the life essence.[26] It is the innate ability of an organism or ecosystem to create and sustain life. Mauri has both tangible aspects, such as water quality, and intangible elements, as an intuitive sense of the health of a water body. All interactions either positively or negatively impact mauri. Māori are obliged to enhance, or at least not negatively impact, the mauri of the environment in their exchange with atua. Maintaining and growing mauri is the main driver of the Māori value of kaitiakitanga – whereby atua are respected.

Mana

When the actors in an exchange are human, the main unit is mana. Mana imbues people with power and prestige. While some sources of mana are fixed (from atua and ancestors), mana tangata, or personal mana, varies depending on the actions of an individual or their social group.[27] The mana of individuals and groups grows when they return an exchange at the same or greater value. Mana also grows with the ability to distribute rather than accumulate, which not only drives productivity and provides group security, but also encourages innovation and entrepreneurship as individuals seek to grow their personal mana.[28] Mana also manifests as two key Māori ethics, manaakitanga – fostering strong relationships through kinship and/or shared experience that provide a shared sense of wellbeing – and whanaungatanga – enhancing the mana of others, including the environment, through a process of showing proper care and respect.[29]

Tapu

Tapu is a different kind of unit, it also relates to human-nature exchanges but functions more as a way of identifying aspects of the cosmological family that are or need to be protected. While mauri and mana are granular, tapu is binary. Tapu "means sacred, holy, sanctified, pertaining to the gods", denoting the "intersection between the human and the divine."[30,31] A core component of tapu is the understanding that "the world is not ours." [32] Tapu teaches respect for all of nature.[32] A person, place, plant, or animal dedicated to an atua is removed from the sphere of the profane, known as noa, and put into the sphere of the sacred it becomes untouchable, no longer able to be put to common use. In practice, an area that needs protecting or has had its mauri depleted can be put under a rāhui, a particular type of tapu designed for resource protection.

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26. Reid, J., & Rout, M. (2018). Can sustainability auditing be indigenized? *Agriculture and Human Values, 35*(2), 283–294.

27. Gallagher, T. (2008). Tikanga Māori Pre-1840. *Te Kāhui Kura Māori 0*(1). https://nzetc.victoria.ac.nz/tm/scholarly/tei-Bid001Kahu-t1-g1-t1.html
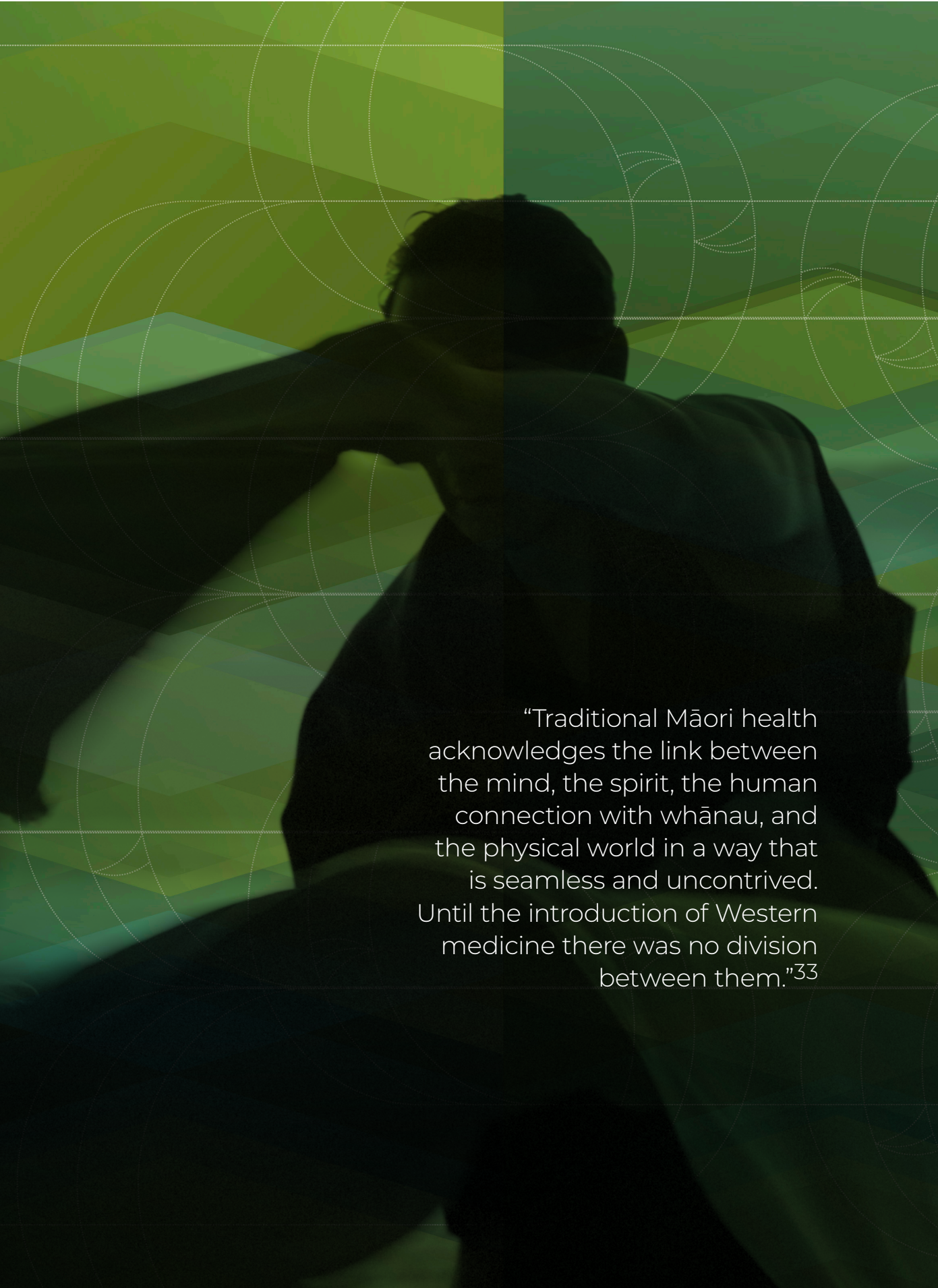
28. Metge, J. (2002). Returning the gift—Utu in intergroup relations: In memory of Sir Raymond Firth. *The Journal of the Polynesian Society, 111*(4), 311-338.

29. The Treasury. (2023). He Ara Waiora. Website accessed on 21 February 2024: https://www.treasury.govt.nz/information-and-services/nz-economy/higher-living-standards/he-ara-waiora

30. Buck, P. H. (1910). *Medicine amongst the Māoris, in ancient and modern times* (Doctoral dissertation, University of Otago), p. 21.

31. Benton, R., Frame, A., & Meredith, P. E. (Eds.). (2012). *Te Mātāpunenga: A compendium of references to the concepts and institutions of Māori customary law.* Hamilton: Te Matahauariki Research Institute, p. 404.

32. Patterson, J. (1994). Māori environmental virtues. *Environmental Ethics,* 16(4), 397–409, p. 402.

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Determining environmental intelligence needs of MACs and Iwi   13 to inform the design of a kaitiaki intelligence platform

> "Traditional Māori health acknowledges the link between the mind, the spirit, the human connection with whānau, and the physical world in a way that is seamless and uncontrived. Until the introduction of Western medicine there was no division between them."[33]

3

Māori Environmental Monitoring Frameworks

Many MEFs have been developed by Māori organisations, often in partnership with government entities, for broader catchment and regional scales as well as targeting specific species or ecosystems. These have largely emerged as a consequence of the growing role of Māori in environmental and resource management in conjunction with local, regional, and central governments. They have grown in prominence and scale over the last two decades experiencing widespread adoption.

At a broader level there has been a complementary growth in MWFs, which also have an environmental component given their holistic framing through whakapapa. As the explanation for Te Wheke, one of the earlier Māori MWFs, explains:

> "Traditional Māori health acknowledges the link between the mind, the spirit, the human connection with whānau, and the physical world in a way that is seamless and uncontrived. Until the introduction of Western medicine there was no division between them."[33]

Originally, these wellbeing frameworks were more oriented towards physical, mental, and spiritual health, though in recent years as wider interest in 'wellbeing' has grown these models have also expanded to include the environment.

Various MWFs and MEFs are reviewed and examined below. It needs to be noted that the review is not exhaustive and that emphasis has been placed on those that are most prominent and widely adopted. The general intent is to illustrate the core focus and intent of MWFs and MEFs. The frameworks are reviewed below according to the core mātauranga axioms underpinning their design. A summary outline of each framework is undertaken while specific details are covered within tables communicating the environmental domain/s they focus on (e.g., forests, land or water), their core objectives, and the indicators and metrics they use. Where there are too many metrics to list, the nature of the metrics is described. The tables will also note whether the framework has a reporting capacity, that is whether it is being used in environmental monitoring and reporting, and the geographical/environmental scale it has been designed for.

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33. Pere, R. (2023). Māori health models _ Te Where. Ministry of Health website, accessed on 25 February 2024: https://www.health.govt.nz/our-work/populations/maori-health/maori-health-models/maori-health-models-te-wheke armsworth & Tipa (2006).

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Whakapapa and atua

Understanding the natural world as the domains of the atua "permeates all aspects of communal life establishing a set of obligations and responsibilities to protect the life sustaining capacity of the environment to enable communities to flourish."[34] The 'cosmic taxonomy' provides a system for thinking about the entities that should be considered when monitoring environmental relationships. Firstly, whakapapa cosmology situates humans in a junior relationship to other non-human people, fundamentally acknowledging the human dependency on broader environmental systems, who are symbolically expressed as atua, the progenitors and personifications of all known phenomena. Secondly, whakapapa identifies the key atua that should be taken into consideration when monitoring relationships.

There have been several atua frameworks developed for a variety of different assessment purposes.[35] Recently, a ngā Atua kaitiaki framework has been produced which focuses on environmental assessment.[36] Their framework places the key domain of interest at the centre, with a periphery of related atua around this central domain, and then uses a set of mauri-based indicators to evaluate the impacts of an action or activity between entities. Five iwi, in collaboration with six councils and the Department of Conservation, have also developed an atua framework called "Te Aotūroa" to support their biodiversity strategy.[37] The Te Aotūroa framework they produced "is an explanation of the physical expression of attributes of the environment which are representative of a Māori cosmogony."[37] The Kauri Cultural Health Indicators Monitoring Framework is also based on "nga atua domains and other key attributes including", with a dominant focus on ngahere(forest)/Tāne Mahuta along with other the atua domains.[38]

> Understanding the natural world as the domains of the atua "permeates all aspects of communal life establishing a set of obligations and responsibilities to protect the life sustaining capacity of the environment to enable communities to flourish."[34]

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34 Forster, M. (2022). Amplifying the influence of Māori knowledge in environmental management. Environment and Planning F, 1-18, p. 7.

35 Rainforth, H. J.,& Harmsworth, G. R. (2019). Kaupapa Māori Freshwater Assessments: A summary of iwi and hapū-based tools, frameworks and methods for assessing freshwater environments. Perception Planning Ltd. 115 pp.

36 Walker, D. P., Ataria, J. M., Hughey, K. F., Park, P. T., & Katene, J. P. (2021). Environmental and spatial planning with ngā Atua kaitiaki: A mātauranga Māori framework. New Zealand Geographer, 77(2), 90-100.

