Unlocking New Zealand's environmental information

July 2026

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

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July 2026

ISBN

978-0-473-79656-3 (print)
978-0-473-79655-6 (online)

Cover images

International Space Station orbiting over New Zealand, NASA; Modelled 1-in-100-year flood depth in Whakatāne under a 2°C global warming scenario, New Zealand LiDAR 1 m DEM, and Bay of Plenty east 0.2 m aerial photos (2024–2025) (adapted from ESNZ, LINZ and BOPLASS, respectively, licensed for reuse under CC BY 4.0); Remote environmental monitoring site on the West Coast, West Coast Regional Council.

Chapter header images

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Acknowledgements

The Parliamentary Commissioner for the Environment, Simon Upton, is indebted to a number of people who assisted him in producing this report. Special thanks are due to Dr Robert Dykes who led the project, supported by Dr Eleni Hackwell, Dr Warren Fitzgerald, Dr Geoffroy Lamarche, and Dr Anna Hooper. Leana Barriball, Meg Crozier, Brigitte Marulli de Barletta, Matt Paterson, Geoff Simmons, and Rebecca Thornley all provided valuable support.

The Commissioner would like to acknowledge the following organisations for their time and assistance during this investigation:

- Bioeconomy Science Institute – Maiangi Taiao
- Department of Conservation – Te Papa Atawhai
- Earth Sciences New Zealand
- Environment Information Australia
- Land Air Water Aotearoa
- Lynker Analytics Ltd
- Ministry for Primary Industries – Manatū Ahu Matua
- Ministry for the Environment – Manatū Mō Te Taiao
- Natural Hazards Commission – Toka Tū Ake
- New Zealand Space Agency
- Occam
- Standards New Zealand ISO/TC211 International Review Group for Geographic Information/Geomatics
- Stats NZ – Tatauranga Aotearoa
- TAIAO – Time-Evolving Data Science and Artificial Intelligence for Advanced Open Environmental Science
- Takiwa
- Te Uru Kahika – Regional and Unitary Councils Aotearoa
- Toha Network
- Toitu Te Whenua – Land Information New Zealand
- Waikato Regional Council – Te Kaunihera o Rohe o Waikato
- Wilderlab NZ

Special thanks are due to the following councils for their assistance with the regional examples:

- Bay of Plenty Regional Council – Toi Moana
- Christchurch City Council – Te Kaunihera o Ōtautahi
- Environment Canterbury Regional Council – Kaunihera Taiao ki Waitaha
- Hastings District Council – Te Kaunihera ā-Rohe o Heretaunga
- Hawke's Bay Regional Council – Te Kaunihera ā-Rohe o te Matua-a-Māui
- Napier City Council – Te Kaunihera o Ahuriri
- Selwyn District Council
- Tauranga City Council
- Western Bay of Plenty District Council – Te Kaunihera o rohe mai i Ngā Kuri-a-Whārei ki Otamarakau ki te Uru

The Commissioner wishes to thank the following individuals for reviewing earlier drafts of the report. While he has benefited hugely from their insights, any errors, omissions or opinions are entirely his own.

- Dr. David Medyckyj-Scott
- Dr. Edward Abraham, Dragonfly Data Science
- Professor John Reid, University of Canterbury – Te Whare Wānanga o Waitaha
- Dr. Thomas Dowling, University of Auckland – Waipapa Taumata Rau

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Necessary but not sufficient: A user warning for consumers

For almost nine years now I have been drawing attention to the often-threadbare state of environmental information in New Zealand. Almost every investigation I have undertaken has been hampered by a lack of reliable information. It's hard to make judgements – or run your business – if you lack key facts.

This report builds on all my previous work to make the case for investing in making better use of the data we have and adding to them by filling gaps and constructing entirely new insights into the nature of our physical environment. Until recently, my calls have been greeted politely but not accorded any particular urgency or priority.

Recent decisions to upend our planning and resource allocation laws have exposed the need for a less complacent approach. There is no small irony in the fact that a decision to focus new planning laws on economic development rather than environmental protection has been the catalyst for a change of mind about the importance of environmental information. But the logic is inescapable. If you want to hurry up urban expansion, roll out new infrastructure and make the conservation estate available for economic activity "to the greatest extent possible", you need to know what's there or what problems you might be buying into if you're not sure. A world of pre-approved permitted uses without the information needed to monitor them is inviting trouble.

To that end, the Government has decided to build a digital backbone for its new planning system and do so in a way that should enable the federation and sharing of large amounts of information – as this report recommends. That is a positive step. $41 million is to be invested in a digital platform to underpin the new planning system and $61 million has been allocated to environmental data.[1] So, there is a genuine recognition that we have to improve the information on which we rely to make sensible rules and monitor them. That is to be welcomed.

But it is only a downpayment on what is needed. If I seem begrudging, let me put that $61 million in perspective. It would fund approximately one kilometre of a new four-lane road such as the proposed Northland Corridor.[2] We are currently planning to add at least 150 kilometres as part of

1 There is additional investment to develop the New Zealand Flood Map.

2 The indicative cost of a four-lane highway or motorway is around $56 million per kilometre, assuming a cost of $14 million per lane kilometre (NZTA, 2025, p.9).

the Roads of National Significance.[3] Somehow, we have no difficulty contemplating spending large numbers on hard infrastructure. But despite endless protestations that we are living in an exciting, dematerialising, information-based, post-industrial age, we have difficulty seeing information as infrastructure. Yet it is a key realisation I have been forced to accept.

But – and here is the user warning – while better information is necessary, it is not sufficient. To pose the warning in those terms – as I frequently have – is trite. We all know that we will never have enough information. Indeed, in some respects, the more we have, the more there is to argue over. I often hear calls for 'evidence-based' policies. I also witness interest groups scrambling to select the evidence that best suits their cause. In a world of burgeoning disinformation and in which artificial intelligence can be enlisted to question or justify anything, we risk buyer's remorse through a collapse in trust.

Trust is everything. So the way we procure, manage and present data is possibly even more important than the data themselves.

Beyond that, the most important thing decision makers have to internalise is that the possession of high-quality information doesn't remove the need to make judgements and trade-offs. Information cannot dispense with the need for human judgements. And the sort of information we can collect about the environment through some of the ingenious tools described in this report is only a part of what will inform those judgements.

'The environment' is not some inert 'thing' out there waiting to be described. It is both dynamic and alive. We are part of it. Māori will rightly insist that whatever biosystematics has to say about biodiversity, mātauranga based on centuries of observation should also be called upon. So should the lived experience of every farmer and every bach owner. We should resist the temptation to delegate the business of wrestling with trade-offs to experts arguing over 'the evidence'.

This report is offered with these important caveats in mind. I will continue to call for better information. If we can afford to fast-track ports, mines and motorways, we can afford to fast-track the upgrading of our environmental management system. But I will also continue to monitor the way it is used. That will be the test of whether its benefits justify the costs.

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3 Based on currently announced four-lane Roads of National Significance (Daly, 2024; NZTA, 2026). The actual number will be significantly higher as proposed roads are finalised.

E hiahiatia ana engari kāore i te rawaka: Tā te kaiwhakamahi whakatūpato mā te hunga kiritaki

Kua tata hipa te iwa tau ināianei e whakaatu ana au i te āhua ngoikore o ngā mōhiohio taiao i Aotearoa nei. Tata ki te katoa o āku whakatewhatewha i raru i te korenga o ngā mōhiohio pono. He uaua te whakatau – te whakahaere rānei i tō pakihi - mēnā kāore ō meka matua.

E noho ana āku mahi o mua hei tūāpapa mō tēnei pūrongo kia tautoko i te whakangao kia pai ake te whakamahi o ō tātou raraunga, kia tāpiri atu hoki ki aua raraunga mā te whakakī kōhao, mā te waihanga māramatanga tino hou hoki e pā ana ki te āhuatanga o tō tātou taiao ōkiko. Ko te urupare ki aku tohutohu he huatau, kāore i kakama, ā, kāore i whakaritea hei kaupapa matua. Kua panonihia tēnei inakuanei.

Nā ngā whakataunga nō nā tata nei kia panoni rawa i ō tātou ture whakamahere, tuari rauemi hoki i hura te hiahia ki te ahunga kaha ake. He mea ohorere pea, arā, nā te whakataunga kia arotahi ngā ture whakamahere hou ki te whakawhanaketanga ohaoha, kaua ko te whakahaumaru taiao, i panoni ai te whakaaro mō te hiranga o ngā mōhiohio taiao. Engari kāore e taea tēnei whakaaro te whakahē. Ki te hiahia koe ki te whakatere i te whakawhānuitanga ā-tāone, ki whakaputa i te tūāhanga hou, ki te whakawātea hoki i te whenua whāomoomo mō te mahi ohaoha “ki te tino whānuitanga e āhei ana”, me mōhio koe he aha ngā raruraru ka puta pea ki te kore koe e tino mōhio ināianei. Ina whakaaetia ana ngā whakamahinga āhei i mua, ahakoa kāore i te whai i ngā mōhiohio e hiahiatia ana kia aroturukihia, he raruraru kei te haere.

Nā reira, kua whakatau te Kāwanatanga ki te waihanga i te tuarā matihiko mō tana pūnaha whakamahere hou, ā, ka whakamahia kia whakamana i te whakakotahitanga me te tuaritanga o ngā mōhiohio tino nui – e hāngai ana ki te tohutohu o tēnei pūrongo. He ahu whakamua tērā. Ka tuku Tahua 2026 i te $41 miriona hei whakangao ki te atamira matihiko e noho ai hei tūāpapa mō te pūnaha whakamahaere hou, ā, kua tuari i te $61 miriona ki ngā raraunga taiao.[1] Nā reira, he māramatanga tūturu tēnei me whakapai ake i ngā mōhiohio e whakawhirinakihi ai tātou ki te waihanga i ngā tikanga pai, ki te aroturuki i aua tikanga hoki. Me mihi ka tika ki taua māramatanga.

Engari he utu paku noa iho mō tērā e hiahiatia ana. Kei pōhēhē e matapiko ana au i taku whakamiha, engari me tuku horopaki mō taua $61 miriona. Ka utu i tōna 1 kiromita o te rori me ngā ara e whā, pērā i te Kauhanga Tai Tokerau.[2] Ināianei e whakamahere ana tātou ki te tāpiri kia kaua e iti iho i te 150 kiriomita hei wāhanga o ngā Huarahi Hiranga ā-Motu.[3] Nā, kāore he paku raru te whakaaro ki te whakapau i te pūtea nui mō te tūāhanga mārō. Engari, ahakoa ngā tautohe mutunga kore e mea ana ka noho tātou i te ao hiamo, memeha, tūāpapa mōhiohio, i muri i te ahumahi, he uaua te kite i ngā mōhiohio hei tūāhanga. Engari he tino māramatanga tēnei i toko ake i roto i au.

Engari – nei rā te whakatūpato mā te kaiwhakamahi – ahakoa e hiahiatia ana ngā mōhiohio pai ake, ehara i te rawaka. Ehara te tuku whakatūpato pērā – i auau taku tuku – i te mea hou. E mōhio ana tātou e kore tātou e whiwhi ki ngā mōhiohio rawaka. Otirā, ka taea te kī, ina nui ake ana ngā mōhiohio, ka nui noa atu ngā kaupapa hei tautohetanga. He riterite te rongo i te tono i ngā kaupapahere ‘pūtake-taunakitanga’. Ka kite hoki au i ngā rōpū aronga e whakapau werawera ana ki te kōwhiri i te taunakitanga e tino tautoko ana i ō rātou ake kaupapa. He ao tēnei e piki ana te kōrero horihori, ā, ka whakamahia te atamai hangahanga kia pātaihia, kia parahaua rānei ngā mea katoa. He whakamōrea kaniawhea kaihoko ki te hinga te whakapono.

Kāore i tua atu i te pono o ngā kōrero. Nā, ko te āhua o tā tātou whiwhi, whakahaere, tāpae hoki i ngā raraunga te mea nui. Nui ake pea i aua raraunga anō.

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1 He whakangao anō hei whakawhanake i te Mahere Waipuke o Aotearoa.

2 Ko te whakapae o te utu o te huanui matua, huanui rānei e whā ngā ara, ko tōna $56 miriona mō ia kiriomita, mēnā $14 miriona te utu mō ia kiriomita o ia ara (NZTA, 2025, p.9).

3 Nā runga anō i ngā Huarahi Hiranga ā-Motu ara e whā kua whakapuakitia ināianei (Daly, 2024; NZTA, 2026). He nui rawa atu te nama tūturu ina whakaotia ana ngā rori e marohia ana.

I tua atu i tērā, ko te kaupapa matua hei whakaarotanga mā te hunga whakatau, ahakoa ka riro i a rātou ngā mōhiohio kounga nui me whakatau tonu, me aro tonu ki ngā āhuatanga tuku. Ehara i te mea mā ngā mōhiohio e whakakorehia ai te hiahia kia tuku mā te tangata e whakatau. Waihoki, he wāhanga noa iho ngā momo mōhiohio mō te taiao e taea ai te kohi e tātou ki ētahi o ngā taputapu atamai i tautuhia i roto i tēnei pūrongo.

Ehara 'te taiao' i tētahi 'mea' e tatari ana i waho rā kia tautuhia. He mea nekeneke, he mea ora. He wāhanga tātou nō te taiao. Kāore e kore ka whakahau a Ngāi Māori ko te whakamāramatanga a ngā pūnaha ā-koiora mō te kanorau koiora, me aro atu ki te mātauranga i puta nō ngā rautau o te āta tirotiro. Me pērā hoki te wheako ā-ao o ngā kaipāmu katoa, o ngā kaiwhiwhi whare tātahi katoa hoki. Kia karo atu tātou i te whakawaitanga kia tuku i te mana o te whakarite i ngā āhuatanga tuku ki ngā mātanga e taupatupatu ana i 'te taunakitanga'.

E tāpaehia ana tēnei pūrongo me te aro tonu ki ēnei whakatūpato matua. Ka tono tonu au i ngā mōhiohio pai ake. Ina āhei ana te utu mō te whakatere i ngā wāpu, ngā māina me ngā huanui, ka āhei tātou te utu kia tere ake te whakapai ake i tō tātou pūnaha whakahaere taiao. Engari ka aroturuki tonu au i te āhua e whakamahia ai tēnei. Koinā te whakamātautau kia kitea mēnā e parahau ana ōna painga i te utu.

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Smooth shield fern, *Parapolystichum glabellum*

1 Introduction

The information base on which environmental decisions are made is critical. Environmental information is a key input into environmental decision making, adaptive management and long-term environmental stewardship. Understanding the delayed and complex way in which the environment responds to pressures requires systematic monitoring over extended periods of time. High-quality, comprehensive environmental information (Box 1.1) is needed to develop and evaluate environmental (and many non-environmental) operational and policy decisions.[1] It is also needed in taking budget and investment decisions. Members of Parliament have little hope of knowing whether environmental expenditure represents value for money if they can't be confident that environmental outcomes are accurately described and tracked. Importantly, environmental information is not static. It is continually being collected, updated, integrated, interpreted, reinterpreted and reused by different organisations over time.

A lack of accessible environmental information is impeding better environmental management and adding costs to the system. This problem seems to be greater for environmental information than for economic and social data due to the fragmented way in which environmental information is collected by a wide range of public and private organisations, each with its own functions, priorities and methodologies.

To address these issues, this report investigates the shortcomings of New Zealand's environmental information system (chapter 2) and actions to build an effective system going forward, including pursuing a federated system (chapter 3). Advances in sensor, data processing and infrastructure technologies are introduced that could fill the many gaps that exist and make it easier and more cost effective to collect, distribute and use environmental data and information (chapters 4–7). The gap between where we are and where we could be (chapter 8) is then discussed along with an examination of the recent government announcements to make significant investments in environmental data infrastructure to support current planning reforms (chapter 9).[2] Finally, a series of recommendations are made that, if taken up, could unlock environmental information in the future (chapter 10).

1 The current state of knowledge for 55 environmental attributes is summarised in Lohrer et al. (2024).

2 Bishop et al., 2026.

Box 1.1: What is environmental information?

Environmental data can take many forms. They can be derived from routine or targeted surveys or monitoring, generated from experiments or created as a model output. Data can be geospatial and aspatial, collected periodically or continuously, and at different temporal and spatial scales (e.g. local, regional, national). Data can be seemingly random until they are organised.

Environmental information is data that have been analysed and interpreted to add meaning and value. This process is how environmental data are made useful. An environmental information system can be described simply as a network of information that includes how information is collected, analysed, stored and used. In short, a good system ensures that data and information are accessible, discoverable and usable.

Data integration is the process of combining and linking data from different sources, formats or systems so they can be used together to create a joined-up view and generate new insights. Data integration increases the value of the data through reuse and interoperability.[3]

3 Mansell et al., 2017.

Prickly shield fern, *Polystichum vestitum*

2 Shortcomings of New Zealand's environmental information system

The consequences of a deficient environmental information have been described at length in two office of the Parliamentary Commissioner for the Environment (PCE) reports: *Focusing Aotearoa New Zealand's environmental reporting system*, and *Environmental reporting, research and investment: Do we know if we're making a difference?*[1] These reports highlighted that a lack of leadership, coordination and consistent resourcing are perennial issues that undermine the environmental information system. They also contribute significantly to dissatisfaction with the costs imposed by regulatory systems that rely on environmental data.

The following sections build on these reports to highlight six key problems that plague New Zealand's environmental information system:

- complexity and fragmentation
- duplication and overlaps
- gaps
- lack of standardisation
- poor accessibility and reusability
- precarity of sustained resourcing.

Some of the examples presented below have been used in previous reports to highlight issues with our environmental reporting and science funding systems.[2] Here, they are used to illustrate specific systemic issues in the current information system. The fact that they are still issues, some seven years since I first described them, is evidence of the lack progress to date.

1 PCE, 2019, 2022a.

2 The selection of the examples used is not an indication of any priority of datasets or issues to fix, per se. For example, many similar examples exist in areas not focused on in this chapter, such as marine and fisheries management, and atmosphere and weather.

Complexity and fragmentation

Numerous organisations collect and hold environmental information. Many of these organisations are governed by legislation that can impose environmental reporting requirements and set national environmental direction and regulations (Box 2.1). Legislation can also devolve responsibilities to local government that require them to collect and use environmental information. Others, such as iwi/hapū/Māori, community groups, industry bodies, farmers, universities, infrastructure companies and non-governmental organisations, also contribute to the environmental information system in various ways, depending on the outcomes they are trying to achieve. Because different players collect information for different purposes, making the best use of it can be a complex business.

Box 2.1: Examples of legislated data collection

Conservation Act 1987, Cadastral Survey Act 2002, Environment Act 1986

The Conservation Act 1987 confers broad powers on the Director-General of Conservation to gather information and conduct and commission research to enable the Department of Conservation – Te Papa Atawhai (DOC) to perform its functions (Conservation Act 1987, s 53). Similar powers are given to the Surveyor-General (often, but not always, the Chief Executive of Toitū Te Whenua – Land Information New Zealand (LINZ)) in relation to managing New Zealand's cadastral system (Cadastral Survey Act 2002, s 7), and to the Secretary for the Environment under the Environment Act 1986 (s 31(b)).

Data and Statistics Act 2022

The broadest example of data collection powers concerns those given to the Government Statistician, who may produce official statistics on any matter relating to New Zealand, including its environment (Data and Statistics Act 2022, s 43). The Government Statistician is also the Government Chief Data Steward and plays a wider system role alongside six other system leads appointed under the Public Service Act 2020. As system leaders, they can set standards for agencies to operate within.

Waste Minimisation Act 2008

The Waste Minimisation Act 2008 and subsequent regulations enable data collection on net tonnage and waste categories to be collected from waste disposal facilities for the purposes of administering the waste levy.[3]

Regulations and policies are often developed and implemented in isolation, so environmental information often ends up being collected for a single purpose, be it biosecurity, water quality or natural hazards. Information does not readily travel horizontally between organisations or vertically between local and central government. New Zealand's environmental reporting system under the Environmental Reporting Act 2015 exemplifies this. To construct environmental indicators, existing information is passively harvested from different organisations then processed into static indicators, which may only be updated periodically.[4]

The fragmentation of responsibilities within an area or environmental domain also means that multiple organisations are separately responsible for information collection. How the biosecurity system deals with native ecosystem weeds provides an example of this. There are many disconnected databases, and much of the information that does exist is not easily accessible. There is no comprehensive, up-to-date, authoritative database that pulls together information on exotic plant species, neither is there a clear custodian with defined

3 Waste Minimisation (Calculation and Payment of Waste Disposal Levy) Regulations 2009.

4 MfE and Stats NZ, 2025b, pp.10 and 51. See PCE (2019) for extended discussion of the environmental reporting system.

management practices. Instead, this information is spread across the Ministry for Primary Industries – Manatū Ahu Matua (MPI), regional councils, territorial authorities, research organisations, universities, and citizen science platforms such as iNaturalist.[5]

The result is a wide range of organisations collecting and storing environmental information without any attempt to focus all that effort on a coherent, joined-up information ecosystem.

Central government has an overarching role in the environmental information system. This stems from its role as an environmental regulator, land manager, and research and information provider. Its key responsibilities include system stewardship, setting or enabling standards, assigning roles and responsibilities, capability development, and funding data collection.

Agencies with a clear environmental remit include the recently established Ministry for Cities, Environment, Regions and Transport (MCERT, which incorporates the former Ministry for the Environment – Manatū Mo Te Taiao (MfE)), MPI, DOC, and LINZ. Less obvious agencies, such as KiwiRail and the New Zealand Defence Force – Te Ope Kātua o Aotearoa, also have a role.[6]

The Government contributes a significant amount of funding to the generation of environmental information. It does this through a mix of direct funding to research organisations, including Public Research Organisations (PROs),[7] universities, independent research organisations, and consultancy work purchased by ministries and agencies to fulfil their functions. Contestable research funding models inherently operate on short cycles (one to five years), are project-based, often have strong commercial incentives and are distributed across several agencies. Direct procurement of environmental information is also geared towards project delivery rather than long-term interoperability and shared infrastructure. Combined, this adds to the fragmentation of information, as this funding is provided without any assessment of how it might address the need for accessible, useful environmental information and wider data stewardship functions.

PROs have a central role in the collection and management of large amounts of environmental information. For example, together they hold 24 of the 26 Nationally Significant Collections and Databases and a considerable number of other publicly available or known databases.[8] They also hold a lot of non-public environmental information, some of which is yet to be digitised. The purpose of the PROs is governed through their statements of core purpose, which currently have a heavy focus on innovation and commercial outcomes.[9]

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5 PCE, 2021.

6 Other agencies include the Environmental Protection Authority – Te Mana Rauhī Taiao; Stats NZ; Water Services Authority – Taumata Arowai; Department of Internal Affairs – Te Tari Taiwhenua; Ministry of Business, Innovation and Employment – Hīkina Whakatutuki (MBIE); NZ Transport Agency – Waka Kotahi; the former Ministry of Transport – Te Manatū Waka; Natural Hazards Commission – Toka Tū Ake; and Maritime New Zealand – Nō te rere moana Aotearoa. MfE, the Ministry of Transport, the Ministry of Housing and Urban Development, and the local government functions of the Department of Internal Affairs were merged into the new MCERT, which became operational in July 2026.

7 At the time of writing, the PROs are still governed by the Crown Research Institute Act 1992 (CRI Act). New legislation to replace the CRI Act is expected in 2026. The two most relevant PROs for the purposes of this report are Earth Sciences New Zealand (ESNZ), which is made up of the National Institute of Water and Atmospheric Research (NIWA) and GNS Science (GNS), and the Bioeconomy Science Institute – Maiangi Taiao (BSI), which includes Manaaki Whenua – Landcare Research (MWLR) and Scion (New Zealand Forest Research Institute).

8 See PCE (2020, pp.37–44). A list of the collections and databases can be found on the MBIE website (www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/strategic-science-investment-fund/funded-infrastructure/nationally-significant-collections-and-databases).

9 MBIE, 2025a, 2025b.

Source: MWLR (2026a)

Figure 2.1: The Biota of New Zealand database, hosted by the Bioeconomy Science Institute (BSI), provides access to information about the fungi, land invertebrates and plants that are found in, or are relevant to, New Zealand.

Universities are also producers of environmental information in New Zealand and are home to some collections. Academia is frequently at the forefront of developing new techniques and technologies that can be used to monitor the environment and generate important data. However, a lot of this information is linked to individual researchers or projects. The systematic publication of underlying data in public repositories is variable but increasing, and availability is often only indicated in accompanying academic publications. This can result in the fragmentation of information across numerous online repositories. Alongside universities, museums also hold large collections of specimens.

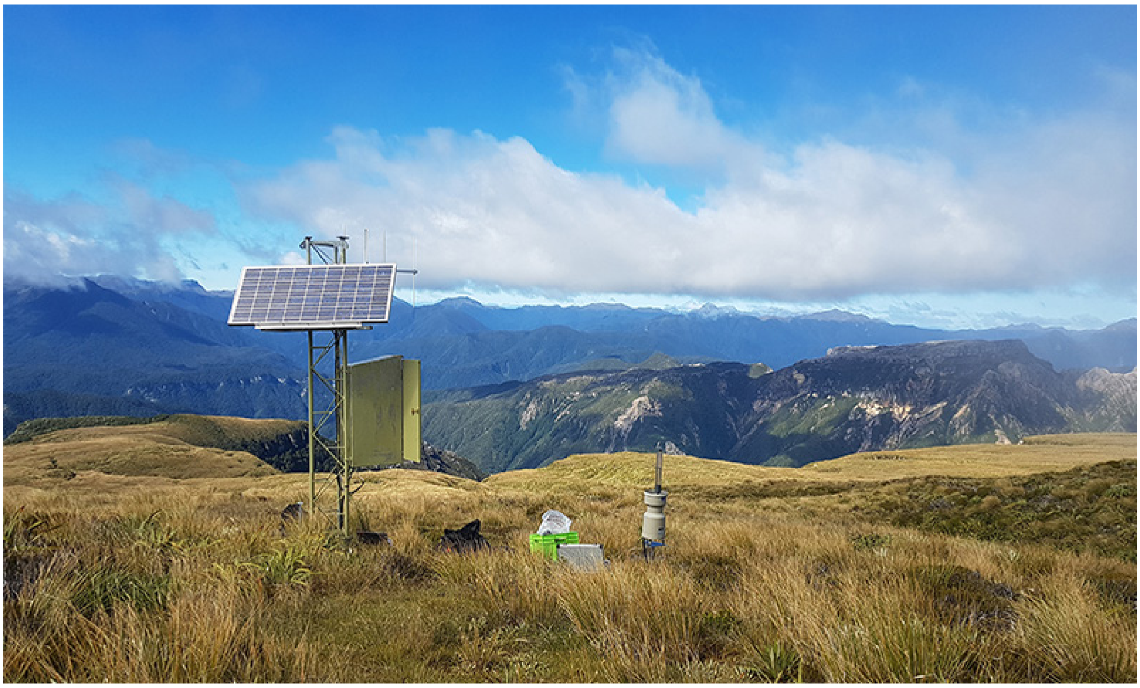
Local and regional councils collect and hold vast amounts of information gathered in the course of conducting the wide-ranging functions delegated to them.[10] The Resource Management Act 1991 (RMA), in particular, requires large amounts of environmental information to guide local and regional decision making. This includes state of the environment information, assessments of environmental effects, and consent monitoring information.[11] The planned replacement legislation for the RMA will only intensify the demand for information.[12] Some – but by no means all – of this information is publicly available, or available on request (e.g. state of the environment).

Councils also collect information to fulfil other statutory functions covering fields, such as council property, water services and transport. While some of this information may not traditionally be considered environmental, it contains important contextual information that can directly or indirectly inform environmental management.

10 Local government includes unitary authorities, as well as regional, district and city councils. Functions include those under the RMA, Local Government Act 2002, Water Services Act 2021 and Biosecurity Act 1993.

11 RMA 1991, ss 35 and 108. Local government is also directed by central government to collect information to implement national direction and secondary legislation, e.g. the National Policy Statement for Freshwater Management and National Environmental Standards for Air Quality.

12 PCE, 2025c.



Source: West Coast Regional Council

Figure 2.2: Data are sourced from rainfall, river flow and climate sites throughout the West Coast region. These sites are operated by a range of agencies, including regional councils, Earth Sciences New Zealand (ESNZ), MetService, Meridian and Manawa Energy.

As part of this investigation, Mātaki Environmental was contracted to identify and collate environmental information held by local government through a stocktake and survey of a subset of 15 councils.[13] This stocktake revealed large variability between the examined councils. For example, the Bay of Plenty Regional Council identified 67 data and information sources across four domains (land, water, biodiversity and biosecurity), while a smaller regional council, West Coast, identified 18. Marlborough District Council, which has dual unitary functions, identified 112. A small district council, Tararua District Council, identified only five, being wholly reliant on the regional council and others for certain types of information. Overall, regional councils (and unitary authorities) generally collect and hold more information about the environment than local territorial authorities. This is primarily a result of their respective functions. But the size of the councils (including the available resourcing) plays an important role in determining how much, and what, information is collected.[14]

One of the reasons why there is variability is that councils are directed to monitor the environment "to the extent that is appropriate to enable the local authority to effectively carry out its functions" under the RMA.[15] There is naturally discretion about what constitutes "appropriate" information, resulting in inconsistency between councils in some areas. This variability contributes to difficulties in comparing data across councils.

Despite this, the information they do collect is very valuable but often not collected in a standardised way.[16] For example, biophysical data and information are used by both local territorial authorities to guide decisions, and by MfE and Stats NZ as part of reporting on the state of New Zealand's environment under the Environmental Reporting Act 2015.

13 Doole, 2024.

14 Doole, 2024.

15 RMA 1991, s 35(2)(a).

16 Schattschneider and Young, 2023.

Finally, environmental information is also collected by iwi/hapū/Māori, citizens,[17] community groups, catchment groups,[18] industry bodies, farmers, businesses, consultancies, infrastructure companies and non-governmental organisations. This can include water quality monitoring data collected by catchment groups,[19] and farm information held in AgriBase.[20] This information may be in a similar form to that collected by central and local government, or it may take other forms that can complement the more structured monitoring programmes of government. Some guidance is available to ensure that data are collected in a standardised way so that they are comparable and able to be harmonised, but more work is needed.[21]

When all of these factors combine, the result is a complex and fragmented environmental information system with numerous organisations collecting different data for different purposes.[22]

In addition, several other persistent issues contribute to the fragmentation of the environmental information system. The liability management of organisations is often structured to minimise legal, regulatory, financial and reputational risk associated with data collection and information sharing. Where information is procured, consultancy business models tend to focus on creating bespoke analyses for clients, linked to project delivery, rather than long-term solutions. Agencies and other organisations can also be territorial about the information that they hold.

Consequently, anyone trying to build a comprehensive picture of the environment needs to draw on information from a multiplicity of sources. This can be a complex business. That is partly a function of the environment itself. However, the systems and structures put in place to collect and manage environmental information have exacerbated this complexity. In many cases, organisations are doing the best they can to fulfil their functions. But in an environment where there is no framework to promote access, sharing and reuse of data, they must go it alone. This can lead to duplication of effort.

Duplication and overlaps

The fragmented and siloed nature of our environmental information system has resulted in an information base riddled with duplication and overlaps.

Most organisations are working alone with limited collaboration. In some situations, this has resulted in information being duplicated in terms of collection, purchase and storage across different portals, while in others, accessing multiple portals is required to collate all the information needed for a single purpose.[23]

Having access to multiple similar datasets can lead to confusion. For example, sea-level data appears to be available from at least four different places: the LINZ, GeoNet and Earth Sciences New Zealand (ESNZ) websites, as well as some regional council and territorial authority websites.[24] Although some make it clear where this information is sourced from, and therefore what data may overlap with others (e.g. ESNZ), others do not.[25] Without clear labelling it is difficult to know if they contain the same data, largely similar data or different data. Without clear lineage, it can also be difficult to know if data have been derived from another source and what the quality of those data is. This adds complexity and relies on individuals knowing where data are stored or having clear signposting by an organisation. This is not always done.

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17 For example, through iNaturalist (www.inaturalist.org) or other platforms.

18 Examples of catchment group efforts can be found on the Wai Connection – Tatai Ki Te Wai website (www.waiconnection.nz/pages/focus-catchment-resources).

19 Milne et al., 2023b.

20 AsureQuality, 2026.

21 Valois and Milne, 2021.

22 This mirrors wider issues of fragmentation in the way that the Public Service designs and procures digital services (Collins, 2025, p.2).

23 Mackey, 2024.

24 LINZ (2026c), GeoNet (2026, selecting coastal sea-level gauge and Deep-ocean Assessment and Reporting of Tsunami (DART)) and ESNZ (2026g). For council data, see Greater Wellington Regional Council (2026, selecting tide levels) and Tasman District Council (2026), for example.

25 For example, LINZ collates sea-level data from several organisations, but the source of that data is not always clear (LINZ Data Service, 2026d).

Similarly, where information isn't publicly available in an easily usable form, significant time and effort is needed to identify, source and harmonise data for use in national-level analysis. Examples include the development of the Protected Areas Network of New Zealand map and national water quality and quantity analysis.[26] This work is often associated with a single project and output. When subsequent iterations or similar projects are later commissioned, the process of identifying, sourcing and harmonising data is then repeated. Even if the same organisations are involved, changes in what data are available, how they are licensed, lack of standardisation in format and content, and project objective all mean that analyses need to be repeated.[27] The net result is a duplication of effort and costs.

Another example of duplication was highlighted by the response to and recovery from Cyclone Gabrielle, when multiple agencies procured similar remote sensing data and products. Better coordination (e.g. through harmonised procurement) could have potentially enabled authoritative datasets to meet multiple needs, reducing duplication and cost. LINZ has since issued guidance for capturing aerial and satellite imagery for response and recovery purposes.[28] This highlights the need and value of providing national leadership in these spaces.

Finally, in some cases, separate agencies see the production of similar or even the same information as part of their functions. The most obvious example of this was the production of weather forecasting by both MetService and the National Institute of Water and Atmospheric Research (NIWA). Despite several reviews over the last 25 years, both organisations continued to provide weather forecasting services, effectively resulting in the Government funding two organisations to carry out the same work. As part of the recent science system reform, ESNZ (formerly NIWA) acquired MetService to bring government meteorological and climate science capabilities under a single entity.[29]

Duplication is sometimes defended on the grounds that there are different statutory responsibilities, that information needs to be tailored to local contexts, or because the data needed are known to exist but are not accessible and so are collected again. These claims should always be tested because duplication can generate significant inefficiencies. Too often, a lack of leadership and coordination within the environmental system has allowed overlaps to develop.

Gaps

There are many knowledge and data gaps that prevent us from improving our understanding and monitoring of the environment. Gaps can be of a temporal, spatial or thematic nature. Similarly, gaps can arise when important fit-for-purpose or complementary information is not collected, hampering the usefulness of existing data.

The non-exhaustive gap analyses presented in the 2019 and 2022 PCE reports illustrated the sheer volume and breadth of gaps in New Zealand's environmental monitoring system.[30]

For example, New Zealand has:

- temporal and spatial gaps in data regarding concentrations of fine particulate matter (PM2.5)
- inconsistent and patchy soil quality monitoring across the country[31]
- a lack of information related to contaminated soil
- limited data on diffuse sources of pollutants (such as chemical contaminants like pesticides and pharmaceuticals)[32]
- gaps in waste disposal data.