37 KIC Ltd. (2015). Aotūroa Framework, Section 3: Te Tau Ihu Iwi Whakamahere Whakatu. http://www.nelson.govt.nz/assets/Environment/Downloads/Nelson-Plan/Nelson-Plan-Iwi-Aoturoa-Framework-Dec2015.pdf

38 Chetham, J., & Shortland, T. (2013). Kauri Cultural Health Indicators – Monitoring Framwork. https://www.cbd.int/financial/micro/newzealand-kci-monitoring.pdf

Key

Yes	🟢
Yes but subjective	🟡
No	🔴

Table 1: Whakapapa and atua

Framework	Domain	Objective	Indicator	Metric	Reporting	Scale
Ngā Atua kaitiaki Framework	All atua - specifically identified: Tāne Mahuta, Tūmatauenga, Rongomātāne, Haumiatiketike, Ruaumoko, Tangaroa, Tāwhirimātea	Originally assessing the wellbeing of indigenous forests, expanded to over wider geographical contexts including urban design and spatial planning	Not listed	Qualitative and quantitative mauri metrics	🔴	All scales
Kauri Cultural Health Indicators Monitoring Framework	Tāne Mahuta, Tāwhirimātea, Tamanuiterā, Tangaroa, Tūmatauenga	A framework to enable the use of cultural indicators in the surveillance and monitoring of Kauri Dieback	Indicators cover each atua domain	Qualitative and quantitative mauri metrics	🟡	Forest scale
Te Aotūroa Framework	Papatūānuku, Tāwhirimātea, Tangaroa, Rongomaraeroa, Tāne Mahuta, Haumiatiketike	A Māori framework to assist the Nelson City Council in their decision making in regards to the Whakamahere Whakatu-Nelson Management Plan. The Aotūroa framework is an explanation of the physical expression of attributes of the environment which are representative of a Māori cosmogony.	Not listed	Not listed	🔴	Regional scale - but with smaller scales incorporated

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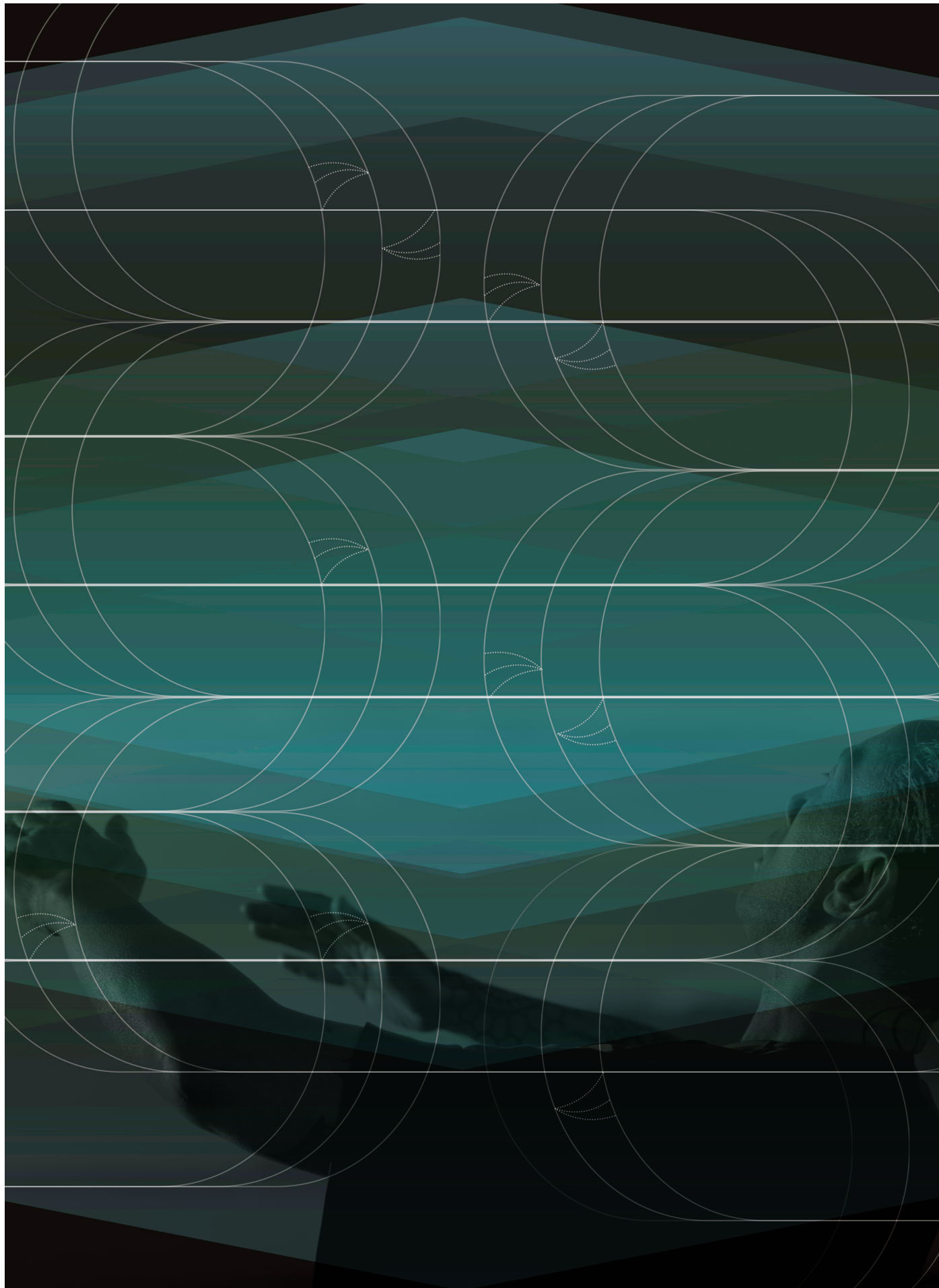
Mauri

Mauri is the most commonly utilised metric across MEFs, with numerous frameworks utilising this measure – and for this reason not every EMF using mauri will be covered here, but rather a selection that provides insight into the scope and scale. In keeping with the nature of mauri, the metrics are both objective and subjective, measuring everything from nutrient levels to the language or sound of a river.[39] The Cultural Health Index (CHI) was one of the first MEFs and has become widely incorporated into a number of other subsequent frameworks.[19] It was produced to assess the health and mauri of waterways using both quantitative and qualitative measures. The CHI was developed in partnership with a PSGE, Te Rūnanga o Ngāi Tahu, and has had uptake with many others. It is now recommended by the Ministry for the Environment and the data obtained is reported on by Statistics New Zealand.[40,41] The CHI was also used in the first rohe/takiwā scale MEF, the State of the Takiwa, developed by Ngāi Tahu to report on their Mountains to the Sea Natural Resource Management framework.

In past decades numerous MEFs for different ecosystems have been developed, including for forests, wetlands, and oceans – with at least ten focused on measuring the health of freshwater alone – while a number have been developed to monitor mahinga kai as well as taonga.[35,42]

The State of the Takiwā is a framework built on the CHI and focused on bringing knowledge from local scales and generating region-wide scores regarding cultural health of significant sites, natural resources and the environment within a rohe/takiwā.[43] Many subsequent MEFs built on the CHI. The Māori Land Use Opportunities Assessment (MLUOA) similarly uses mauri as its primary metric. However, it is largely concerned with offering a tool for decision makers to evaluate the land use investment options most likely to optimise mauri.[44] The Mauriora Systems Framework (MSF) offers a process for land governors to develop their own frameworks for monitoring the mauri of taonga. While the framework could be applied at farm scale, it does not have any

39. Bishop, C. (2019). A review of indicators used for 'cultural health' monitoring of freshwater and wetland ecosystems in New Zealand. Auckland Council discussion paper.

40. Ministry for the Environment. (2006). Using the Cultural Health Index: How to assess the health of streams and waterways. https://environment.govt.nz/publications/using-the-cultural-health-index-how-to-assess-the-health-of-streams-and-waterways/ ;

41. Statistics NZ. (2017). Cultural health index for freshwater bodies. https://www.stats.govt.nz/indicators/cultural-health-index-for-freshwater-bodies/

42. Awatere, S., & Harmsworth, G. (2014). Ngā Aroturukitanga tika mo ngā Kaitiaki: summary review of mātauranga Māori frameworks, approaches and culturally appropriate monitoring tools for management

of mahinga kai. Landcare Research contract report LC1774. Landcare Research, Hamilton, New Zealand. 45p.

43. Pauling, C., Lenihan, T., Rupene, M., Tirikatene-Nash, N & Couch, R. (2007). State of the Takiwā: Te Āhuatanga o Te Ihutai, Cultural Health Assessment of the Avon-Heathcote Estuary and its Catchment. https://api.ecan.govt.nz/TrimPublicAPI/documents/download/1862390#:~:text=State%20of%20the%20Takiw%C4%81%20is,R%C5%ABnanga%20o%20Ng%C4%81i%20Tahu%202003

44. Harcourt, N., Robson-Williams, M., & Tamepo, R. (2022). Supporting the design of useful and relevant holistic frameworks for land use opportunity assessment for indigenous people. Australasian Journal of Water Resources, 1-15.

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monitoring and reporting functionality but is rather focused on guiding decision-making.

The Mauri-o-meter offers a number of insights and useful indicators. It is a process-oriented framework that enables mātauranga-centred monitoring systems to be built at any scale, and for any environmental system.[45] Furthermore, the model attempts to measure mauri in four dimensions – environmental wellbeing (taiao mauri), cultural wellbeing (hapu mauri), social wellbeing (community mauri) and economic wellbeing (whānau mauri). The Mauri-o-meter enables both tangible scientific measures and intangible qualitative measures to be built into monitoring. While several MEFs have these intangible, subjective measures of mauri, such as He Waka Taurua and Mauri of the Waterways Kete, the Tūhoe Forest Framework best captures the full scope of mauri, including indicators that focus on the 'nature of the river' and the 'nature of the forest', with measures like the 'smell of rivers or streams', the 'language or sound of the forest' and the 'strength of inspiration, essential force or awe (ihi) felt within a forest'.[46] Similarly, the Wai Ora Wai Māori EMF has qualitative measures, including 'are the senses awakened at the mahinga kai?'[47]

Tapu teaches respect for all of nature. A person, place, plant, or animal dedicated to an atua is removed from the sphere of the profane, known as noa, and put into the sphere of the sacred it becomes untouchable, no longer able to be put to common use. In practice, an area that needs protecting or has had its mauri depleted can be put under a rāhui, a particular type of tapu designed for resource protection.

45. Morgan, T. K. K. B. (2006). Waiora and Cultural Identity: Water quality assessment using the Mauri Model, AlterNative, 3(1).

46. Lyver, P., Timoti, P., Jones, C. J., Richardson, S. J., Tahi, B. L., & Greenhalgh, S. (2017). An indigenous community-based monitoring system for assessing forest health in New Zealand. Biodiversity and Conservation, 26(13), 3183-3212.

47 Taura, Y., Reihana, K., Awatere, S., Harmsworth, G., & Forrest, E. (2018). Wai Ora Wai Maori – a kaupapa Maori assessment tool for Ngati Tahu-Ngati Whaoa. Report by Manaaki Whenua Landcare Research. https://static1.squarespace.com/static/643c7c74a9be6666d8a899f8/t/643e0c5e0a0120620b3ddfa0/1681788001112/MahingaKai_project-outline.pdf
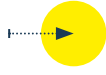
Table 2: Mauri
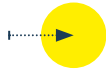
Framework	Domain	Objective	Indicator	Metric	Reporting	Scale
Cultural Health Index	Freshwater originally but expanded over time to cover all domains	Provide iwi with means to evaluate streams/river cultural health, & communicate and coordinate with water managers	Indicators cover: 1. site status, 2. mahinga kai, and 3. cultural stream health	1. Yes/No; 2. Mauri across four measures; 3. Eight quantitative measures of stream health	🟢	Stream up to catchment, then multiple scales
State of the Takiwā	Significant sites, natural resources and the environment within a takiwā	Provide a cultural values based environmental monitoring and reporting system	Largely derived from CHI but with site specific indicators as well.	Qualitative and quantitative metrics including mauri	🟢	Site and ecosystem specific within territorial context
Māori Land Use Opportunities Assessment	Land use	Tool for land managers to evaluate potential land uses against core values and principles and mauri-based criteria	Indicators cover: 1. significant cultural sites and treasures, 2. significant ecosystems, 3. education, 4. community, 5. partnerships, 6. intergenerational equity, assets, and 7. employment	Selected metrics examine: 1. the mauri of significant sites, food-gathering areas, and culturally significant plants, 2. the mauri of culturally significant waterways is enhanced, 3. mauri of the iwi/hapū and wider community is enhanced	🔴	All land scales
Mauriora Systems Framework	Multiple including farm	Protect, maintain and enhance the mauri of taonga	Indicators cover: One (soil), Hau (air), Whenua (land), Wai (water)	Mauri as sole metric	🟡	All land scales including farm scale
He Waka Taurua	Multiple including farm	Tool for accommodating two worldviews in co-governance and co-management	Indicators cover: Kaitiakitanga, Manaakitanga, Whakatipu rawa	Mauri as sole metric	🟡	Multiple scale including farm scale
Mauri of Waterways Kete	Waterways	Mātauranga Māori-based planning tool for uptake by iwi/hapū within a resource management-planning regime	Indicators cover: 1. Extent to which local authorities protect mauri; 2. Extent to which tangata whenua protect mauri; 3. Extent to which other agencies protect mauri; 4. Extent to which actions of the wider community affect mauri	Mauri as sole metric	🟡	Stream up to catchment

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Table 2: Mauri cont'd

Framework	Domain	Objective	Indicator	Metric	Reporting	Scale
Mauri-o-meter	Multiple - climate change, polluted site, land use assessment etc.	Decision making framework that combines a stakeholder assessment of worldviews, with an impact assessment of indicators to determine sustainability and trends over time	Indicators cover: 1. ecosystem, 2. cultural, 3. community, 4. economic	Qualitative and quantitative mauri metrics. Selected metrics examine: 1. Impact on flora, impact on fauna, land use, pollution levels, resources used; 2. kaitiakitanga, mahinga kai, resource gathering, tikanga, traditional knowledge	●→	Multiple scale
Tūhoe Forest Framework	Kauri	Develop a Māori community-based monitoring system that primarily tracks the health of a forest ecosystem but also community well-being	Indicators cover: 1. Procurement of food; 2. Natural productivity; 3. Nature of water; 4. Nature of land; 5. Nature of the forest; 6. Long burning fires of occupation of land and place; 7. Spiritual dimension; 8. Physical health; 9. Mental health	Scientific and mauri. Selected mauri metrics examine: 1. Aesthetics of river or streams; Smell of rivers or streams; Language or sound of the rivers or streams. 2. Language or sound of forest, Aesthetics or beauty of forest; Strength of inspiration, essential force or awe (ihi) felt within a forest, Strength of loneliness felt within a forest. 3. Presence and strength of life force in a forest, Presence and strength of energy flow (ia) in a forest	●→	Forest and supporting ecosystems
Wai Ora Wai Māori	Freshwater	Developed to support iwi/ hapū participation in setting freshwater standards under the National Policy Statement for Freshwater Management, particularly in relation to mahanga-kai sites/ values	Indicators cover: 1. Taiao Ora – Flourishing nature; 2. Whānau Ora – Thriving families; 3. Mauri Ora – the essence of vitality	Selected metrics examine: Are the senses awakened at the mahinga kai?, Do tangata tiaki feel connected to the mahinga kai?	●→	Stream up to catchment
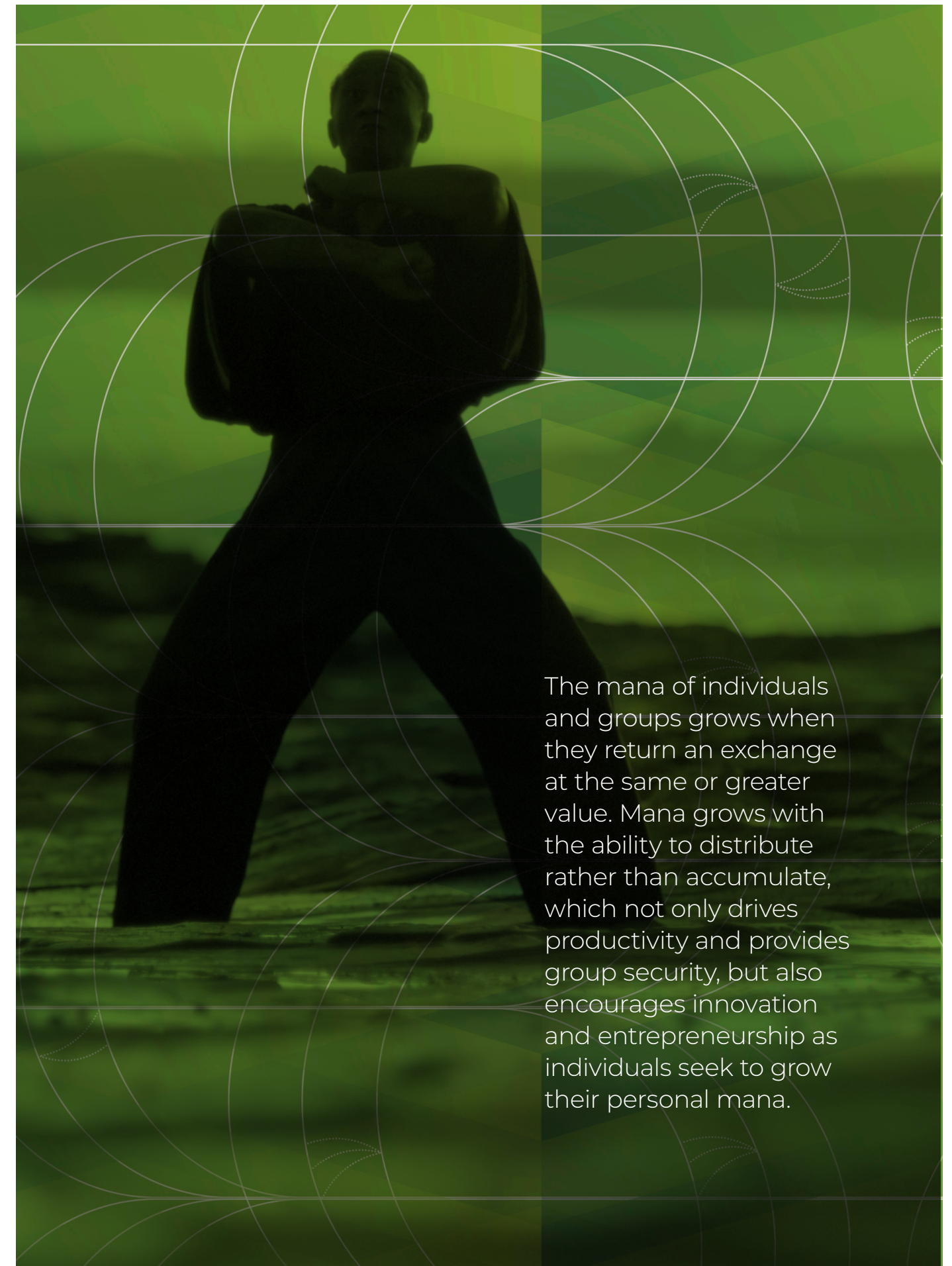
The mana of individuals and groups grows when they return an exchange at the same or greater value. Mana grows with the ability to distribute rather than accumulate, which not only drives productivity and provides group security, but also encourages innovation and entrepreneurship as individuals seek to grow their personal mana.

Mana

Caring for the environment and treating plants, animals, and ecosystems with respect by increasing their mauri simultaneously acknowledges, raises, and upholds an individual or group's mana. Likewise, humans treating each other in a caring and respectful way that enhances mauri simultaneously acknowledges, raises, and upholds mana. Protecting the environment and enabling communities to flourish "is achieved by upholding the authority or mana of the atua, the environment and communities. Actions that acknowledge and enhance mana are highly valued in te ao Māori. This is reflected by the term mana-enhancing practices that promote empowering and constructive interactions. Mana-enhancing practices have significant implications for operating at the interface by establishing norms of conduct that encourage thinking and acting in ways that generate strong mutually beneficial relations and respect autonomy."[34 (p.7)]

There are few MEFs that expressly seek to measure mana. The Planning Under a Co-operative Mandate (PUCM) kaupapa Māori framework includes mana as one of the three kete, or baskets of outcomes and indicators. It is focused on mana whenua, noting that "tribal mana is widely considered to be diminished where we fail in our duty as kaitiaki."[48 (p.18)] The

indicator measures the "extent to which Local Authorities acknowledge Mana Whenua."[48(p.21)] A framework developed by Manaaki Whenua Landcare Research for the Ministry for the Environment includes mana whakahaere, or governance, as one of its principles, listing two measures and methods: 'Active participation of Māori in resource management decision making, indicated by: number of Māori city/district/regional council members; and Active participation of Māori in resource management decision making, indicated by: number of iwi environmental management plans'.[49] The proposed monitoring framework for Auckland Council Wai Ora Wai Māori programme has an indicator focused on whakatipu rawa (intergenerational equity, local investment), though it lists no indicators and metrics.

Two MEFs that do provide useful mana metrics are the MLOUA and Wai Ora Wai Māori. The first has indicators focused on partnerships, intergenerational equity and assets, and employment, with metrics that focus on commercial relationships, the distribution of money between shareholders, and the rate of employment. Wai Ora Wai Māori has indicators that cover whānau ora or thriving families, with metrics that focus on whether whānau can exercise manaakitanga and participate in whanaungatanga.

Wellbeing monitoring frameworks provide a number of useful indicators and measures. For example, the Living Standards Framework's He Ara Waiora lists a number of objectives for the target domain of te tangata people), noting that "People (tangata) and collectives (kainga) thrive when they":

- Have a strong sense of identity and belonging (mana tuku iho)
- Participate and connect within their communities, including fulfilling their rights and obligations (mana tauutuutu)
- Have the capability to decide on their aspirations and realise them in the context of their own unique circumstances (mana āheinga)
- Have the power to grow sustainable, intergenerational prosperity (mana whanake).[29]

Likewise, the Whānau Rangatiratanga Frameworks (WRF), aims to "provide a platform and a guide – from within a Māori world view – for collecting, analysing and using data about whānau wellbeing" also provides an array of indicators and metrics that are useful for monitoring the flows of mana on a MAC.[50] For example, under its economic indicator it has measures like 'whānau can manage and leverage collective resources' and 'whānau are able to support each other financially and to accumulate financial reserves'.[50] These two MWFs provide a more concrete means by which mana can be measured, though the

collective focus of the WRF provides a more suitable framing for MACs, in particular.

Mana as a metric is mostly applied when determining whether the mana of a group or organisation is being upheld, which operates in both directions. That is, both in the way itself behaves, the way it treats the environment and other human groups, and in terms of the way it is being treated by others. There is an emphasis on mutually-beneficial partnerships, sustainable prosperity, intergenerational equity, and widespread stakeholder employment, which are typically associated with core Māori values such as kaitiakitanga and rangatiratanga.

> Mana as a metric is mostly applied when determining whether the mana of a group or organisation is being upheld, which operates in both directions. That is, both in the way itself behaves, the way it treats the environment and other human groups, and in terms of the way it is being treated by others.

48. Jefferies, R., & Kennedy, N. (2009). A report to iwi on the kaupapa Māori environmental outcomes and indicators kete. IGCI, The University of Waikato.