26 Planzer et al., 2023, p.2; Booker et al., 2024, 2026, pp.15 and 83.

27 Planzer et al., 2023, p.2; Booker et al., 2026, p.15.

28 LINZ, 2024c.

29 Moore et al., 2024; Brown and Reti, 2025.

30 PCE, 2019, pp.28–29, 2022a.

31 When surveyed in 2017, Gisborne, West Coast, Otago and Nelson councils did not monitor soil quality (although Gisborne was about to start monitoring) (Cavanagh et al., 2017, p.16).

32 PCE, 2022b.

Source: iStock

Figure 2.3: New Zealand has limited data on diffuse sources of pollutants, such as chemical contaminants like pesticides.

Overall, gaps of different types exist across every environmental domain. The nature of these gaps can be usefully illustrated by reference to data collected about New Zealand's land.

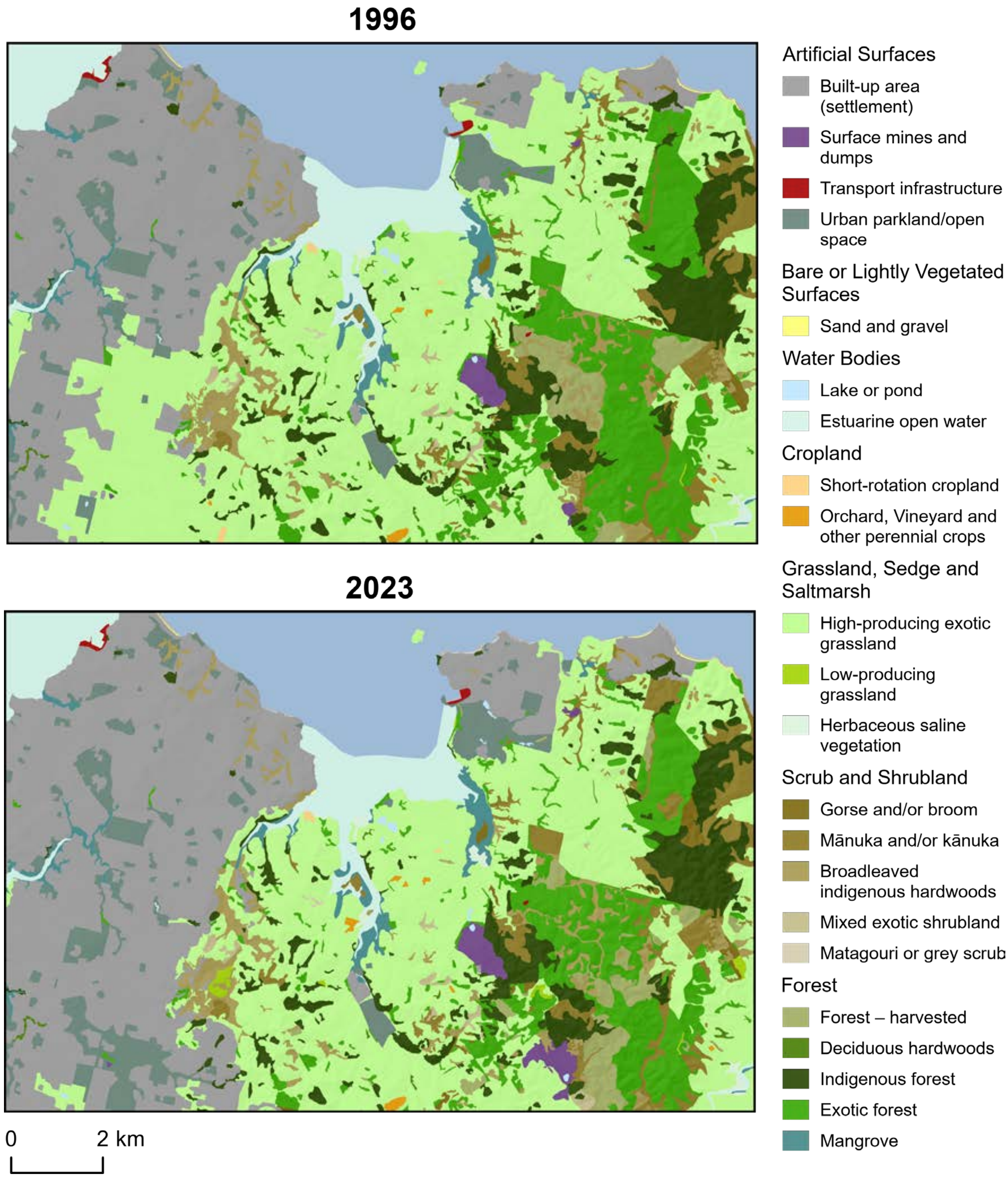
Having detailed information about the land enables us to better understand the impacts of land-based activities on biodiversity, water quality and greenhouse gas emissions. At a minimum this includes land use and land cover, and how these are changing. However, the information needed to provide that understanding is often missing.

Take the New Zealand Land Cover Database (LCDB) as an example (Figure 2.4). The LCDB categorises the country's land cover from satellite data and calibrates and validates these data using other reference and field observation data. However, New Zealand has only six time points available to track land cover changes stretched over three decades because only six national land cover maps have ever been produced.[33] The inconsistent gap between iterations and the fact that the 'current' map has at times been up to seven years out of date have caused issues for temporal analysis. The LCDB is also designed for national-scale assessments, with a nominal minimum mapping unit of 10,000 square metres (1 hectare), which can make it unsuitable for fine-scale or property-level decision making.[34] The low frequency, relatively coarse scale and aggregation of some key vegetation classes mean that the LCDB does not align with many desired uses.[35]

33 Maps created from imagery captured in the summers of 1996/97, 2001/02, 2008/09, 2012/13, 2018/19 and 2023/24 (MWLR, 2025b).

34 MWLR, 2025a.

35 Pearce et al., 2014; Joy et al., 2021; Langer et al., 2021.



Source: Adapted from MWLR (2025b)

Figure 2.4: Map of LCDB land cover classes showing the expansion of East Tamaki in grey.

Despite the LCDB being used by many organisations,[36] its history is one that typifies New Zealand's investment in environmental information. It is not considered one of the 26 Nationally Significant Collections and Databases mentioned earlier, so it does not receive any dedicated funding. As such, funding has been difficult to secure and maintain. Each iteration has effectively been a separate project relying on one-off funding from willing agencies.[37]

Issues with funding are only partially responsible for the infrequent LCDB updates. The labour-intensive methodology used to create the maps means that it takes around 1.5 to 2 years from the date of imagery capture to map release. Researchers and officials are trying to find ways to reduce this time, including the use of machine learning techniques. However, at least for now, such techniques incur significant trade-offs.[38]

Despite the importance of land cover data, they tell us very little about how land is being *used*. Currently, we lack a real-time, comprehensive and nationally representative dataset that characterises New Zealand's land use and how it's changing. Instead, national estimates are often compiled from multiple partial datasets and proxy indicators derived from a variety of sources.[39] In the absence of nationally consistent land use data, other datasets, such as the Land Use and Carbon Analysis System Land Use Map (LUCAS LUM), are sometimes used. However, these datasets were developed for different purposes and have their own limitations.[40]

Our lack of knowledge about the land extends beyond land cover and use to the soil itself. Understanding the distribution and composition of soils across New Zealand should be fundamental, given the importance of soil productivity to the national economy.

Much of New Zealand's soil information is available in S-map, a digital soil information system and map, which has been developed by the Bioeconomy Science Institute (BSI) (Figure 2.5).[41] Despite consistent efforts over the last 10 years, as of May 2026 S-map only covered 11.8 million hectares. This equates to 44.3% of New Zealand's total land area, or 78.2% of the most productive land.[42] S-map coverage varies significantly between regions: from almost 100% of the Hawke's Bay region to just 7% on the West Coast (Table 2.1). Even where data do exist, S-map has limited and variable resolution. The nominal scale of S-map ranges from 1:30,000 to 1:50,000.[43] For some purposes (e.g. property-level decision making) this scale will be of limited use. Further, not all soil properties are captured. For example, S-map does not capture heavy metals (e.g. cadmium) and other contaminants, elevated concentrations of which may limit particular types of food production (e.g. vegetable growing).

36 For example, it is relied upon for some national indicators and by regional councils (e.g. Bellingham et al., 2016; MfE and Stats NZ, 2025a; NEMS, 2025a).

37 For example, for the 2018 (LCDB5) and 2023 (LCDB6) updates, MfE, MPI, and DOC had a three-way funding partnership as this data gap needed to be urgently filled (Alderton, 2026).

38 For example, instead of 33 land classes using current methods, only 16 can be produced using machine learning techniques (Dymond et al., 2026).

39 MfE and Stats NZ, 2018, pp.104–105, Table 3.

40 At the time of writing, MCERT has commissioned BSI to assemble a national land use map using the recently developed land use and management classification system (Law et al., 2024).

41 Most underlying soil data in the National Soil Data Repository, which were used to develop S-map, are not publicly available. While the legacy National Soils Database component is publicly accessible, these legacy data only represent around 10% of the data in the National Soil Data Repository.

42 MWLR, 2026b. Most productive land includes classes 1–4 of Land Use Capability (LUC) system.

43 MWLR, 2026f.

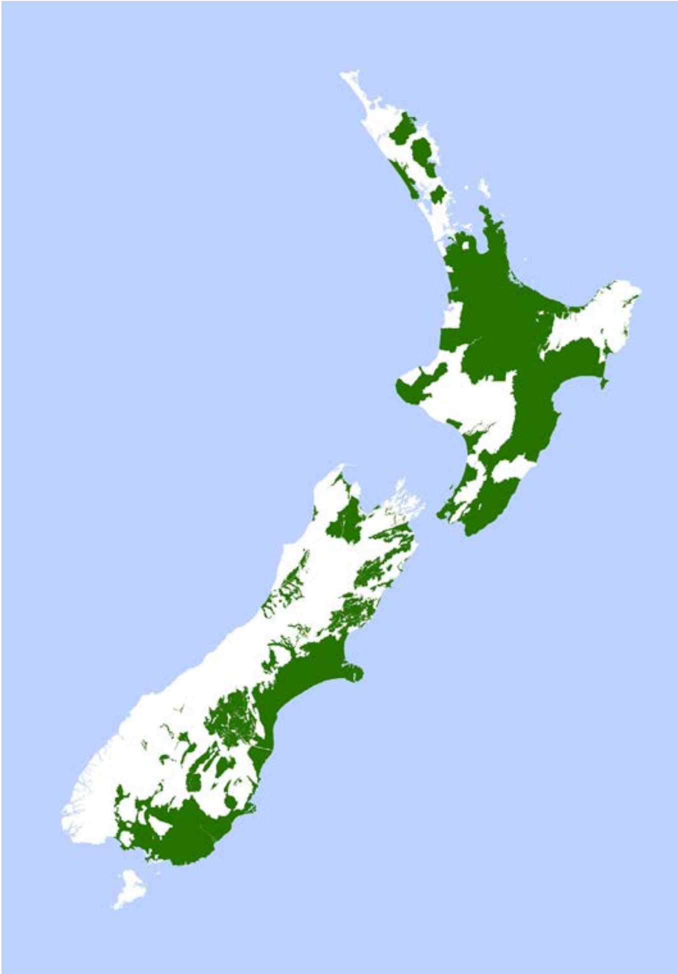
Table 2.1: S-map coverage across regions of New Zealand.[44]

Region	S-map coverage (%)
Hawke's Bay	100
Waikato	93
Wellington	78
Bay of Plenty	61
Canterbury	50
Taranaki	37
Otago	36
Tasman	33
Northland	32
Manawatū-Whanganui	32
Auckland	31
Marlborough	28
Southland	26
Gisborne	23
Nelson	18
West Coast	7

Like the LCDB, S-map has been plagued by sporadic funding. Over the last decade funding has come from contestable sources, such as the Endeavour Fund and Envirolink, but it has also received funding from the Government's 2019 Productive and Sustainable Land Use package and regional councils.[45] This has made it difficult to devise a dedicated work programme. At the time of writing, significant funding sources have come to an end, and only minimal funding remains. Overall, it is surprising that a country like New Zealand lacks an open, comprehensive, up-to-date, digitised soil database.

44 BSI, pers. comm., 20 May 2026.

45 The 2019 funding of $6.25 million was for a nation-wide project to expand S-map (MWLR, 2026b).



Source: BSI (2025a)

Figure 2.5: S-map coverage across Aotearoa New Zealand as of May 2026. S-map provides data on fundamental soil properties (e.g. depth, stoniness, clay and sand content) and derived properties (e.g. risk classifications, soil moisture retention) obtained from field observations, expert knowledge and modelled outputs.

Ultimately, decisions about land use with far-reaching economic and environmental impacts are taken using the best available information. Unfortunately, gaps in existing data, as well as their limited accessibility, mean that the 'best available' data fall well short of what is optimal.

Lack of standardisation

Consistent standards are paramount to making data accessible, discoverable and usable. For environmental information this includes the collection, processing, curation and management of it.[46] However, the New Zealand environmental information system lacks the standards that would enable the easy aggregation of information from different sources.[47] This leaves many individuals and organisations working with inconsistent information and dealing with different data conventions. Without consistent standards, it is challenging to automate data sharing, integration and processing. While it is technically feasible to address some inconsistencies using more sophisticated processing techniques, this can be time-consuming and inefficient.

46 Data management includes data quality assurance and quality control standards, classification and taxonomy standards, and versioning standards.

47 There are currently only four mandated standards used by government: date of birth, person name, street address, gender, and sex (data.govt.nz, 2026).

A lack of standardisation in data collection can stem from differences in context, scope, purpose and methodological approaches – that is, what, why, when, where and how something is measured. This can result in differences in naming conventions, data collection techniques and data storage formats. One example is recording species observations using different taxonomic names. The invasive weed Asiatic knotweed (Figure 2.6) has been referred to by three different scientific names – *Reynoutria japonica*, *Polygonum cuspidatum* and *Fallopia japonica*. This creates the potential for confusion when comparing which species are present or managed across the biosecurity system.

Source: Shutterstock

Figure 2.6: The Asiatic knotweed is an example of how inconsistent naming can lead to issues for the management of pest species.

Another example is the indicator of faecal contamination *Escherichia coli (E. coli)*.[48] Most regional councils collect *E. coli* data, albeit for two different reasons: to inform the public about the suitability of various freshwater locations for swimming, or to report on the state of freshwater quality in various waterways. As a result, two different monitoring networks and programmes are run. Each has different site selection, sampling frequency and duration, and indicator types.

Similarly, inconsistencies in how water quantity information is collected and analysed prevent the creation of consistent national estimates of water quantity allocation and use.[49]

The storage and documentation of information is also not standardised. As detailed by Mātaki Environmental, some councils could not readily identify all the environmental data they held.[50] Manual collation was required because of the lack of a complete council catalogue. This issue extends equally to other organisations. The result is an opaque environmental information system where it is often unclear what information exists, where it is held and who holds it.

In other words, existing data and information are often poorly documented. This may be due to poor documentation about what the data are and how they were generated (in technical terms, the metadata). Without documentation, it is also hard to assess how robust and (scientifically) meaningful the environmental information is and, therefore, the level of confidence one can place in it. Documenting available data and developing central repositories with standardised metadata to guide data extraction and collation would improve the internal and external use of data.[51] Half the battle can be won from simply knowing *what* is available, what it is *about*, and *where* to access it.

48 Perrie et al., 2012, p.133. This example is also profiled in the appendix of PCE (2019).

49 Booker et al., 2024.

50 Doole, 2024, p.43.

51 Doole, 2024.

A regional council-led initiative set out to address the lack of national standards for environmental monitoring data by creating National Environmental Monitoring Standards (NEMS).[52] The NEMS initiative was undertaken to "ensure consistency in the way environmental monitoring data is collected and handled throughout New Zealand".[53] The NEMS prescribe technical standards, methods and other requirements that aim to aid national and inter-regional analysis. At the time of writing, the NEMS cover only some topics and indicators, leaving many indicators without agreed-upon standards.[54] Due to the voluntary nature, varying capabilities, and costs associated with meeting these standards, their implementation has been variable.[55] Their voluntary nature also means that many organisations outside the regional sector do not follow the NEMS. This is an issue when, for example, monitoring is collected by communities (e.g. catchment groups) in place of council staff.[56]

Establishing consistent frameworks and standards across agencies is essential if we are to reap the benefits of standardisation, such as more coherent archiving and storage, easier access to information for all and improved usability of data.

Poor accessibility and reusability

The fragmentation and lack of standardisation within the environmental information system have also significantly impeded access to and sharing of information. Many, if not all, previous PCE reports highlight these issues. Instead of being standardised and automated, it remains ad hoc, on request, point-to-point and inconsistent.[57]

At best, these issues can result in information being accessible behind paywalls,[58] and at worst being simply unavailable to third-party organisations. Poor accessibility limits information sharing and contributes to low reuse of collected information. As a result, information is not only underused, but the full value of investing in it in the first place is not realised. This is despite the fact that environmental decision making is predicated on the sharing of information.

Information is not accessible for a variety of reasons, including commercial considerations or because sharing requirements are not enforced. Even when specific information is known to exist, access often remains limited. Industry-held information – for example, farm management data – is generally deemed commercially sensitive and private and is not therefore accessible to either local or central government agencies. For example, the AgriBase database, developed and maintained by AsureQuality, holds geospatial and farm-level information on approximately 144,500 rural properties across New Zealand. It provides some information on land use class and stocking rates.[59] The data are available under commercial licences, meaning users must pay to access them.[60] This limits the use of the information for many applications, especially where funding is a constraint. Efforts to overcome such commercial barriers have proven difficult.[61]

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52 The NEMS initiative, established in 2011, has been supported by individuals from local government, MfE, Stats NZ, NIWA and industry partners.

53 NEMS, 2026a.

54 As of March 2025, 21 different standards and a glossary have been developed. Two of the 21 are under review. Seven additional standards are under development, two are awaiting funding and 20 more have been proposed. For a list of the standards see the NEMS website (www.nems.org.nz/documents).

55 NEMS, 2023, p.7.

56 Doole, 2024, pp.39–42.

57 Point-to-point sharing is where data and files are shared directly between individuals or organisations, often in the form of spreadsheets. This even includes information accessed via websites that is downloaded.

58 An arrangement whereby access is restricted to users who have paid to or subscribe to a specific site.

59 AsureQuality, 2026. AsureQuality is a state-owned enterprise and must therefore ensure it is as profitable and efficient as comparable businesses not owned by the Crown (State-Owned Enterprises Act 1986, s 4 and Schedule 1).

60 Manderson et al., 2018, p.2.

61 Paskin, 2019; Scarlatti, 2023a.

Source: Shutterstock

Figure 2.7: Commercial sensitivity, such as stocking rates of dairy farms, can prevent data from being accessible.

Commercial sensitivity can lead to commercial licensing or information being protected by non-disclosure agreements. Commercial sensitivity arises when companies seek to protect information they believe could prejudice their commercial interests. These interests could, for example, be competitive or reputational in nature. For example, environmental surveys carried out by consultants for development and infrastructure projects are often subject to restrictions, such as non-disclosure agreements. This means much of the information gathered for specific projects may not be accessible to agencies, researchers and the wider public. As a result, subsequent projects may have to re-gather the same information. The ability exists to anonymise, de-identify or generalise data in many situations. But it is fair to ask whether reputationally compromising information is something that should be protected when it relates to common pool resources.

The Crown Research Institutes Act 1992 (CRI Act), which currently governs the PROs, requires them to operate in a financially sustainable manner.[62] This means they are not immune to commercial considerations and have monetised access to information, even when the generation of that information was originally publicly funded. Examples include daily climate station data, virtual climate network time series, regional sea-level rise spatial data and regional high-intensity rainfall statistics gridded datasets.[63] PROs also administer a number of publicly available databases, such as the New Zealand freshwater fish database and New Zealand vegetation survey bank. However, they represent a fraction of the information held by PROs.

Information sharing can also be limited by intellectual property (IP), privacy and data sovereignty concerns. These are discussed in chapter 3.

A lack of digitisation exacerbates inaccessibility and opaqueness, with a wealth of information still only held in analogue form. Efforts to digitise the Crown Aerial Film Library (Figure 2.8) and Manaaki Whenua – Landcare Research's (MWLR) invertebrate specimen information are examples of digitisation projects that have unlocked a wealth of historical information that previously could not be used.[64]

62 It is assumed that the upcoming legislation that will replace the CRI Act will include similar requirements for financial viability (e.g. CRI Act 1992, s 5).

63 ESNZ, 2026b.

64 BSI, 2026b; LINZ, 2026a.

Sources: Retrolens (2026) and LINZ Data Service (2026d)

Figure 2.8: The digitisation of aerial photography means that changes in New Zealand's landscape can be tracked over time. For example, the top image is a digitised aerial photograph of Wellington City taken in September 1945 showing the city before the construction of the Wellington Urban Motorway and the Beehive. Below is the same scene taken in January 2025. The historical aerial archive dates back to the 1930s in some places.

Even when information is supposedly freely available, preparing it for release may be costly, thereby requiring organisations to charge for it. Examples include data contained in commissioned research papers or held as complex data types that require specific software or knowledge to use.

Licensing is an area that can either aid or inhibit accessibility. Despite greater use of Creative Commons licensing (such as CC BY 4.0) by government agencies, a lot of environmental information remains under restrictive licences. Worse still, there are numerous datasets that have either no or ambiguous licensing. A lack of clear licensing can hamper the distribution of information amongst agencies or prevent it from being shared or reused. Information gaps due to missing or restrictive licensing are one of the key issues that the Protected Areas Network of New Zealand map has encountered.[65] The map is unable to display certain protected area data because of commercial interests and a general lack of understanding of the licensing requirements needed to reuse data.[66] The most recent public version has improved coverage, but has required significant manual work to identify and catalogue data and appropriate licences.[67]

Despite these issues, initiatives such as the National Environmental Data Centre (NEDC) and Land Air Water Aotearoa (LAWA) have made some progress in improving data discoverability, accessibility and sharing.[68] However, issues remain. The NEDC does not host datasets itself. Instead, it provides links to external PRO webpages with additional information on data quality for the linked datasets. This results in the NEDC being more of a list of a select (small) number of datasets that PROs hold, not a database where you can see all the data in one place. Similarly, despite aggregating regional council state of the environment data, LAWA isn't designed to disseminate raw data.

Data being available or accessible is not enough. Data need to be easily usable and reusable too, otherwise a lot of the effort of collection will be in vain. In practice, even when information is accessible, the features that make an environmental dataset reusable are often absent. This includes metadata, provenance and lineage information, explanations of data quality, the purposes for which the data are fit to be used, clear licensing and, critically, the information needed for non-experts to correctly interpret the data.

Overall, large amounts of information collected remain entirely unavailable to the public, are only available in inaccessible formats, or do not possess the required contextual information to be reused.

Precarity of sustained resourcing

As the preceding examples show, appropriate resourcing is a critical aspect to the success or failure of these projects and databases. Resourcing comes down to three intertwined aspects: funding, capability and capacity, each of which are perennial issues within various aspects of the environmental information system.

Sustaining funding over extended periods of time has proven difficult. Despite the Nationally Significant Collections and Databases being considered 'nationally significant' and therefore eligible for national funding, their funding arrangements do not account for inflation. Annual funding has only increased by 16% since 1992, from $19 to $22 million, while consumers price index inflation has increased by 121% over the same period.[69] These funding pressures can create significant challenges for agencies attempting to maintain the viability of these databases over time, let alone grow and modernise them for future applications.

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65 Protected Areas Network of New Zealand (MWLR, 2025c) is a database that aggregates legally protected areas into a single map, providing a unified national-level view of these protections. Formally protected areas include the Crown Conservation Estate, regional parks, and a range of covenant schemes, including Ngā Whenua Rāhui, the Nature Heritage Fund and the Queen Elizabeth II National Trust.

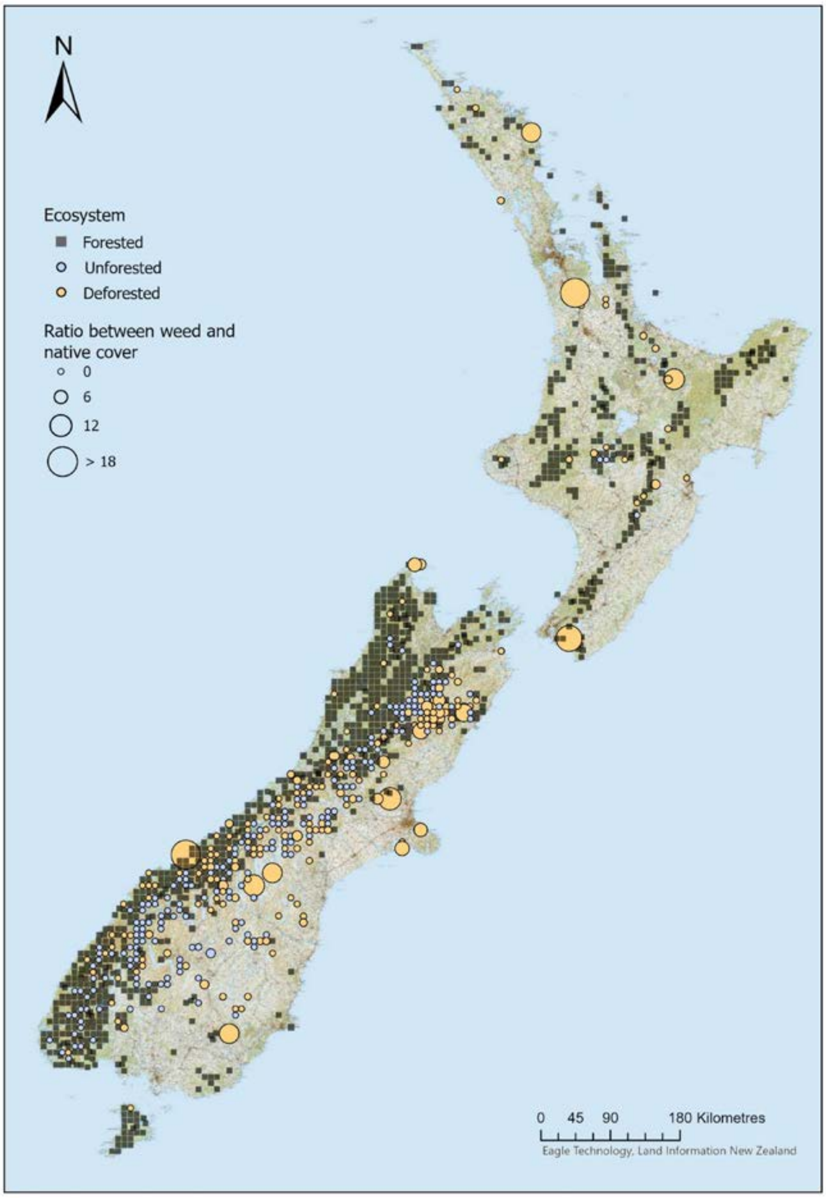
66 Other issues include data being of varying quality and availability, funding issues, lack of records and lack of mandate (Planzer et al., 2023, 2024).

67 For a list of data sources and their licences see the Protected Areas Network of New Zealand Github (MWLR, 2026e).

68 The NEDC (www.nedc.nz) is a collaboration of the PROs to create a directory for PROs data. LAWA (www.lawa.org.nz) is a portal that pulls together regional council and unitary authority state of the environment data together in a single web interface.

69 As part of Budget 2020 (New Zealand Government, 2020). Nationally Significant Collections and Databases are currently funded through MBIE's Strategic Science Investment Fund.

Funding issues are also present in well-established programmes, as highlighted by DOC's Tier 1 monitoring programme (Figure 2.9).[70] Due to changes in funding, the frequency with which sample plots are surveyed has reduced from 5 to 10 years. Such decisions need to be well considered as such changes reduce statistical power to detect trends in species and lessen the programme's ability to detect declines early enough to implement timely management interventions.[71] DOC is considering how to ensure the viability of the programme through various measures to ensure that meaningful data continue to be collected and that continuity is preserved.



Source: Bellingham et al. (2024)

Figure 2.9: DOC Tier 1 monitoring of permanent plots on an 8 km grid on public conservation land (shown based on their ecosystem type). Circle sizes are proportional to the ratio of weed and native plant species cover. Larger circles indicate more weedy sites.

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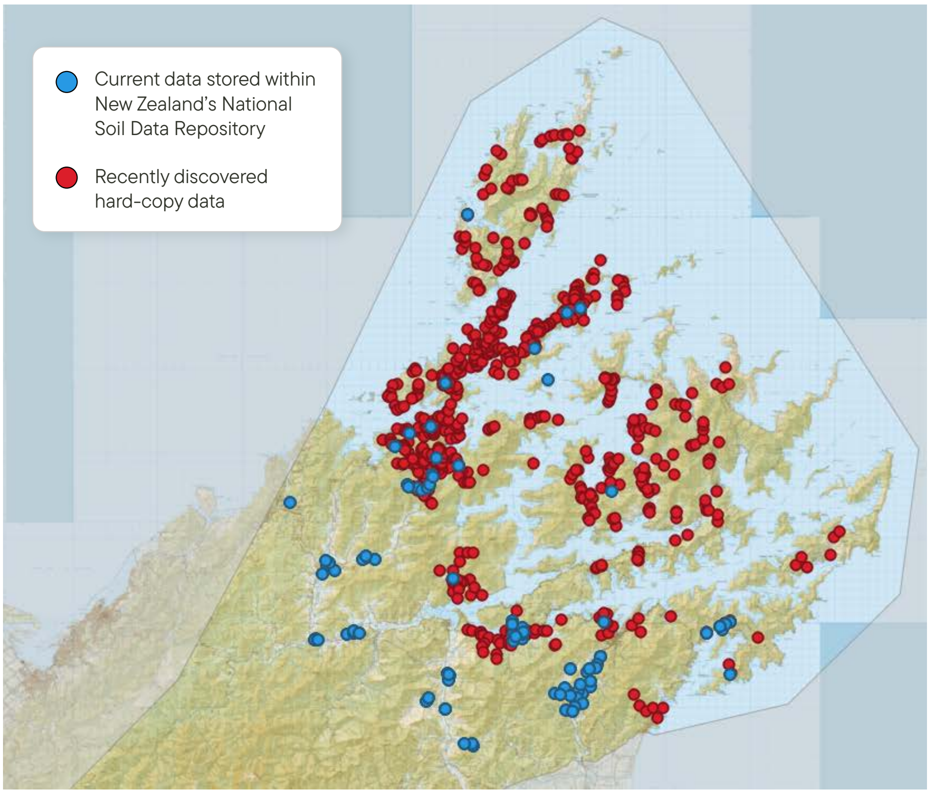
70 DOC's tier 1 terrestrial monitoring programme provides a systemic sampling programme of biodiversity across the landscape allowing broad-scale monitoring to occur for the national context. Data can be explored on the DOC website (www.doc.govt.nz/our-work/monitoring-reporting/plot-level-report).

71 MacLeod et al., 2024.

Within councils, resourcing and **capability** (particularly in science, information technology and geographic information systems (GISs)) are not evenly distributed and are often lacking in areas facing particularly critical environmental challenges.[72] A lack of in-house expertise and funding constraints limit the effectiveness of data and information management for any given council and also affect their ability to contribute to other datasets.[73]

Capacity issues are common across New Zealand's environmental information systems. There are many occurrences where the acquisition of data or the curation of a database is only 'one or two people deep'. A recent report on soils in the Marlborough Sounds highlighted the consequences of this. In 1988, the researcher responsible for developing the Marlborough regional soil map was made redundant, so the reporting of soil surveys was never completed. Due to a lack of cataloguing or digitisation, hard copies of these surveys lay in MWLR's physical archive for three decades, unknown until they were recently rediscovered (Figure 2.10).[74] Similar data collected today could cost around $4–5 million due to the exceptionally high standard, detail, location and analysis of the original dataset.[75] This highlights the impact that changes in funding can have on capacity and information discoverability.



Source: Deuss et al. (2025)

Figure 2.10: Marlborough Sounds soil samples. The blue points represent the current data stored within New Zealand's National Soil Data Repository. The red points represent the recently discovered hard-copy data collated by Laffan et al. between the 1960s and 1980s. Note that the georeferencing is approximate (hand-drawn).

The precarity of resources has also come to light through previous attempts to improve the environmental information system. A lot of initiatives have been developed over the years to address some of the identified issues, but they have failed to gain much traction and have

72 Doole, 2024.

73 Doole, 2024.

74 Deuss et al., 2025.

75 BSI, pers. comm., 26 May 2026. If similar data were collected today the same detail and analysis would likely not be applied, reducing costs.

been shuttered due to project funding ending, a lack of ongoing investment, and challenges in transforming defined data-gathering projects into operational services. A recent example was an attempt to pilot an improved exchange of data between landowners, industry and others in New Zealand's agrifood sector.[76] The pilot was wrapped up in 2024, when the National Science Challenges, which had funded the initiative, came to an end. Similarly, the Marine Geospatial Information Working Group and the Common Operating Datasets for Emergency Management (CODEM) were halted due to a lack of funding in 2024.[77]

Summary

Many of the issues highlighted in this chapter have a common cause: a lack of leadership in our environmental information system. New Zealand lacks an environmental information 'champion' with the expertise and remit to oversee and provide stewardship of this system. This lack of oversight has led to duplication or preferential focus in some areas and gaps in others, with no overall prioritisation. There are many areas where we don't know enough about environmental conditions, although it is not always clear what data exist or where they are held.

The way in which New Zealand manages environmental information is also complex and fragmented. It is collected by a wide range of organisations for an equally wide range of purposes. While this has resulted in a significant amount of environmental information being collected, analysed and stored, it has been undertaken to satisfy the specific needs of specific organisations. Ultimately, we have no real way of knowing what exists and the potential for reuse. A detailed audit of all agencies would likely reveal a treasure trove of information. Arguably, agencies should already have this information at hand, given the requirements of the Public Records Act 2005 and mandatory Archives New Zealand Information and Records Management Standards to identify and manage high-value and high-risk information and records.[78] Environmental information collected by the agencies described above would likely fall into this category.

The fragmented nature of this process has led to a siloing of information across and within organisations. Some information is used as intended, some beyond its original purpose. Other data languishes in warehouses or spreadsheets, on an individual's computer or an organisation's server, never to see the light of day. Some information is inaccessible to others due to commercial or other sensitivities. Other data are not discoverable because they haven't been curated appropriately. Regulatory rigidity and technological incompatibility can impose further barriers.

A lack of information sharing can force constant reinvention of the wheel and duplication of effort. Ad hoc and bespoke solutions have been developed and continue to proliferate as agencies focus on what they consider to be their core responsibilities without appreciating where those responsibilities might align or overlap with others. Where their data fits in the bigger picture is also often not well understood. What we are left with is a system that can barely cope with existing data flows and decision-maker demands. These demands are only set to increase with the substantive changes proposed for New Zealand's environmental legislation, and with any increased use of technologies.

76 Scarlatti, 2023a, 2023b.

77 PCE, 2024c. Recent funding announcements will hopefully address many of the issues that the CODEM system was addressing (Mitchell, 2026).

78 Archives New Zealand, 2023.

Source: Shutterstock

Figure 2.11: The rediscovery of soil surveys in the Marlborough Sounds region will contribute to improved soil maps in the future.

Environmental information is not static. Its collection is, or at least should be, ongoing. Accounting for ongoing and new information streams is vitally important. Existing issues will compound and be amplified if nothing changes.

One major consequence of this fragmentation is that we do not make the most of the data that we currently collect or have collected in the past because we lack the systems to effectively use and reuse the information that already exists. In economic terms, we do not get the return on the investment that we could have expected. And even where we do have information, it is often riddled with gaps, inconsistencies, unclear provenance and ownership, and questions about whether it is fit to reuse and in what contexts.

The upshot is that, currently, the right environmental information is often not available to the right people, at the right time, in the right format. The ability of central government, local government and the private sector to make good decisions quickly and efficiently is constantly hampered by either inadequate or inaccessible information. This is costly for all parties who need to provide information to support investments and regulatory compliance.

These are the unplanned consequences of a system that lacks national direction, coordination and consistent resourcing. In summary, environmental information is not currently treated as an asset that can enable better decision making. Neither is it being used to evaluate the outcomes of those decisions and support long-term environmental stewardship. Actions to better marshal existing data are clearly needed.

Getting New Zealand's environmental system right has value not only in meeting current needs better, but also in developing a cohesive and adaptive environmental intelligence capability. Being able to understand and anticipate environmental changes, model future scenarios, automate reporting, and link actions to outcomes is crucial for a well-functioning environment and society.

Thousand leaved fern, *Hypolepis millefolium*

3 Building an effective environmental information system

If New Zealand is to give itself a fighting chance of facing the environmental challenges that are starting to place our economy, infrastructure and wildlife at risk, we have to equip ourselves with much better information. That won't happen without a step change. Current arrangements are not fit for purpose. The inertia of the status quo is holding the entire country back.

Current reforms to the Resource Management Act 1991 (RMA), the science system, water services, local government, conservation and the Environmental Reporting Act provide a once-in-a-generation opportunity to place information at the centre of environmental management. Whether or not that happens will be fundamental to the success of many of these reforms. This is because new agencies and new regulations will be even more dependent on environmental information than their predecessors. The reformed resource management system is premised on high-quality, granular environmental information that is at present not consistently available and rarely available in a timely manner.[1] The recently announced $41 million investment in national data standards, an e-Plan viewer, and the core system architecture needed to support the new planning system is a step in the right direction.[2] Chapter 9 analyses the extent to which the wider $294 million investment package addresses the totality of the issues raised in this report. Suffice to say that improvements are needed across the system and are wider than current legislative reforms.

Other central government agencies are also recognising that improving the quality and accessibility of environmental information are critical priorities and, as such, are taking greater action. For example, the Department of Conservation (DOC) has developed a new prioritisation tool, BioInvest, that leverages data integration to assist the prioritisation of its work programme.[3] The Government has also announced investment in a common operating picture for emergency management to ensure that emergency management personnel have a single, shared view of information and data.[4] How all these new systems and tools ultimately work together will be vital so that we don't repeat the past and simply end up with a duplication of 'integrated' systems, siloing and fragmentation, only at a larger scale.

1 PCE, 2025c. The two bills that will replace the RMA – the Planning Bill and the Natural Environment Bill – were introduced to Parliament in December 2025 and are expected to pass in 2026.

2 Bishop et al., 2026; MfE, 2026a. See also 'Strategic priority 4: Improve the quality and accessibility of evidence for all decision-makers' in MfE (2026b, p.20).

3 Macdonald, 2026. See also Theme 1, Action A, 'Develop a publicly accessible source of biodiversity information to inform action at national, regional and community levels', in New Zealand Government (2026, p.12).

4 Mitchell, 2026.

I made the case for developing a federated data system on which New Zealand's environmental information should be built in a note published in April 2025.[5] This chapter revisits that note, providing an overview of what a federated system entails and the benefits it would provide for the whole environmental information system. It also further develops some of the underlying issues that need to be addressed before we can make the most of any federated system.

This includes issues related to standardisation, sharing and ownership, and infrastructure.

A federated system: Enabling New Zealand's environmental information system

To address system deficiencies and develop an effective environmental intelligence capability, we need solutions that better draw together, connect and integrate existing information from disparate sources, enabling it to be more effectively used. Adopting these solutions will also allow us to more effectively use new and existing technologies to fill information gaps (see chapters 4–7 for more information), expand our understanding of the natural world and support long-term environmental stewardship. This could be achieved through different system models for coordinating, sharing and accessing environmental information across organisations (Figure 3.1).

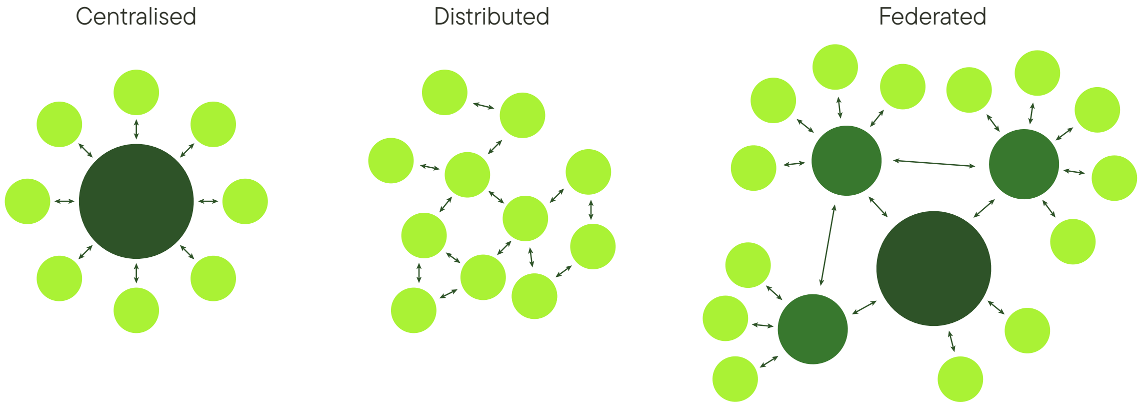
The appropriate organisation and structure of a data and information system depend on its function and purpose. New Zealand needs one that is flexible and can deliver useful, robust information, in an integrated way, to the people who need it. The ability to standardise, harmonise and integrate disparate datasets is key to ensuring we maximise the value of the environmental information we already possess and any that we gather in the future.

In the socio-economic sphere, the centralised Integrated Data Infrastructure (IDI) has demonstrated the value of well-organised information for tracking issues, targeting government services and assessing their effectiveness. The IDI has become an invaluable tool that informs operational government policy and supports New Zealand through critical research and policy evaluation.[6]

The function, purpose and complexity of environmental information, coupled with the multi-layered and widely distributed nature of entities collecting and using it, suggest a different system model. A federated system (Figure 3.1) is the most promising way of enabling an integrated environmental information system that works for the environment. At its core, a federated system connects data held across multiple organisational systems through shared standards and coordination arrangements to create a unified environment in which data can be more easily shared, discovered and used.

5 PCE, 2025a; MfE, 2026a.

6 Jones et al., 2022; Milne, 2022.



Source: PCE

Figure 3.1: Representation of centralised, distributed and federated system models. Each system has its strengths, depending on the purpose and type of data sharing it is designed to enable.

Federation could help address many of the issues within the current system, such as trust, privacy and ownership.[7] This is because federated systems are built on relationship-based partnerships that allow data stewardship to remain with the original custodian. These partnerships increase the likelihood of collaboration and data sharing among a network of individuals and organisations.[8] It is a mechanism to enable the environmental information system to embed FAIR and CARE guiding principles.[9]

A federated environmental information system should also be designed to accommodate both public and private and commercial data sources. Subject to appropriate access rights applied to manage sensitive data,[10] users within such a system would be able to access data from multiple sources simultaneously, enabling them to build a much more powerful picture of the environmental complexity that confronts land managers, developers and regulators.

Federation also helps manage the tension between central oversight and local control of data. More broadly, this can help address the dispersed, poorly accessible nature of current datasets and may shed light on areas with significant gaps, fragmentation or duplication. This approach to data management would be more effective and less costly. Allowing organisations to collaborate and share resources, without compromising control over their data, can also help alleviate data sovereignty issues. For example, integrating geospatial data from different organisations would allow geospatial overlays representing different information sets to be viewed together. Being able to align these layers enables better comparisons and greater insights.

Federated systems are inherently modular and scalable, providing a framework for the easy integration of future data programmes. They could also 'evolve' more easily. Two federated systems could merge into a single system, or one could be split, as data use or needs change over time.[11]

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7 Stats NZ has done some work on changing the government's current data system to an increasingly federated model, and what the implications of that are (Stats NZ, 2023b).

8 This includes government agencies, local governments, Māori groups (whānau, marae, hapū, iwi, Māori consulting companies, Māori landowners, Post-Settlement Governance Entities, mandated iwi organisations and other Māori groups), communities, businesses, academia and non-governmental organisations.

9 The FAIR Guiding Principles for scientific data management and stewardship are that data are findable, accessible, interoperable and reusable (Wilkinson et al., 2016). The CARE Principles for Indigenous Data Governance are Collective Benefit, Authority to Control, Responsibility, and Ethics (Global Indigenous Data Alliance, 2026).

10 Access to data could be through subscriptions, contracts, roles or usage agreements, with appropriate access rights applied to manage sensitive data.

11 Aspects of the environmental information system could operate other system types as nodes. For example, data commons (Mansell et al., 2017) could be developed where relevant public and private information is collated and could more easily be built upon by government, iwi/Māori, community groups, environmental consultancies, and others. A federated data system could then incorporate information from the data commons where licensing and other restrictions made it possible.

In *A federated system to improve environmental information*, I recommended that "the Government should set up a federated data system to manage environmental information" and that "Cabinet should provide an explicit mandate to develop a more connected environmental information system, centred around some type of federated system."[12]

I also suggested a work programme, including:

"the appointment of a steering group to:

a. consider issues related to governance and who takes the lead in standing up a federated environmental information system;
b. consider how issues around access, sharing, privacy, data sovereignty, and ownership of information might be addressed;
c. develop the investment and business cases for such a system; and
d. advise on how the system might be developed using a modular or pilot approach."[13]

I have also recommended that "a lead central government agency [...] coordinate cross-agency advice to Ministers on the system and [...] lead the development of standards for environmental information using a modular approach."[14] The Ministry for the Environment (MfE), Stats NZ and Toitū Te Whenua – Land Information New Zealand (LINZ) were suggested as possible contenders for this lead agency. Alternatively, this role could be given to an independent agency or the Environmental Protection Authority (with an expanded mandate and resourcing), as suggested in my *Environmental reporting, research and investment* report.[15]

Pursuing a federated system fundamentally changes how environmental data and information is recognised, positioning it as strategic infrastructure. Just like physical infrastructure (e.g. roads, wastewater), it requires long-term investment and planning, ongoing maintenance and renewal, clear governance and stewardship arrangements, standards, equitable access provisions, and ongoing monitoring and reporting.[16] New Zealand seems to be able to mobilise billions of dollars to build hard infrastructure.[17] But the effort needed to support an investment in data infrastructure that is orders of magnitude less costly seems to have eluded us and it has taken reform of the whole planning system to start to make a dent.

If we are to make progress and seize current opportunities, then some key obstacles concerning standardisation, sharing and ownership, and infrastructure and investment cannot be avoided. Although discussed separately below, these three areas are interrelated and need to be considered together.

Standardisation

The basis of any kind of information system is the use of shared standards and a common language. As described in chapter 2, the New Zealand environmental information system currently lacks such standardisation. This poses challenges across the data lifecycle and limits interoperability, hindering automated data sharing, integration and processing.[18]

An interoperable system, such as a federated system, is heavily reliant on the standardisation of at least four key areas: collection, storage, classification and sharing.

12 PCE, 2025a, p.15.
13 PCE, 2025a, p.15.
14 PCE, 2025a, p.15.
15 PCE, 2022a, p.77.
16 Carpenter et al., 2025, p.10.
17 New Zealand Infrastructure Commission, 2026, p.25.
18 data.govt.nz, 2023.

Source: Shutterstock

Figure 3.2: Shared standards and common language are essential to avoid any complication or dispute over what constitutes a property, its boundaries and other designations.

Firstly, having standardised methodologies for data collection is important. The use of differing methodologies, even if resulting in similar – but not identical – data, may limit geographic or temporal comparisons (e.g. differences in *E. coli* monitoring for water quality and human health).[19] Likewise, different models often generate different results due to differences in approaches and assumptions, thereby hampering interoperability and the comparison of results.[20] Flexibility in the methods of data collection and modelling to suit local context is often needed. However, there needs to be clear documentation linked to the data to ensure that they are not used for an inappropriate purpose or with greater certainty then the underlying data would suggest possible. This is particularly important for natural hazards data such as coastal inundation, flooding and landslide data.

Secondly, the storage of data and information in a standardised and structured way is required so that people (and information systems) know what to look for and how it maps to their use. This includes having shared conceptual models that define how attributes and relationships are represented and exchanged between systems. This can range from using the same field names in a table to ensuring appropriate metadata are included.

Metadata are particularly important for discoverability and interoperability by ensuring that consistent, comprehensive and standardised descriptions of data are available. For automated data sharing, the metadata must be very rich in terms of content and specificity. Currently, agencies record metadata in different ways, with little consistency.[21] For example, many councils

19 As discussed earlier in the 'Lack of standardisation' section in chapter 2.

20 Schattschneider and Young, 2023; PCE, 2024a.

21 data.govt.nz, 2023; Schattschneider and Young, 2023. Metadata are data that describe other data, which can include structural data (e.g. vocabularies and taxonomies), descriptive data (e.g. author and title), administrative data (e.g. permissions), and legal data (e.g. copyright). Metadata standards can be domain specific, such as ISO 19115:2014 Geographic Information – Metadata (ISO, 2014).

make consent information publicly available.[22] However, there is no standardised format for collecting, storing and presenting consent information such as effluent discharge. The location reported on public maps, for example, may be either the dairy shed, the point of discharge, the centre point of the associated land parcel, or in some cases just the address of the consent holder.[23] This means that anyone attempting to integrate information across regions needs to spend time harmonising it. Such issues should be addressed through government investment in data and digital foundations for the new planning system.

Thirdly, having standards for classifying and sorting data is fundamental so that when two agencies – or systems – talk about a concept, they are referring to the exact same thing in the same way.[24] This is not as easy as it sounds. Typologies are often purpose and context dependent, discipline specific, and culturally situated, meaning it isn't always possible to agree on a single definition. However, standardising where possible is beneficial. For example, agreeing on a simple definition, such as what constitutes a property or a farm, can be complex, especially where a term is used across domains. As a result, reaching consensus can take considerable time and effort due to the differing definitions embedded in legislation, organisational processes, research communities, and public understanding.[25] Crucially, there are no agreed-upon typologies for critical elements, such as certain land uses, ecosystems and taxonomies.[26]

Finally, having transfer and data-sharing standards is essential for interoperability and the actual sharing of data within the system. Currently, the lack and non-use of standards makes data sharing between central and local government organisations, Public Research Organisations (PROs), iwi/Māori, industry and others difficult and time-consuming.[27] Technologies are making this easier than ever before but are often hampered by the use of proprietary software and incompatible data formats. Several examples were described in the process of writing this report. Agencies and researchers recounted being provided with a range of data formats, from access to an application programming interface (API) and whole databases,[28] through to proprietary data formats or simple spreadsheets emailed directly. Going forward, persistent identifiers like digital object identifiers (DOIs) and universally unique identifiers are critical in federated environmental information systems because they provide stable, globally unique references for samples, datasets, models and other related digital resources.[29] As well as provenance, they support long-term discoverability, traceability, attribution, version control and reuse.

There is a clear and compelling need for improved standardisation across the system to enable data and information from different organisations to integrate coherently and automatically. It is this that will enable a federated information system to succeed. Elements include standards that support semantic interoperability and machine integration, allow data quality and provenance to be expressed, and make consistent use of persistent identifiers and associated registries (discussed more in chapter 6). These elements are vitally important and should be an initial focus of investment in new digital and data systems for the new planning system.

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22 Such as Northland (Northland Regional Council, 2026), Bay of Plenty Regional Council (BOPRC, 2026d), and Environment Canterbury Regional Council (ECan, 2026b).

23 Further details are included in the consent conditions, but as these number in the thousands for just one region, interrogating these is not practical.

24 This includes concepts such as taxonomies, typologies and ontologies.

25 LINZ, 2023.

26 Work was underway by MfE (now MCERT) to start to address land use (Law et al., 2024) and ecosystem (McCarthy and Wiser, 2024; MfE, 2026c) typologies building on other international classifications.

27 Office of the Controller and Auditor-General, 2018.

28 An API is a set of definitions, rules or protocols that enable two software components or applications to communicate with each other.

29 A DOI is a persistent digital identifier used to uniquely identify various physical, digital or abstract objects. They are fixed over time irrespective of location or other metadata changes and are widely used by academic, professional and government organisations (doi Foundation, 2026). A universally unique identifier (also known as a globally unique identifier) is a unique 128-bit number that can be assigned to a record. It is computer readable and used to harmonise data and resolve issues with duplication and inconsistencies of records (Davis et al., 2024). Blockchain technologies are also useful for tracking assets by using a shared, immutable digital ledger that records transactions.

This work does not need to start from scratch. International standards exist for many aspects, including those derived from the International Organization for Standardization (ISO) and the Open Geospatial Consortium. New Zealand is already party to many of these standards, and existing networks and committees provide a useful starting point for wider adoption.

The main barriers to developing standards and ensuring their implementation include the voluntary nature of many initiatives and the limited resources and expertise available to develop and implement them. The work of the New Zealand Marine Geospatial Information working group, led by LINZ, is an example of this. It developed a set of metadata standards and a controlled vocabulary for marine data. This ensured that data could be published in a consistent language and format that is easily discoverable and reusable (adopting a 'collect once, use many times' approach).[30] Unfortunately, in 2024 LINZ withdrew from its leadership role in this project.[31] The longevity of its metadata and vocabulary initiatives is therefore in question.

This experience provides an insight into what so often seems to happen to data and information initiatives in the public sector. Sensible, bottom-up, domain community- or agency-driven initiatives to drive standardisation are, in the absence of an agreed government-wide strategy, vulnerable to the demands of the moment – in this case, a search for across-the-board budget cuts.[32] Unless the value of environmental information – and the cost of not having it – is understood by decision makers, it will always be an easy 'saving' to make in the short term.

Issues with standardisation and leadership are not unique to New Zealand. Australia has proposed a National Environmental Standard for Data and Information (see Box 3.1 for more information), which could provide some valuable insights for a New Zealand context.

Box 3.1: Australian environmental information system reforms

An independent review of the Australian Environment Protection and Biodiversity Conservation Act found that Australia's environmental information system was inefficient, disorganised and incomplete.[33] The review suggested the development of "a national supply chain of information to deliver the right information at the right time to those who need it. This supply chain should be an easily accessible, authoritative source on which the public, proponents and governments can rely."[34] The review emphasised the need for immediate investment to support the reform.

In response to this review, the Parliament of Australia passed a large reform package in late 2025, comprising seven Acts, including changes to how environmental information is managed.

The Environment Information Australia (EIA) Act 2025 establishes a Head of EIA responsible for the stewardship of environmental information. In addition to providing high-quality information and data to the Minister for the Environment and Water and others, they are responsible for national state of the environment reports, environmental economics accounts, and declaring national environmental information assets. The Head of EIA is not subject to the direction of the Minister when performing many of their functions.[35] Alongside this work, EIA is also involved in the development of a National Environmental Standard for Data and Information.[36]

30 LINZ, 2026b.

31 PCE, 2024c.

32 Valuable initiatives backed by Cabinet, such as the New Zealand Geospatial Strategy (New Zealand Government, 2007), can equally fall by the wayside due to changes in priority.

33 Samuel, 2020.

34 Samuel, 2020, p.154.

35 EIA Act ss 9–11.

36 Department of Climate Change, Energy, the Environment and Water, 2024, 2026.

Any form of national direction should help data and information stewards improve the coordination and interoperability of the environmental information system. This work should incorporate, and not duplicate, existing initiatives, such as the National Environmental Monitoring Standards (NEMS, see chapter 2), and available international standards. If national standards are created, they should focus on both data collection within an environmental domain (e.g. soil quality) and the more difficult challenge of harmonising data across domains.[37]

Ultimately, to be effective, the use of standards must be championed and incentivised. Standardising data and information systems is a dry business that holds little appeal for policy makers. But their ability to make sensible policy is shackled by its absence. That is why communities outside of government, such as researchers and businesses, need to insist on its importance. Improving standardisation will be invaluable in enabling interoperability and sharing across all elements of a federated environmental data system, both public and private.

Sharing and ownership

There are many situations where information is not, and should not, be shared. However, there are also instances where sharing is currently limited and could be improved through greater clarity in legislative requirements, the application of consistent principles and better digital infrastructure. These concerns will need to be navigated if a federated system is to be developed and operationalised.

Work over the last two decades has attempted to improve data and information sharing by government agencies. Initiatives include the Government's open data policies,[38] the establishment of the Government's Chief Data Steward (currently the Chief Executive of Stats NZ), and the development of platforms and portals to improve data access and availability.[39] Despite this work, issues remain. Different organisations often have varying interpretations of what should be made available. There is non-alignment between mandates and commercial imperatives. Finally, a lack of capacity and funding to publish and maintain open datasets and portals. All of these intersecting challenges lead to the uneven application of open data policies.

One important factor to consider is that the benefits of sharing information do not always accrue to those who do the sharing. Part of the reason is that the act of sharing entails costs and effort that are unlikely to be recouped, particularly under open sharing arrangements.

However, almost all organisations sharing information are also users of other organisations' environmental data. In other words, agencies are both producers and consumers of environmental information, meaning that inefficiencies in sharing impose reciprocal system-wide costs.

There are likely to be significant economic and environmental opportunities lying dormant in the material locked up in government agencies that will often not be released on terms that would allow reuse by others.[40] Specific thought will need to be given to how those in the system are resourced to ensure that information sharing is encouraged.

To facilitate such sharing, many non-technical issues also need to be overcome. These include commercial constraints, such as intellectual property (IP) rights and commercial sensitivity, as well as issues with sensitive data, privacy and data sovereignty. These issues need to be considered and addressed from the outset of any attempt to develop a federated environmental information system in New Zealand.

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37 Medyckyj-Scott, 2018, p.16. As discussed, this will require domain communities of practice to maintain harmonised conceptual models, vocabularies and ontologies, drawing on international standards and semantic models where available to ensure that New Zealand-specific contexts are accounted for.

38 Such as described in the New Zealand Government Open Access and Licensing (NZGOAL) framework (New Zealand Government, 2014) and the Declaration on Open and Transparent Government (Cabinet Office, 2011).

39 For example, data.govt.nz, MBIE's (2022) open research policy, and the increasing number of datasets available on individual organisation websites.

40 New Zealand Government, 2014, p.5.

Commercial constraints

There are many commercial constraints that act as barriers to sharing environmental information. These may limit the availability of information that could be incorporated into a federated system. These constraints include licensing, commercial sensitivity (discussed in chapter 2) and IP rights.

Source: Shutterstock

Figure 3.3: Wairakei geothermal power plant. Commercial considerations and information on resource availability and sensitive environments can all impede the sharing of data.

The PROs serve as an example of how commercial constraints can hinder data and information sharing. Given the volume of data the PROs hold, incorporating this into a federated system would be extremely beneficial. As discussed in chapter 2, PROs are currently incentivised to treat data as a commercial asset.[41] Information paid for by taxpayers can have access restrictions, find itself behind a paywall or only be accessible by contracting with the host organisation. Currently, the Ministry of Business, Innovation and Employment's (MBIE) open research policy only "strongly recommends, rather than mandates, that research data arising from funded projects be made openly available whenever [possible]."[42] As the owner of the PROs, the Government needs to review this. Some cost recovery is understandable in certain cases to maintain the data and infrastructure on which it relies. But the balance between funding sources should be transparent. Given the significant ongoing changes to the science system, there is an opportunity to clarify, better incentivise, or even mandate (coupled with appropriate funding) open access sharing of information held by the PROs wherever possible.[43]

41 The Crown Research Institutes Act 1992 does not require proactive public release of research data, although this is encouraged through the open data principles the Government has signed up to. For example, the Declaration on Open and Transparent Government sets out a government-wide approach of actively releasing high-value public data it collects and holds on behalf of taxpayers. The New Zealand Data and Information Management Principles guide government release of data. The International Open Data Charter builds on these principles and the declaration. The NZGOAL framework provides guidance for agencies when releasing copyright and non-copyright material for reuse by others.

42 MBIE, 2022, p.6.

43 Reti, 2025.

Open access to environmental information is something that New Zealand has been pursuing within the wider science sector for some time. For example, in 2010, the Ministry of Research, Science and Technology published an Environmental Data Management Policy Statement with the vision that "in 2015, open access to environmental research data from public funding is easy, timely, user-friendly and preferably web-based".[44] A core part of this work was to empower Crown Research Institutes to drive better data management. As discussed, only moderate gains have been made in the intervening 16 years. Part of this can probably be put down to the loss of technical expertise over the years as the Ministry of Research, Science and Technology merged into MBIE. In the future, MBIE and the New Zealand Research Council should provide stronger direction for requiring the environmental information it funds to be made publicly accessible, usable and discoverable, and enforce compliance with any such policy.

There is an obvious tension between safeguarding non-government funded information to protect commercial interests (e.g. IP rights and commercial sensitivity) and sharing data for mutual or public benefit.

More readily shared and accessible information would likely reduce costs for all players in the system, including industry.[45] To the extent that information is about the physical environment and related ecosystems, requiring it to be reported safely and in an agreed format that protects company-specific and individual interests would be a significant boost to both environmental managers and other land users. New Zealand already does this with geotechnical information (such as soil composition, water levels and rock layers from boreholes) to improve performance and reduce costs for the building sector. Funded by MBIE, the New Zealand Geotechnical Database is a free, centralised platform for sharing geotechnical data where under the Terms of Use those downloading data are obliged to upload new data as they become available.[46] Similarly, fisheries data are collected by the Government and industry and used for regulatory purpose, to allow for assessment of the status of New Zealand fish stocks and to monitor the environmental impact.

Changing requirements associated with the consenting process could be one mechanism to require organisations to deposit collected information into public data repositories. The valuable information within consent documentation/applications could be used to fill in gaps and update existing data layers where possible. The push towards a more permissive planning system as part of RMA reforms is also predicated on the availability of environmental information.[47] To be successful, there is a case for requiring activities, irrespective of status, to provide baseline environmental information to ensure that the system is responsive. Having such information publicly available would improve spatial planning and would likely reduce costs and duplication in the long run, leading to a more efficient planning system. The Crown needs to determine what baseline information is needed and how this can be incorporated into the RMA reform.

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44 Ministry of Research, Science and Technology, 2010, p.5.

45 Scarlatti, 2023a, 2023b.

46 New Zealand Geotechnical Database, 2025. Users can now also use a natural language artificial intelligence interface to interrogate the data (Ai Leen, 2026). For more information, see the New Zealand Geotechnical Database website (www.nzgd.org.nz).

47 As evidenced by investment in the digital and data components required to implement reforms.

Managing sensitive information

Despite federated systems allowing individual organisations to retain control of their information and how they share it, it is to be expected that many will be worried about the management of sensitive information, including issues of privacy and confidentiality.

Environmental information can directly contain sensitive information, whether it is about people, property, or the locations of vulnerable species. There will also be cases where sensitive information can be exposed or recreated (intentionally or otherwise) through the aggregation of several datasets. Each dataset may not contain sensitive data itself, but when combined, could identify individuals or at-risk species, or create legal or regulatory sensitivity. As such, appropriate safeguards need to be put in place to protect this information. This can, for example, include aggregating information on vulnerable species to larger geographic scales, similar to the practice of the Global Biodiversity Information Facility, or de-identifying information as undertaken by the IDI.

Source: iStock

Figure 3.4: The Nationally Critically Endangered Otago skink. The location of certain species may be considered sensitive information to aid conservation efforts and prevent illegal trafficking.

The Office of the Privacy Commissioner has stated that the Privacy Act 2020 provides ample scope for the sharing of government-held data and information. The main barriers to information sharing identified were operational, including misunderstandings or uncertainty about the law and security concerns.[48]

Guidance is needed on the privacy and confidentiality protocols that must be applied to ensure appropriate use of environmental information and support the growth of trust and confidence in those providing it. For example, including appropriate access controls in a federated environmental information system could engender greater trust.

48 Office of the Privacy Commissioner, 2017, 2023.

Data sovereignty and Māori data

Within New Zealand, the concept of data sovereignty is understood to refer to data that are subject to the laws of the nation within which they are stored.[49] With increasing use of cloud services to store data, data are frequently stored in locations outside the country in which they were created. As a result, people and organisations can mistrust attempts to share information as there is a risk that it will be subject to other countries' laws. Therefore, for many countries, the issue of data sovereignty is presented as an issue of national security.

In contrast, Indigenous data sovereignty is the concept that data are subject to the laws of the country where they were collected. In New Zealand, this concept has been adapted to suit Māori, and is called Māori data sovereignty. It is the concept that Māori data (see Box 3.2) should be subject to Māori governance and aims to ensure Māori control over their own data.[50]

Box 3.2: Mātauranga Māori and Māori data

New Zealand is in a unique position in which two distinct knowledge systems – biophysical science and mātauranga Māori – are connected through the relationships established between Māori and the Crown through Te Tiriti o Waitangi.

Mātauranga Māori is the body of knowledge that has been generated and transmitted over many generations since the arrival of the first Polynesians to Aotearoa. Mātauranga Māori is not just information; it is subject to tikanga (processes and ways of knowing). In the same way that Māori regard themselves as connected to, and a part of, the land, the knowledge that has been accumulated is often strongly related to place. As a result, the information, data and knowledge created within a te ao Māori framework is different to biophysical 'environmental knowledge'.

Māori data are "digital or digitisable information or knowledge that is about or from Māori people, [their] language, culture, resources or environments."[51] Māori data are a living taonga to iwi/hapū/Māori.

Iwi/hapū/Māori collect and use a multitude of data related to the environment, with rōpū collecting data using both tikanga and biophysical science methodologies. While there is a lot of historical mātauranga Māori held by Māori that could be utilised as 'environmental data', it cannot and should not be interpreted outside of a te ao Māori framework. Instead, authority over the use of these data is with those who have mana over them, often at the whānau, marae or hapū level.

As such, mātauranga and Māori data are considered outside the scope of this report and have not been included as a source of information. Considerations about improvements that could be made are not specific to how mātauranga Māori is produced, stored or shared, as it is the right of Māori to determine that. However, data sovereignty should be considered, where relevant, for publicly funded information. Some initiatives, like the Kaitiaki Intelligence Platform and the Aotearoa Genomic Data Repository, have worked to incorporate the principles of Māori data sovereignty into their work.[52]

49 Te Mana Raraunga, 2025.
50 Te Mana Raraunga, 2025.
51 Te Mana Raraunga, 2018.
52 Reid et al., 2025a, 2025b; Genomics Aotearoa, 2026.

Overall, having a better understanding and resolving issues related to Māori data management rights and responsibilities are foundational challenges in developing a more trusted and connected environmental information system.[53] These aspects need to be considered by system stewards in collaboration with Māori and organisations that specialise in data sovereignty and the needs of Māori. If a federated system is implemented, then considerations associated with Māori data will need to be addressed early, as they could have major implications for how federation would work in practice.

Infrastructure and investment

To function effectively, a federated system needs to be built not only upon sound governance and standards but also on physical and digital infrastructure. This infrastructure must be fit for purpose, reliable and maintained. Furthermore, because a federated system is all about sharing information, catering to a wide variety of uses and users is also important. As such, any investment in information storage and management should be required to support open data publication standards. Rapid technological advances in both hardware and software (some of which are discussed in chapter 6) are lowering the cost of implementing a federated system. However, like any infrastructure investment, they need to be coordinated, with a clear strategy and the agility to make the most of innovative technology. Without these, a continued proliferation of ad hoc and inefficient platforms will result.

Importantly, this is not about building a new bespoke system from scratch. Many organisations have information management systems that could be integrated with moderate effort. That is the benefit of federation, compared to centralisation. However, some parts of the system will require greater investment. Otherwise, there will be weak links in the system that will affect overall performance and interoperability.

Significant and sustained investment in the environmental information system is unavoidable. However, the benefits will outweigh the costs. For example, conservative estimates of the net benefits of improving environmental data systems associated with resource management reform range from $1.3 billion to $1.9 billion over 30 years, based solely on reduced environmental degradation and fewer pollution-related harms.[54]

Having appropriate infrastructure can also be used to leverage numerous other benefits, such as an improved capability to ingest data from new sensors and technologies, increased automation of information sharing, and enhanced environmental reporting. Improved infrastructure focused on better interoperability will also make integration easier, which in turn will make it easier to participate in shared initiatives and the use of external data sources. For example, it will enable organisations to more easily contribute to existing efforts, including initiatives such as the Global Biodiversity Information Facility, and to make better use of citizen science and privately held data.

An agency appointed to lead any such initiative needs to be able to drive structured, ongoing investment in both data and the infrastructure needed to support its use and sharing. Not everything can be done at once, so the Government needs to be clear that it is embarking on a long-term and evolving project. This investment will need to be ongoing, not just in the underlying infrastructure but also in governance, standards maintenance, coordination, monitoring and institutional stewardship.

53 Initiatives set up over the years, such as the Mana Ōrite relationship agreement (Vercoe and Sowden, 2021) and Māori data governance model (Kukutai et al., 2023), are usually agency- or organisation-specific. This limits the wider implementation of Māori data sovereignty in data collection, analysis and use.

54 Carpenter et al., 2025.

Summary

The benefits of a federated system cannot be fully realised without substantial changes to the underlying structures on which these systems are built. It is this wider framework within which New Zealand's environmental information system operates that will determine how environmental information is ultimately used and reused. Without addressing the underlying causes of the information barriers that currently hinder environmental management, we cannot expect better, less costly or more timely decisions from elected officials or public servants. Improving efficiency and reducing costs is a reason on its own to enact change. However, we should not lose sight of the improved environmental outcomes that are possible by enacting change in New Zealand's environmental information system. Without change we cannot expect to reverse current trends in environmental degradation and head off oncoming challenges.

Improving the environmental information system could provide a raft of benefits if we value the information and infrastructure that enable it as strategic assets. Getting the system right also holds the key to maximising the benefits of innovative technologies that are on the horizon.

The balance of this report: Technological innovation and environmental information

Significant time and resources are spent on collecting and analysing environmental information across New Zealand. The way we collect some of this information has remained largely unchanged since its collection was initiated. The reasons for such inertia are not hard to find. The need to maintain the continuity of a time series is a powerful reason to leave well alone. The time and resources needed to develop and implement new methods can equally be hard to find.

However, technological developments mean that data collection that was previously either not possible or required significant time or financial cost is now feasible.[55] Many technological advances could be leveraged to improve our understanding and stewardship of New Zealand's environment and the effectiveness of environmental policies.

In short, the balance has tipped in favour of disruption. This is due to innovations in sensor technology, expansion in storage capacity and improvements in the analysis of complex data streams. Advances in remote sensing; high-frequency, continuous and automated monitoring; and environmental DNA (eDNA) are among the developments that have changed the investment calculus. Advances in analysis techniques, such as artificial intelligence, can leverage new data streams, unlock legacy data and improve data management in ways that weren't previously possible. Similarly, data infrastructure, like cloud computing, communications and sharing technologies, can ensure that environmental information is readily available to those who need it.