49. Scheele, S., Carswell, F. E., Harmsworth, G. R., Lyver, P., Awatere, S., Robb, M., Taura, Y., & Wilson, S. (2016). Reporting environmental impacts on Te Ao Māori: a strategic scoping document. Ministry for the Environment.

50. Baker, K. (2016). The Whānau Rangatiratanga Frameworks: Approaching whānau wellbeing from within Te Ao Māori. Research report for Social Policy Evaluation and Research Unit. https://thehub.swa.govt.nz/assets/Uploads/Whanau-rangatiratanga-frameworks-summary.pdf

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Table 3: Mana

Framework	Domain	Objective	Indicator	Metric	Reporting	Scale
Planning Under a Co-operative Mandate (PUCM) kaupapa Māori framework	Multiple	Tool for use by RMA practitioners that reflects a kaupapa Māori perspective	Indicators cover: mana, mauri, tapu	Selected metrics cover: extent to which Local Authorities acknowledge Mana Whenua; extent to which Other Government Agencies acknowledge Mana Whenua; extent to which Tangata Whenua assert Mana Whenua	(green)	Stream up to catchment, then multiple scales
Ministry for the Environment Framework	Multiple	Framework for providing the measures that allow for a comprehensive picture of the impacts on and state of the environment from a Te Ao Māori perspective	Indicators cover: Mana whakahaere, turangawaewae, whanaungatanga, Taonga tuku iho, Te Ao Tūroa	Metrics examine: number of Māori city/district/regional council members, number of iwi environmental management plans	(green)	Site and ecosystem specific within territorial context
Proposed monitoring framework for Auckland Council Wai Ora Wai Māori programme	Freshwater	Broader framework focused on freshwater, He Au Putea (economic growth) indice selected	Indicators cover: kaitiakitanga, manaakitanga, whanaungatanga, whakatipu rawa (intergenerational equity, local investment)	Not listed	(green)	Streams, rivers, catchments
Māori Land Use Opportunities Assessment	Land use	Tool for land managers to evaluate potential land uses against core values and principles and mauri-based criteria	Indicators cover: 1. significant cultural sites and treasures, 2. significant ecosystems, 3. education, 4. community, 5. partnerships, 6. intergenerational equity, assets, 7. employment	Selected metrics examine: 5. inter-iwi and intra-community commercial relationships are maintained, 6. equitable distribution amongst beneficiaries and future generations, long-term retention and accumulation of fixed assets, 7. A balanced approach for managing labour		Multiple scales

Table 3: Mana cont'd

Framework	Domain	Objective	Indicator	Metric	Reporting	Scale
Wai Ora Wai Māori	Rivers	Developed to support iwi/ hapū participation in setting freshwater standards under the National Policy Statement for Freshwater Mangement, particularly in relation to mahanga-kai sites/ values	Indicators cover: 1. taiao ora; 2. whānau ora (thriving families); 3. mauri ora	Selected metrics examine: 2. - can whānau exercise manaakitanga, and can whanua participate effectively in whānaungatanga?	(red)	Rivers
Living Standards Framework - He Ara Waiora	Individual, whānau, community wellbeing	The Living Standards Framework is a flexible framework that prompts our thinking about policy impacts across the different dimensions of wellbeing, as well as the long-term and distributional issues and implications of policy	Indicators cover: 1. Identity and belonging, 2. Participation and connection within their community, 3. Capability to decide on their aspirations, and 4. power to grow sustainable, intergenerational prosperity	Selected metrics examine: 4. Income, Income adequacy, Savings/net worth, Financial skills, Retirement/savings plan, Employment, NEET, Business ownership, Business growth, Business opportunity	(green)	Multiple scales
Whānau Rangatiratanga Frameworks	Whānau wellbeing	Framework provides a platform and a guide – from within a Māori world view – for collecting, analysing and using data about whānau wellbeing	Indicators cover: whakapapa, manaakitanga, rangatiratanga, kotahitanga, wairuatanga with capability dimensions including economic	Selected metrics examine (economic): whānau can manage and leverage collective resources; whānau are able to support each other financially and to accumulate financial reserves; whānau enjoy economic security; whānau can navigate barriers to success; and whānau can access their material and non-material resources	(green)	Whānau

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Tapu

Most commonly tapu is referenced in environmental management and monitoring plans in relation to wahi tapu, which refers to lands that are 'sacred' and as such access to the land may be prohibited or restricted. It is usually monitored in terms of whether such prohibitions are effective or being followed. Broadly, tapu may apply to an ecosystem, area, or species, whose mauri has significantly declined and needs to be protected. As a result, a rāhui may be declared forbidding people from exploiting or using that entity. Conversely, if an ecosystem, area or species is thriving and can be utilised for productive output then it is considered noa, meaning it is available for use. As Awatere and Harmsworth explain,

> "concepts such as tapu, rāhui, and noa… were practical rules to sustain the well-being of people, communities, and natural resources. Everything was balanced between regulated and deregulated states where tapu was sacred, rāhui was restricted, and noa was relaxed or unrestricted access."[42]

Although tapu is rarely mentioned in MEFs, its influence is clear. For example, in the Mauri of the Waterways Kete all of the indexes are essentially focused on determining the state of mauri and the possible need for protection. They are all focused on measuring the extent to which different groupings protect mauri.[35] In this way, they are seeking to determine areas which may need to be placed in rāhui, so it is indirectly focused on tapu.

The Tūhoe Forest Framework has several measures relating to tapu in their indicator on 'the spiritual dimension' including 'presence and strength of sacredness (tapu)' and 'presence or encounter rates with supernatural forest dwelling beings (e.g., tūrehu, patupaiarehe)', these beings only being present when tapu is being respected.[46]

Table 4: Tapu

Framework	Domain	Objective	Indicator	Metric	Reporting	Scale
Tūhoe Forest Framework	Kauri	Objective Develop a Māori community-based monitoring system that primarily tracks the health of a forest ecosystem but also community well-being	Indicators cover: 1. Procurement of food; 2. Natural productivity; 3. Nature of water; 4. Nature of land; 5. Nature of the forest; 6. Long burning fires of occupation of land and place; 7. Spiritual dimension; 8. Physical health; 9. Mental health	Selected metrics examine: Presence or encounter rates with supernatural forest dwelling beings (e.g., tūrehu, patupaiarehe), Presence of environmental guardians (e.g., taniwha), Strength of sacredness surrounding species (e.g., kererū, ruru); Presence and strength of sacredness (tapu)		Forest and supporting ecosystems

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Discussion and Synthesis

The range of MEFs and MWFs all apply to different environmental domains and at different scales, and as such employ a plethora of indicators and qualitative and quantitative metrics. While different frameworks thematically align with the mātauranga axioms of whakapapa, atua, mauri, mana, and tapu, these concepts either explicitly, or implicitly, run throughout all frameworks.

These axioms provide a powerful way of framing and guiding the selection of domains, indicators, and metrics required for the design of an environmental sensor network, and how the intelligence generated by this network should be structured and communicated. Based on a synthesis of the different frameworks (Table 5), whakapapa and atua provide a structure for selecting the environmental domains that a sensor network should target, and in turn the types of indicators required for determining their health and wellbeing. Mauri and mana provide key concepts for considering the appropriate metrics that should be used in a sensor network for measuring changes in the vitality and standing of human and environmental domains - including both qualitative and quantitative metrics. Moreover, tapu provides a concept for determining which domains should be closed or protected, and in turn the development of metrics for measuring levels of restriction via a sensor network. The concepts of utu and tauutuutu, while not explicitly covered in the frameworks, offer additional and important concepts regarding the relationship balance between the human and environmental domains.

Table 5: Synthesis

Te Ao Māori	Synthesis
Whakapapa and atua	Frames the environmental monitoring systems by identifying the atua, supporting the selection of indicators for determining the health and wellbeing of atua, and mapping their connections and importance.
Mauri	Provides a concept for gauging the vitality, health and wellbeing of environmental domains; including physical and spiritual health. Other indicators consider significant ecological and cultural sites, and taonga species. **Possible metrics:** A mixture of qualitative and quantitative measures are used to gauge mauri.
Mana	Provides a concept for gauging whether relationships are mana enhancing or diminishing. There are various indicators used for gauging mana including the presence of positive partnerships, the existence of intergenerational equity and assets, the generation of employment, and growing whānau income/wealth. **Possible metrics:** A mixture of qualitative and quantitative measures are used.
Tapu	Provides a concept for gauging domains that need to be closed or protected. Rāhui is often used if needed. **Possible metrics:** Qualitative metrics including presence and strength of sacredness; Respect of tapu area; Use of rāhui to protect areas with diminished mauri.
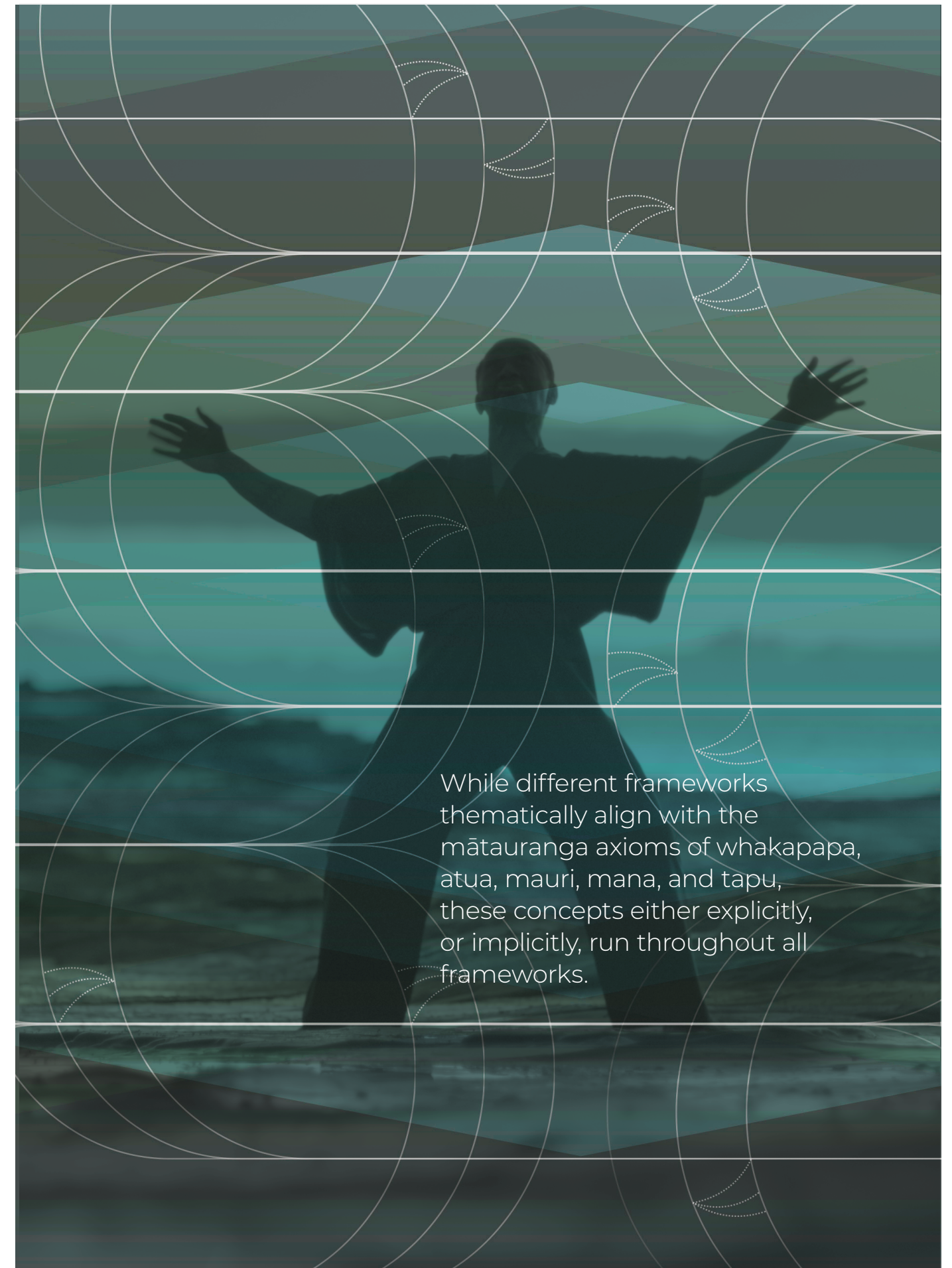
While different frameworks thematically align with the mātauranga axioms of whakapapa, atua, mauri, mana, and tapu, these concepts either explicitly, or implicitly, run throughout all frameworks.