The emergence of these innovative technologies provides an opportunity to address some of the historical issues that have plagued New Zealand's environmental information system, as described in chapter 2. They could also facilitate and be leveraged in a federated system, as envisioned in chapter 3. Simply having more or better data will not solve all the current shortcomings. But it will put us on a more informed footing to track environmental changes and respond accordingly in a more efficient and timely manner.

The following chapters discuss these technologies in turn.

- Chapter 4 covers remote sensing technologies, including optical sensors, radar, LiDAR (light detecting and ranging) and other sensors used in New Zealand.
- Chapter 5 covers innovations in placed-based monitoring technologies, such as high-frequency water quality monitoring, camera and acoustic monitoring, and eDNA.
- Chapter 6 covers artificial intelligence and digital infrastructure and communication technologies that can unlock existing and new monitoring technologies and data streams.
- Chapter 7 highlights examples where the integration of technologies is improving our understanding of the New Zealand environment and why there isn't wider adoption of the technologies discussed in the preceding chapters.
- Chapter 8 uses three regional examples to highlight where we currently stand and where we could be in the future.

55 DOC and LINZ, 2023.

4

Filmy fern, *Hymenophyllum rufescens*

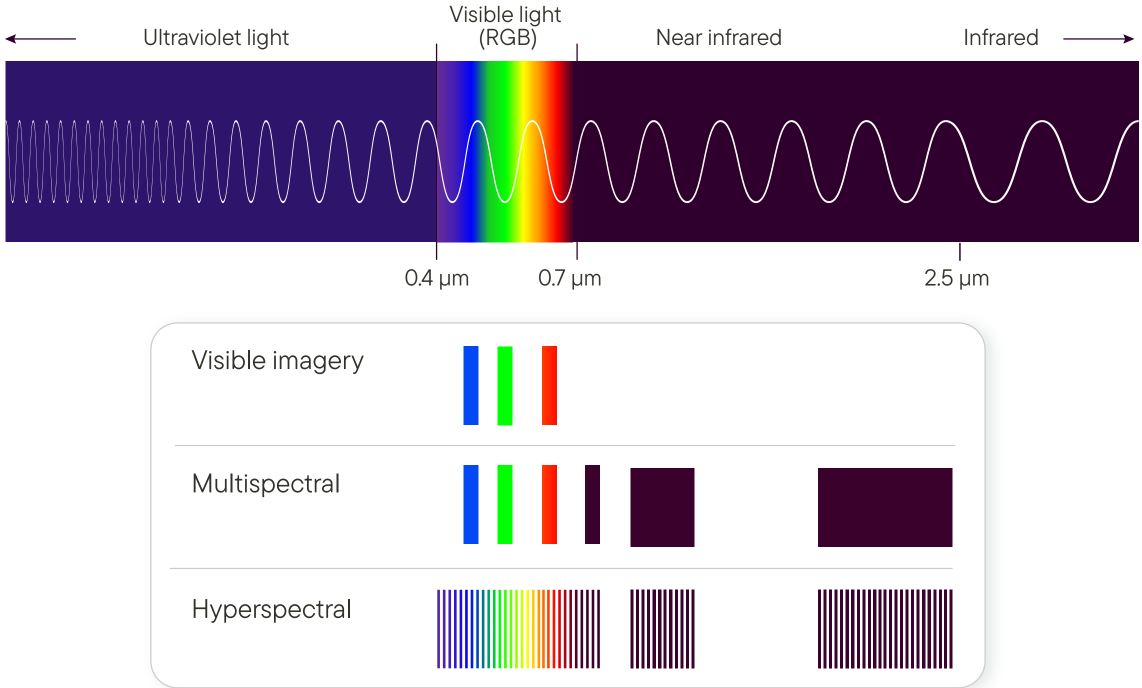
Remote sensing for environmental monitoring

Advances in remote sensing are transforming how environmental information is collected, analysed and used in New Zealand and globally. Greater incorporation of remote sensing data is needed to improve the timeliness, coverage and detail of environmental monitoring and decision making in New Zealand. This is because *in situ* sampling does not always provide a complete spatial and temporal picture of the state of the environment.

At its simplest, remote sensing is the collection of information from a distance. This will often involve detecting energy that is reflected (or emitted) from the area of interest (passive remote sensing). Examples include everything from the camera on your phone to satellites in orbit that use the reflection of sunlight (electromagnetic energy) to take images of the Earth's surface (Figure 4.1).[1] Alternatively, sensors can emit a signal and collect the response to provide information about a target area. This is called active remote sensing. Examples include things as simple as a laser rangefinder you might use to measure distances around the home, to complex systems, such as light detection and ranging (LiDAR) and synthetic aperture radar (SAR) used to develop detailed models of the Earth's surface.[2]

1 Other types of passive sensors include thermal imagers and radiometers.

2 Other examples include acoustic and near-acoustic sensing, such as sonar, seismograms and ultrasound sensors.

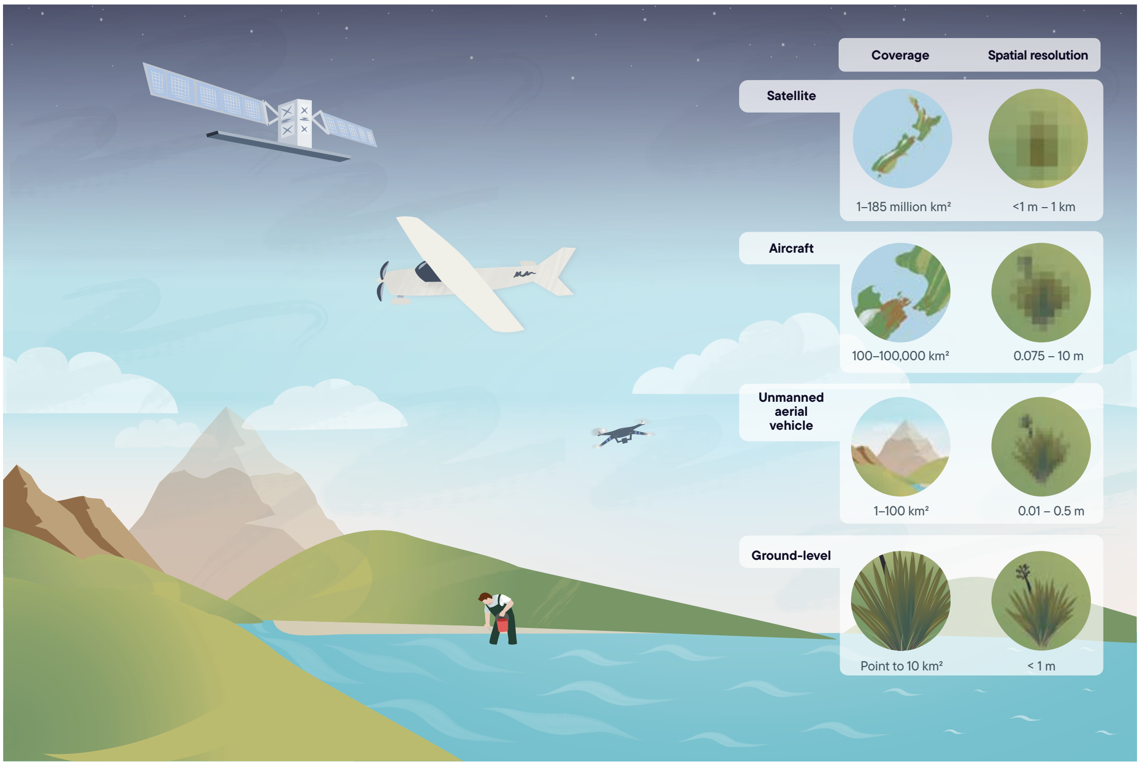


Source: Adapted from Cote et al. (2025)

Figure 4.1: Illustration of the parts of the electromagnetic spectrum that different optical sensors collect data across. Visible imagery collects data in the visible part of the spectrum (similar to standard photography). Multispectral imagery collects four to ten relatively broad spectral bands (though some can cover up to 36). Hyperspectral imagery collects data across hundreds of spectral bands at uniform increments.

Remote sensing enables more widespread and frequent data to be collected – often in areas that are not easily accessible. For example, satellite remote sensing enables the rapid, consistent observation of large areas of the Earth at regular intervals.[3] Figure 4.2 sets out the different platforms that can be used to gather information from global to sub-metre scales.

3 For example, Sentinal-2 satellites operated by the European Space Agency (ESA) pass over New Zealand roughly every five days. The 10 m resolution multispectral imagery is made freely available by the ESA and is used by a wide range of New Zealand organisations. Commercial satellite constellations often have higher resolution and can revisit the same location daily.



Source: Adapted from Cote et al. (2025)

Figure 4.2: Types of remote sensing data collection platforms, the area that they can cover, and the range of spatial resolution they can collect. A range of instruments and sensors can be deployed from these platforms, including visual, multispectral, and hyperspectral imagers, radar, SAR, LiDAR and thermal infrared sensors.

The combination of sensor, platform and data-collection frequency makes remote sensing a powerful tool for environmental monitoring. Data can be gathered on topography (e.g. elevation and slope), biological and ecological characteristics (e.g. changes in land cover, species occurrence or ecosystem health), chemistry (e.g. water nutrients and atmospheric gas concentrations) and meteorological variables (e.g. temperature and rainfall). National-scale remote sensing data can also be used to prioritise monitoring on the ground, improving the responsiveness and effectiveness of monitoring programmes.

Remote sensing is not new. It has formed an important basis for environmental data collection and monitoring in New Zealand since the early 20th century. For example, aerial photography provided the basis for many historical applications from producing topographic maps through to urban planning and river management (Figure 4.3). Satellite observations are increasingly used to provide key insights across national, regional and local scales.

What is new is the rapid development and refinement of remote sensing technology, the range of platforms that can be used to capture data (such as the explosion in the availability and use of unmanned aerial vehicles),[4] the ability to employ smarter data processing, and significant improvements in data analysis (such as machine learning) to generate meaningful information in a fraction of the time taken previously. With these improvements come their own challenges, including maintaining continuity and consistency with more traditional methods and datasets, ground truthing remote sensing datasets, and managing the ever-increasing volume, speed of acquisition and complexity of the available data.[5]

4 Autonomous underwater vehicles are also used in New Zealand for research and operational applications such as biosecurity monitoring.

5 For example, it is estimated that by 2032 satellite Earth observation will generate over 2 exabytes (2 billion gigabytes) of data (Kawade, 2023).

Source: PCE (2023, p.74)

Figure 4.3: Aerial photography has formed the basis of planning and management of the New Zealand environment since the 1940s due to its relatively cost-effective nature, high level of detail, and ability to target acquisition to areas of interest. For example, the images on the left show Hamilton East in 1943 (top) and 2016 (bottom). The images on the right are an example of the type of information that can be extracted from aerial images. In this case, they show the level of infill development that has occurred over the 73-year period.[6]

Advances in the use and availability of optical imagery, radar and LiDAR are unlocking data and insights that were previously beyond reach.[7] Each of these sensing technologies can be deployed from a range of platforms, such as satellites, aircraft and drones.

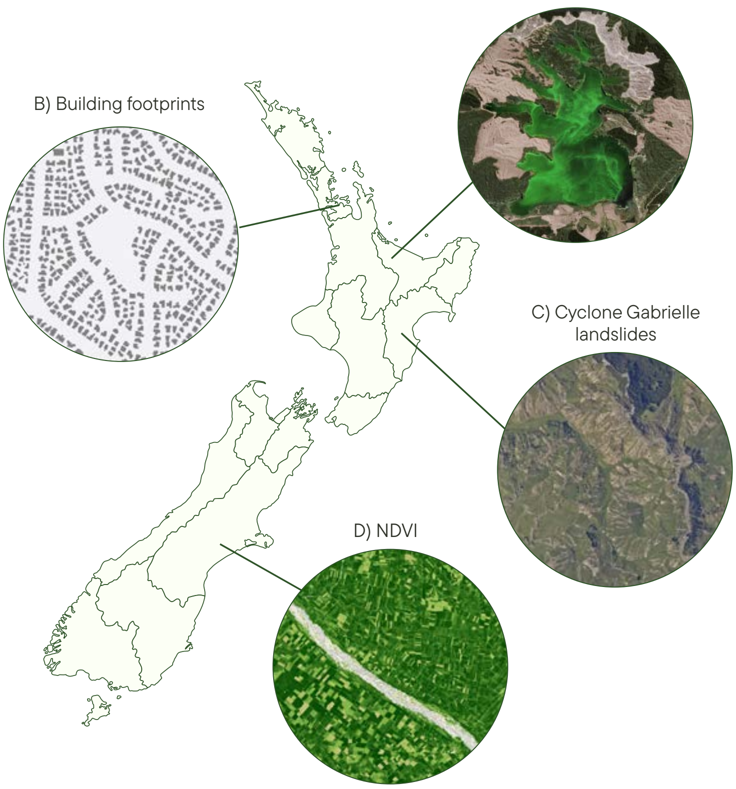
6 For more see PCE (2023).

7 More information on these technologies and their applications can be found in Remote Sensing for Environmental Decision-Making in Aotearoa New Zealand (Cote et al., 2025). A copy of the report is available on the PCE website (www.pce.parliament.nz).

Optical sensors

Optical sensors passively measure sunlight (electromagnetic energy) that is reflected by the Earth's surface. By collecting information across many frequency bands (Figure 4.1), different aspects of the Earth's surface that are invisible to the naked eye can be imaged. This is because the different chemical compositions of objects cause them to reflect electromagnetic waves in different ways, which is known as a spectral signature.[8] The images themselves can also be used to characterise other aspects, such as the shape, texture and morphology of objects such as trees and buildings.

In New Zealand, optical remote sensing has formed the basis for understanding and tracking environmental changes for over 30 years. Some example uses are shown in Figure 4.4 and discussed below. Many other examples exist, some of which are discussed in the report Remote Sensing for Environmental Decision-Making in Aotearoa New Zealand, which was commissioned for this investigation and accompanies this report.[9]



Sources: LINZ Data Service (2025) and ESA (2026b)

Figure 4.4: Selection of optical remote sensing applications. (A) Algal blooms can be identified by detecting chlorophyll a from Sentinel-2 imagery.[10] (B) Building footprints are extracted from aerial imagery for urban planning.[11] (C) Imagery is used to map the extent of natural hazards such as landslides after Cyclone Gabrielle.[12] (D) The normalised difference vegetation index (NDVI) can be used to assess vegetation health and productivity (greener is healthier), and identify high-risk agricultural activities such as winter grazing.[13]

8 For example, vegetation typically reflects more in the green and near-infrared parts of the spectrum.

9 Cote et al., 2025.

10 Lehmann et al., 2018; Schütt et al., 2022. Similarly, a range of water quality parameters can be identified for estuaries (Shao et al., 2022). In all cases, data derived from satellite imagery supplement existing monitoring regimes and rely on the *in situ* monitoring to ground-truth results.

11 Lynker Analytics Ltd, 2026a, 2026b.

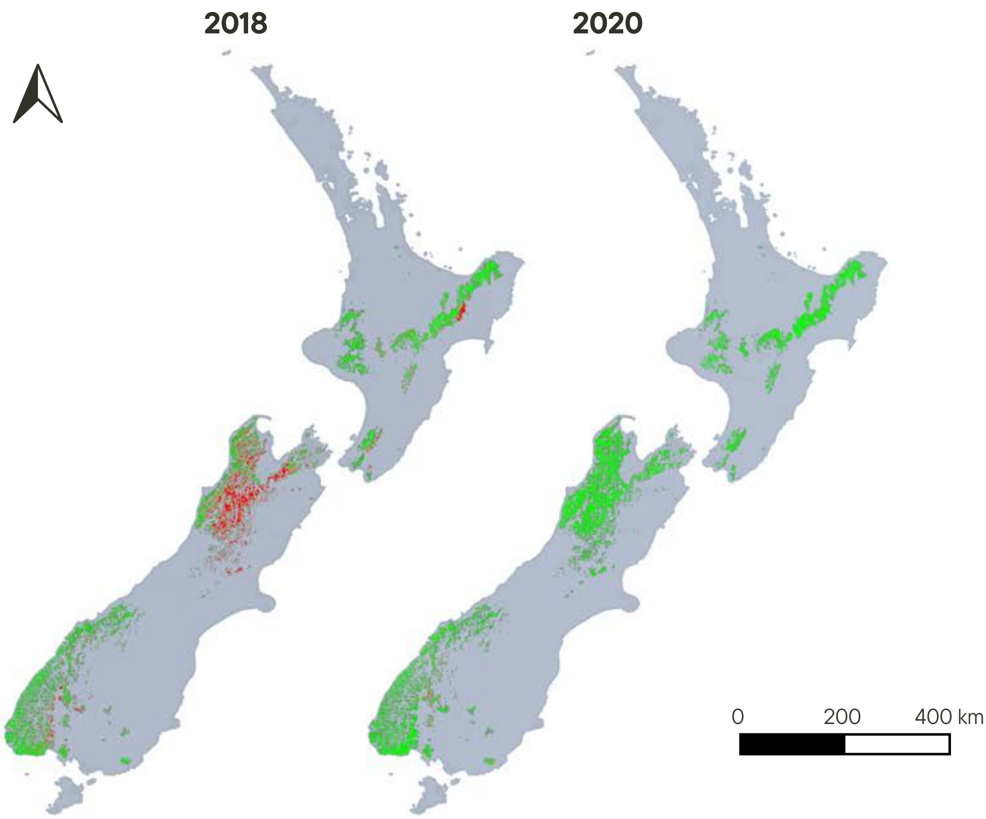
12 GNS Science, 2023; McMillan et al., 2023.

13 Belliss et al., 2019; Amies et al., 2021. Other vegetation, soil and water indices can also be derived by combining spectral bands (e.g. Chen et al., 2025).

Optical imagery highlights some of the wider benefits of remote sensing.

A single dataset can often be used for multiple applications. For example, aerial imagery can be used to map building outlines (Figure 4.4), track river and coastal changes, and identify greenspaces and individual trees. Alternatively, multiple datasets can be integrated to describe different aspects of a system. For example, a range of sensors is being used to describe the state of and changes in forest cover, assess forest health, and map storm damage after major weather events.[14]

National-scale applications show the versatility of optical sensors. One example is in the detection of southern beech flowering, a precursor for a beech mast event. This information can be used in planning predator control operations (Figure 4.5). Marine primary productivity (using near-surface concentrations of chlorophyll a), sea surface temperature, and total suspended sediment around New Zealand have also been derived from satellite imagery to highlight spatial and temporal trends.[15] New Zealand Land Cover Database (LCDB) and Land Use and Carbon Analysis System Land Use Map (LUCAS LUM) maps also fall into this camp.



Source: Adapted from Jolly et al. (2022)

Figure 4.5: Heavy beech flowering during springtime of 2018 and 2020 using Sentinel-2 imagery. Heavy flowering is shown in red, green represents areas where heavy flowering is not detected, and grey is outside the area of interest.

14 Camarretta et al., 2024; BSI, 2025a; Pearse et al., 2025; Watt et al., 2025a. Often this is achieved by combining imagery with other sensor data such as radar or LiDAR data.

15 Pinkerton et al., 2019, 2022, pp.31–33, 2023; Gall et al., 2022. Satellites used include Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua, Advanced Very High Resolution Radiometer (AVHRR), and Sea Viewing Wide Field-of-view Sensor (SeaWiFS). Data from these satellites are used to inform indicators for New Zealand's Environmental Reporting Series (MfE and Stats NZ, 2019, 2022).

When operationalised, optical sensors can also reduce costs. For example, the use of high-resolution aerial photography to detect and target small individual wilding conifers could reduce treatment costs by an order of magnitude when compared with existing control techniques, such as random search-and-destroy helicopter missions.[16] Data can also be captured in a timelier manner to support impact assessments and recovery from major disasters.[17]

Optical sensors have their limitations. For example, there is a trade-off between the spatial and temporal resolution of satellite imagery. The higher the spatial resolution, the smaller the area of the Earth's surface that can be captured and the more time it takes to revisit the same location.[18] Less frequent revisit times compound one of the major limitations of using optical imagery in New Zealand – clouds. Clouds interrupt the transmission of sunlight, resulting in pictures of clouds rather than of the Earth's surface. Optical sensors also cannot collect many data at night. As a result, complete coverage of large areas often requires combining imagery across several months into cloud-free mosaics. For example, despite the five-day revisit time of Sentinel-2 satellites, generating cloud-free national mosaic imagery is difficult at anything greater than a seasonal time scale.[19] Similarly, the angle of the sun during satellite passes can cause shadowing and distort the images. Calibration of sensor information is also often needed.

Having appropriate ground-truth data is vital to ensure that the captured information can be used reliably. For example, additional processing and information is often needed to use the normalised difference vegetation index (NDVI) due to New Zealand's diverse landscape and NDVI's sensitivity to landscape features and pasture conditions.[20]

The cost of acquiring and storing imagery can also be an issue, as is maintaining continuity between newly collected data and those gathered by older sensors and methods.[21]

Radar

Radar is a complementary sensor that overcomes some of the shortcomings associated with optical sensors.

Radar is an active sensor that emits microwaves towards the Earth's surface and measures the time and changes in the reflected signals. The use of longer wavelengths means that radar can penetrate clouds and produce images of the Earth's surface at night – a major advantage over optical sensors. They can also penetrate vegetation and soil, depending on the frequency used.

One of the most common radar sensors used is synthetic aperture radar (SAR).[22] By analysing the returned radar signal,[23] SAR sensors can estimate surface elevations, roughness and moisture levels. They can be applied to sea ice cover mapping, estimating forest coverage and biomass, and mapping soil moisture and wetlands.[24] Repeating these measurements can detect certain changes over time. In New Zealand, SAR has been used to better understand landslides, flooding and coastal land cover, amongst other applications.[25]

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16 Greene et al., 2020, p.1.

17 GNS Science, 2023; McMillan et al., 2023; Allen et al., 2024; Jones et al., 2025. Guidelines exist for agencies wanting to procure imagery rapidly after an event (LINZ, 2024c). New Zealand is also party to The International Charter: Space and Major Disasters, making access to some imagery easier.

18 To reduce the revisit time, constellations of satellites are increasingly used. However, this comes at a greater cost and these constellations are primarily operated by commercial operators.

19 Shepherd et al., 2020. As is the case with LCDB and LUCAS LUM.

20 Tran et al., 2025.

21 Some sensors and missions are designed for continuity (e.g. National Aeronautics and Space Administration's (NASA) Landsat and ESA Sentinel programmes) whereas others have 'design lifetimes' of between three and five years.

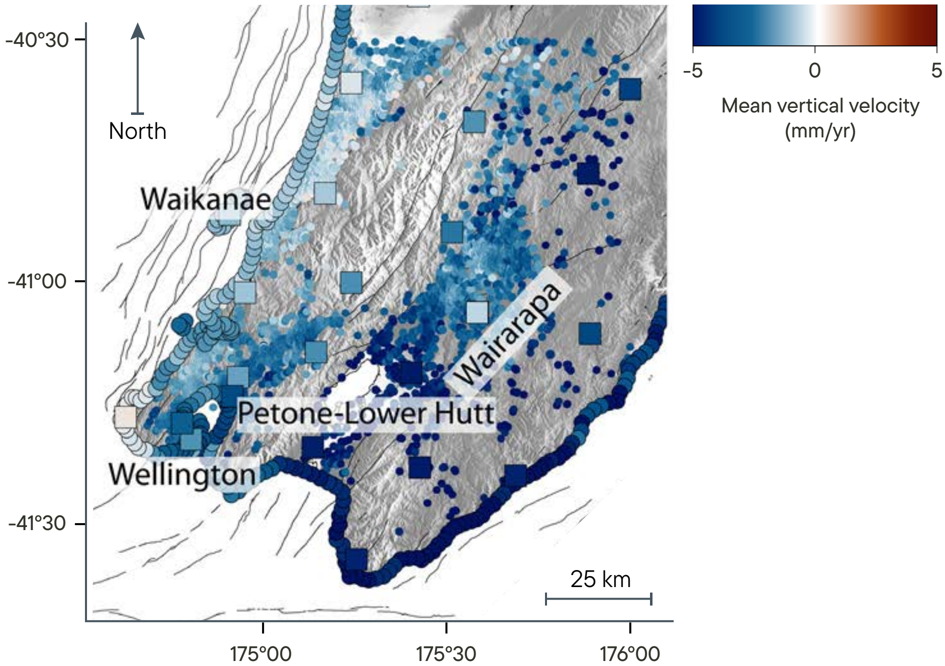
22 SAR sensors combine multiple shorter radar sensors to simulate a larger antenna. By mounting the sensor on a moving platform (a satellite or aircraft), the change in position between the antenna and the target creates a synthetic aperture. Other radar sensors include radar altimeters, which are used to measure sea level, ocean waves and ice sheets.

23 The returned signal is actually the backscatter due to the signal bouncing off the ground, vegetation or buildings, which affect the returned signal strength and polarisation.

24 Lythe et al., 2020, p.22; Das et al., 2025.

25 Collings et al., 2022; Cook et al., 2023; Dragonfly Data Science, 2026.

A particularly useful technique is SAR interferometry (InSAR), where two or more SAR images are subtracted to quantify changes in the Earth's surface over time. InSAR has been used to measure vertical land movement in New Zealand due to tectonics, sediment compaction and groundwater drainage. Future relative sea-level rise can be calculated by combining vertical land movement (Figure 4.6) with sea-level projections for more informed decisions on coastal hazards and climate change.[26]



Source: Naish et al. (2024)

Figure 4.6: Mean vertical velocity of the land surface in the Wellington region derived from InSAR data. Darker blue areas show land subsidence, which, when coupled with sea-level rise, is compounding the impacts of coastal flooding and inundation.[27]

A key future use of SAR will be estimating the above-ground biomass of forests over time. This provides invaluable information about carbon sequestration, productivity and the health of forests globally.[28] Two recently launched SAR missions – NISAR and Biomass – are set to greatly improve data availability and will have many potential applications within New Zealand.[29] For example, eight New Zealand sites will be used to ground-truth data from the Biomass mission, with a specific focus on water movement through forests.[30]

26 MfE, 2024. Relative sea-level rise combines both land movement and changes in sea level to give the net change over time.

27 Hamling et al., 2022; Naish et al., 2024; Kearse et al., 2025. For more and maps showing the relative sea-level rise see the NZ SeaRise | Our Changing Coast website (www.searise.nz).

28 Flores-Anderson et al., 2019.

29 NISAR (NASA-ISRO Synthetic Aperture Radar) collects data at two radar frequencies (L-band and S-band) (NASA, 2026). Biomass (Earth Explorer 7) is a longer-waved P-band SAR instrument (ESA, 2026a). For more information on SAR frequency bands see Table 2.3 in Flores-Anderson et al. (2019, p.29).

30 BSI, 2025c.

Despite its advantages, SAR remains underutilised due to its relatively limited availability, historically high cost, high technical thresholds for users and the significant processing demands compared to more common optical sensors.[31] However, with increased access to free satellite data (e.g. Sentinel-1, NISAR and Biomass), a wider range of sensor types, and developments in processing techniques, these barriers are waning. Despite these developments, moving the use of these technologies beyond a primarily academic space and into broader applications in New Zealand will be difficult without significant investment in capacity and capabilities to interpret and use the data.

LiDAR

Light detection and ranging (LiDAR) is a sensor technology used to build a three-dimensional representation of the Earth's surface.[32] LiDAR maps topography by measuring the time taken by a pulse of light to travel to the surface and back to the sensor. Two types of LiDAR are available: topographic LiDAR, which uses a near-infrared laser to map the land, and bathymetric LiDAR, which uses green light that can penetrate shallow water to map riverbeds, coastal zones and the seafloor. Surveys typically collect data at regional, local or site-specific scales, using aerial platforms.[33]

Capturing accurate elevation data across large areas, especially areas that are difficult and dangerous to access, makes LiDAR invaluable across multiple disciplines. Key applications include natural hazard assessments and hydraulic and water-quality catchment modelling. For example, LiDAR data underpins regional and national coastal inundation and flood modelling (Figure 4.7).[34] They are also used to track changes in riverbed levels and to understand sediment movement across river systems to support better management decisions.[35]

In addition to elevation data, many derivative datasets (e.g. slope) can be generated and used as inputs for assessments of erosion vulnerability and landslide susceptibility, water quality modelling, and improving soil maps and land use capability classifications.[36] Derived datasets are also used in land management, planning and compliance.[37]

The identification of tree and forest characteristics (Figure 4.8), including the estimation of above-ground biomass, is also possible. These metrics can be used to improve production, understand risks and estimate carbon sequestration.[38]

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31 SAR data can also be harder to interpret. Variations in topography can further complicate results.

32 The three primary LiDAR outputs are the individual 3D measurements (point cloud), a digital surface model representing the first point of reflectance (e.g. ground or tree canopy), and a digital elevation model that has all trees and buildings removed.

33 They can also be deployed from the ground and space.

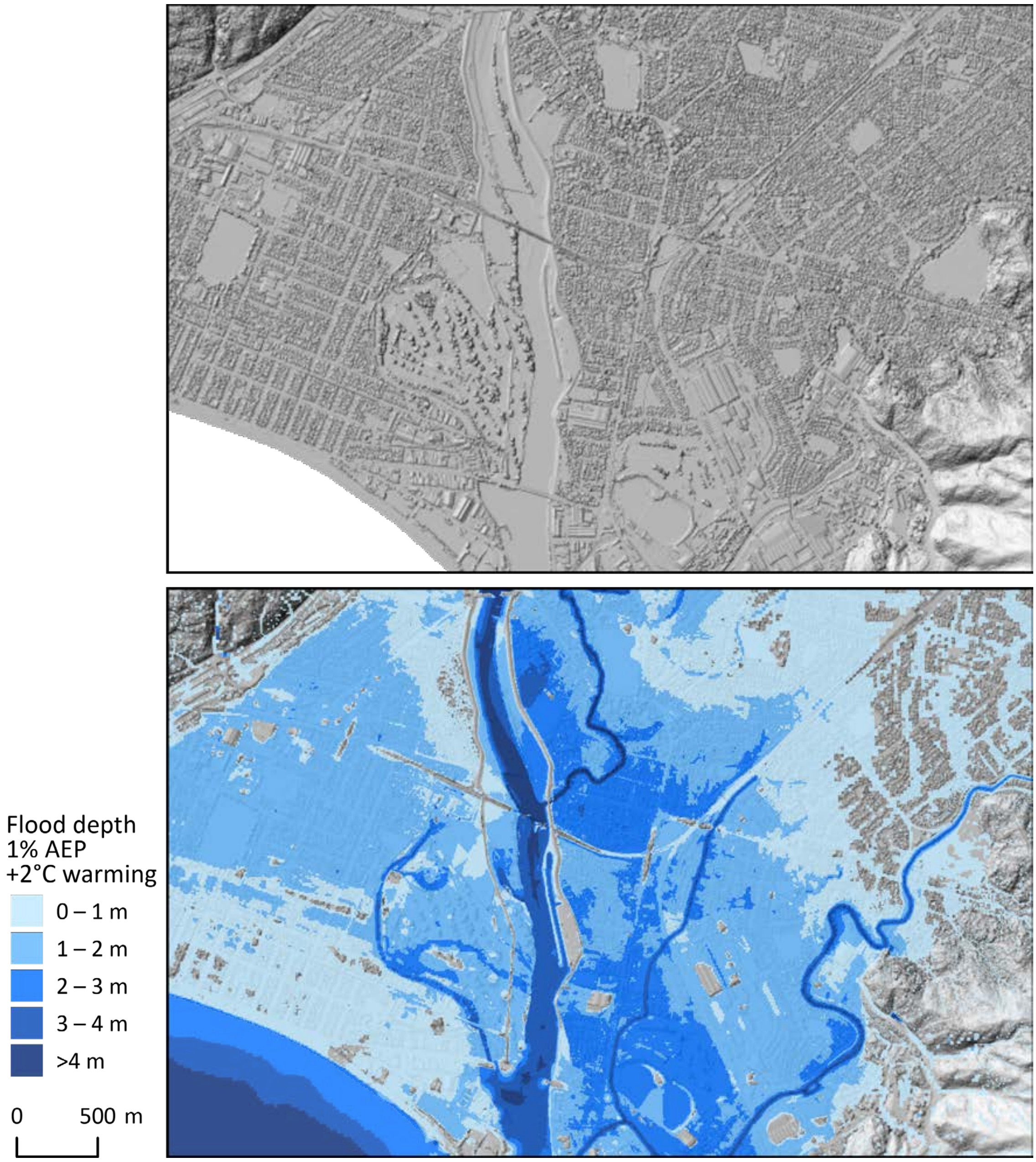
34 LINZ, 2024b, pp.16–33.

35 See, for example, in the Waiho River (Beagley and Gardner, 2024) and Waipaoa River in Gisborne (Rosser and Jones, 2022).

36 Boon, 2023; LINZ, 2024b; Odgers, 2024; Smith et al., 2024a; PCE, 2025d.

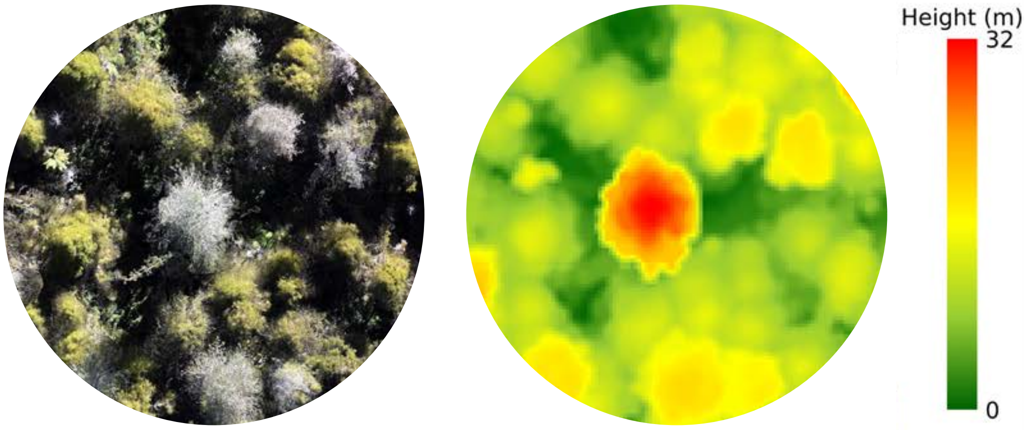
37 LINZ, 2024b. Such as identifying critical source areas that require additional management.

38 Bleeker et al., 2023; McMillan et al., 2025; Watt et al., 2025b. The use of LiDAR data in production forestry is particularly well developed, especially by larger organisations. However, integration into current reporting regimes is difficult (Te Uru Rākau – New Zealand Forest Service, 2024).



Sources: LINZ Data Service (2026b) and ESNZ (2025a)

Figure 4.7: LiDAR data are vital to understanding the impacts of natural hazards such as flooding. The top image is a hillshade model of Lower Hutt derived from the same LiDAR data used in the ESNZ national flood depth modelling (bottom) associated with a 1% annual exceedance probability (AEP) in a world dealing with 2° C warming.



Source: McMillan et al. (2025, pp.17–18)

Figure 4.8: Tree and forest characteristics, such as height, age, crown shape and canopy density, can be estimated using LiDAR data. The example here is a plot-level analysis of rimu trees captured using a LiDAR-capable drone. Left, aerial photo. Right, canopy height model where green is the ground and red is the maximum height of 32 m.

There are both technical considerations and temporal and spatial coverage limitations that affect the use of LiDAR. On the technical side, aspects such as the point density of a survey and its vertical and horizontal accuracy are particularly important when comparing surveys across time and space. For example, the timing and sampling densities of regional LiDAR may be vastly different between adjacent regions.[39] Processing the data also requires specialist knowledge to ensure that the derived products are physically plausible and accurate.

Over the last 10 years, LiDAR coverage in New Zealand has increased dramatically from 20% to over 80%, thanks to the Elevation Aotearoa programme and ongoing work by regional councils.[40] Bathymetric LiDAR is also in the process of being acquired for up to 40% of New Zealand's coastline (centred on highly populated areas). Data collected through these programmes and regional councils are made freely available, with base national standards set by Toitū Te Whenua – Land Information New Zealand (LINZ).[41]

Having national LiDAR coverage provides an important baseline that is being leveraged across many domains and industries. Additional analysis and the collection of complementary data are adding greater value. Importantly, the benefits accrue far beyond the organisations that fund data collection. For example, one of the largest applications is in planning and infrastructure development.[42] Other commercial uses, such as estimating potential residential rooftop solar output, are also increasing.[43]

As important as a national baseline is, it only tells us about a moment in time. The aftermath of Cyclone Gabrielle showed how coupling baseline and post-event LiDAR data is invaluable for assessing the impact of flooding, bank erosion and landslides.[44]

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39 For example, LiDAR data for the Wairarapa collected in 2012–13 for Greater Wellington have an average point density of 6 points per m^2 (OpenTopography, 2026b) compared to data collected in 2024 for the Tararua District with a point density of 21 points per m^2 (OpenTopography, 2026a).

40 Co-funded by the Provincial Growth Fund, councils, industry and others. For more information see the 'Elevation data' (www.linz.govt.nz/products-services/data/types-linz-data/elevation-data) and '3D Coastal Mapping' (www.linz.govt.nz/products-services/data/3d-coastal-mapping) web pages on the LINZ website.

41 LINZ, 2024b, pp.5–8. See also LINZ (2024a).

42 LINZ, 2024b, pp.12–15. Fifty-five percent of requests for LiDAR data through LINZ distribution channels came from infrastructure-related projects (e.g. roading, land development, flood protection).

43 Lynker Analytics Ltd, 2026c.

44 NIWA, 2023; Tsyplenkov and Smith, 2024; Biggs et al., 2025. Similar post-earthquake LiDAR data has improved understanding of fault rupture processes (Clark et al., 2017).

Slower changes in New Zealand's landscape from natural processes and human development (e.g. infrastructure and housing) are also occurring and need to be captured. For example, LiDAR data are used as the basis of flood modelling. Any changes that take place after the LiDAR data were captured (e.g. flood mitigation structures associated with subdivision development) will often not be reflected in the modelling, resulting in potential overestimation of flood hazard.

Having a dedicated, ongoing programme to regularly capture LiDAR data and make them available nationally is fundamental to assessing and responding to our dynamic landscapes.[45] The current arrangements, where the timing of collection is largely dictated by regional council budgets, are not sufficient. A national programme, underwritten by the Government, to ensure that LiDAR data are systematically captured across the country at a regular interval (e.g. 5 to 10 years) would greatly improve our ability to track long-term changes and update related information (e.g. flood modelling) in a coordinated and systematic way.[46]

Other sensors used in New Zealand

Remote sensing is not just about imaging the Earth's surface. Other techniques can provide information about the subsurface.

For example, aerial electromagnetic mapping can improve our understanding of water availability. Electromagnetic data are used to develop three-dimensional maps of groundwater systems (to depths of up to 300 metres) by measuring differences in electrical conductivity and pore fluid properties. Aqua Intel Aotearoa has undertaken such surveys in Northland, Gisborne and Southland.[47]

Radiometric surveys (also known as gamma-ray spectrometry) have also been used in some regions, like Southland and Northland, to inform water quality management by regional councils.[48] These surveys map the natural radioactive decay of three elements (potassium, thorium, and uranium) in the top 30–45 centimetres of the Earth's crust. The relative abundance of these elements indicates the geological makeup of the area, which, when combined with water quality data, can identify areas at greater risk of contaminant loss.

Finally, novel applications, such as the Rongowai mission, are mapping climate variables and soil moisture by using Global Navigation Satellite System (GNSS) signals reflected from the Earth's surface and measured from an Air New Zealand aircraft.[49]

Remote sensing limitations and improving its availability and use in New Zealand

Rapid advances in sensor technology, the deployment of new satellites, and the increasing capabilities of drones over recent years have given rise to an ever-increasing volume of data. This is the 'big data' syndrome, which requires new approaches and methods to cope with data storage, processing and analysis. The ability to automate the ingestion and analysis of remote sensing data using artificial intelligence and machine learning will be critical going forward.

The development of uncertainty estimates is also underway to unlock the potential of these data across many fields. There needs to be ongoing work to ensure that such uncertainty estimates and limitations are effectively communicated to all users and remain linked to the datasets themselves. If this information becomes unlinked, it risks being used for a purpose other than it was designed for. Clear metadata and provenance information help address these issues making them almost as important as the data themselves.

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45 LINZ, 2024b.

46 Similar to geotechnical data and the New Zealand Geotechnical Database, normalising the depositing of non-regional LiDAR data in online repositories (with appropriate metadata and quality assessments) would be beneficial.

47 See Aqua Intel's website (www.aquaintel.co.nz).

48 See Rissmann and Pearson (2020) and Rissmann et al. (2020) for examples in Northland and Southland, respectively.

49 University of Auckland, 2026. GNSS is the general name for a network of satellites that provide navigation and positioning information. The United States Global Positioning System (GPS) is one type of GNSS.

However, remote sensing alone is not a panacea. There are trade-offs, including the size of observable objects (spatial resolution), the interval between data acquisitions (temporal resolution), the range of the electromagnetic spectrum the sensor can detect (spectral resolution), and the levels of detail at which the data can be expressed (radiometric resolution). Each sensor and platform has different characteristics, which make them more or less suitable for particular applications.

There are also issues and increased costs associated with collecting or accessing data at appropriate spatial and temporal resolutions for decision making (e.g. changes on an individual property over time). Moreover, the appropriate application of remote sensing data requires expertise and capacity.[50]

Remote sensing data also need to be ground-truthed to ensure they are calibrated and validated with the real world. The storage and distribution of ground-truth data are just as important as the remote sensing data themselves. Ground-truth data both build trust and allow for cross- and re-validation of data as new methods are applied. Having appropriate ground-truth data makes all data more useful and valid for longer periods of time.

To be fully used, raw remote sensing data need to be analysed and processed into distinct indices or products. The availability of value-added products is an important factor in widening the uses to which remotely sensed data are put. Currently, there are many observational datasets, such as aerial and satellite imagery, but fewer products designed for New Zealand conditions are available for easy use by environmental scientists and other end users.[51]

One of the most obvious value-added products available is the LCDB. There are other estimates of land cover or ecosystem extent maps, but they do not disaggregate land cover classes sufficiently for many applications.[52] The LCDB illustrates the value of authoritative national datasets that can be leveraged across sectors. Their value can also be enhanced when they are linked with other information, such as business and consent data, to derive land use. An authoritative, national, real-time land use dataset is sorely lacking.[53] It could be invaluable to high-quality spatial planning decisions, including urban growth and the management of contaminant hotspots in rural catchments.

The way regional LiDAR data have been leveraged across thousands of different projects highlights the importance of the government providing coordinated, authoritative, analysis – ready products for public good purposes. The coordinating and standard-setting role that LINZ has played in this should not be understated and highlights the value of vesting responsibility in a single entity with a clear mandate. The New South Wales Government's Foundation Spatial Framework is a good example of such an approach. Approximately 300 datasets (grouped into 10 themes, including land parcel and property information, elevation and depth, imagery, water, and land cover) have been identified as authoritative spatial data to be used state-wide. Agencies must use the identified datasets rather than procuring, developing or using alternatives.[54] For this to work, there needs to be publicly available, authoritative datasets available released under appropriate licences.

The ability to integrate datasets from different sensors will be important for developing a better understanding of certain aspects of the environment. For example, tree characteristics and forest biomass derived from optical, SAR and LiDAR data are needed to better understand

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50 Morgenroth et al., 2025, p.13.

51 By adding value to the raw data, such datasets are likely to be seen as commercial assets by the research providers that produce them, limiting availability.

52 For example, LCDB 6 includes 33 land cover classes compared to the 11 in the ESA global land cover map (www.esa-worldcover.org/en). Recent work has indicated more frequent (e.g. annual), moderately detailed (16 classes), and cost-effective New Zealand mapping is possible, which could augment, but not exactly replace, the more detailed LCDB (Dymond et al., 2026).

53 Note that some progress has been made towards producing an authoritative land use classification system and dataset. In 2025 MfE published a report proposing a land use classification system for New Zealand, which has been adapted from the Australian Land Use and Management Classification system (Law et al., 2024; MfE, 2026b, p.9). At the time of writing, an authoritative national real-time land use dataset is yet to be produced (Stats NZ, 2022, p.12).

54 New South Wales Government, 2025. Although they can tailor and build on the datasets for their specific use case.

the content and structure of forests at scale.[55] When linked with other information, these data become invaluable for carbon accounting and other markets. However, 'fusing' datasets such as these is not straightforward (as discussed in chapter 3 regarding standardisation) and requires collaboration across scientific disciplines and environmental domains. This is difficult when expertise is distributed across several organisations, and there is a lack of leadership and coordination regarding what data are needed and how data collection and management is funded.

To make the most of remote sensing data, work is needed to improve their accessibility and integration within decision-making frameworks. Effort is needed to coordinate data collection and availability, validate indices and metrics for New Zealand applications, and develop value-added products that are freely available for use. More generally, there is a need to shift applications from the research and proof-of-concept stage and into ongoing monitoring programmes. The application of remote sensing technologies could address many shortcomings of current monitoring systems, creating a timelier response to environmental concerns.[56]

To be effective, operational workflows need to be developed to enable the cost-effective integration of remote sensing data into federated environmental information systems and the sharing of those data across organisations.[57] Although network bandwidth continues to improve, high-capacity data transfer capability is necessary for the sharing of large datasets, such as SAR and LiDAR datasets. While research institutions have access to high-speed networks, transferring data to organisations with more limited network capacity can present significant challenges.

One way to overcome this is a greater emphasis on the generation and dissemination of derived, value-added data products discussed above, rather than relying primarily on the distribution of processed source data.

Internationally, coordination has been achieved by assigning national responsibilities to scientific agencies tasked with managing the pipeline of remote sensing information.[58] These range from sourcing data to making relevant products available to end users.

The Australian Earth Observation Data Cube, known as Digital Earth Australia, is an example of such an arrangement. Led by Geoscience Australia, in conjunction with CSIRO (the Commonwealth Scientific Industrial Research Organisation) and the National Computational Infrastructure, the open data cube framework is used for accessing, managing and analysing large quantities of satellite data.[59] Analysis-ready data produced through the programme are made publicly available. These data are leveraged across government and non-government activities, including the Digital Atlas of Australia.[60] Such data cubes (Figure 4.9) have also been established in other countries.[61] A similar New Zealand data cube could provide a central repository for analysis-ready products and act as a point in a federated system that all users can access.

55 Dymond et al., 2019; Camarretta et al., 2023, p.30; Morgenroth et al., 2025.

56 Reid and Castka, 2023.

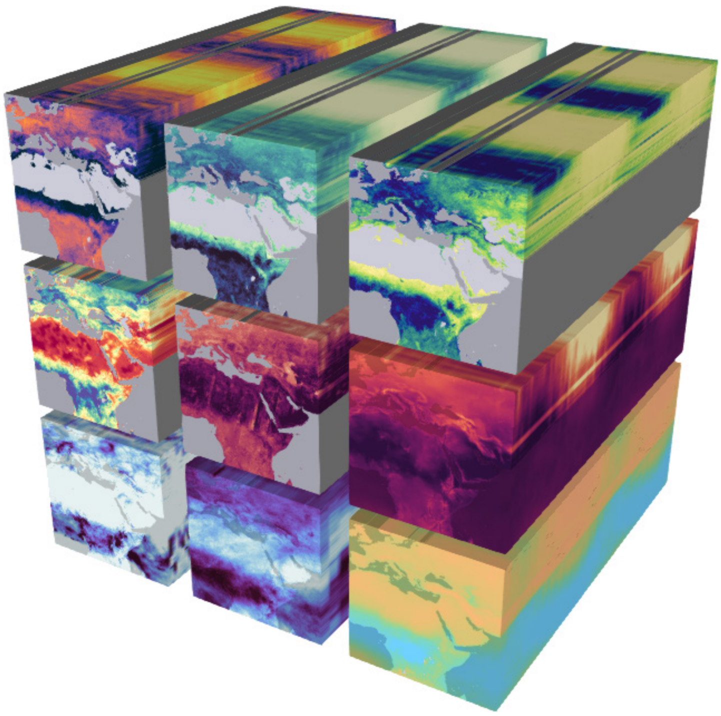
57 For example, environmental (and many others) organisations are now collecting a significant amount of unmanned aerial vehicle data (e.g. RGB imagery). Having systems in place to facilitate the sharing of these data, with appropriate metadata and access controls, would make this investment even more significant.

58 Examples of the way that nations coordinate remote sensing activities are discussed in Cote et al. (2025, pp.85–93).

59 A data cube is a way to organise data, simplify data management and improve performance of queries and analysis by structuring data in an array of multiple dimensions (Kopp et al., 2019). For more, see the Digital Earth Australia website (www.ga.gov.au/scientific-topics/dea).

60 Geoscience Australia, 2024. See also the Digital Atlas of Australia website (www.digital.atlas.gov.au).

61 Kopp et al., 2019.



Source: Mahecha et al. (2020)

Figure 4.9: Visualisation of an Earth system data cube showing the variables (individual segments) and spatial (horizontal and vertical dimensions) and temporal (depth dimension) components that can be integrated. Variables shown in the figure (from top left to bottom right) are sensible heat, latent heat, gross primary production, surface moisture, land surface temperature, air temperature, cloudiness, precipitation and water vapour.

The potential use of a data cube has been explored in New Zealand with limited success in the past, as the technology at the time was not considered cost effective or fully functional.[62] However, improvements in technology and growing demand for analysis-ready and derived data products mean that there is renewed interest in some form of centralised coordination and repository for remote sensing data. Other platforms could also be leveraged to enable wider access and analysis.[63]

National procurement of satellite remote sensing data could also be pursued to reduce barriers to accessing data across government, as cost is often a significant limiting factor. However, overreliance on international platforms could pose a long-term risk. Innovation in New Zealand's aerospace sector, such as Kea Aerospace's stratospheric Earth observation system and Dawn Aerospace's low-cost satellite launch systems,[64] highlight that having national capabilities in some of these areas could be possible in the near future.

Without action, the existing siloed development and application of remote sensing data is likely to continue, and the nation's ability to capitalise on a wide range of economic and environmental opportunities will drift.

62 Jolly, 2018.

63 Cote et al., 2025, p.94. The use of such platforms will need to consider national security issues as part of any procurement process under Rule 26: Manging national security risks of the Government Procurement Rules (MBIE, 2026a).

64 For more, see the Kea Aerospace (www.keaaerospace.com) and Dawn Aerospace (www.dawnaerospace.com) websites.

5

New Zealand tree fern, *Dicksonia squarrosa*

Place-based monitoring innovations

Physical environmental observations and measurements, often referred to as *in situ* monitoring, are vital for certain types of information and for ground-truthing remote sensing data. The growing availability of low-cost sensors, along with their expanding range and performance, is changing how place-based monitoring is conducted. This is resulting in a larger number of variables being monitored more regularly and across more locations (including those that were previously inaccessible). Increasing demands on monitoring networks to detect the impacts of policy changes are also contributing to the uptake of new monitoring technologies across many domains. Despite the growing potential of these technologies, many overarching challenges remain. These include managing and validating the greatly increased volume of data produced, and matching technologies to the right monitoring purpose.

The following sections highlight three areas where innovations are transforming place-based monitoring: the use of autonomous high-frequency sensors for monitoring water quality; cameras and acoustic recorders for biodiversity; and eDNA.

High-frequency water quality monitoring

A key area of interest in place-based monitoring sensor technology is the use of high-frequency (or continuous) water monitoring to autonomously measure a range of water quality indicators in rivers, lakes, aquifers and coastal waters.[1] Indicators include water temperature, dissolved oxygen, turbidity, conductivity, nitrate, chlorophyll a, and algal fluorescence.[2] To convert some measurements into water quality metrics, sensors often need to be co-located with other monitoring equipment (e.g. flow).[3]

Compared to the discrete (e.g. monthly) sampling often used in existing water quality monitoring regimes, *in situ* water quality sensors continuously track changes over time. This means rapid, episodic changes in water quality, such as those associated with heavy rainfall or unconsented discharges, can be detected more quickly. Subtle changes over time can also often be tracked. Amongst other things, they can enable a better understanding of the way ecosystems respond, identify ephemeral pollution events and fill gaps in time series data.

1 The observational interval for high-frequency water quality monitoring varies depending on the purpose and water domain. In river systems it typically refers to 5–10-minute intervals but can be up to 1 minute in urban streams. For water treatment plants the interval can be 1 second for operational decisions.

2 McKergow, 2025a, 2025b; McKergow and Hughes, 2025; McKergow and Vincent, 2025.

3 Site-specific calibration is also required, which involves collecting water samples under a range of flow conditions (Ausseil et al., 2023e).

Despite their promise and growing use, high-frequency water quality monitoring sensors are often used only to augment existing monitoring networks or in novel research and analysis.[4] This is partly due to a lack of information relative to existing methods, operational issues (e.g. biofouling), a lack of confidence in quality assurance, increased data processing requirements, and cost.[5] The upfront cost of sensors and supporting infrastructure means that in the short term, manual sampling can be more cost effective. But when considered over longer timescales (e.g. 10 years), automated sensors may be more cost effective per data point sampled, depending on the sensor type and variable being measured. However, site visits and lab and field checks of sensor output are still required for automated sensors. The frequency of these is simply reduced from 12 times a year for monthly sampling to potentially 4 times a year depending on conditions.[6]

Source: Stephan Heubeck, NIWA

Figure 5.1: Macrophytes, biofouling, mud snails and burial of high-frequency (continuous) water quality monitoring sensors are common issues that need continuous management.

The result is that the use of high-frequency water quality monitoring needs to fit with the monitoring and reporting purpose to which it is applied. For example, assessing the state and trend of many water quality variables doesn't normally require sampling at 5-minute intervals.[7] But monitoring the state of the environment is not the only use of water quality monitoring data. High-frequency monitoring can contribute to assessing the effects of interventions or site-specific issues (e.g. ephemeral pollution events), predicting intervention outcomes and engaging stakeholders, among other things.[8] To do this, monitoring networks will require different design, planning and operational approaches than existing (and often manual) monitoring methods.

4 Rozemeijer et al., 2025.

5 Milne et al., 2023a; McKergow and Hughes, 2025.

6 Westerhoff et al., 2022; Ausseil et al., 2023b, 2023e.

7 McDowell et al., 2024, p.8.

8 Stoffels et al., 2025.

Not all water quality indicators can be measured using high-frequency sensors because of either technical limitations or cost.[9] There are also no sensing technologies for macroinvertebrates and periphyton indices, as well as other monitoring data for indices of ecosystem health (e.g. Fish Index of Biotic Integrity in rivers). The use of eDNA technology (discussed below) is being trialled as a complementary and less invasive monitoring technique.[10]

Of all the potential barriers to deploying high-frequency monitoring, the sheer volume of information and the speed with which those data are generated pose the biggest challenges for users – particularly regional councils. The need to clean, calibrate, process, store and analyse data all adds to the cost and resourcing requirements.[11] Manually processing the data is possible when only a small number of sites are operated with high-quality sensors and appropriate field operations, but it is often impractical when the number of sites increases. This means automation is recommended to reduce cost and ensure that any corrections are applied consistently. This includes the automated detection of anomalies (e.g. due to sensor fouling), calibration drift and data transmission errors. Many guides and tools exist for such activities, but they require time, resources and expertise to be applied effectively.[12]

The combined effect is that the use of high-frequency monitoring is currently limited for regional councils whose resourcing is already stretched. This underlines the value of the Government maintaining a centre of excellence that can provide some of the technical advice and back-up needed to avoid councils having to laboriously develop parallel capabilities. This is a problem that also exists in respect of councils' use of water catchment models.[13] A technical agency like the Environmental Protection Authority could provide some of the leadership and guidance that is needed.[14] Work completed through Envirolink and National Environmental Monitoring Standards (NEMS) highlights the benefits of coordinated development of guidance across regional councils.[15]

Camera and acoustic monitoring

Arrays of cameras and passive acoustic monitoring devices are increasingly deployed to monitor the environment in place, especially for biodiversity monitoring.[16] They are non-invasive techniques that can help increase spatial and temporal coverage compared with traditional approaches. Cameras are particularly useful for studying nocturnal, rare and cryptic species. Passive acoustic monitoring is more suited to the study of highly vocal, low-population-density birds and marine mammals.[17] Metrics collected include presence, abundance, distribution, diversity and morphology (via camera observations). Passive monitoring reduces human observer disturbance and bias, and data processing can be automated (using machine learning techniques), standardising analysis. Monitoring devices can also be deployed in remote locations, including marine environments, for extended periods.[18]

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9 Ausseil et al., 2023b, 2023d.

10 Ausseil et al., 2023a, 2023c; White et al., 2025. The Fish Index of Biotic Integrity is used under the National Policy Statement for Freshwater Management National Objectives Framework to assess fish species richness compared to what would be expected in the absence of humans and is derived from freshwater fish monitoring using techniques such as electrofishing.

11 Similar issues arise when compiling water use data collected by councils (Booker et al., 2024, p.12).

12 NEMS, 2025b, 2026b, 2026c; Wood, 2025, p.4.

13 PCE, 2024a.

14 A range of guidance is currently available from the ESNZ website (www.niwa.co.nz/freshwater/high-frequency-water-quality-monitoring-guidance).

15 See the ESNZ website for guidance on the use of high-frequency water quality monitoring, which was funded through the Envirolink fund (www.niwa.co.nz/freshwater/high-frequency-water-quality-monitoring-guidance).

16 Passive acoustic monitoring devices record the soundscape of animals. Other uses include in river and stormwater monitoring (Our Auckland, 2024).

17 Another application is in monitoring soil fauna (Robinson et al., 2024).

18 Buxton et al., 2018. They can also be paired together, allowing detection of complementary species.

In New Zealand, the greatest use of automated cameras is in pest management to estimate the presence and abundance of invasive animals, and the success of eradication programmes.[19] They provide more information than traditional techniques, such as chew tags and tracking tunnels.[20] Cameras and thermal imaging technology are also being incorporated into traps to aid targeted predator control.[21] For example, AI-enabled cameras were used in the 2026 biosecurity response to yellow-legged hornets in Auckland. The cameras allowed monitoring hornet movements and supported pinpointing areas with high hornet activity. Drone-based thermal imaging was also used to locate nests in dense vegetation.[22] Other uses of cameras include the ability to identify individual animals, such as individual kākā in Wellington, to track population growth (Figure 5.2).

Source: PCE

Figure 5.2: A combination of video recordings and machine learning is being used to characterise unique aspects of the beak and body of kākā so they can be re-identified in a non-invasive manner rather than relying on leg bands. This allows researchers to track population growth.[23]

Passive acoustic monitoring for birds includes monitoring presence and behavioural studies, through to tracking individual birds by their song characteristics and estimating population size, such as for the reintroduction of the roroa/great spotted kiwi to Nina Valley in Lake Sumner Forest Park.[24] Similarly, the distribution and abundance of vocalisations (e.g. echolocation clicks) of whales and dolphins is modelled using passive acoustic monitor technology to guide conservation and mitigation efforts.[25] Its use is often mandatory on seismic vessels.

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19 Zero Invasive Predators, 2020; Nichols et al., 2022; Sweetapple and Hickling, 2024; Latham et al., 2025.

20 Anton et al., 2018.

21 DOC, 2024.

22 MPI, 2026a. Other innovative technology such as radio trackers – tiny radio transmitters attached to worker hornets – were also successfully used to detect hornet nests. The radio trackers were a core tool in the 2026 biosecurity response programme (MPI, 2026b).

23 Maddigan et al., 2024.

24 Bedoya and Molles, 2021; Jahn et al., 2022. Passive acoustic monitoring has also shown promise for detecting the presence of possums (McEwen et al., 2024).

25 Warren et al., 2021; Valdés Hernández et al., 2024; Andrews, 2025; Clement et al., 2025. The sounds and species that can be heard in the Cook Strait can be listened to on the ESNZ website (www.niwa.co.nz/oceans/acoustic-monitoring-whales-and-dolphins-new-zealands-cook-strait-region).

There are many logistical and operational limitations to the use of automated cameras and acoustic recorders. For example, many low-cost commercial automatic cameras are designed to detect larger animals (often game) and can miss smaller animals such as rats and mice. Detection rates are also limited by a camera's field of view, the sensitivity of the trigger mechanism, and its vulnerability to damage or breakage.[26]

A significant issue is often the volume of data collected.[27] Automation (using machine learning) is now the norm, with free online tools lowering the barrier for use.[28] However, further differentiating species (taxa) often requires the development of new machine learning models or more advanced sensors (such as thermal cameras). Recent developments in predator control are further lowering barriers, with some sensors now internally processing images and audio recordings (known as edge computing) to identify predators and bird species.[29]

Despite these advances, further research and development is needed to fully harness the potential of camera and acoustic monitoring. There are many organisations creating bespoke systems that duplicate effort and reduce the efficiency with which these technologies are deployed across applications. A coordinated effort is needed to invest in more research and development to reduce costs and tailor technologies and analyses to the New Zealand context. This would allow them to be used more widely, and in conjunction with other technologies such as eDNA,[30] while also filling spatial and temporal gaps in our understanding of biodiversity. This should be a key priority for agencies and considered as part of the environmental research pillar administered by Research Funding New Zealand.[31]

eDNA

Advances in non-invasive environmental monitoring using eDNA (environmental deoxyribonucleic acid) are making it possible to detect the presence of species from traces of genetic material left behind in water, soil or air. This can help us assess the health of species' habitats, detect biosecurity incursions and monitor the outcomes of policy and management interventions.[32] Traditional monitoring approaches required the physical presence of the organism and involved laborious manual interventions that might not have been possible given the sampling conditions or the rarity or mobility of the species in question. Being able to overcome these problems has led to an exponential increase in the use of eDNA over the last decade, as has the reduction in sample processing costs, particularly compared with morphologically based taxonomic analysis.[33]

26 This can be caused by weather, hardware malfunctions, battery failure or damage by animals such as possum or kea. Some of these problems can be overcome with thermal imaging cameras (Ross and Ryan, 2019; The Cacophony Project, 2024).

27 For example, during a 6-month operation to assess the impact of a deer repellent cereal bait, over 383,000 images were recorded using automatically triggered camera traps (Sweetapple and Hickling, 2024).

28 Such as CamTrapNZ for images (MWLR, 2024) and AviaNZ for bird recordings (Marsland et al., 2019). It is unclear what ongoing support these tools currently have.

29 For example, see The Cacophony Project (2024) and wildlife.ai (www.wildlife.ai/projects/wildlife-watcher)

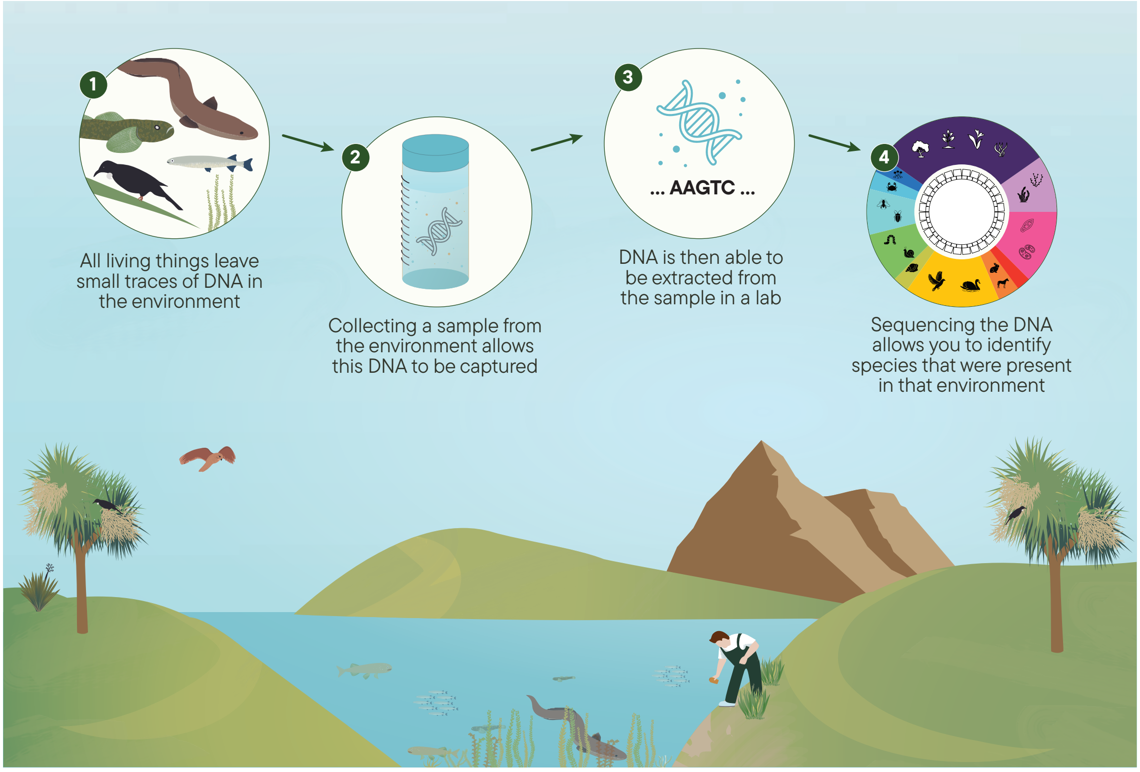
30 See, for example, Bell and Malerba (2025). Combining technologies can reduce monitoring costs and improve the detection of a wide range of species.

31 This recently appointed "independent board has been established to consolidate funding decision makers across the science, innovation and technology system" (MBIE, 2026b).

32 Melchior and Baker, 2023.

33 Jeunen et al., 2019; Suren et al., 2024, p.2. For example, in New Zealand the number of eDNA river samples has gone from near zero in 2019 to 50,000 in 2024 (Bunce and Jarman, 2024).

eDNA monitoring (Figure 5.3) involves collecting samples from soil, water or air that contain DNA released by organisms as they interact with their environment.[34] Samples are then processed in a lab and matched against reference libraries to identify the presence of different species, providing a genetic snapshot of the biota present at a given location and time.[35] Protocols and testing kits have been developed, allowing a wide range of people to collect samples.[36]



Source: PCE

Figure 5.3: Simplified infographic of the collection and analysis of eDNA samples.

An important consideration in the application of eDNA is that to many Māori, DNA is a physical representation of whakapapa. As such, any DNA collected from taonga species is considered to be a taonga in its own right and subject to tikanga. As a result, Māori consider that their rights and expectations should be respected in the use of eDNA. This may include collaboration in the design, collection and availability of results, as well as how reference material is stored and made available.[37]

34 eDNA allows for detection of the overall presence of organisms, including deceased organisms as well as cells shed when living organisms pass by the sampling site. Sources can include skin, scales, hair, mucous, faecal matter and decomposing tissue. Environmental RNA (eRNA) is a complementary technology that indicates current living organisms in a sampling area as RNA degrades more quickly (Giroux et al., 2022; Zhang et al., 2024).

35 DOC and LINZ, 2023; van der Reis et al., 2024; Tulloch et al., 2025.

36 Melchior and Baker, 2023; Smith et al., 2024b.

37 Sterling et al., 2024; Dhami et al., 2025.

Source: Stuart Mackay, NIWA

Figure 5.4: Water ecologist collecting a water sample that will be sent to a lab where technicians will extract DNA and identify traces of any species that were present in the environment.

eDNA is increasingly being used by government agencies, such as the Department of Conservation (DOC), regional councils, iwi and hapū, and other community organisations.[38] Applications have focused on aquatic environments, including measuring the impacts of aquaculture, monitoring native freshwater fish, conducting marine biodiversity assessments and the early detection of aquatic invasive species.[39] Examples include the discovery of a new population of Clutha flathead galaxias by DOC and the detection of the gold clam, koi carp and fringed water lily in rivers.[40] eDNA is also being trialled in the identification of invasive terrestrial species, such as rats and wallabies, as an indicator of soil quality and condition, and to monitor groundwater health.[41] Through the Wai Tuwhera o te Taiao – Open Waters Aotearoa programme, the Environmental Protection Authority is encouraging the use of eDNA by providing test kits and information to iwi/hapū and community groups to monitor their environments.[42]

38 DOC and LINZ, 2023.

39 Pochon et al., 2019; Thomson-Laing et al., 2021; Melchior and Baker, 2023; Picard et al., 2023; Bird et al., 2024; Suren et al., 2024.

40 Collins et al., 2022; RNZ, 2023a, 2023b; Horizons Regional Council, 2024.

41 Hermans et al., 2017, 2020; Webber and Weaver, 2024; Steibl et al., 2025; Kroos et al., 2026.

42 See the Wai Tuwhera o te Taiao – Open Waters Aotearoa programme website for more, including a list of community projects (www.epa.govt.nz/community-involvement/open-waters-aotearoa).

eDNA monitoring also has the potential to be integrated into monitoring the outcomes of policy and management interventions. The taxon-independent community index is a recent example of this. It condenses the DNA sequence data into a single metric that indicates river health. Similarly, the use of eDNA to monitor macroinvertebrates as an indicator of river health shows promise. eDNA sampling is also being used in conjunction with other monitoring techniques, such as spotlight surveys, to monitor threatened freshwater species.[43]

To be effective, eDNA relies on a comprehensive and accurate DNA reference library. This is a collection of DNA barcodes for known species, which are matched against those in the sample being processed. The reference library must include genetic information for taxa found in the sample environment. However, there are significant data gaps in many of the large publicly available libraries, especially for regionally specific data, and there is often bias in the species represented.[44] This makes it difficult to identify and differentiate underrepresented New Zealand species, particularly plant and bird species. Yet these are obviously some of the species we are most concerned about. Without these data, incorrect or missing identifications (false positives) can occur as barcodes are matched to closely related species or assigned to higher-level taxa, reducing the sensitivity of the results.[45] New, often invasive, species may also be missed if they are not present in the reference database used. To address this, one option could be to invest in a national reference library for New Zealand that seeks proactively to populate that library on the basis of acknowledged gaps and management priorities.[46] Again, this should be prioritised by agencies and considered as part of the environmental research pillar administered by Research Funding New Zealand.

eDNA is not without its limitations. It cannot distinguish important metrics (such as age, or the abundance of species present).[47] Samples can degrade or be contaminated.[48] And eDNA is more difficult to use for monitoring terrestrial species.[49]

Despite these caveats, some of which can be addressed through a combination of robust sampling protocols and additional research, eDNA represents a valuable tool that complements (and, in some cases, could replace) existing monitoring regimes. However, there is a lack of central leadership on how to incorporate eDNA into monitoring programmes, with existing initiatives fragmented across organisations, and there is a lack of research that is needed to support its wider use.[50] Improved coordination and resourcing is needed to fully unlock eDNA's potential.