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4

Environmental intelligence needs of macs and iwi - determining indicators and metrics

The range of MEFs and MWFs outlined provide valuable insight into the structure and approach used in Māori environmental monitoring and reporting approaches. While the same mātauranga axioms implicitly apply across all frameworks, as outlined above, each framework is designed for a specific purpose, environmental domain, and scale, and as such the indicators and metrics they use are context dependent. Consequently, none of these frameworks may be 'picked up' and directly applied to the design of a KIP given its broad scope across all environmental domains, and its specific application to MACs and iwi contexts. However, the mātauranga axioms that underpin the frameworks do provide a good structure for a KIP, whereby the whakapapa may be used to determine and frame relevant environmental domains, mana and mauri to gauge the nature of the relationship between humans and the environment, and tapu the domains to be protected or excluded. To apply this general framework to MACs and iwi, however, it is necessary to identify the specific indicators that MACs and iwi use, and consider important, to ensure that it is context relevant.

The purpose of this section is to identify relevant environmental indicators through an analysis of MAC and iwi strategic documentation. This documentation is produced by MACs and iwi as a way of publicly stating their values, objectives, and desired outcomes, and as a basis for measuring their progress and undertaking annual reporting. An analysis of 60 strategic documents was undertaken to identify the most common indicators that MACs and iwi use for understanding the health and wellbeing of the environment. The method used for this analysis is outlined first in this section, followed by a description of the indicators emerging from this analysis. Next, a range of metrics are proposed that can be used to measure and report against these indicators using a sensor network. It needs to be noted that only biophysical metrics are selected given that a sensor network is not able to gather qualitative data - such data should be gathered separately and used to augment environmental intelligence generated by a sensor network. Finally, it is discussed how the indicators and metrics generally fall into common atua domains – contextualising the indicators within a whakapapa framework.

Method

The strategic reporting frameworks (Appendix A) were gathered through a desktop analysis. A list of Māori trust, incorporation, and iwi owned agricultural operations as well as a list of Mandated Iwi Organisations was used along with search terms including 'sustainable', 'environment', 'indicators', 'monitoring', 'values', and 'framework'. A second researcher conducted separate analysis to ensure that no reporting frameworks had been missed. Subsequently, framework documentation was gathered and examined in concordance software, CasualConc. This software enables large corpora (bodies of text, in this case all the documentation from the MACs and iwi) to be analysed using several different methodologies. The method employed was to undertake a frequency examination of the most commonly appearing environmental indicator categories across documentation. Through this process the researchers were able to determine what might be viewed as the key environmental indicators most frequently used by MACs and iwi.

Key environmental indicators

It is critical that the development of indicators is centred on the key stakeholders' worldview and value set, here the MACs and iwi. This ensures that the indicator suite achieves buy-in with these stakeholders and that it is well calibrated to the specific context in which it will be used, thus giving it both legitimacy and

fidelity. [51] Fortunately, the ways in which the Māori worldview and value set relate to agriculture and land management are well documented and determining indicators is relatively simple. Using the methodology above, analysis of the documentation provided a clear overview of the primary environment indicators valued prioritised by MACs and iwi. These were:

- **Biodiversity and Habitat Preservation:** Efforts to increase biodiversity, protect wildlife and plant habitat, and maintain ecological balance
- **Water Quality:** Focus on improving water quality, from on-farm streams to catchments
- **Soil Management:** Need to maintain and improve soil health and reduce erosion
- **Climate Change and Greenhouse Gas Reduction**: Practices aimed at reducing greenhouse gas emissions and addressing climate change impacts
- **Ecosystem Protection:** Fencing off delicate ecosystems and waterways to prevent damage and erosion, and replanting riversides
- **Sustainable Farming and Land Management:** This includes practices like matching stock class to land suitability, retirement of wetland areas, and introduction of native plants, as well as more mundane elements like stock numbers, fencing patterns, and water management.

51. Reed, M. S. (2008). Stakeholder participation for environmental management: a literature review. Biological Conservation, 141(10): 2417-2431.

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Operationalising and measuring

These categories reflect a comprehensive approach to environmental management, emphasising sustainability, biodiversity, cultural values, and resource efficiency. The next step was to clearly delineate these environmental indicators in a way that would enable meaningful monitoring and measurement against them using a sensor network. This may be viewed in Table 6, where the indicators, while being retained, have been defined and demarcated in a way that will allow measurement. These indicators are, however, general categories, and multiple measurements need to be taken and aggregated to formulate an indicator. For example, to formulate an indication of water quality multiple measurements need to be aggregated, such as the presence or absence of taonga species, pH levels, nitrates and phosphate levels, and aquatic species diversity – amongst others. To identify the types of measurements needed under each indicator category we examined the types of quantitative and scientific biophysical metrics used across MEFs and MWFs, and by MACs and iwi. These were categorised under relevant indicators, which can be viewed in Table 6. It was determined that these selections could later be validated through engagement with iwi and MACs when designing the sensor network.

Following the process used in the MEFs outlined above, the indicators were then placed, or grouped, into different atua domains, to provide an underpinning whakapapa architecture to the indicator framework (Table 6). Although there are variations in whakapapa and atua domains between iwi and hapū, within MEFs the common atua used include: Tangaroa - associated with water and water creatures; Hine-ahu-one - associated with soil; Tāwhirimātea - associated with air and air movement; Tāne Mahuta - associated with forests, plant life, and many forest creatures; and Rongomātāne associated with cultivation and farming. These categories may be considered 'placeholders' in the indicator framework with each hapū or iwi using their own specific atua domains relevant to their context. When a sensor network generates data across these metrics it will provide biophysical intelligence regarding the mauri of the atua domains, and whether the relationship between people between humans and these domains is mana enhancing or diminishing.

However, as outlined briefly above relying solely on biophysical quantitative measures cannot fully capture the state of the mauri of atua. Māori authorities typically use a combination of standard scientific indicators and mātauranga, providing a comprehensive understanding of local environments. For instance, the mauri of a waterway might be gauged using standard scientific measures such as nitrate, phosphate, pH, and sedimentation levels. Simultaneously, indicators derived from mātauranga, such as changes in the behaviour or abundance of certain species, seasonal cycles, and areas known as sensitive to environmental change. Such knowledge is usually highly localised and is not generalisable across an environmental intelligence platform.

Qualitative indicators may also be incorporated, such as the intuitive and emotional sensing of an environment's vitality. Such knowledge is usually expressed through artistic and creative mediums such as waiata, visual representations, and karakia. These expressions are also deeply rooted in local knowledge and the sense of place and help convey the personal experiences mauri and mana degeneration or regeneration. The incorporation of this qualitative knowledge into the KIP would need to be done on a case-by-case basis and adapted to context due to constraints on generalisability. It would also need to be wrapped into the platform user interface when communicating environmental intelligence.

Table 6: Atua Domains, Indicators and Metrics

Atua Domain	Indicator categories	Metric categories
Tāne Mahuta	Terrestrial Biodiversity	Native Habitat presence Species diversity Taonga Species presence Presence/absence of pest and weed species Riparian Planting
Tangaroa	Water Quality and Quantity	Nitrates Phosphates Turbidity pH Species diversity E. coli Taonga Species Surface flow rates Groundwater
Hine-ahu-one	Soil Quality	Erosion Compaction Moisture Levels PH Heavy metals Microbial density and diversity
Rongomātāne	Stock Management	Paddock lines Stock numbers
	Water use Efficiency	Soil moisture levels Ground water quantity Surface water flows
	Water quality	Levels of N and P in soils and groundwater
Tāwhirimātea	Greenhouse Gases	Emissions Sequestration

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Conclusions

There are multiple MEFs and MWFs in use in A-NZ that apply to different environmental domains and at different scales, and as such employ a plethora of indicators and qualitative and quantitative metrics. While different, these frameworks thematically align with the mātauranga axioms of whakapapa, atua, mauri, mana, and tapu, with these concepts either explicitly, or implicitly, running throughout all frameworks. Given their common use, these axioms provide a good structure for a KIP, whereby the whakapapa may be used to determine and frame relevant environmental domains, mana and mauri to gauge the nature of the relationship between humans and the environment, and tapu the domains to be protected or excluded.

However, none of the MEFs and MWFs reviewed may be 'picked up' and directly applied to the design of a KIP given its broad scope across all environmental domains, and its specific application to MACs and iwi contexts. To apply this general framework to MACs and iwi, it is necessary to identify the specific indicators and metrics that MACs and iwi use, and consider important, to ensure that it is context relevant. Based on textual analysis of MACs and iwi strategic documentation, and reviews of metrics used in MEFs and

by MACs and iwi, a set of biophysical indicators and metrics were identified, and using a whakapapa framework organized into different environmental domains. Through this process a set of 28 metrics were identified grouped under seven indicators, which were in turn framed using five atua domains. Qualitative indicators were excluded from this analysis, given qualitative methods are required to generate this data, which environmental sensors are unable to capture. However, this is not to dismiss qualitative data, such data may be incorporated and built into reporting systems to augment quantitative data as is commonly done throughout MEFs and MWFs.