43 David et al., 2021; Bunce and Freeth, 2022; Suren et al., 2024; Wilkinson et al., 2024; Orchard et al., 2025, pp.47–50. Taxon-independent community index scores throughout New Zealand can be explored on the Wilderlab website (www.wilderlab.co/explore).

44 Hotaling et al., 2021; Dhami et al., 2025. For example, New Zealand plant species are underrepresented in two large publicly available databases. These also often lack full metadata information about who collected the data and when they were collected (Dhami et al., 2025).

45 Bilewitch et al., 2022, p.5; van der Reis et al., 2024.

46 Dhami et al., 2025. This could provide an opportunity to embed data stewardship and sovereignty principles, as well as tikanga, into its development.

47 In some situations, the abundance of DNA barcodes correlates with actual abundance in the environment, but this is not a reliable metric. This is partly because some organisms shed DNA more readily than others, and DNA can travel significant distances from its source to the collection point.

48 Melchior and Baker, 2023, pp.63–64.

49 Although it is increasingly possible (Reeves et al., 2025; Kroos et al., 2026).

50 Bunce and Freeth, 2022; Collins Consulting Ltd, 2025.

Small Kiokio, *Blechnum procerum*

6 Artificial intelligence and digital infrastructure and communication technologies

Analysis is needed to transform environmental data into useful information to better understand the environment (e.g. state and trends) and to inform decision making (e.g. determine the effectiveness of management actions and policies).[1] The growing capabilities and use of artificial intelligence (AI) are proving central to unlocking many new and existing data streams. At the same time, innovations in the way information is processed, transmitted and stored – such as edge computing, communications technology and cloud computing – are changing what is possible. The following sections discuss these technologies in turn.

AI and advances in the analysis of environmental information

Analysis can take many forms but often involves the use of statistical techniques to examine the relationships between environmental variables and trends, such as the direction or rate of change.

AI is increasingly being used for these tasks, but more traditional analytical techniques still have a place and continue to improve our understanding of the environment.[2]

AI is an umbrella term used to describe machine-based systems that endeavour to mimic human intelligence.[3] It works by giving computer systems a way to map information, find patterns in data, make connections, and then use those patterns and connections to make predictions. It incorporates computational methods and techniques that learn to solve tasks, often through iteration.

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1 Snelder et al., 2021.

2 In the future, quantum computing may also be applied to environmental issues (e.g. University of Waikato, 2025).

3 The current OECD definition is “a machine-based system that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments” (OECD, 2019, p.9).

While AI has recently captured global public attention, particularly with the advent of generative AI chatbots such as ChatGPT,[4] AI and machine learning applications have been used in environmental sciences for decades.[5] What is new is the development of new techniques, the availability of data to train models, and an increase in computing power to train and run AI models and systems.[6]

The following discussion predominantly focuses on the application of AI for data analysis, rather than the generative AI applications. However, the integration of generative AI with data analysis is likely to increase in the future as applications evolve. An example of this was the Find Data platform developed as part of the Our Land and Water National Science Challenge. It integrated a generative AI chatbot with over 12,000 publicly available land and water datasets to answer users' queries.[7] Such uses are likely to affect the usability and uptake of environmental information for decision support at all scales, from farmers to central government.

Currently, the two most common subsets of AI are machine learning and deep learning (Figure 6.1). Machine learning involves creating models by training an algorithm to make predictions by learning patterns in training data.[8] Deep learning, particularly artificial neural networks, is a popular subset of machine learning inspired by the human brain. Neural networks use complex algorithms to develop layers of 'understanding' that build on one another to find hidden patterns and features in the data.[9]

4 Generative AI uses models capable of generating complex and original content such as text or images. ChatGPT uses large language models to generate text, speech and images.

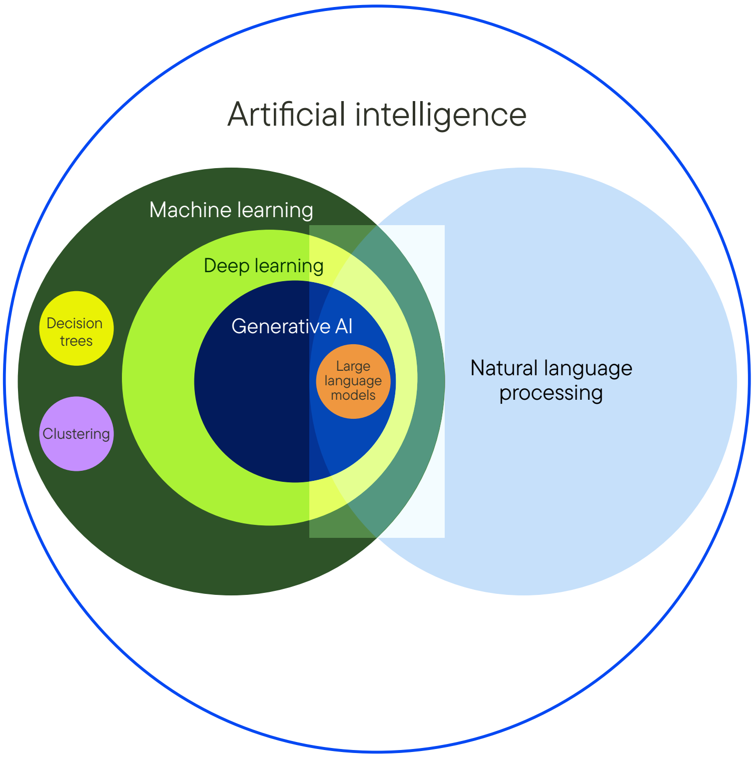
5 See, for example, Dyer and Moninger (1988).

6 Training and running AI models often requires significant power and water use. Jevons paradox may result in any efficiency gains being negated in the future (Aczel et al., 2026).

7 McAleer, 2024. This platform appears to no longer be available.

8 There are many types of machine learning, including linear regression, logistic regression, decision trees, random forest, support vector machines, k-nearest neighbour, clustering and more. Each approach is suited to different kinds of problems and data. In terms of training, learning can be supervised (using data labelled by a human), unsupervised (analysis of data to identify patterns and make predictions) or reinforced (correct actions are reworded and reinforced) (Stryker and Kavlakoglu, 2026).

9 Examples of neural networks include convolutional neural networks, which are a specialised type of algorithm commonly used for image classification and object recognition tasks. Other examples include transformer and generative adversarial networks.



Source: Adapted from Stryker et al. (2026) and Maaz et al. (2024)

Figure 6.1: Overview of some of the different types of AI and how they relate to each other.

The data analysis and pattern recognition capabilities of AI present significant opportunities for environmental sciences.[10] The ability to handle large volumes of diverse data is particularly useful when combining disparate datasets and dealing with high-frequency, automated and real-time data. As such, AI primarily acts as an enabling technology that increases the ability to process, interpret and, therefore, use information. Hence the references to its use in the previous technologies discussed.

Other uses of AI in New Zealand include:

- identification of individual native trees from multispectral aerial imagery for use in biodiversity and carbon assessments (Figure 6.2) – deep learning approaches have also been applied to planted forests[11]
- automated detection of wilding conifers from aerial and satellite imagery[12]
- monitoring fish populations in marine protected areas and locating and identifying Māui and Hector's dolphins from drone aerial imagery[13]
- improving water quality modelling to generalise beyond current monitoring data in both spatial and temporal dimensions[14]
- improving weather and climate predictions by developing physics-informed and AI-driven climate downscaling and climate and weather projections.[15]

10 Hajkowicz et al., 2022; DOC and LINZ, 2023.

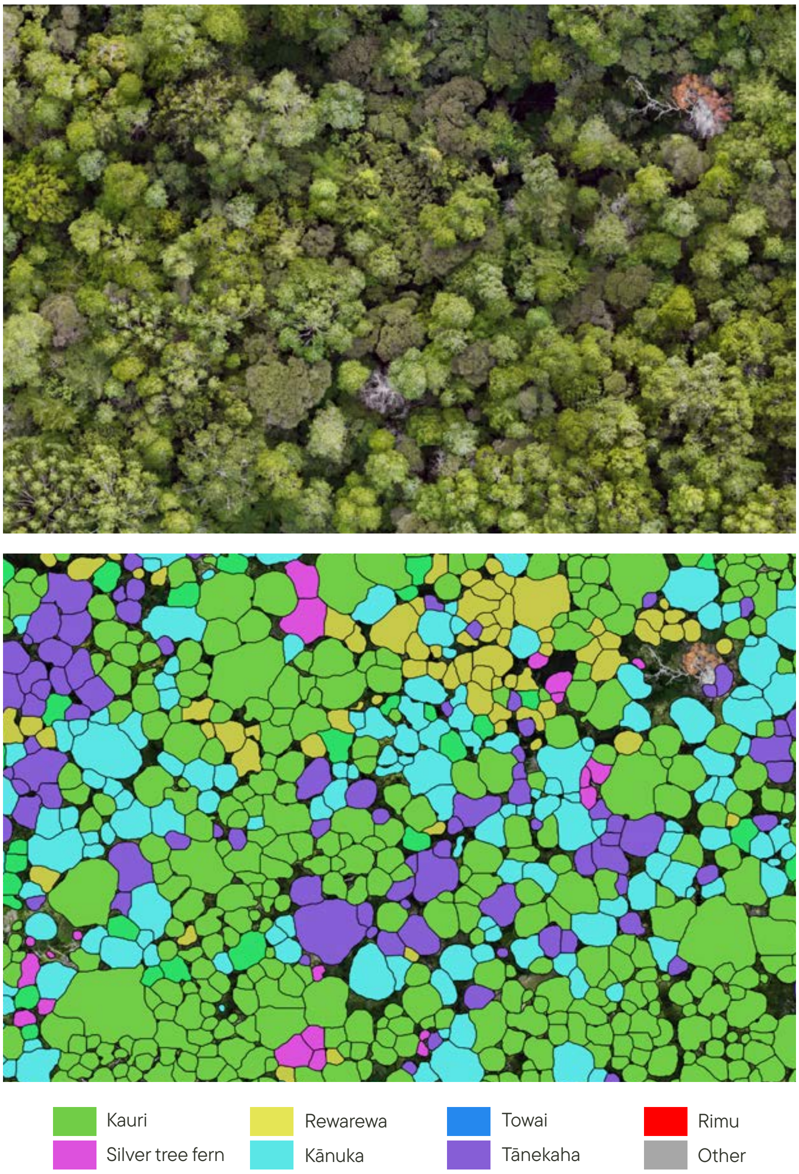
11 Scion, 2023; Pearse et al., 2025. The model has been further developed by Scion and Indufor Asia Pacific Ltd into a platform (ForestInsights, www.dwell.systems/forest-insights) that can be used by councils and industry to map and describe (e.g. volume, maturity and damage) planted forests (BSI, 2025b).

12 Using support vector machines and random forests (Dash et al., 2019; Greene et al., 2020; Klinger et al., 2024).

13 Fonda (2025) and Maui63 (www.maui63.org).

14 Using artificial neural networks, random forests and decision trees (Xu et al., 2020; Armstrong et al., 2022; Whitehead et al., 2022; Henkel and Thachapilly, 2025; Dost et al., 2026).

15 ESNZ, 2025b, 2026a; Rampal et al., 2025.



Source: McMillan et al. (2025)

Figure 6.2: Example of detection of tree species in Whenuakite, a regenerating forest dominated by kauri and tanekaha. High-resolution (1.6 cm) unmanned aerial vehicle imagery was captured and analysed using a combination of deep learning techniques to classify tree canopies by species, primarily using shape (morphology) and texture.

It is not only data analysis that is changing. The ability to extract and use historical and administrative information is also changing the environmental information landscape. Information from historical records, reports and consents can be digitised and analysed using optical character recognition, natural language processing and other analytical techniques.

Finally, AI can be used to more effectively manage environmental data. This includes unlocking legacy data hidden in existing data storage systems by extracting structured information and making it visible, searchable and more accessible for potential reuse. AI is also increasingly invaluable for improving data quality by cleaning and validating data inputs, including detecting duplicates, missing values, inconsistencies and likely errors. The automation of these tasks is likely to free up significant time in the future.

Source: ESNZ

Figure 6.3: The digitisation of historical records has many benefits, including the potential to use AI tools to convert handwritten information into machine-readable formats.

Despite the benefits that AI offers, there are also limitations. The biggest technical issue is that AI systems need to be built on high-quality data with rich semantic and contextual information to interpret and use the data reliably. If the underlying data used to train a model are incomplete or flawed, the old truism of 'garbage in, garbage out' applies. Biases in the training data will be propagated into the models' outputs. Use outside the original context (i.e. events not present in the training data) can result in incorrect outputs. AI models can also suffer from over- or under-fitting data or, in the case of generative models, hallucinations.[16] This can erode trust in the use of AI.

Having sufficient data for training models for specific tasks may be prohibitive in some instances. For example, in a trial to identify potential forest loss using machine learning as part of the Land Use and Carbon Analysis System (LUCAS) monitoring, over 15,000 training annotations were required to build a model capable of detecting changes across the entire country. Despite the extensive training dataset, some land use classes lacked sufficient examples to enable high-confidence classification.[17] In some instances, manual classification may be more cost- and time-effective. This was the case in the mapping of broom, lupin and gorse in the central North Island from aerial imagery. The amount of work required to reduce false positives ended up being less cost effective than manual classification.[18] Therefore, having the right-sized approach to the specific application is an important consideration. In some cases, the effort to apply AI will be worth it in the long run due to potential cost savings. In other cases, traditional statistical or manual approaches may be best.

Ground truthing of AI models is also necessary to ensure they perform well. This includes having separate validation and test datasets that models are compared against to ensure that the model is performing appropriately, further increasing data requirements. The lack of long-term and geographically representative reference datasets in New Zealand will cause issues in applications going forward.

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16 An overfit model can result in high model accuracy on training data but low accuracy on new data due. This means the model is not good at generalisation. An underfit model performs poorly on training and testing data because it fails to 'learn' patterns in a dataset (Mucci, 2026). AI hallucinations refer to responses that contain false or misleading information presented as fact.

17 Lynker Analytics Consortium, 2020, p.18.

18 Peterson et al., 2024.

Interpretability of AI is another issue. Most AI models are not readily interpretable, explainable or transparent. The result is a lot of 'black box' algorithms, where the answer given might be right, but how the AI model got there is unknowable. There is a growing amount of research into developing explainable AI to try to mitigate this issue. AI also presents unique challenges regarding privacy, trust and data ownership, particularly in applications that use generative AI.

As the capabilities and applications of AI continue to expand, it is more important than ever to get the basics right: good quality data, with known provenance (for context, transparency and auditability) that can be trusted, and collected in consistent ways, in machine-readable formats. To let AI loose on New Zealand's many incomplete or outdated datasets would simply amplify their weaknesses. Facilitating collaboration between environmental and data scientists will be critical, as without subject-matter experts in the loop, ill-informed decisions could be made that amplify biases or draw the wrong connections between cause and effect.[19]

Ultimately, AI models are simply another tool in the toolbox. Without solid foundations, we won't be able to make the most of the rapid developments taking place. Worse still, negative environmental outcomes might result from poor data and its use. Our ongoing and historical poor practices in data documentation and stewardship have become significant constraints. AI could increasingly help to improve some of these factors in the future, but doing so will still require subject matter experts. **There is a warning for New Zealand in this. If we try to apply AI to the current inadequate state of environmental data, we will almost certainly end up regretting any reliance on it and undermining the social licence to use it.**

Digital infrastructure and communication technologies

To undertake advanced data collection and analysis, there needs to be appropriate infrastructure in place to transfer, store and process the data. Three areas have changed rapidly in the last 10 to 20 years to facilitate this: edge computing, communications technology and cloud computing.

Advances in processing data directly within monitoring devices, known as edge computing, are reducing the need to transfer large volumes of raw data, improving the efficiency of data transmission. Edge computing is designed to optimise speed, reduce data-transfer costs, and address potential security considerations. In practice, this typically involves transforming raw data into other forms or formats prior to transmission – for example, the ability of cameras to automatically identify species within the camera and just transmit the identification, or link with a trap to catch invasive species.[20]

Increased device connectivity and transmission of data means that information from a wider range of sensors can be collected in near real-time. Although some monitoring systems, such as weather stations and river flows, have used telemetry networks to transmit data for decades, their use has been relatively limited to sites of greatest importance. Other monitoring systems have traditionally stored data on the device for later retrieval, potentially months after data collection. This is changing as old monitoring sites are refreshed and new sites are commissioned.

Improvements in digital connectivity in recent years have been enabled by the advent of 3G, 4G and 5G mobile connectivity.[21] Similarly, satellite communications enable real-time collection of remote monitoring data that would otherwise have been impossible with traditional technologies.

The increasing capabilities and ubiquitous use of smartphones is also leading to a revolution in citizen science initiatives. They leverage many of the technologies discussed here with a willingness to contribute to understanding and managing our environment. One of the most significant examples is iNaturalist, a platform where users upload observations (typically photos) of plants and animals for identification by the community of users. This information can also

19 The TAIAO (Time Evolving Data Science and Artificial Intelligence for Advanced Open Environmental Science) data science programme (funded by MBIE) is one such initiative (www.taiao.net). Equally, AI expertise and use is also increasingly embedded across PROs, universities and industry.

20 Hess, 2025; The Cacophony Project, 2025.

21 The 'G' refers to generation and signifies the evolution of digital cellular technology to transmit voice and data. Each generation is faster, lower latency, and supports a larger number of devices.

be used by scientists and government organisations for research and monitoring of exotic species.[22] A New Zealand based example is the Earth Sciences New Zealand (ESNZ) (formerly the National Institute of Water and Atmospheric Research (NIWA)) Citizen Science app, where the public can upload information on a range of topics, including fish passage assessments, pictures of flooding, and snow depth.[23] Coupling this information with the use of AI models, such as for object recognition, could increase the data available in a number of fields.

The ability to collect, transmit and make sense of significant amounts of data using advanced sensors, edge computing and enhanced connectivity in near real time will be invaluable in some contexts.[24] Water quality monitoring and pest management are two such examples. The use of cameras and radar, coupled with machine learning, to monitor stormwater infrastructure and flooding in Auckland, also shows a real-world application of combining technologies.[25]

However, all that information needs to be stored somewhere and processed into meaningful information. This is where cloud computing comes in.

Cloud computing is where information is stored, or processing is undertaken by a network of remote servers rather than on a local server or computer. It allows users to store and process significantly more information than would have otherwise been possible. Cloud computing covers everything from the hosting and storage of data to the use of high-performance computing environments to run complex simulations. In New Zealand, examples of high-performance computing environments include those operated by Research and Education Advanced Network New Zealand and ESNZ. Despite recent investment, there remain key challenges with maintaining national high-performance computing environments.[26]

Source: NIWA (2025a)

Figure 6.4: Investment in high-performance computing environments, such as NIWA's previously operated systems Mahuika and Māui (pictured) and their new Cascade and Rapids systems, are vital for the storage and processing of environmental data.[27]

22 PCE, 2021, p.81. For more see the iNaturalist website (www.inaturalist.org).

23 NIWA, 2022.

24 This includes the 'internet of things', a catch-all term for smart objects like appliances and watches that are connected to a network and collect and share data. Similar systems, sensors and autonomous AI-enabled unmanned aerial vehicles are also increasingly being deployed across the primary industries sector.

25 MacDonald, 2025.

26 MBIE, 2022.

27 NIWA, 2025a.

The use of technologies such as cloud computing also raises privacy and data sovereignty concerns (discussed in chapter 3), given that most data centres are located outside New Zealand. While current access arrangements appear stable, increasing dependence on overseas cloud infrastructure creates growing strategic and resilience risks for New Zealand and should be considered.

Complementary technologies and standards need to be implemented to effectively apply these technologies. This includes the use of application programming interfaces (APIs) and related technologies to enable automated data and information sharing and the use of digital object identifiers (DOIs) and universally unique identifiers to track data provenance and its use. Metadata are equally important, as discussed in chapter 3.

The infrastructure-related technologies discussed here enable the use of other technologies such as remote sensing, high-frequency monitoring and AI. Coordinated investment (both short and long term) and collaboration are needed to facilitate uptake and use. This is important irrespective of the type of data and information system employed – federated or otherwise. However, these infrastructure technologies are fundamental if a federated data system is to succeed (as described in chapter 3).

Crown fern, *Lomaria discolor*

7 Integrating technologies and why we don't at present

When it all works together

Immense opportunities exist to advance our understanding and management of the environment by combining some of the technologies discussed in this report. These technologies are available now, and many are already being used in New Zealand in some form. They are also being combined, and we are starting to see glimpses of what is possible when that occurs. Bringing it all together requires skill and effort, not to mention collaboration across disciplines and sustained funding.

One recent New Zealand example is the work completed as part of the Forest Flows research programme (2019–2024) funded by the Ministry of Business, Innovation and Employment's (MBIE) Endeavour Fund, which examined how water is distributed, used and circulated in forested catchments. An average of 360,000 daily observations were collected by 1,717 sensors (Figure 7.1) from seven sites, transmitted to a central, cloud-based data storage platform, and analysed using machine learning. Periodic remote sensing measurements were made with satellites (Soil Moisture Active Passive (SMAP) and Sentinel-2) and an aerial platform that used synthetic aperture radar (SAR) to measure soil moisture from a plane to a depth of 1.5 metres.[1] These data were used to understand and predict water use, water storage and water release in planted forests. The collection, integration, analysis and prediction of such large amounts of data would not have been possible using traditional methods.[2]

1 L- and P-Band SAR sensors were used, which have the same frequency range as the recently launched NISAR and Biomass satellites discussed in chapter 4. For more on the SMAP satellite see the National Aeronautics and Space Administration (NASA) website (www.jpl.nasa.gov/missions/soil-moisture-active-passive-smap).

2 BSI, 2026a.

Source: Dean Meason

Figure 7.1: As a part of the Forest Flows Endeavour programme, information from weather stations, dendrometers, and soil moisture, streamflow and groundwater monitoring sensors was collected to build a picture of how water is distributed, used and circulated in forested catchments.

Safeswim is another example of leveraging technologies and data integration. Safeswim is Auckland Council's programme for managing public health risk from swimming in the natural environment. Information about water quality and the risk of illness from swimming is communicated for 163 beaches across the Auckland region live on the internet using standardised symbology and advisory messaging. To do this, Safeswim integrates data from multiple sources. Water quality predictions are generated every 15 minutes from computer models that use real-time data on environmental conditions and weather, including rainfall, tide, wind and sunlight data, to simulate water quality at each beach and estimate when water quality poses a higher risk of illness. Different beaches use different model types (e.g. machine learning regression models and process-based models) depending on the information available, and are continually validated against year-round routine and targeted water quality sampling.[3] Safeswim also integrates live detection of wastewater overflows from sensors on Watercare's wastewater network, overriding predicted model results to show when wastewater overflows will affect nearby beaches.[4] The integration of monitoring, modelling, cloud computing and the live updating of publicly available online maps demonstrates what is possible through leveraging technologies. The outcome is that the public has access to timely, accurate and reliable information on public health risk at popular swimming locations, which enables swimmers to make informed decisions about their risk exposure.

3 Tuckey et al., 2019. For an overview of the programme, see Doole (2024, pp.33–34), and to explore the results, see the Safeswim website (www.safeswim.org.nz).

4 Manual alerts can also be published when other conditions posing a risk to public health and safety arise, such as algal blooms, unexpected water quality breaches detected during sampling, or other contamination events.

Data can equally be pulled together at smaller scales, such as for a farm. Many farms are already on the path to integrating business, animal performance, and some environmental data, given the productivity and efficiency gains. With the rollout of more environmental sensors across farms and by leveraging other technologies, such as remote sensing, better environmental outcomes could be achieved.[5]

Replicating environments by developing digital twins has also garnered interest.[6] Their use in the future could help improve planning decisions, test responses to new policies and engage communities. The monitoring network deployed as part of the Forest Flows project effectively created a digital twin of the studied forests. Digital Twin Victoria equally highlights what is possible with digital twins for improving environmental understanding, urban development, asset and infrastructure management, and disaster response.[7] For example, as part of the programme they have an eComply project to create a self-service digital assessment tool. Building compliance processes are streamlined and sped up by automatically pre-checking 3D building designs against Victoria's Small Lot Housing Code.

Why isn't there greater use of these technologies?

The preceding examples give a sense of what is possible. But they are just that – examples. Their widespread use is currently limited. Which begs the question: Why, given their promise and the potential to integrate so much data and information, aren't the technologies discussed being more widely deployed?

Part of the reason is that the maturity of the technologies is not all at the same level of technological readiness. Some, such as passive acoustic sensors, require greater validation and demonstration in an operational environment. Others are proven technologies that need further work to assess whether they will meet operational needs, such as eDNA's use in water quality monitoring to meet requirements under the National Policy Statement for Freshwater Management National Objectives Framework. While others, such as many remote sensing products, are proven and reliable technologies that aren't widely deployed due to non-technical reasons (e.g. capability, capacity or funding). Many infrastructure-related technologies also fall into this camp.

This final point is critical. A large part of the answer as to why there isn't greater use of technology is that the abilities and potential of disparate technologies are nothing without a system that enables and supports their use.

Where a technology is mature and well supported, such as LiDAR, significant advances are being made. But this takes time and vision to achieve. National LiDAR coverage didn't happen overnight; it was a slow and incremental process over decades. It also doesn't end. New Zealand is a dynamic country, ever-changing due to natural processes and human interventions, requiring constant data capture.

One contributing factor is that technological applications, data and products developed by research organisations are often tied to projects or contestable funding. Research organisations can develop them, but are often not incentivised to maintain them as there is no ongoing funding. Equally, research organisations are also not service organisations. The culture is primarily focused on scientific projects, science outputs, and innovation rather than long-term products and service delivery, user support and, in the case of services, operational reliability. Operating data product pipelines and national data services requires different governance, skills and operational capabilities from those primarily needed for scientific research. The same point can equally be made for policy-orientated ministries.

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5 Durie, 2025. See, for example, the Kaitiaki Intelligence Platform and the potential to deploy environmental sensing technology to enable Māori agribusiness collectives to enhance farm operations and protect and enhance the environment (Reid et al., 2025b).

6 A digital twin is a virtual replica of a physical object, system or process, using data to replicate the behaviours and characteristics of its real-world counterpart.

7 State Government of Victoria, 2026. A similar spatial digital twin is being developed for New South Wales (New South Wales Government, 2025).

Councils and other agencies also don't always have technological capabilities or resources to support the implementation or ongoing maintenance of data and products that they commission. Examples include many outputs from Endeavour programmes over the years, and the wealth of information generated by the National Science Challenges. These have come to an end – and so have the means to carry them forward.

The issue is not that we lack technical innovation in New Zealand. It is that potential long-term benefits and cost savings are often trumped by the upfront costs of developing or implementing innovative technologies and by the lack of expertise and experience to operationalise innovations at scale.

Current reforms propose cutting environmental research (amongst other things) to bolster 'technology for prosperity'.[8] It will be important to ensure that technologies that change how we gather and interrogate environmental information are seen as contributors to 'prosperity'. Otherwise, we risk simply running down natural capital at the expense of future prosperity. There is a rising global awareness of just how fragile some of our key dependencies on the natural environment are. The sensors and data management technologies needed to manage our environment much more effectively will create huge opportunities for the technology companies that can turn them into services. New Zealand has a choice: make a virtue of necessity in leveraging a better understanding of our environment for both commercial and environmental benefit, or import the technologies and allow home-grown expertise to wither. The choice facing our public science system is as stark as that.

To aid the uptake of technologies and ensure we get the most out of current and future innovations, changes are needed to the way the environmental information system is organised and funded. A pipeline is needed to maintain a line of sight between technological development and operationalisation to address New Zealand's needs.[9] Importantly, when deployed, these technologies need to contribute to a data system that is well organised to ensure that information and data products are readily available, accessible and (easily) usable by those needing to use the information and data. Availability and access are not enough.

This highlights that pursuing technological innovation alone will only get us so far. Work on reorganising New Zealand's environmental information system (discussed in chapter 3) needs to be carried out in tandem with a dedicated research strategy linked to the adoption of technological innovations. We need joined-up thinking if true data-driven innovation is to occur.[10]

Optimistically, if we get this right, improved efficiency and better-informed decisions will be possible in the future. The gap between where we are and where we should aim to be is discussed in the next chapter, using three regional examples that highlight the data and information we currently have and how that could be enhanced in the near future through greater use of technologies and better-integrated systems.

8 Prime Minister's Science, Innovation and Technology Advisory Council, 2026, p.19. There are four proposed pillars: Primary Industries and Bioeconomy; Technology for Prosperity; Environmental Sustainability and Resilience; and Healthy People and a Thriving Society. The Technology for Prosperity pillar includes advanced technologies like AI, quantum and advanced materials.

9 This mirrors the wider issue that there is no line of sight between the allocation of research funding and the Government's environmental priorities highlighted in PCE (2020).

10 Stats NZ, 2023a, pp.22–23.

Banks Peninsula fork fern, *Tmesipteris horomaka*

8 Where we are and where we could be

This chapter provides a snapshot of three locations facing a multitude of different, interconnected challenges. These locations are:

- the Tūtaekurī, Ahuriri, Ngaruroro and Karamū (TANK) catchments in Hawke's Bay
- the Tauranga Moana catchment in the Bay of Plenty
- the Selwyn Waihora catchment in Canterbury.

These examples highlight where we currently stand in terms of environmental information, including specific datasets available to support decision making on key challenges, and what additional environmental information is desired and could be available in the future to improve decisions.

While following a similar format, the three examples focus on different ways to improve the existing evidence base that informs decisions. The TANK catchments illustrate the need to improve the quality of existing data by increasing the frequency, duration, coverage and resolution of data collection. The Tauranga Moana example focuses on data integration, as our ability to make informed decisions relies not only on the quantity and quality of available information but also on our ability to combine and connect it across different sources. Finally, the Selwyn Waihora example illustrates how improvements to currently available data and modelling could facilitate better evaluation of the effectiveness of policies, rules and on-the-ground interventions.

The focus of this chapter is on the environmental information held by central and local government, which is used to inform policy and operational decision making.[1] The identified datasets held by the Crown and regional, district and city councils do not constitute a comprehensive stocktake of all information available for the selected locations. Numerous other organisations, such as iwi/hapū/Māori, community/catchment groups, universities, Public Research Organisations (PROs), industry bodies, farmers, infrastructure companies and non-governmental organisations, among many others, also collect and hold relevant environmental information.

An important caveat is that, given the slightly different environmental pressures faced by each region and the aggregation of datasets by councils, direct comparisons between the three locations are not appropriate. However, the Sankey diagrams presented in this chapter have been chosen to illustrate common issues across the motu. In these instances, datasets from all three locations have been combined to present a common picture.

1 The amount of environmental information held by councils is constrained by their available resources (Doole, 2024).

The examples below provide a tangible illustration of common data quality issues and how technological improvements could help address them. The point of the examples is not to predict the future or to be exhaustive, but to sketch out how investing now could significantly improve the information available to decision makers. It would be naive to think that the presence of better information will automatically equate to better decision making. But having more complete, high-quality information will at least allow for an examination of those decisions and a better grasp of the direction of travel, be it positive or negative.

Tūtaekurī, Ahuriri, Ngaruroro and Karamū catchments

Catchment context and key environmental challenges

The Tūtaekurī, Ahuriri, Ngaruroro and Karamū river catchments (abbreviated to TANK) range from the hill country of the Ruahine and Kaweka ranges to productive alluvial plains that are home to around 85% of Hawke's Bay's population (Figure 8.1). The catchments lie within the boundaries of the Hawke's Bay Regional Council – Te Kaunihera ā-Rohe o te Matua-a-Māui and include Napier City Council – Te Kaunihera o Ahuriri, large parts of Hastings District Council – Te Kaunihera ā-Rohe o Heretaunga, and parts of Rangitikei District Council and Central Hawke's Bay District Council - Te Kaunihera ā-rohe o Tamatea.[2] These catchments face several environmental challenges, including problems with water quality and quantity, the impacts of land use intensification, urban growth, biodiversity loss and natural hazards – including flooding and landslides. Our changing climate is likely to amplify many of these pressures and introduce additional environmental challenges and hazards.

The highly productive alluvial plains of the lower catchments enable intensive agriculture, including cropping, horticulture and viticulture. As a result, water demand in the catchments is high, with Tūtaekurī surface water resources being 50–75% allocated,[3] and Ngaruroro and Karamū resources fully (or over) allocated.[4] This means that (at least on paper) the total rate of permitted water take exceeds the allocation limit of specific zones. On the other hand, high rainfall events increase the risk of flooding and landslides, necessitating significant flood-control and drainage schemes to maintain land productivity and manage flood events.

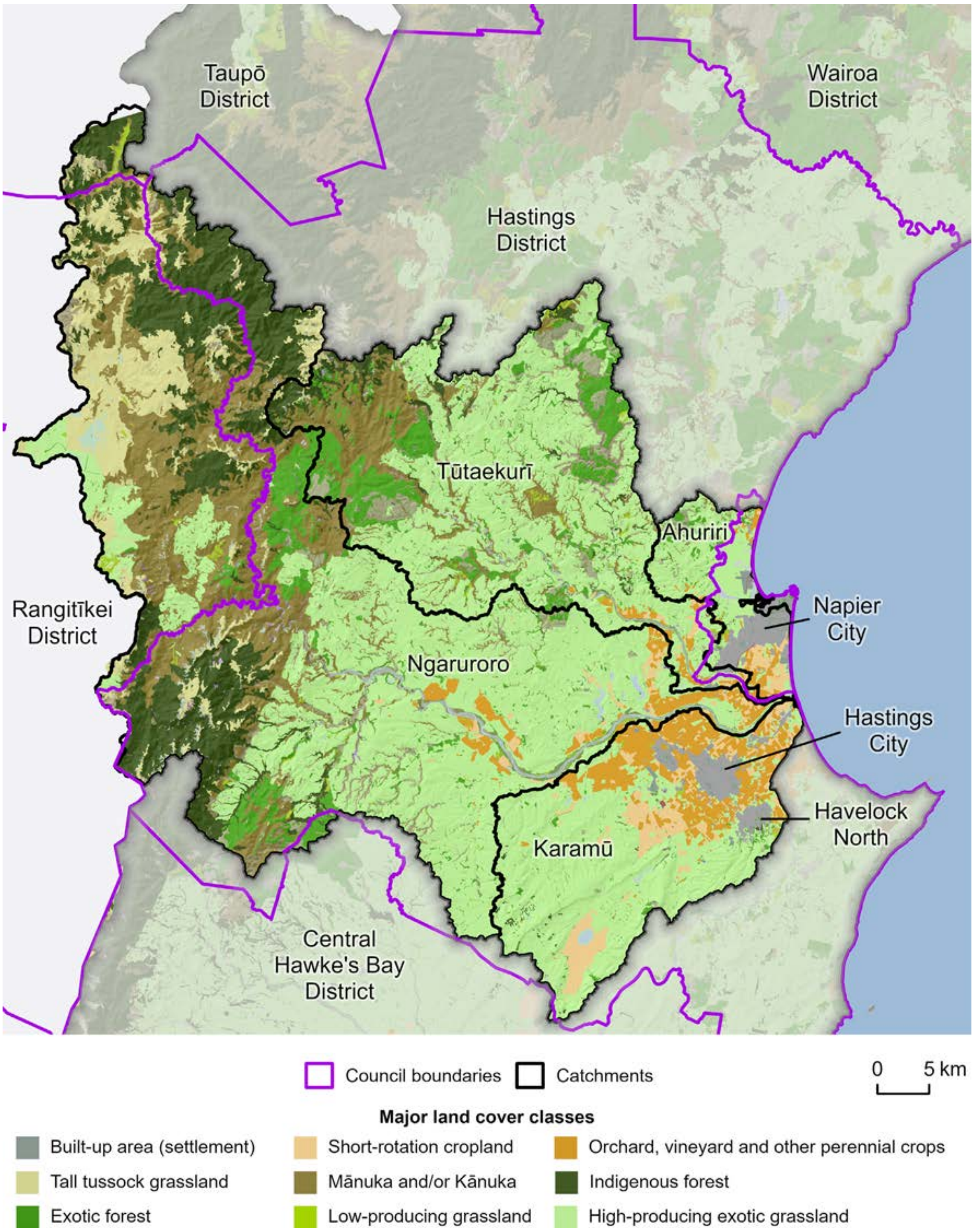
Both rural and urban pressures on water resources directly affect their quality, with nutrient accumulation, increased algal growth, and diminished clarity as rivers descend towards the coast. The connection between surface and groundwater resources places the security of existing groundwater supplies at risk.

The Ahuriri Estuary and surrounding wetlands provide ecological richness, even though much of the lowland environment has been transformed by human activity.

2 Note that environmental information held by Rangitikei District Council and Central Hawke's Bay District Council has been excluded from the snapshot presented, given that these two district councils cover relatively small areas of the TANK catchments in comparison with the other two territorial authorities.

3 Depending on whether the Regional Resource Management Plan (HBRC, 2006) or TANK plan (HBRC, 2025) allocation methods are used. HBRC, pers. comm., 8 June 2026.

4 HBRC, no date, p.5.



Sources: Adapted from HBRC (2026c) and MWLR (2025b)

Figure 8.1: Map showing the boundaries and land cover in the Tūtaekurī, Ahuriri, Ngaruroro and Karamū catchments. The white area on the left-hand side represents land outside the Hawke's Bay Regional Council's boundaries.

Quality of the currently available information and necessary improvements

On the surface, the TANK catchments appear to be information-rich, with over 120 Crown- and council-held environmental datasets identified by relevant councils on matters that can be used to inform decision making across the six environmental challenges, including water quality, water quantity, land use intensification, urban growth, biodiversity loss and natural hazards.[5]

Most datasets are held by the Hawke's Bay Regional Council (55%), with the Crown and the territorial authorities (Napier City Council and Hastings District Council) contributing the remaining 23% and 21% respectively (Figure 8.2). The regional council holds more data to support decisions across the environmental challenges than the city and district councils, reflecting the respective councils' responsibilities.

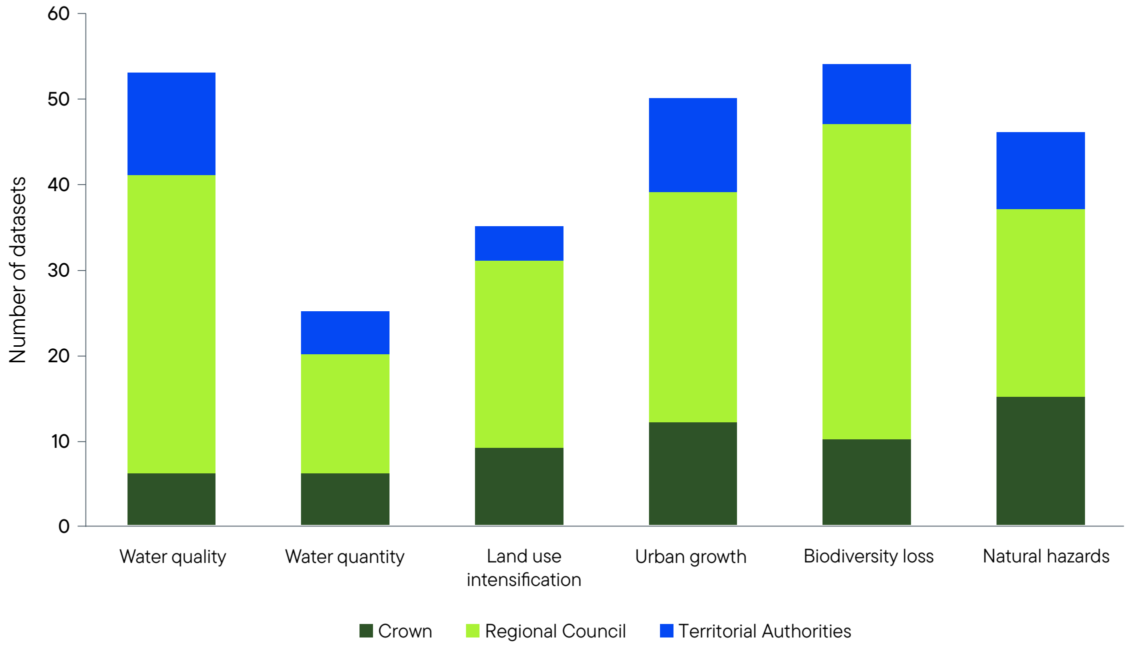


Figure 8.2: Number of datasets held by the Crown, Hawke's Bay Regional Council, and Napier City Council and Hastings District Council (combined as territorial authorities), informing the six environmental challenges in the TANK catchments.[6]

While there are many data, their usefulness often depends on the purpose for which they were collected. A single datapoint or sampling event may be sufficient for some purposes, while ongoing monitoring may be more appropriate for others. The design of monitoring programmes often determines how environmental information can be used, or whether it can inform other environmental challenges. Figure 8.3 shows how datasets that inform water quality within the TANK, Selwyn and Tauranga Moana catchments also inform other challenges those regions face, particularly urban growth and land use intensification.

5 Note that while this number of environmental datasets provides a strong indication of the range of data sources held, maintained and used by councils in the TANK catchments, it is not exhaustive. The datasets identified do not represent all information available for the location, and some datasets have been aggregated.

6 Based on information provided by the councils (HBRC, pers. comm., 19 May 2026). The councils also identified datasets held by other organisations (including private organisations) such as AgriBase, NZ SeaRise, Costal Change dataset, QEII open space covenant data, satellite imagery, and power and cell providers outage information.

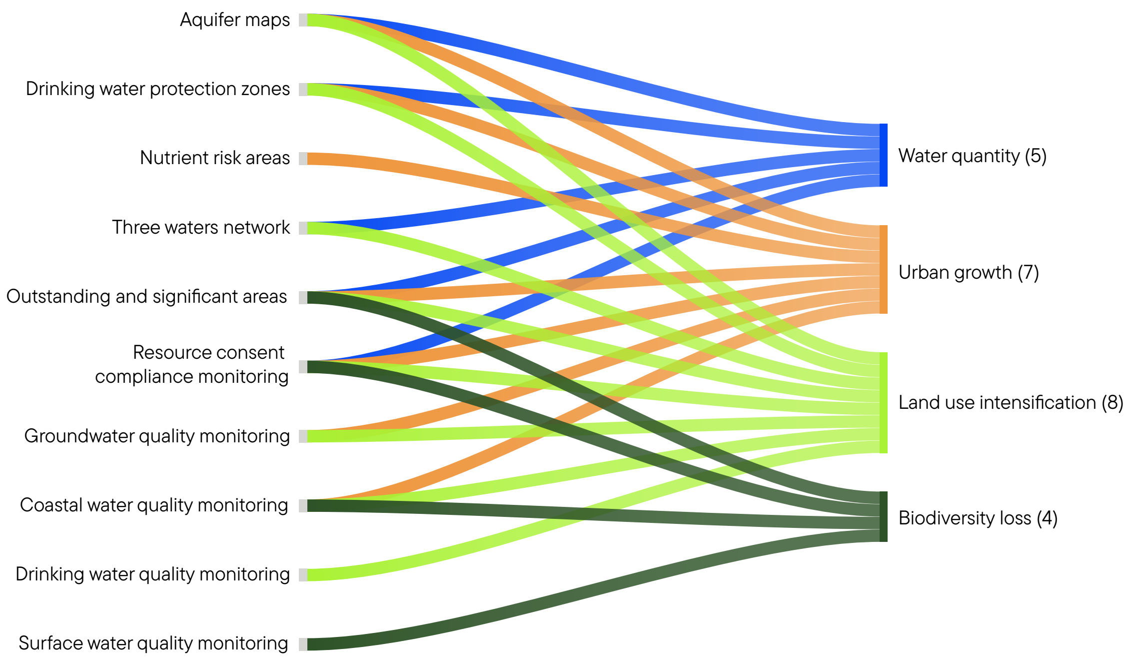


Figure 8.3: Datasets that inform the water quality challenge also inform other environmental challenges. The datasets shown are common across all three profiled catchments.[7]

The ability to use data to gather a wide range of insights depends on several factors, including the frequency, duration, coverage and resolution of monitoring programmes.[8] Various examples are provided below to highlight how these factors influence our understanding and management of environmental challenges in different contexts.

Frequency of monitoring programmes

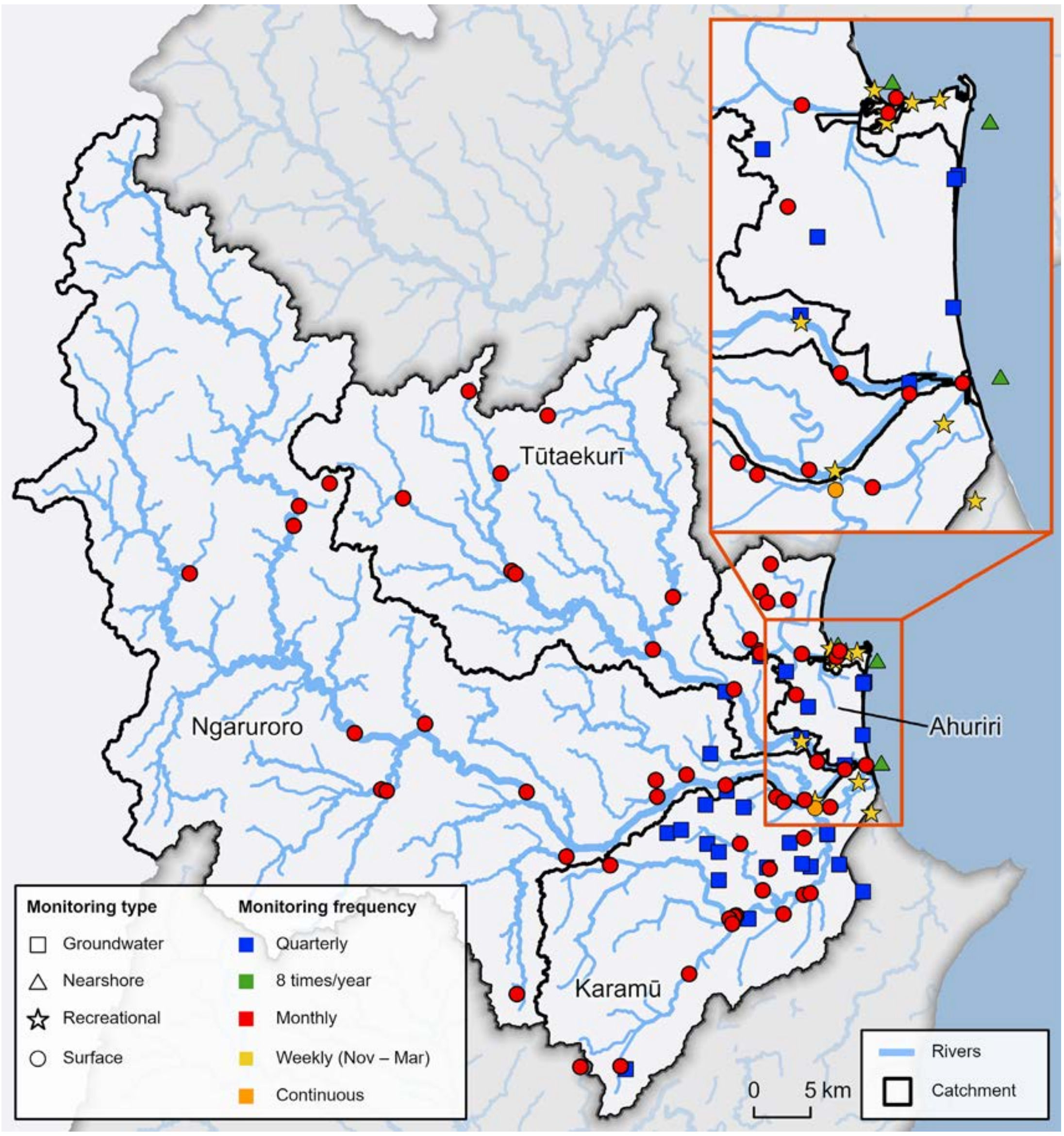
Water quality is a major concern in the TANK catchments and the wider Hawke's Bay region. While there are several water quality monitoring programmes covering freshwater (surface and groundwater) and coastal waters, monitoring is generally not more than once a month (Figure 8.4). Low monitoring frequency might be sufficient to observe long-term states and trends, but detecting shorter-term changes requires greater frequency to ensure adequate statistical power.[9]

For example, a monthly sampling frequency is unlikely to be sufficient to detect transient changes in contaminant concentrations in water during high flow events. This is because contaminants are typically transported by water, either in water or bound to soil particles. High precipitation events increase water flows and mobilise soils, leading to a pulse of these contaminants entering receiving environments. Detection of these pulses and their effects on the environment are therefore limited by the monitoring frequency.

7 Sankey diagram created using information provided by the councils.

8 Site accessibility and stability, the ability to maintain equipment at a site, and the validation and calibration of equipment (which can be labour intensive) are also important factors that influence data quality.

9 McDowell et al., 2024; Patil et al., 2024.



Sources: Adapted from HBRC (pers. comm., 8 June 2026)

Figure 8.4: Location and frequency of water quality monitoring sites in the TANK catchments.

The good news is that improving monitoring frequency is possible with existing technologies. The Hawke's Bay Regional Council already uses high-frequency monitoring in its hydrographic and climate networks to provide near-real-time data on parameters such as rainfall, water levels and flow, temperature, dissolved oxygen concentration, turbidity, and climate patterns, among other things.[10] These networks are crucial to support time-critical decision making, such as flood response and water allocation management. Upgrades are currently underway to improve the coverage, timeliness and resilience of sites within the network.[11]

However, only one of the 60 surface water quality monitoring sites has telemetry capabilities.[12] Understanding water quality could be greatly enhanced by more timely data. Earlier detection of anomalies can enable faster interventions in areas such as compliance monitoring, thereby

10 HBRC, 2026e.

11 As of June 2026, 26 of the 42 identified sites across the Hawke's Bay region have been upgraded (HBRC, 2026d, 2026f).

12 HBRC, pers. comm., 8 June 2026. Telemetry involves the transmission of data over communications networks to a central repository. It is more frequently used for hydrographic and climate parameters than for water quality.

preventing avoidable environmental harm. Some regions – although outside the TANK catchments – have also extended the use of telemetry to stormwater and wastewater networks to inform assessments of human health and natural hazard risks.[13]

The eDNA monitoring programme in the TANK catchments would also benefit from increased sampling frequency. eDNA provides valuable insights at individual locations, but the potential to use the information for decision making is amplified by adopting a broader systematic approach to its use. Since 2022, the Hawke's Bay Regional Council has conducted annual eDNA sampling at approximately 62 water quality monitoring sites within the catchment, as well as ad hoc eDNA testing for biosecurity surveillance.[14] This led to the discovery of an alligator weed (Alternanthera philoxeroides) incursion, which triggered an eradication response. By way of contrast, in 2024, the presence of an exclusion pest, Senegal tea (Gymnocoronis spilanthoides), in the Clive River was identified after reprocessing historical eDNA samples against an updated reference library. Senegal tea is usually rooted along waterways; it spreads quickly and forms infestations in deep water, blocking drains and causing flooding. Unfortunately, the data were two years old when discovered, and a Senegal tea population had already become established.[15]

New Zealand is no stranger to invasive species. Timely identification can minimise their impacts and enable quicker, less costly responses.[16] However, monitoring and surveillance still remain patchy and often rely on luck.[17] This reinforces the need for systemic and routine monitoring programmes, as well as investment in genomic sequencing to ensure reference databases are up to date.

Duration of monitoring programmes

The duration of monitoring programmes is a key factor influencing data quality, as the ability to detect changes in land use practices is obviously limited by the period over which monitoring has occurred. Developing a network of long-term, high-quality reference sites (including in minimally impacted catchments) provides a baseline against which environmental change can be measured. Additionally, maintaining a network of legacy sites is important for calibration and helps ensure that updated methodologies and technologies preserve dataset continuity rather than leading to its fragmentation.

Both the frequency and duration of monitoring programmes help track changes in environmental conditions over time. Some surveys of the TANK catchments, such as aerial imagery, have run since the 1930s, while many water quality and quantity metrics have been measured since the late 1960s. Pressures on other environmental domains, such as air quality, have only been measured since the turn of the century. The digitisation of legacy records has helped backfill datasets, retrospectively increasing their duration and improving insights into past behaviours.

Spatial coverage of datasets

The challenge of land use intensification naturally lends itself to geospatial data. Some datasets cover the entire catchment, others do not. This can be because datasets are only concerned with affected areas, such as flood extent models in low-lying areas, or because they represent individual locations, such as water quality monitoring sites (Figure 8.4). Increasing the number of monitoring sites is also necessary to improve the representation of highly variable catchments, such as those across the lower TANK catchments (and the wider Heretaunga Plains, which they form part of) and their hill country tributaries. Improving spatial coverage would help identify localised issues (i.e. areas responsible for disproportionate environmental impacts) that are currently masked by sparse networks.

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13 For example, in Auckland (Our Auckland, 2024; Watercare, 2025).

14 The future of the annual monitoring is uncertain due to financial and resource constraints. HBRC, pers. comm., 5 June 2026.

15 Collins Consulting Ltd, 2025.

16 Epanchin-Niell et al., 2013; Holden et al., 2016; Hester and Cacho, 2017; Koch et al., 2020.

17 PCE, 2021.

While the existing spatial coverage of the datasets reflects (at least in part) their purpose, full spatial coverage is often desirable, though practical constraints (such as a lack of resourcing) often lead to gaps. Integrating existing datasets and using data beyond their original purpose can help improve spatial coverage without additional monitoring or associated costs. Consent compliance data, state of the environment monitoring, and community and industry datasets can all help fill spatial and temporal gaps across the Hawke's Bay monitoring network if thoughtfully integrated.

Resolution of data

A related issue is the resolution of spatial datasets. Generally, datasets with coarse resolution are inappropriate for use at the property scale, especially in a regulatory context. A case in point is the use of coarse and outdated underlying data (i.e. the national Land Use Capability dataset in the New Zealand Land Resource Inventory (NZLRI)) to identify land that qualifies as highly productive. Realising the challenges associated with identifying highly productive land, Hawke's Bay Regional Council explored an alternative method, using the digital soil map S-map as the basis for identifying it. This approach resulted in vastly different outcomes, with only 41% overlap between the two different methodologies.[18]

Additionally, new insights and products can be derived from higher resolution data. For example, Manaaki Whenua – Landcare Research has suggested that reliable vegetation classification would be possible if aerial imagery had a spatial resolution (specifically ground sample distance) of 0.1 metres or better.[19]

More broadly, land use maps are a critical input into decisions on land use intensification. There is a clear desire for frequently updated, comprehensive, detailed land use maps, combined with land-management details, to better understand and manage land use intensification. Repeat light detection and ranging (LiDAR) and more frequent satellite imagery could also help improve understanding of land use intensification.

A similar narrative emerges in terms of data availability and quality when looking at natural hazards and their impacts on urban growth. Complete spatial coverage and high-resolution datasets on natural hazards are critical for informing accurate assessments of likely impacts on urban areas, including individual properties.

Improving the frequency, coverage and resolution of data enhances the quality of derived outputs, such as natural hazard models. However, some datasets are incomplete, and data are primarily mapped at the regional scale. This makes it challenging for use at the property scale. As a result, many existing datasets are only suitable for regional screening purposes. There is a risk of prolonged debates and disputes if datasets are interpreted with false precision (e.g. definitive constraint boundaries at the property scale). As mentioned above, data that are spatially coarse have limited operational usefulness when it comes to fine-scale spatial planning, operational decision making and site-specific risk assessments.

For example, the delineation between flood zones has a reported accuracy of approximately 5 m in steep areas, and up to 50 m in flat areas.[20] This limits the applicability of modelled outputs for site-specific or property-level decision making. Similarly, the national flood hazard overview from Earth Sciences New Zealand is intended for general purposes and can be used as a high-level national screening tool for flood exposure, supporting early-stage risk assessment. However, as with many other hazard maps, it uses crude 'in/out' classifications that do not adequately represent hazard intensity, likelihood or consequences. It also fails to account for coastal and engineered defence measures, potentially overestimating inundation risks. To provide operational insights, these high-level national screening tools, many of which are held by the Crown,[21] need to be complemented by detailed local flood and hazard modelling.

18 For more details, see PCE (2025d, pp.24–26).

19 HBRC, pers. comm., 19 May 2026. See, for example, Figure 6.2.

20 Hawke's Bay Independent Flood Review, 2024; HBRC, 2026b.

21 For example, NIWA Extreme Coastal Flood Map, National Coastal Change Dataset, NZ SeaRise data.

Repeat LiDAR data can be processed into products that inform land use decisions at the sub-metre scale. LiDAR differencing helps reveal how landmasses and sediments move, which affects river flow and flood dynamics. More up-to-date information can also fundamentally alter our understanding of the risks posed by natural hazards. For example, a post-Cyclone Gabrielle analysis has shown that a Cyclone Gabrielle-scale event at some sites in the Hawke's Bay region is now assessed as low as a 1-in-80-year event, rather than more than a 1-in-1,000-year event, as previously thought.[22]

The use of LiDAR to map erosion and deposition from these extreme events underscores how integral repeat LiDAR capture is for emergency response and recovery, informing flood models and helping protect communities from subsequent events. The use of radar from the Sentinel-1 satellite also demonstrates how complementary technologies help build a richer picture of the challenges the TANK catchments and the wider region face.[23] The same data and modelling can also be used to inform decisions on urban growth – i.e. by identifying the areas that have experienced significant flooding, landslides or other issues in the past.[24]

In summary, the TANK catchments illustrate the need to improve the quality of existing data by increasing the frequency, duration, coverage and resolution of monitoring programmes. Expanding existing programmes to cover spatial gaps (e.g. the Nūhaka and Wairoa wetlands) in combination with new technologies could greatly improve the understanding and management of sensitive environments. For example, wider adoption of automated sensors and telemetry networks can increase hydrological and species data – both important factors of wetland function – while also potentially reducing the costs associated with manual monitoring approaches.

Moving from individual to continuous sampling methods can help capture the full variability of events (e.g. storm-driven sediment and nutrient pulses), which are often missed by low-frequency or triggered sampling approaches. This provides a more accurate estimate of total loads (e.g. sediment and nutrients) that drive ecological outcomes and are critical to understanding the impacts of land use. Finally, improvements across all these factors are required to provide high-quality baseline data, crucial for monitoring environmental change and attributing the impacts of land use activities, which is a fundamental requirement under a more permissive resource management regime.

Tauranga Moana catchment

Catchment context and key environmental challenges

The Tauranga Moana catchment (Tauranga Moana in short) in the Bay of Plenty includes Te Awanui/Tauranga Harbour and the adjacent coastal marine area (Figure 8.5). The catchment predominantly lies within the boundaries of the Bay of Plenty Regional Council – Toi Moana and includes large areas of the Tauranga City Council and Western Bay of Plenty District Council – Te Kaunihera o rohe mai i Ngā Kuri-a-Whārei ki Otamarakau ki te Uru.

The catchment faces several interconnected environmental challenges, including the impacts of rapid urban growth, natural hazards, biosecurity threats and biodiversity loss.

Tauranga Moana covers 130,000 hectares and comprises a diverse range of land uses, from the predominantly native forest of the Kaimai Ranges to intensive horticulture in the lowlands. These landscapes drain into Te Awanui/Tauranga Harbour, which faces excessive sedimentation and nutrient enrichment, threatening the biodiversity of one of New Zealand's largest estuaries and an Outstanding Natural Landscape.[25] The harbour also includes New Zealand's largest commercial port, bringing with it the risk of marine pest incursion through pests hitching a ride as 'biofouling' on boat hulls, or in ballast water.[26]

22 Lane, 2024.

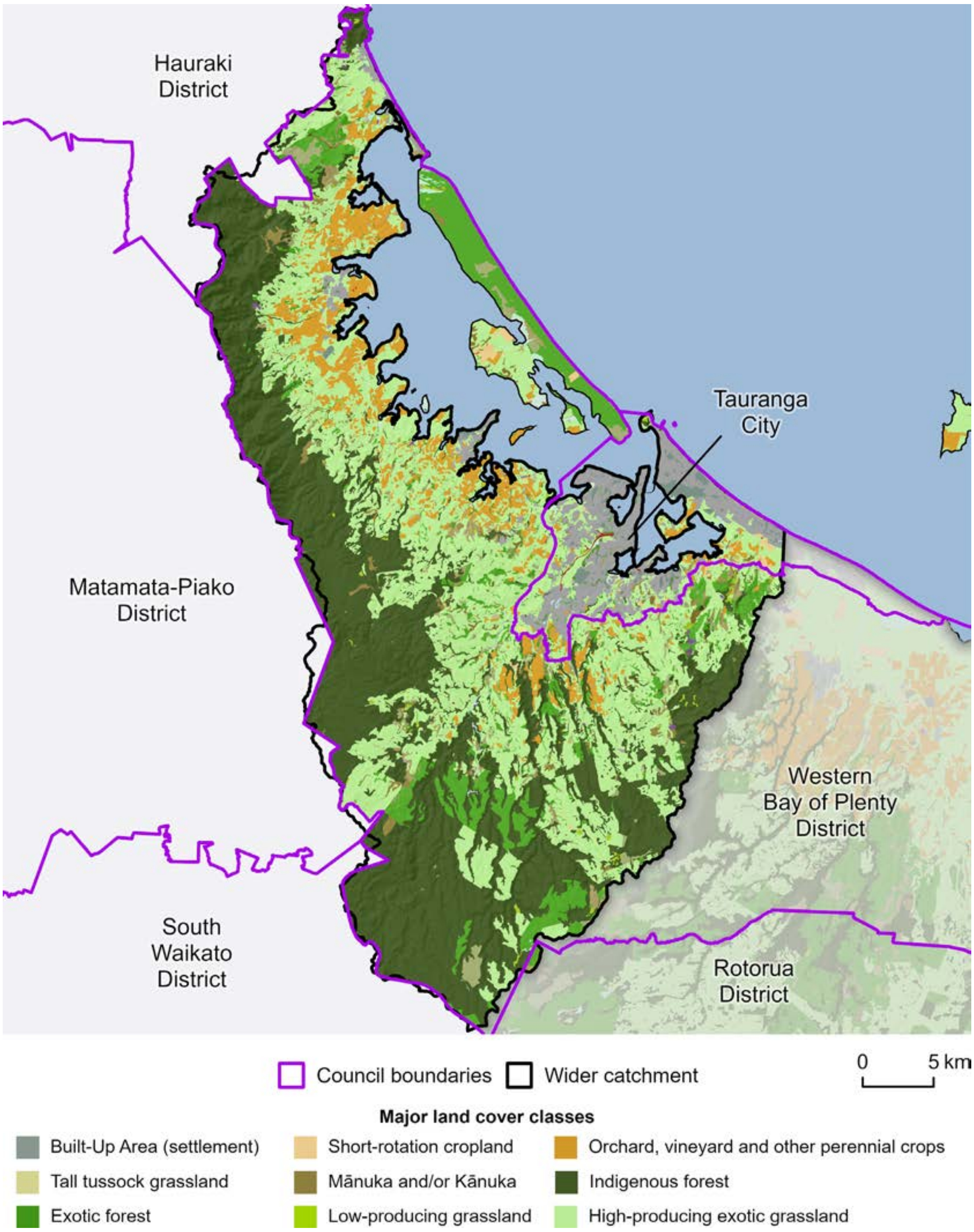
23 HBRC, 2026a; LINZ Data Service, 2026a.

24 For example, satellite-based radar, visual observations and other mapping are being used to identify the extent of flooding in the Hawke's Bay to help inform future decisions (HBRC, 2026a; LINZ Data Service, 2026a).

25 BOPRC, 2023b.

26 For example, BOPRC (2023a, 2026e).

The region is experiencing significant population growth, with a 75% increase in population since 2000.[27] Approximately one-third of the future population growth is expected to be accommodated by infilling existing urban areas, with the remaining two-thirds in greenfield developments.[28] The catchment and the wider Bay of Plenty region is also heavily exposed to natural hazards, shaped by an active tectonic and volcanic setting, a dynamic coastline, sensitive groundwater systems and a changing climate.



Sources: Adapted from BOPRC (2026c) and MWLR (2025b)

Figure 8.5: Map showing the boundaries and land cover for the Tauranga Moana catchment. The white area represents land outside the Bay of Plenty Regional Council's boundaries.

27 Priority One Tauranga Moana, no date.

28 SmartGrowth, 2024, p.152.

Integration of currently available data and necessary improvements

A strong foundation of spatial and non-spatial information exists across the Tauranga Moana catchment to support evidence-based decision making, with over 100 Crown- and council-held environmental datasets providing information across four of the environmental challenges identified by the relevant councils in Tauranga Moana.[29] Sixty-six of these inform two of the most important challenges in the catchment – natural hazards management and urban growth (Figure 8.6).[30]

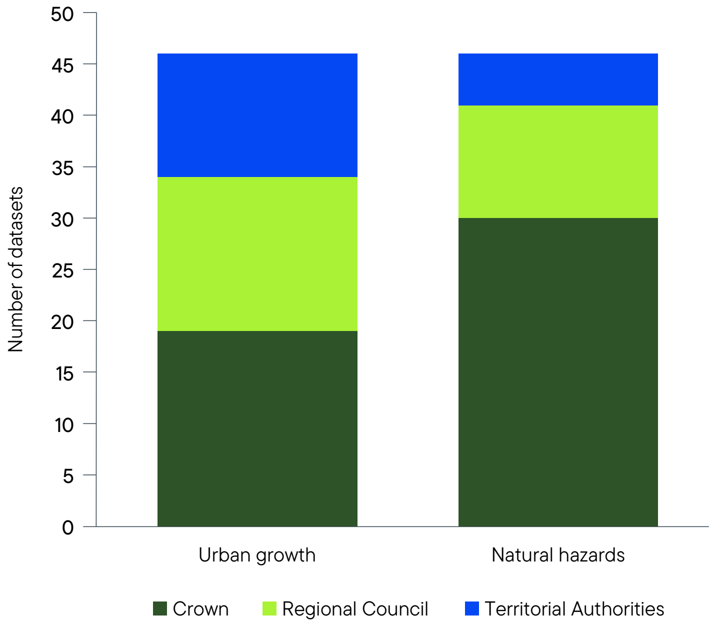


Figure 8.6: Number of datasets held by the Crown, Bay of Plenty Regional Council, and Tauranga City Council and Western Bay of Plenty District Council (combined as territorial authorities), which inform urban growth and natural hazard challenges within the Tauranga Moana catchment.[31]

While the quality of the existing datasets suffers from the same issues as those in the TANK catchment datasets, another consistent theme in Tauranga Moana is the insufficient integration of existing datasets (e.g. within and between the regional council and territorial authorities).[32] This is evident in information on several environmental challenges, including natural hazards and urban growth.

In the context of urban growth, Tauranga Moana has well-developed spatial plans and strategies that use integrated data (Figure 8.7).[33] However, many other datasets held by the councils would also greatly benefit from improved integration. Regional councils commonly encounter integration issues when working with territorial authority datasets. This can frustrate efforts to develop models and digital tools that require a unified view across different areas. Information regarding natural hazards, which present both immediate risks (acute events such as flooding, landslides or tsunamis) and slow-onset pressures (such as sea-level rise, groundwater rise, coastal erosion and increased rainfall intensity), is often held by individual councils.[34]

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29 This only includes data for urban growth, natural hazards, biosecurity threats and biodiversity loss, and combines data provided by the councils with data provided for Doole (2024) as well.

30 Note that other organisations and individuals also have relevant information.

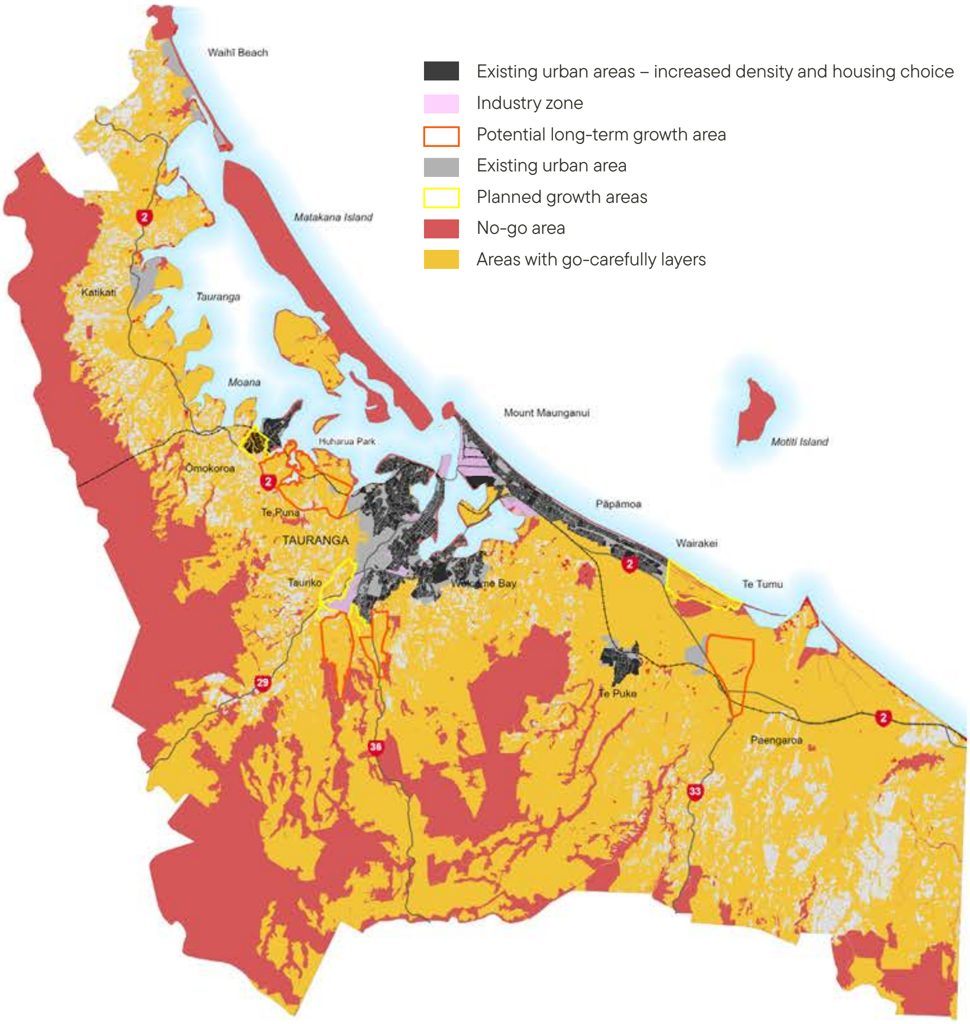
31 Based on internal categorisation by PCE of information provided by the councils (BOPRC, pers. comm., 7 May and 8 June 2026) and Doole (2024). Some datasets have been aggregated.