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Appendix A

Legend:
- **YES** — green
- **PERHAPS INDIRECTLY** acknowledging Indigenous rights — yellow
- **NO** — red

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Ngāi Tahu Farming	Ngāi Tahu	(Values and goals expressed in 2019 Sustainability report)	Water, Land, Animals, People	When land and water are sustained, people will prosper	YES	Climate change - reduce Greenhouse Gas emissions by 29%. Water & Soils - Lower P and N by 15% by 2030. Biodiversity – plant 1.2M trees at Te Whenua Hou, restore Mahinga Kai. Sustainable Development Goals: 2: Zero Hunger; 6: Clean Water and Sanitation; 7: Affordable and Clean Energy; 13: Climate Action; 15: Life on Land; 12: Responsible Consumption and Production	Statistical evidence of Fertiliser use, Nitrogen loss, Water quality / consumption, Nitrate levels provided in Annual report
Ngāi Tahu Farming	Ngāi Tahu	Environment Canterbury Good Management Practices (required)	Land, Water (directly), People (indirectly)	Improvement of water quality	NO	Financial Gain. Pre-empt Regulator visits. Pride in 'Doing the right thing'. Encourage markets - demand to meet environmental standards	NO
Ngāi Tahu Farming	Ngāi Tahu	Synlait 'Lead with Pride'	Water, Land, Animals, People	Four Pillars: Environment; Animal Health and Welfare; Milk Quality; Social Responsibility	NO	Documentation of high performance in four pillars in order to gain certification - Intended to lead to higher quality milk and higher prices	NO
Ngāi Tahu Farming	Ngāi Tahu	New Zealand Farm Assurance Programme	Animals, People	Origin & Traceability; Security & Food Safety; Animal Health & Welfare	NO	Provide confidence and certainty to consumers world-wide that A-NZ meat and wool is authentic, genuine, and safe.	NO
Mangatu Blocks Incorporation		(Values expressed on Mangatu website, and on Integrated Foods Ltd. website)	Land, Animals, People, Water	To be guardians of our ancestral land optimising resources to create a sustainable future for our people'. To treat our people, our livestock, the environment with respect and care	YES	Environmental sustainability including protection of waterways. Adequate animal feed, health, and veterinary attention	

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Ngāi Tahu Farming	Ngāi Tahu	Forest Stewardship Council Certification	Land, People	Fight Climate change; Protect biodiversity; Support communities	PERHAPS INDIRECTLY	The 10 Forest Stewardship Council (FSC) Principles: • Comply with all applicable laws • Maintain or improve social and economic wellbeing of workers • Uphold rights of Indigenous peoples • Maintain or improve social and economic wellbeing of local communities • Manage products and services in a way that maintains or improves long term economic viability, social benefit, and environmental benefit • Maintain, improve and/or restore the ecosystem services and environmental values of managed forests; and avoid, repair, or mitigate negative environmental impacts • Establish management plan outlining economic, environmental, social objectives • Demonstrate progress toward meeting objectives • Maintain or improve high conservation values • Ensure all management activities comply with FSC principles and criteria	NO
Wakatū Incorporation	Ngāti Koata, Ngāti Rarua, Ngāti Tama, Te Atiawa	Whenua Ora	Land, Water, People, Animals	Ensure everything we do enhances our environment and our people'. Kaitiakitanga, expressing Rangatiratanga	NO	Improved waste management - zero to landfill. Carbon neutral by 2030. Tikanga-led land and water regeneration. LEAN (TIKA) Principles across organisation. Increase and maintenance of flora and fauna habitat corridors	NO
Wairarapa Moana Incorporation		(Values expressed on Wairarapa Moana website)	Land, People	Overarching value: Kaitiakitanga. Tika / Integrity. Whanaungatanga / Communication. Rangatiratanga / Courage. Wananga / Knowledge. Kotahitanga / Working together. 'Our people, our place, our future'	YES	Protect and enhance assets. Industry leader. Growth beyond current assets. Shareholder pride. Pay a dividend	NO

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Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Miraka		Te Ara Miraka Farming Excellence Programme	People Land Water Animals (Cows)	Environmental sustainability Animal welfare Food safety Traceability Milk quality assurance	(green)	People: Focus on employee wellbeing, investment in local rural communities Environment: Focus on water quality (i.e., runoff, leaching, toxin pollution), and soil quality (stock pressure) Cows: Animal welfare associated with five freedoms, increased productivity through welfare Milk: product safety and quality (financial incentives for quality) Prosperity: Proactive monitoring of costs, community prosperity	(red)
Onuku Limited Premium NZ Honey		OAye product authentication system	People	Guarantee of authenticity, quality, and safety	(red)	Consumer can check product authenticity	(red)
Onuku Limited Premium NZ Honey		Unique Mānuka Factor Honey Association UMF certification	People	Intended to allow consumers to distinguish authentic Mānuka honey from 'fake' Mānuka products	(red)	Grading system indicates degree of 'signature' mānuka compounds present in product: Leptosperin, DHA, and Methylglyoxal	(red)
Onuku Limited Premium NZ Honey		New Zealand Fernmark Licence Programme	People	Promotion of New Zealand Story and authentic New Zealand products	(red)	Indicate to international consumers that product is an authentic product of A-NZ. Aims to increase export success and competitiveness through this assurance	(red)
Onuku Limited Premium NZ Honey		Halal Certification (FIANZ)	People Animals	Assures Muslim consumers of appropriateness to consume	(red)	Indicates that ingredients in product have been certified as halal and appropriate for Muslim consumption. Ensure that principles of Halal and Tayyiban are integral part of certification. Ensure that Halal integrity preserved at all stages of production/handling. Ensure Halal certification scheme operated competently and impartially. Aim to give confidence to all interested parties that Halal requirements fulfilled	(red)

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Onuku Limited Premium NZ Honey		Non-GMO Project Certification	People	Believe that all have right to know what is in their food, and access non-GMO choices Consumer purchasing power can shape food production Belief in eventual transition to non-GMO food supply Integrity of genetic inheritance essential to environmental health and ecological harmony	(red)	Indicates that product contains no Genetically Modified Ingredients or substances	(red)
Omapere Rangihamama Trust	Ngāpuhi	(Values expressed on Omapere Rangihamama Trust website)	Land People Water Animals	Kaitiakitanga Ensure land is delivered to future generations with mana intact	(green)	Water & Habitat Protection through fencing and riparian vegetation Protection of fauna including mudfish, eel, karaka, and kiwi	(red)
Te Awahohonu Forest Trust		(Values expressed on Te Awahohonu Forest Trust website)	People Land	Whakapono: Honesty, integrity, transparency and trust Kaitiakitanga: Nurturing our taonga, whenua, tikanga and tangata Whanaungatanga: Unity, connection, pride Tauwhirowhiro: Excellence, innovation, enquiry, improvement, risk minimization Ihi: Energy, drive, exploring potential	(green)	Protecting and enhancing the taiao Empowering our tangata Facilitating opportunities for whanau development Continuing building business excellence	(red)
Kapenga M Trust	Tuhourangi	(Goals expressed in PerrinAg case study on Integrating Forestry for profitable and sustainable land use)	Land People	Original trustees had vision for Kapenga that it would be the food source for Tuhourangi for years to come	(green)	Creating a more ethical and environmentally sustainable farm business with greater incorporation of forestry and native trees Revitalise wetland which was once 'the food bowl of Tuhourangi'	(red)

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Atihau Whanganui Incorporation		(Values expressed on Atihau Whanganui Incorporation website)	Land Water Animals People	Morimori: By looking after nature, nature will look after us. Belief in connection of all life, and duty of reciprocal care Welfare and comfort of animal stock, following five freedoms	(green)	Fencing off delicate ecosystems and waterways to prevent damage and erosion; Replanting riversides and creation of habitat corridors; Placing areas under 25 year Ngā Whenua Rāhui covenants; Sparing use of fertilisers and nutrition supplements; Stock grass-fed, free range and free from growth supplements; Following five freedoms for animal wellbeing	(red)
Pukahukiwi Kaokaoroa No.2 Block Incorporation	Ngāti Pikiao	(Values expressed on Kahukiwi Experiences website)	Land People	Kaitiakitanga 'Our land is our identity, our growth, our future'	(green)	Cultural Vitality; Social Equity; Economic Prosperity; Environmental Sustainability; Has exited farming to allow restoration of whenua; Sale of nitrogen to Lake Rotorua Incentive Scheme	(red)
Puketapu 3a Block Incorporation		(Values expressed on Puketapu website)	People (primarily) Land (mentioned)	Tangata Whenua Growth Leadership	(green)	Asset growth in order to deliver benefit to owners *"to build on the achievements of yesterday for the benefit of our people tomorrow"*	(red)
Parininihi ki Waitotara		(Values expressed on Parininihi website)	People Land Animals	Manaakitanga: Care of our present and future generations Kaitiakitanga: Commitment to leadership Whakapono: Adherence to our tikanga and belief in our future Whanaungatanga/ Kotahitanga: Belief in collective action with trusted partnerships	(green)	Environmental sustainability while creating wealth for shareholders; Caring for our people and animals, and ensuring systems and processes set the highest standards	(red)

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Kōkako Trust		(Values expressed on Kokaku Trust website)	People Land	Manaakitanga: Identity, authenticity and cultural awareness Rangatiratanga: Identity, pride, respect, leadership, skilled and successful Kaitiatikanga: Effective management and guardianship of resources and history Aroha: Whakaaro pai ki te katoa	(green)	To acknowledge and embrace: our cultural, educational and environment responsibilities which will create a sustainable food basket for our whānau. Ensure its farming operations are carried out in most sustainable manner while connecting with affiliated blocks, providing significant economic growth opportunities, and maximising engagement and participation.	(red)
Ngāti Pahauwera Development Trust	Ngāti Pahauwera	(Environmental goals expressed in Ngāti Pahauwera 2021 Annual Report)	Land Water Animals	Environmental accountability: Taiao	(green)	1. Protection of all lands, coastal marine areas, waterways, ecosystems, wildlife, flora and fauna; 2. Influencing and monitoring resource consents; 3. High water quality standards promoted and maintained; 4. Elimination of pests and noxious plants; 5. Efficient waste management; 6. Protection of customary fishing; 7. Develop and Climate Change emergency plan; 8. Develop a water storage plan	(red)
Te Manawa o Tūhoe		(Values expressed in Te Manawa o Tūhoe 2021 Annual Report)	People Land	Pono (integrity, accountability) Rangatiratanga (leadership, vision) Kaitiakitanga Manaakitanga (valuing and respecting people according to Tūhoetanga) Whanaungatanga (Growing and maintaining relationships)	(green)	Environmental goals for Hatupere Farm expressed in 2021 report: Creation of Environmental Plan; Replacement and improvement of effluent ponds; Reduction of Nitrogen use; Improvement of stock feed	(red)

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Tapuaetahi Incorporation		(Values expressed on Tapuaetahi section of First Light Farms website)	Land People Animals Water (Coast)	Kaitiakitanga	(green)	Ensure that whenua (land) and moana (adjacent coast) is preserved for tamariki mokopuna (future generations). Through cross breeding Wagyu, render the best return while upholding values through less intensification and a focus on animal welfare.	(red)
Putauaki Trust	Ngāti Pahipoto	(Values expressed on Putauaki Trust website)	People Land	Rangatiritanga Kaitiakitanga Manaakitanga Whakapapa Kotahitanga Whanaungatanga	(green)	**Commercial:** Strategic investment, sustainable returns, growth in capability **Social:** Support wellbeing of shareholder, create employment opportunities **Environment:** Practice Kaitiakitanga over our land **Cultural:** Support Kokohinau Marae and uphold the tikanga of Ngāti Pahipoto	(red)
Ngāi Tukairangi Trust		(Values expressed on Ngāi Tukairangi Trust website)	People Land	Rangatiratanga Whanaungatanga Kaitiakitanga Kia Tu Tonu Tatou Kotahitanga	(green)	To counter threat of urbanisation on Matapihi peninsula, and retain and develop land to better meet the needs of our people	(red)
Parengarenga Incorporation		(Values expressed in 2022 Newsletter, and goals expressed on website)	Water Land Animals People	Whakapono Me Te Tika: Honesty, Trustworthy, Integrity Kaitiakitanga: Stewardship, Guardianship Manaakitanga: Generosity, Reciprocity, Kindness, Aroho Ki Tetahi Rangatiratanga: Leadership, Teamwork, Growth	(green)	Enhanced water quality Soil stabilisation and conservation Providing a buffer against flooding during storms Shading waterways for aquatic life Enhance wildlife and plant habitat leading to increased biodiversity A reduction in greenhouse gases Economic and social benefits to the community and the Parengarenga forest owners	(red)
Whangara Farms		McDonalds Flagship Farmers	Land People Water Animals	Intended to promote sustainability in farmers who supply to McDonalds restaurants, through sharing of experience, methods, and technology.	(red)	Areas of intended sustainable action stated on website: **Environment:** Conserving forests, Climate change, Reducing Waste, Water, Soil, Biodiversity and Ecosystems **Ethics:** Human rights and wellbeing, Animal health and welfare, Collaboration and business relationships, Communities **Environment:** Advancing economically viable farming, Production quality	(red)

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Whangara Farms		(Values expressed on Whangara Farms website)	People Land	Leadership, commitment, integrity, respect, and ongoing achievement in the NZ Agri-business sector Kaitiakitanga	(green)	1. Uphold the legacy for future generations, including cultural sensitivities 2. Enable the entity to be in a position to take on more opportunities 3. Ensure what we have today improves and continues to provide for our people Also a list of specific farming goals listed on site, which include: Sustainable farming systems/ resource management, and Efficient business with reduced environmental footprint	(red)
Mangatawa Papamoa Blocks Incorporation		(Values expressed on Mangatawa Papamoa website)	People Land	Tikanga: Observe Maori Protocol Whanaungatanga: Hospitality Mahi Tahi: Work as one Kawa: Customs Rangatiratanga: Leadership Whakapapa: Genealogy Kaitiakitanga: Sustainable practices Manaakitanga: Respect and care Whakanui: Celebrate success	(green)	*"At the core of the organisation is a desire and commitment to drive prosperity for their shareholders and their families, so there is a strong focus on whānau, sustainability, and future generations."*	(red)
Rowallan Alton Incorporation		(Values expressed on Rowallan Alton website)	Land People Animals	*"In our time we are only caretakers of the land for those who follow after us"*	(red)	A variety of land and wildlife conservation project described, including: Pest Control Wildlife Preservation (tree planting) Solar sustainability Carbon credit (offset through native forest management)	(red)
Otakanini Topu Incorporation		(Values expressed on Otakanini Topu website, and in article on NZ Farm Environment Trust website)	Land People Water	*"The backbone of the business is its strong cultural values - channels a strong understanding of Maori culture"* *"...to farm, cultivate and ultimately use our whenua productively and with innovation, while enhancing/ celebrating its natural and heritage values."*	(green)	Fencing out cultural sites Fencing/perimeter planting sandblows and waterways - enhancing riparian vegetation vegetation around waterways Matching stock class to land class and suitability Retirement of wetland areas Introduction of locally sourced native plants	(red)

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Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Te Uranga B2		(Values expressed on Te Uranga B2 website)	People Land	*"Productive land and productive people"* **Rangatira:** Leading with courage, honour, integrity and dignity **Umanga:** Managing a sustainable, viable enterprise **Kaitiaki:** Retaining our lands, operating our enterprise and growing our assets for our shareholders **Manaaki:** Responding to the needs of our shareholders and stakeholders	🟢	Umanga desired outcomes: Profitable primary industry enterprise, strong returns for our shareholders, exemplary environmental management infrastructure, and innovative industry practices	🔴
Te Uranga B2		Horizons Regional Council Whole Farm Plan - part of its Sustainable Land Use Initiative	Land Water	To reduce erosion of hill soils into waterways through a "mountains to the sea" approach	🟢 (implied)	To work in partnership with farmers to form 'Whole Farm Plans' to manage erosion and land use	🔴
Maraetahi Incorporated		(Values expressed on Ngāi Tamanuhiri website regarding Tamanuhiri Tutu Poroporo Trust)	People Land Water	*"The prosperity of Tamanuhiri is in our whenua, our moana and whanau."* Core guiding principles: To practise and uphold Rangatiratanga and Kaitiakitanga To build and grow our resource base whilst adopting a carefully considered approach towards risk To maintain and forge new relationships and partnerships	🟢	1. Mana Tipuna: Preserve, maintain, enhance and honour our whakapapa, our tipuna 2. Mana Whenua: Protect and safeguard our lands ensuring presence and visibility in our rohe 3. Mana Moana (Waimaori): Promote, advance and assert our mana moana and te mana o te wai 4. Putea investment: Investment to create opportunities 5. Mana Tangata: Lead and support whanau ora 6. TTPT (Operational): Be the leading iwi administrative hub 7. TTPT (Governance): Be a highly professional governance body	🔴
Oromahoe Trust		(Goals expressed on Oromahoe Trust website)	Land Water			Goals expressed in farm 5 year plan include the continuation of their sustainable approach, the fencing of waterways, and systems to prevent stock from entering waterways.	🔴
Awhi		Unique Mānuka Factor Honey Association UMF certification	People	Intended to allow consumers to distinguish authentic Mānuka honey from 'fake' Mānuka products	🔴	Grading system indicates degree of 'signature' manuka compounds present in product: Leptosperin, DHA, and Methylglyoxal	🔴

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Awhi		Values expressed on Awhi website	People Land Animals Water	*"When nature flourishes, we flourish"* Kaitiakitanga Connection to land Regenerative farming Whānau A belief in the five freedoms of animal welfare	🟢	Retiring erosion prone land from sheep and beef and planting with Manuka for honey Placing 10% of land in 25-year no development covenant Fencing off delicate ecosystems and waterways from stock Creating wildlife corridor from Ruapehu to Whanganui river, by controlling predators and building native population of plants and animals Using fertilisers and nutrition supplements sparingly, and only when unavoidable	🔴
Ngāti Makino (Heritage Trust?)		(Values expressed in Ngāti Makino 2021-2026 Strategic plan - link on website)	People Land	**Tino Rangatiratanga:** To promote delf-determining and self-empowering behaviour **Kia Makino:** Upholding our kawa and tikanga in all dealings amongst ourselves and others **Kohahitanga:** To maintain and promote unity of purpose **Whanaungatanga:** To maintain and build relationships and connections that enhance wellbeing of Ngati Makino **Mana whenua, mana moana, mana tangata:** Develop and foster a sense of ukaipo and the importance of belonging and contribution **Manaakitia te taiao:** Enhance the mana of our taiao **Wairuatanga:** Connectedness to and of our spiritual and physical elements **Pou also mentioned:** Grow, regenerate, and secure our environment for our mokopuna	🟢	Five year goals re: Mana Whakahono: Implementation of iwi management plan Native nursery established Implementation of Waitahanui Integrated Catchment plan Taonga species protected, grown and flourishing Mahi ngataha with all connected stakeholders (other iwi, government, NGOs) Rangahau a Makino	🔴
Rotoiti 15 Trust		(Values expressed on Rotoiti 15 Trust website)	Land People	**Kia whakamana te tangata:** We respect and value people **Kia tina te kaitiakitanga:** We act with integrity **Kia tapu te whenua:** We value the sacredness of land **Kia tu maia:** We are courageous **Kia ngatahi te whakaaro me te mahi:** We believe in working together	🟢	Our environment section: *"We are constantly reviewing our policies to ensure that sustainability, protection, and enhancement of our taiao is at the forefront of our thinking. In commitment to the wellbeing of our whenua the Trust has formed a sub-committee in partnership with DOC charged with the management of Makatiti Dome."*	🔴

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Tuaropaki Trust		(Values expressed on Tuaropaki Trust website)	Land People	Guiding principles: • We will act as a beacon of hope and prosperity for our people. • Protect and advance the interests of our people. • Be at one with our cultural land and resource. • Help build the capability of our people through positive support and encouragement. • Look after the land, and the land will look after you.	(yellow ▶)	Geothermal: *"Ensuring that we manage our geothermal resource in a sustainable and responsible manner is critical to our business."* Trust invests in San Francisco food tech company Treasure8, a company focussed on developing food tech to reduce global waste and increase sustainable food supply. Trust is 50/50 partner in Halcyon Power Ltd., a hydrogen power company intended to produce 'green hydrogen' without use of fossil fuels, and help achieve NZ Carbon free 2050 goal.	(red ▶)
Tauhara North No.2 Trust		(Values expressed on Tauhara North No.2 Trust website)	Land People	*"Hold fast to the lands and make the best use of our lands for future generations"* *"Tauhara North No2 Trust's Land & Food strategy is about recognising our whakapapa to Ngāti Tahu - Ngāti Whaoa and our united desire to be kaitiaki of our whenua and other resources within our region"*	(green ▶)	Sustainably managing resources for future generations of owners and whānau by inspiring and connecting whanau Kai and Farms: Optimise land to increase returns while protecting environment	(red ▶)
Wi Pere Trust		(Values expressed in 2022 Ahuwhenua trophy finalist description)	Land People Water	*"To nurture the Wi Pere legacy for current and future generations with the overarching philosophy of kaitiakitanga"*	(green ▶)	Have developed Land Environment Plan to do the following: Retirement of erosion prone land Fencing all waterways (35 km) Riparian planting Improving water quality	(red ▶)
Ngāti Whakaue Tribal Lands		(Values expressed on Ngāti Whakaue website)	Land People	Kaitiaki Aroha Whakapono Kotahitanga *"Mana whenua, mana tangata"*	(green ▶)	Purpose of Ngāti Whakaue Tribal Lands: • safeguard and improve corpus lands • grow our asset base • contribute to increasing the wellbeing of Ngati Whakaue • achieve owner expectations • provide opportunities for future generations Farms: "seek to exceed environmental standards and demonstrating innovation and leadership to the wider industry"	(red ▶)
Pakihiroa Farms	Ngāti Porou	(Values expressed on Ngāti Porou website)	Land People	A Tatau Pou (Our strategic goals): Rangatira, Whānau, Mātauranga, Kaitiaki, Whairawa A Tatua Tikanga (Our values): Porou, , Aroha, , Kanohi kitea, Manaaki, Tika/Pono, Ringa, raupa, Pakari	(green ▶)	Balancing agricultural output with good environmental management	(red ▶)

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Ngāti Kahungunu	Ngāti Kahungunu	(Values expressed on Ngāti Kahungunu website)	Land People Water Animals	*"We are charged to preserve and protect our air, water and lands and the resources within for the benefit and survival of our mokopuna."*	(green ▶)	Protecting cultural landmarks • Education/training tamariki in the protection and management of the environment • Controlled culling management in marine areas • Restocking, reseeding, re-vegetation of native flora, fauna & fisheries • Set regulatory standards and environmental cleanup strategies in place for waterways, land management, environmental cleanup sites • 200 mile "foreshore" acknowledged • Complete inventory of Ngati Kahungunu estate • Defence of our shoreline - own coastguard Also have produced the "Kahungunu ki Uta, Kahungunu ki Tai" strategic environment plan for the sustainable development of Marine and freshwater fisheries.	(red ▶)
Tainui Group Holdings	Waikato Tainui	(Values expressed on Tainui Group Holdings website, Goals expressed in Waikato Tainui 2020 Annual report)	People Water Land	Mahi Tahi - Teamwork: We work as one to deliver great business outcomes. Manaakitanga - Care in our work: We take care in our work, for each other, our whanau, iwi and community. Kaitiakitanga - Guardianship: We diligently protect, grow and sustain tribal wealth. Pono me te tika - Honesty & Integrity: We build trust by being honest, open and respectful in everything we do.	(green ▶)	*"Working toward the restoration and enhancment of our wai and whenua to the state in Kiingi Taawhiao's maimai aroha"* • Training and support for our tribal members so they can lead Taiao initiatives • Implement a five-year programme of investment to improve wai (including Kaawhia, Aotea, Whaaingaroa and Manakau harbours) and whenua • Secure water rights • Develop and operationalise Iwi Environmental Standards consistent with Tai Tumu, Tai Pari, Tai Ao • Support our whaanau to respond to climate change impacts (and other environmental challenges) on their marae	(red ▶)
Ngāti Awa Farms (Rangitaiki) Ltd.	Ngāti Awa	(Values expressed on Ngāti Awa website)	People Land Water Animals	Manaakitanga - Caring for each other: Our shared obligations to care for one another, with particular emphasis on caring for our youth and our elders. Kaitiakitanga - Guardianship for future generations: Represents our obligations to protect our culture, our environment, our resources and our people, today and for future generations, in accordance with our cultural principles. Ngāti Awatanga - Our language and culture: Uphold an protect our language and culture - which derive from our shared ancestry - as the cornerstone of our unique identity.	(green ▶)	Ngāti Awa have an environment plan which lists a variety of objectives relating to specific resources and environments: https://issuu.com/terunangaongatiawa/docs/env000_na_environmental_plan	(red ▶)

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Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Whakatohea Māori Trust		(Values expressed on Whakatohea website)	Land, People, Water	Whānaungatanga, Manaakitanga, Rangatiratanga, Matawhanui, Kaitiakitanga	(green)	*"As kaitiaki, it is our resposibility to provide leadership and guidance for the following areas: Pest Control, Weed Control, Wetland and Freshwater Restoration, Marae Restoration, Track Maintenance, Hapu Wananga."* Other specific goals/actions mentioned in relation to commercial enterprises: • A cultural values assessment of its marine farm to promote tikanga, kaitiakitangi, and Mauri of environment. • Riparian planting at the Whakahotea Dairy Farm. • Fencing of waterways and weeding of pest species at Whakapaupakihi farm.	(red)
Whakatohea Māori Trust		The Co-operative Difference - Fonterra	People, Land, Animals, Water	Intended to incentivise farmers to improve practices through better milk prices offered, in order to increase overall milk price through better reputation and environmental management. Also to keep Dairy farming an attractive career choice for future generations.	(red)	**Environment:** • Nitrogen surplus less than highest 25% of Fonterra farms • Farm participating in stewardship scheme for plastics and agri-chemicals • No effluent discharge into waterways • 80% farm feed grown across season • Farm has plan to manage winter grazing risks **Animals:** An animal wellbeing plan developed **People and community:** Achieve 100% on foundation level of DairyNZ Workplace 360 Assessment	(red)
Whakatohea Māori Trust		TK - Traditional Knowledge Labels	People	Intended to give indigenous communities some control over the correct use and access to digital cultural material, and to inform potential users of such material about appropriate use and potential restrictions.	(yellow)	Clarify community-specific rules and responsibilities regarding access and future use of traditional knowledge Ensure integrity of labels to allow standardisation and recognition of authenticity	(red)
Maraeroa A and B Trust		(Values expressed on Maraeroa A and B Trust website)	Land, People	Kia mau ki to tatou reo me ona tikanga (Stick to our language and culture) Integrity, respect, transparency and honesty Commitment, vision & compassion Unity, strong relationships, good communication A best practice organisation for its staff, processes, systems and stakeholders Entrepreneurship	(green)	*"Toitu te whenua, toitu te iwi - To nurture that land for the betterment of the people"* Secure the land and understand its potential - By 2020, ensure that all our land has been secured under the kaitiakitanga of the Trust	(red)

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Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Te Arawa Lakes Trust		(Values expressed on the Te Arawa Lakes Trust website, and in Te Arawa Cultural values framework)	People, Water, Animals, Land	**Wai:** Physical representation of water **Wai Ariki:** water of the gods - expresses value of water regardless of type **Wai Ora:** Health benefits of water - including social, cultural economic **Wai Rua:** Spiritual attributes of water - balance, connection **Wai Ata:** Cultural value of water - Te Arawa cultural identity	(green)	**Our Strategic Intent:** • The authority of Te Arawa is readily recognised by all • The quality of the water is such that you can see the footsteps of the koura • Te Arawa Lakes Trust is well equipped for the journey ahead **Several programmes and plans in place for environmental enhancement:** • Sustainable management framework for Te Arawa customary fisheries, developed alongside NIWA • Te Arawa Catfish Killas - programme for elimination of invasive and harmful catfish from Te Arawa waterways • Wetland Team - team for both restoring wetland and educating and upskilling others in wetland management and restoration • Te Ara Ki Kopu - Te Arawa Climate Change Strategy • (Priority Kaupapa of Climate change plan: • Adaptation Planning & Resilience Building • Biodiversity • Circular Enterprise & Economies • Energy Security & Sovereignty • Food & Water Security & Sovereignty • Land Use Change & Practices)	(red)
Te Pumautanga o Te Arawa Trust		(Values expressed on Te Pumautanga o Te Arawa Trust website)	People	**Whānaungatanga:** Working together respectfully and acknowledging our whakapapa **Kotahitanga:** Moving together as one: he waka eke noa **Tikanga:** Doing the right thing and applying our Te Arawatanga in all we do **Rangatiratanga:** Leading with integrity, courage and honour **Manaakitanga:** Embracing all people with oneness and respect **Kaitiakitanga:** Caring for and protecting our taonga for future generations.	(green)	**Our mission:** Creating opportunities to enable vibrant futures for the Affiliate Iwi-Hapu of TPT **Our Kaupapa:** Advancing the Integrity of the Settlement, Touching the People, Ensuring the Best and Effective use of our Taonga, Unified Te Arawa	(red)

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Te Paiaka Lands Trust		(Values expressed in Ngāti Kea Ngati Tuara 2016 iwi environmental management plan)	Land Animals Water	*"The basis for this plan is to express our rangatiratanga in order to exercise our kaitiaki roles and responsibilities within our rohe. It acknowledges the mana whenua of Ngāti Kea Ngati Tuara and our connection with other entities. This is a living document and is inter-generational in acknowledging the past, providing relevance to the present and preparing us for the future."*	●(green)	**Regional Nutrient Policies:** Maintain active awareness and compliance **Soils:** Maintain and improve quality of soild to ensure sustainable future for whenua **Nutrient Management:** Minimise losses **Riparian Management:** Maintain/enhance water quality and biodiversity **Water Quality:** Minimise negative impact of land based practices **Stock Management:** Ensure best compliance while maximising financial return	●(red)
Te Runanga o Ngāti Kea Ngāti Tuara Trust		(Values expressed in Ngāti Kea Ngāti Tuara 2016 iwi environmental management plan)	Land Water	*"The basis for this plan is to express our rangatiratanga in order to exercise our kaitiaki roles and responsibilities within our rohe. It acknowledges the mana whenua of Ngāti Kea Ngāti Tuara and our connection with other entities. This is a living document and is inter-generational in acknowledging the past, providing relevance to the present and preparing us for the future."*	●(green)	**Environmental projects listed in plan:** • Installing a micro-hydro unit at Kearoa Marae, to meet electricity needs of the marae • Riparian planting on Pokaitu River, to assist in cleaning up of waterways • Native tree nursery for use in riparian planting • Erosion control under Waikato Regional Council guidance	●(red)
Rotoma No.1 Incorporation		(Values expressed on Rotoma No.1 Incorporation website)	Land People	Rangatiratanga - Authority Hiranga - Excellence Whanaungatanga - Kinship Kaitiakitanga - Guardianship Whakamana te hapu - Empower the hapu Whakapono - Integrity, honest	●(green)	**Strategic goals:** 1. Our Whenua 2. Our Identity 3. Our Wellbeing 4. Our Prosperity **Strategic goal 1:** Kia mau ki te whenua - Our Whenua **Goal:** A protected, enhanced and growing whenua that is sustainably utilised **Strategies:** 1. Ensure wahi tapu and whenua rahui are continually protected. 2. Educate our people about their whenua (including lakes and streams) and how to take care for it. 3. Ensure direct, effective, sustainable management of our whenua. 4. Retain and increase Rotoma lands held.	●(red)

Entity	Iwi	Programme Name/s	Whakapapa Involved	Stated Values/Intent	Stated Māori values Connection	Stated Goals	Measurement Evidence
Ngāti Porou Seafoods Group	Ngāti Porou	(Values expressed on Ngāti Porou Seafoods Group website)	People Water Animals (Fish	Poroutanga - unrelenting, proud, transformative, energetic, strident: *"We know who we are."* Aroha - empathetic, generous, magnanimous, thoughtful, considerate: *"We care."* Kanohi kitea - visible, approachable, relevant, accessible, reliable: *"We walk the walk."* Manaaki - respectful, reciprocity, mana enhancing, hospitable, inclusive, empowing, kanohi ki te kanohi, open, honest: *"We are team players."* Tika/Pono - accountable, honest, transparent: *"We have integrity."* Ringa Raupa - hard working, industrious, innovative, creative, proactive: *"We show initiative."* Pakari - strong, courage, fearless, resilient: *"We've got guts."* Kaitiaki - Guardianship of resources, responsibility for sustainability: *"We will endure."*	●(green)	*"We are determined that our descendants - and all New Zealanders - will inherit a healthy marine environment that sustains them physically economically socially spiritually and recreationally. While we are willing to forego profit to achieve this, our commitment to innovative science and fisheries management mean it is increasingly possible to have more of our fish, and eat them too. This is the essence of kaitiakitanga."* **Research section mentions research into:** • Production systems: ways to sustainably grow fish stocks and support sustainable resource management • Marine Biotechnology: Ways to improve usage of all parts of fish, to reduce waste • Consumer and Market Research: including research into Environmental certification.	●(red)
Rakaia Incorporation		Values expressed on Rakaia Incorporation website)	Land People Water	*"As kaitiaki of our land, sustainability is at the heart of Rakaia Incorporation. Across all our farms, resources are utilised in a way that provides the best ourcomes for the Incorporation, our Sharemilkers, and the environment."*	●(green)	**Subscribes to UN Sustainable Development Goals, specifically:** 2 - Zero Hunger 6 - Clean Water and Sanitation 12 - Responsible Consumption and Production 13 - Climate Action 15 - Life on Land Has also listed some areas of focus Effluent Management Cropping & Cultivation Irrigation Stock Management Nitrogen Fertiliser Imported Feed	●(red)

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Glossary

Atua: Gods

Iwi: Tribe

Haumiatiketike: God of cultivated food

Kaitiaki: Guardians/stewards

Kaitiakitanga: Guardianship/Stewardship

Karakia: Chant, prayer

Mahinga kai: Traditional food resources and their habitats

Mana: Power, prestige

Manaakitanga: Fostering strong relationships through kinship and/or shared experience

Mana tangata: Personal mana

Mana whakahaere: Governance

Mātauranga: Māori knowledge

Mauri: Life essence

Noa: Absence of limitations or conditions

Rāhui: Temporary prohibition, often for resource protection

Rangatiratanga: Chieftainship, the right to exercise authority

Ruaumoko: God of volcanoes, earthquakes and seasons

Rohe: Boundary, district, region

Rongomaraeroa: God of cultivated food

Rongomātāne: God of cultivated areas

Takiwā: District, area, territory

Tamaunuierā: Personification of the sun

Tāne mahuta: God of the forests

Tangaroa: God of water and sea creatures

Taonga: Treasured natural resources

Tapu: Sacred

Tauutuutu: Māori environmental ethic

Tāwhirimātea: God of the wind and air

Te ao Māori: Māori worldview

Tūmatauenga: God of war and humans

Utu: Balanced relationship

Waiata: Song

Whakapapa: Genealogy, organising principle

Whakatipu Rawa: Intergenerational equity, local investment

Whanaungatanga: Enhancing the mana of others/environment, through care and respect.

Acronyms

A-NZ: .... Aotearoa New Zealand

CHI: .... Cultural health index

EMF: .... Environmental monitoring frameworks

KIP: .... Kaitiaki Intelligence Platform

MAC: .... Māori agribusiness collective

MALIT: .... Māori land incorporations and trusts

MEF: .... Māori environmental frameworks

MLOUA: .... Māori Land Use Opportunities Assessment

MSF: .... Mauriora Systems Framework

MWF: .... Māori wellbeing frameworks

PSGEs: .... Post-settlement governance entities

PUCM: .... Planning Under a Co-operative Mandate

RMA: .... Resource Management Act

UCM: .... Planning Under a Co-operative Mandate

WMF: .... Wellbeing monitoring frameworks

WRF: .... Whānau Rangatiratanga Frameworks