32 BOPRC, 2026a. At the time of writing, this report was an unpublished draft and subject to change following review by partner councils.

33 SmartGrowth, 2024.

34 Tools such as the BayHazards Viewer (BOPRC, 2026b) provide a consolidated, region-wide hazard overview and are regularly updated.

An example is the Tauranga City landslide, flooding, liquefaction, and harbour inundation dataset. This dataset is used to provide localised hazard information for urban planning in Tauranga, support risk-based development decisions, and ensure hazard considerations are integrated into future growth areas. However, due to a range of differences between modelling approaches (e.g. scale, data ownership, accountability, legal risk and planning status), this dataset has not been integrated into a region-wide hazard layer.[35]



Source: Adapted from SmartGrowth (2024)[36]

Figure 8.7: The ability to overlay various data layers provides new insights into the cumulative effects of multiple challenges and pressures at any one location (i.e. spatial planning). In this case, areas unsuitable for development in the Western Bay of Plenty were identified as part of the region's spatial planning work. Red areas on the map represent 'no-go' areas for development (e.g. due to environmental, heritage or cultural reasons, or at risk of coastal erosion). Orange areas suggest a 'go-carefully' approach where additional consideration (e.g. due to flood hazard or being highly productive land) is required if development is contemplated.

Compounding this issue is the fact that different hazard assessments may rely on different underlying information (e.g. groundwater, topographic or climate assumptions). The application of different hazard models across the region can therefore lead to inconsistent risk assessments and planning across jurisdictional borders. This has the potential to introduce conflicts between

35 BOPRC, 2026b. The Tauranga City hazard dataset (Tauranga City Council, 2026) is finer scale, designed to support decisions about specific sites (BOPRC, pers. comm., 8 June 2026).

36 SmartGrowth is a partnership of BOPRC, Tauranga City Council and Western Bay of Plenty District Council.

contiguous spatial layers, which creates uncertainty for those interpreting the information. In the context of planning for urban growth, this raises doubts around development zones and whether what's planned on paper will translate into urban growth and development on the ground.

The Bay of Plenty Regional Council is supporting the Natural Hazards Commission's trial national portal, which aims to consolidate data in a single repository. As expected, the project has faced significant challenges because different methodologies and assumptions underlie each hazard layer, and councils structure their source data differently.[37] Where a common view is required, inconsistent data can add significant cost and delay.

Another integration issue is the inability to assess the cumulative effects of multiple challenges and pressures at any one location (e.g. urban growth, biodiversity areas, natural hazard risks). Where data integration is designed around specific outcomes (e.g. growth planning or hazard risk assessment), it can improve the visibility of cumulative effects, alignment between infrastructure and land use planning, and understanding of interacting risks (e.g. flooding, groundwater rise, coastal processes).

Addressing these issues will require standardising data practices where appropriate (e.g. acquisition, storage, quality control, metadata) and improving the leadership and governance of environmental data management within and across jurisdictions.

A tangential issue arising from the lack of integration and coordination among agencies is the absence of authoritative regional datasets. This is an issue across multiple challenges and arises from several interacting factors. Infrequent (or one-off) datasets quickly lag behind real-time changes, limiting the timeliness and responsiveness of decisions to real-time challenges. When combined with limited oversight and transparency between the organisations that collect and maintain the datasets, there is often uncertainty about whether data provided by others are currently being developed or kept up to date. This raises the risk of contested or outdated information being used when important decisions are being made.

Knowing which organisations collect what information and for what purpose is essential for enabling its use and realising its full value. If users can find data easily and understand their purpose and limitations through good metadata, they are more likely to use and integrate the data effectively. Accurate metadata are also crucial for identifying and reducing gaps and duplication.

Having multiple agencies with overlapping remits and jurisdictions requires careful consideration of how these agencies work together. Councils are mandated to collect the information required to fulfil their statutory obligations, but they are not incentivised to do so in a standardised way or in collaboration with other authorities.[38] These issues are exacerbated when environmental catchments straddle the boundaries of several territorial authorities. Standards are therefore needed to ensure that data are collected consistently, enabling their integration (e.g. through a federated data system) and improving transparency. This will help address inconsistencies between regional growth and risk assessments, provide a single source of truth for key datasets, and aid in assessing cascading and compound risks.

The Tauranga Moana example illustrates that work is needed to standardise, integrate, update and govern datasets so they can be reliably used to inform catchment-wide (and region-wide) operational, strategic and regulatory decision making. Some of this work has already begun, providing a glimpse into the observed and expected benefits of appropriately integrating different datasets.[39] Consistent hazard and constraint information across council boundaries can reduce planning uncertainty, support clearer spatial planning, avoid repeated debate, and reduce duplicated data collection and modelling costs. This reduced ambiguity in hazard interpretation can reduce development risks and improve consenting efficiencies by lowering transaction costs for applicants, territorial authorities and regional councils.

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37 BOPRC, pers. comm., 8 June 2026.

38 For example, risk assessments are required under the Resource Management Act 1991, Building Act 2004, Civil Defence Emergency Management Act 2002, Local Government Act 2002 and Climate Change Response Act 2002. This can result in different teams within the councils using and collecting different information.

39 For example, the SmartGrowth Strategy 2024–2074 (SmartGrowth, 2024) and Tauranga City Council's internal work to standardise risk assessments.

There is a strong case for the integration of consistent, high-quality datasets (e.g. natural hazards, growth, infrastructure) that cover areas experiencing high development pressure, such as in rapidly urbanising parts of Tauranga Moana. In these areas, core datasets are repeatedly relied on to underpin significant decisions, making consistency and alignment across agencies invaluable.

Various data quality issues currently inhibiting this integration underscore the need for greater standardisation of underlying data practices. As discussed in chapter 3, implementing clear national metadata and data sharing standards would help address many of the technical issues that councils face with interoperability of data. There will always need to be flexibility in the methods of data collection and modelling to suit the local context. However, having a consistent way for communicating the underlying aspects of the data (e.g. ownership and licensing; its purpose, quality and uncertainty) would make it simpler to harmonise datasets to create an integrated picture.[40]

Selwyn Waihora catchment

Catchment context and key environmental challenges

The Selwyn Waihora catchment is sandwiched between the Rakaia and Waimakariri river systems. It extends from the foothills of the Southern Alps to the receiving Te Waihora/Lake Ellesmere (see Figure 8.8). This shallow, brackish, coastal lake-lagoon is nationally and internationally significant for its cultural, ecological and economic values.[41] The lake is the most important wetland habitat of its type in New Zealand, providing essential habitats for a large range of bird, plant and invertebrate species.

The catchment lies within the boundaries of Environment Canterbury Regional Council – Kaunihera Taiao ki Waitaha (ECan), Selwyn District Council and Christchurch City Council – Te Kaunihera o Ōtautahi.[42] The catchment faces several interconnected environmental challenges, including water quality degradation, water abstraction, land use intensification, rapid urban growth, biodiversity loss and natural hazards.

Primary land uses include dairying, sheep and beef farming, and arable farming, with significant change and intensification occurring over the past few decades.[43] The Selwyn District has the fastest growing population in the country, growing 5.1% a year between 2018 and 2024,[44] and is expected to continue to grow over the next 30 years.[45] This population growth has placed pressure on the land and soil from outward urban expansion onto productive agricultural land. Alongside population growth, land use change and intensification have also occurred, with the catchment seeing a 76% increase in the total number of cows and a 54% increase in the total area of dairy farms between 2004/05 and 2024/25.[46]

40 See, for example, Department of Climate Change, Energy, the Environment and Water (2026, p.17).

41 Te Waihora Co-Governance Group, 2026.

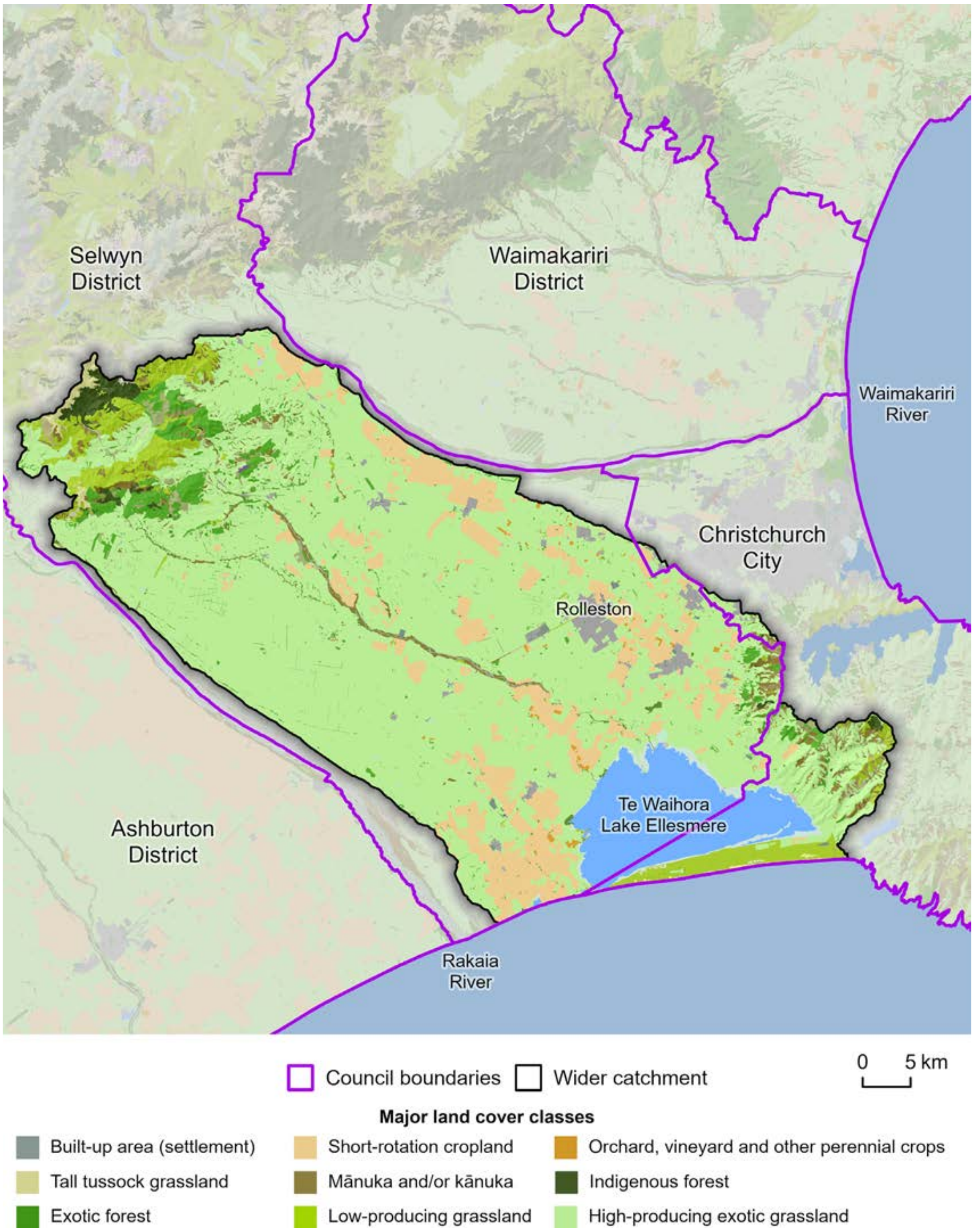
42 The Te Waihora Co-Governance Group (www.tewaihora.org) also plays a large role in the catchment. The group has representatives from Te Rūnanga o Ngāi Tahu, ECan, Selwyn District Council, Christchurch City Council, and the Department of Conservation – Te Papa Atawhai. The parties agree on a shared commitment and responsibility to restore and rejuvenate the mauri and ecosystem health of Te Waihora/Lake Ellesmere and its catchment.

43 Te Waihora Co-Governance Group, 2026.

44 Stats NZ, 2025a, 2025b.

45 Twenty-six percent growth is expected over the next 30 years for the Canterbury region as a whole. However, only 13% growth is expected in Christchurch (38% of total), with 59% growth expected in the surrounding regions (62% of total) (Christchurch City Council, 2026).

46 Livestock Improvement Corporation, 2005; Livestock Improvement Corporation and DairyNZ, 2025.



Sources: Adapted from ECan (2017a) and MWLR (2025b)

Figure 8.8: Map showing the boundaries and land cover for the Selwyn Waihora catchment.

Changing and intensifying land use have led to excessive amounts of sediment, contaminants and nutrients entering water bodies. Environmental bottom lines for both nitrogen and phosphorus are currently being exceeded at multiple locations throughout the catchment, with concerns about water quality extending to drinking water.[47] Over the last 15 years or so, the water quality of Te Waihora/Lake Ellesmere has been characterised as 'very poor'. While still supporting significant ecological values, the lake is supertrophic (Trophic Level Index around 6–7), representing the most advanced state of eutrophication, where excessive nutrient levels

47 The National Policy Statement for Freshwater Management 2020 defines national bottom lines and requires sites that fall below them to be improved, unless there is a specific justification why that would not be achievable (Jacobs, 2025; MacDuff, 2025).

cause large-scale and frequent algal blooms. This eutrophication results from the long-term removal of bush and wetlands, the intensification of agriculture, and the disappearance of naturally occurring macrophytes (floating or submerged plants) from the lake.[48]

The Selwyn Waihora Zone is also overallocated,[49] with the Selwyn River frequently experiencing severe water shortages and large stretches of the river drying up entirely for much of the year. This 'disappearing river' is partially a result of the region's alluvial gravel geology, as well as the high rates of water abstraction for intensive agriculture.[50]

Quality of the currently available data and modelling, and necessary improvements

A significant amount of information is available across the catchment to inform decision making. There are nearly 90 Crown- and council-held environmental datasets that provide information across the six environmental challenges identified by the relevant councils (Figure 8.9). The councils acknowledge that many other groups work within the catchment to collect data to support informed decision making. This includes programmes such as Whakaora Te Waihora and environmental monitoring by Papatipu Rūnanga and their environmental entities. Universities, PROs and other research providers also carry out environmental monitoring in the catchment. As do water management and other entities (e.g. Central Plains Water Ltd), non-governmental organisations, and groups such as Ellesmere Sustainable Agriculture Inc and Eastern Plains Land User Group, among many others.

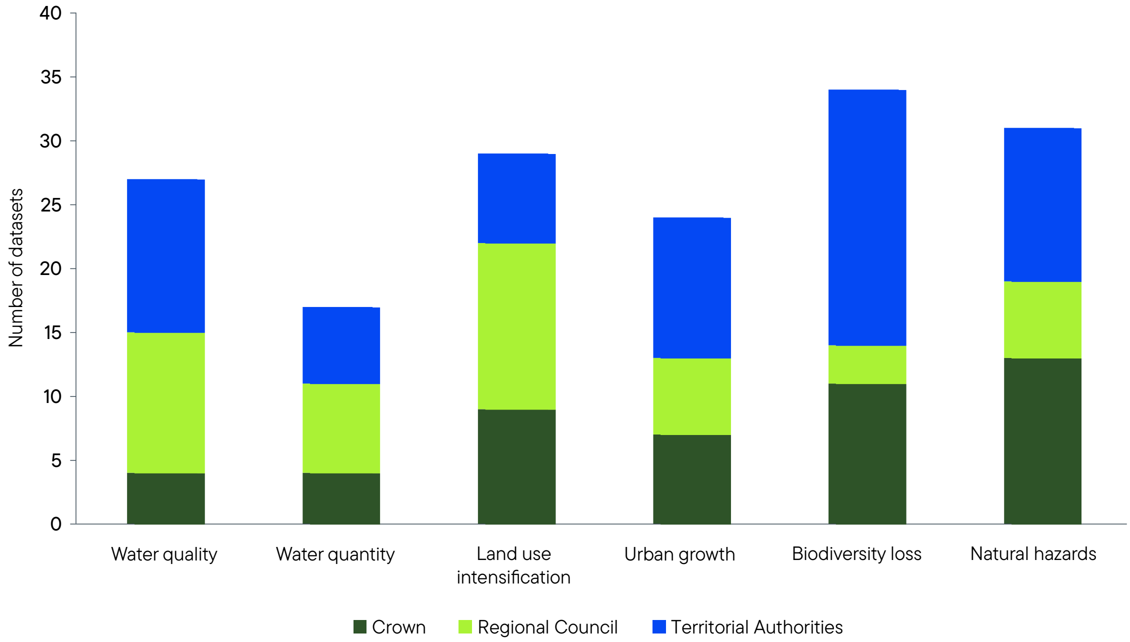


Figure 8.9: Number of datasets held by the Crown, ECan, and Selwyn District Council and Christchurch City Council (combined as territorial authorities), informing the six environmental challenges in the Selwyn catchment.[51]

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48 The loss of macrophytes from the lake happened for a range of reasons, including the impact of the Wahine Storm (Cyclone Giselle) in 1968 (Te Waihora Co-Governance Group, 2026).

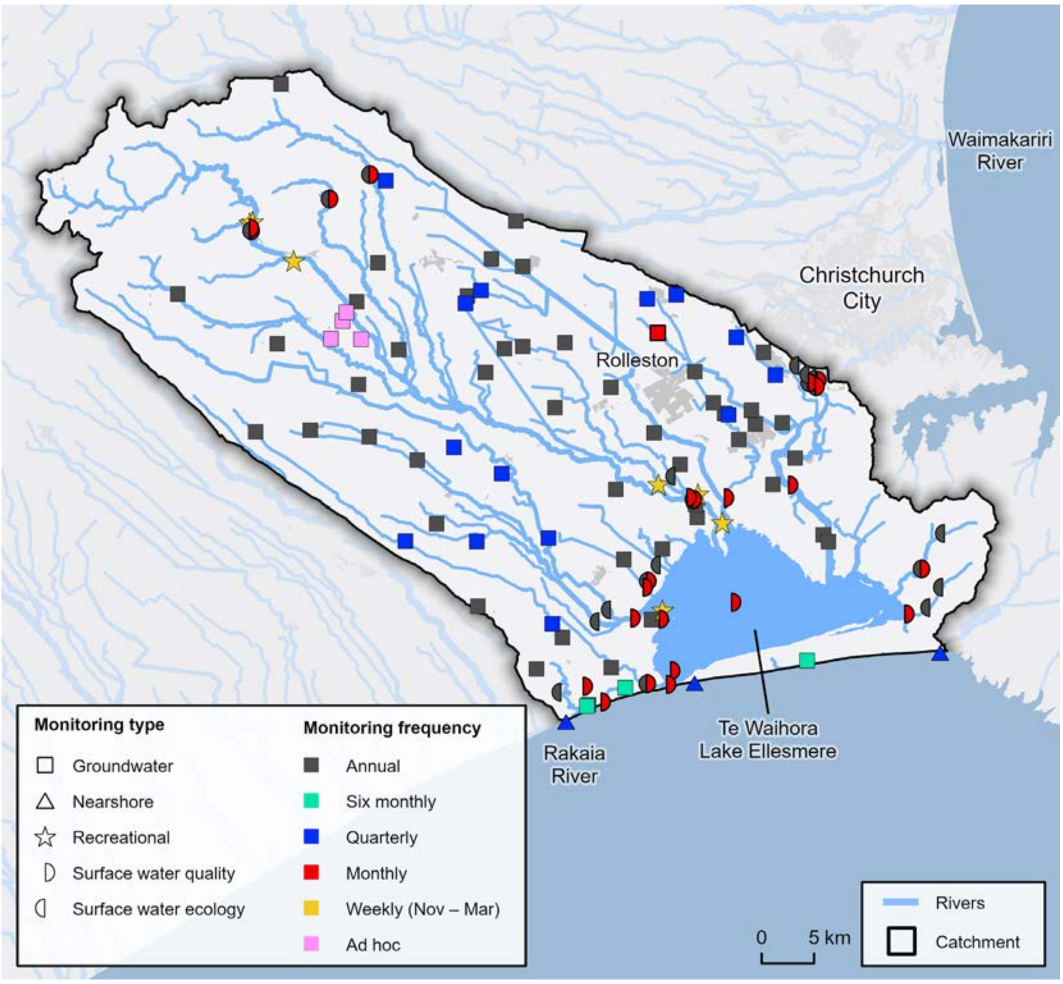
49 Selwyn District Council, 2025, p.42.

50 This geology means in some parts of rivers there is no above-ground flow for extended periods of time. Instead, water continues to flow below ground in the porous gravels that make up the riverbed. Dry climatic conditions play a role in exacerbating dry stretches of riverbed alongside water abstraction.

51 Based on information provided by the councils (ECan, pers. comm., 26 May 2026; Christchurch City Council, pers. comm., 21 May 2026; Selwyn District Council, pers. comm., 22 May 2026). Note that some datasets have been aggregated. The councils also identified datasets held by other organisations (including private organisations) such as AgriBase, NZ SeaRise, Costal Change dataset, and QEII open space covenant data.

Water quality and quantity problems are among the key environmental challenges in the Selwyn Waihora catchment. Given this, it is worth examining the evidence base that has informed past and current policies and plans aimed at addressing these challenges.

As with the TANK catchments, there are issues with data quality, including the frequency and spatial distribution of water quality monitoring across the region. Through the councils' programmes that monitor water quality, 23 surface water quality sites are monitored,[52] with an additional 7 for recreational water quality (in summer months), 3 nearshore coastal sites, and 21 water ecology monitoring sites (Figure 8.10).[53] The sampling frequency of surface water sites is similar to that in the TANK catchments, with most samples collected monthly via manual methods, though weekly sampling is conducted from November to March at recreational sites. ECan also samples groundwater quality at 70 wells in the Selwyn Waihora catchment.[54] Most are monitored through discrete manual sampling, with 48 wells sampled annually, 3 biannually, 14 quarterly and 1 monthly. The remaining 4 are monitored on an ad-hoc basis for an ongoing research project (Figure 8.10).[55]



Adapted from ECan (pers. comm., 8 June 2026) and Christchurch City Council (pers. comm., 4 June 2026)

Figure 8.10: Location and frequency of water quality monitoring sites in the Selwyn catchment.

52 This number includes 17 river/stream and 6 lake water quality monitoring sites. Selwyn District Council monitors surface water quality at an additional 41 waterways quarterly for consent compliance purposes (Selwyn District Council, pers. comm., 18 June 2026).

53 Based on information provided by the councils (ECan, pers. comm., 8 June 2026; Christchurch City Council, pers. comm., 4 June 2026). Water quality and water ecology is sometimes monitored at the same site.

54 ECan, pers. comm., 26 May 2026.

55 ECan, pers. comm., 8 June 2026. Councils may monitor additional groundwater sites for drinking water purposes specifically. Other organisations, such as Central Plains Water Limited, also undertake surface water quality, groundwater quality and groundwater level monitoring within the catchment (Rutter, 2025).

As previously mentioned, an important consideration is the purpose for which monitoring networks were established. This affects their design and operation, including the distribution of monitoring sites and their sampling frequency. In turn, network design and operation affect the usefulness of the collected data for uses beyond their intended purposes.

In the case of state of the environment monitoring, the purpose of the networks is to detect broad-scale changes in environmental conditions and trends, not to monitor consent compliance or detect changes in response to management actions. This means that councils are limited in their ability to monitor the outcomes of policy and land management changes because the networks were never designed for that purpose.[56] As such, these networks do not provide appropriate data for farm-scale planning or operational management decisions.

For example, the current groundwater monitoring network in the Selwyn Waihora catchment is limited in its ability to detect reductions in nitrate-nitrogen concentrations within 30 years, as was desired at the time the National Policy Statement for Freshwater Management 2020 was prepared.[57] This is primarily due to the long lag times between changes in nutrient inputs and their arrival and detection in the receiving environment.[58] This underscores the challenges of using the current monitoring network to assess whether land use mitigations are being implemented effectively and delivering the water-quality outcomes sought by national and regional policies. To improve the responsiveness and detection power of monitoring networks, a higher sampling frequency is required, along with additional monitoring sites in locations with shorter lag times, closer to where the operational changes are being made.

A similar narrative appears when attempting to detect changes in nutrient concentrations and clarity levels in surface water bodies. The ability to detect these changes with a sufficient degree of certainty depends on the number of samples taken at each site.[59] Increasing sampling coverage and frequency could help reduce the time required to detect changes and identify pressure points more effectively. Improved detection also enables more targeted regulatory interventions and improved mitigation efforts, while avoiding unnecessary restrictions where risks are low. That is, a more responsive management system requires higher frequency sampling at an increased number of sites to assess the impacts of land management decisions. This is imperative when moving to a limits-based system, which relies on a comprehensive understanding of how management decisions are connected to environmental outcomes.

On the positive side, high-frequency water abstraction data are collected by consent holders (via water meters) and reported to ECan as part of consent compliance processes.[60] This provides an opportunity to integrate water abstraction and environmental monitoring data, but there are some key limitations. ECan has acknowledged that it is difficult to manage the vast amounts of data received, that the data received are of variable quality,[61] and that there are inconsistencies in how water take is defined.[62]

56 Using data beyond their intended purpose can still have value, but it will have limitations. For example, ECan has used the state of the environment groundwater quality network to determine whether outcomes are on track to meet regional plan targets (ECan, 2026a).

57 Dumont et al., 2024; Central Plains Water Trust, 2025, p.12; McDowell et al., 2025, pp.55–75.

58 Scott et al., 2023; Dumont et al., 2024.

59 McDowell et al., 2024; Patil et al., 2024. Note these papers are not Selwyn catchment specific.

60 ECan receives the data from over 1,000 water meters in the catchment (ECan, pers. comm., 26 May 2026).

61 For example, often datasets with missing data are received from providers (ECan, pers. comm., 8 June 2026).

62 While permitted water abstraction on paper may be high, actual use may be lower – although this is often unknown or not precisely measured. This is compounded by differences in how consents define water take (e.g. peak or average abstraction rates), or in the reporting of consented versus actual water take data. This occurs in part because plans and consents can be written in free-text format, by different people, at different times. Many consents also include conditions that restrict the taking of water when certain limits are reached (e.g. river flows or groundwater levels), and water can be used without a consent when activities are permitted under regional plans. Accordingly, there is potential for significant discrepancies between consented and actual water takes from the natural environment. Standardising how water resource use limits and abstraction rates are defined and applied in regional plans and consent conditions would make them much more useful, enabling their integration and reuse (Booker et al., 2024).

However, just increasing the monitoring frequency and the network distribution would not necessarily provide the full picture. Combining these data with information about what is happening on and with the land is required to accurately model changes and understand whether desired outcomes are being achieved. This includes information such as land use, fertiliser application rates, stocking rates, and farm plan information. From these data, councils, industry groups, farmer representative organisations or collectives, and catchment groups could more accurately link inputs to observable trends, thereby improving mitigation options and responses.

Understanding the nuances of nutrient loss predictions, including time lags, could enable targeted action in areas responsible for disproportionate environmental impacts rather than relying on a one-size-fits-all approach. Gathering data on these inputs would greatly aid in validating the models that councils and catchment groups use to make these predictions. However, these data are primarily collected by individuals and companies and are not readily shared due to privacy and commercial considerations.[63] Overall, if there is sufficient information on the inputs into a system and a monitoring network that can appropriately measure change within a reasonable timeframe, then a catchment can respond to change earlier, iterating as needed through adaptive management to achieve desired outcomes.

Comprehensive land use data are also required to assess the effectiveness of plans and rules designed to address environmental challenges. The councils currently have some regional land use information, such as ECan's modelled regional land use dataset, which is used for land and water resource management planning across the catchment.[64] Model outputs are derived from licensed AgriBase and New Zealand Land Cover Database (LCDB) data and aggregated into 10 square-kilometre hexagons, each showing the percentage of land use breakdowns within it. However, these outputs are only as good as the data they are based on. AgriBase data are voluntary, which increases uncertainty about how up to date or accurate they are. Likewise, as noted throughout this report, the LCDB has issues with update frequency and spatial resolution.

Overall, this means that the catchment (and wider region) is constrained by the information available to inform long-term decision making. Numerous councils across the motu have expressed their desire for an open-source, regularly updated land use map. Increasing the use and frequency of remote sensing technologies, such as aerial imagery, LiDAR and satellite imagery, could enhance both national and regional understanding of land use change. The use of these remote sensing technologies could also help address other challenges facing the catchment, such as natural hazards (flood modelling), river-change monitoring, algal blooms, and biodiversity (indigenous land cover, wetlands, etc). Having such data would improve the councils' ability to model potential future changes and emerging environmental issues, rather than only responding after they arise.

While environmental models can fill some knowledge gaps, including assessing plan effectiveness,[65] the 2024 PCE review of freshwater modelling revealed that no councils used models to formally assess plan effectiveness under the monitoring requirements or the duty to review policy statements and plans. Further, there were very few cases in which models were rerun to assess the effectiveness of nonregulatory programmes or specific plan provisions during the development of new plans. Overall, the PCE review found that freshwater models were not used to their full potential.[66]

63 See chapter 3 for suggestions on how this could be addressed.

64 AgriBase licence restrictions (see chapter 2) mean that some information can only be used by councils internally.

65 Assessing plan effectiveness is not a simple task, given the complexity of plans and the broad-scale design of state of the environment networks.

66 See PCE (2024a) for a detailed review of freshwater models used to support regulation and management of water in New Zealand.

Regardless of policy priorities, high-quality information at appropriate temporal and spatial scales is a critical foundation for decision making, including for on-the-ground actions, preparing plans, or evaluating their effectiveness. Given current issues with the quality of the evidence base in the Selwyn Waihora catchment, several changes are needed to improve monitoring frequency and spatial distribution of the monitoring network. Additionally, more significant shifts are required in establishing:

- co-designed monitoring networks across organisations so that monitoring networks can be more spatially representative and serve multiple purposes
- denser monitoring networks to aid farm-scale planning and assess the effectiveness of operational changes designed to meet policy objectives
- consistent and standardised collection methods and data management processes, including for ecological and administrative purposes (i.e. naming conventions and metadata)
- authoritative risk maps for all regions for contaminants, such as nitrogen, phosphorus, *E. coli* and sedimentation – these should have clear versioning and uncertainties so they can support evidence-based land and water management, and could be modelled and maintained by the PROs as nationally important data layers.

These changes would enable existing and future data to be used more effectively. Similarly, getting consistent, machine-readable data from consent holders, along with detailed information on inputs to land, would improve councils' understanding of the environmental resources they are tasked with managing. Stronger trend data are generally assumed to support more robust policy evaluation and enable councils to more effectively model future changes and assess the outcomes and effectiveness of management practices.[67] Additionally, better integration across datasets would enable clearer evaluation of policy effectiveness (e.g. nutrient limits, minimum flows, land use controls) by more directly linking environmental outcomes to regulated activities.

Environmental datasets held by the Crown

Given that central government has an overarching role in the environmental information system, it is not surprising that councils rely on a range of Crown datasets, including land cover, soils, river classification, climate, and hazard data, to establish environmental baselines, support modelling and assessments, and enable regional and national comparisons.

However, like council-held data, Crown information is often neither comprehensive nor timely. Crown datasets are not immune from the same data quality issues identified above and in chapter 2. Generally, national datasets have lower spatial resolution and slower update cycles than what is required for local use. In the absence of more suitable alternatives, they also have a tendency to be applied beyond their intended purpose.

Across the three profiled locations, at least 40 Crown datasets are used by councils to inform several environmental challenges. The most commonly used Crown datasets are shown in Figure 8.11. These datasets primarily inform biodiversity loss and land use intensification challenges. By comparison, water quality and water quantity challenges are primarily informed by council-held data.

67 The appropriate use of trend data is context dependent, as environmental pressures are not static. Changing climates, demographics, economics and social dynamics reinforce the need for continually updated environmental information to enable informed decision making.

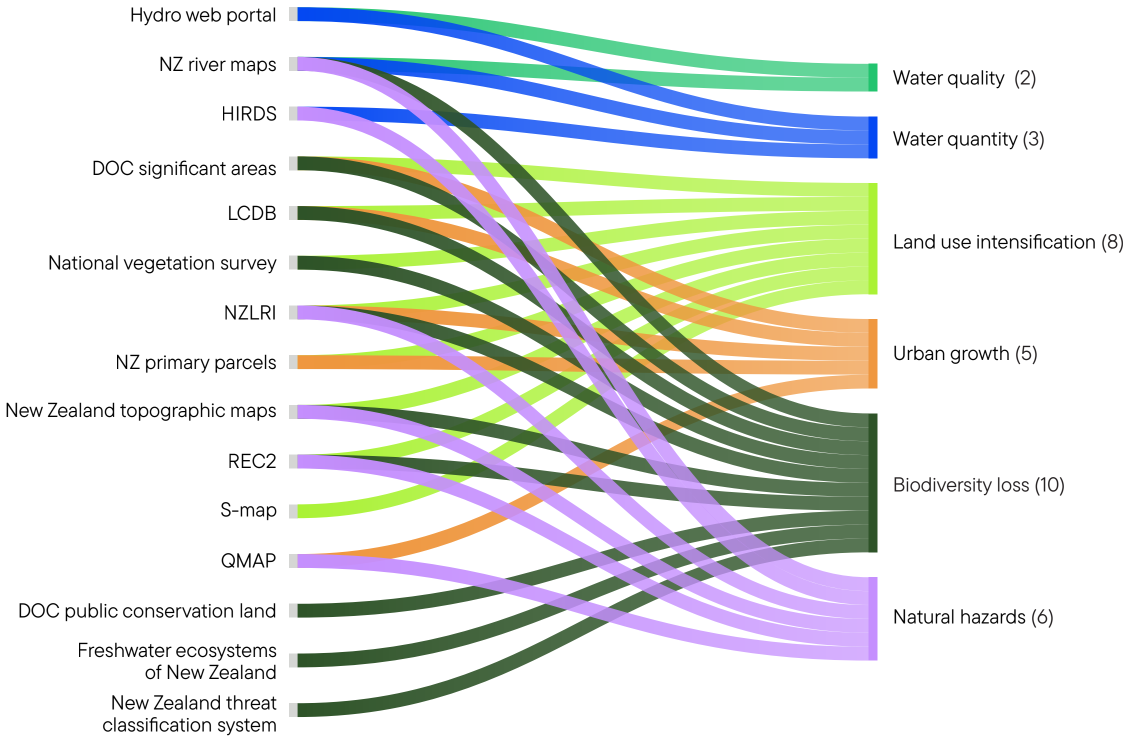


Figure 8.11: Crown-held datasets that are commonly used across the three profiled catchments and the challenges they inform.[68]

Councils, as key users of the Crown datasets, have suggested many improvements to increase the usefulness of these datasets for decision making at the sub-catchment or property scale. These improvements would support more precise and comprehensive environmental assessments, thereby boosting councils' proficiency in local-scale planning and decision making, as well as for catchment management and property-scale policy setting and regulation. They would also improve reliability for decision making and environmental management. These improvements almost systematically revolve around:

- increasing the frequency of monitoring and updates
- expanding spatial coverage
- enhancing resolution, consistency and duration
- enhancing accuracy and local applicability.

A comprehensive list of improvements to specific Crown datasets is provided in Box 8.1.

68 Sankey diagram created using information provided by the councils. High Intensity Rainfall Design System (HIRDS), River Environment Classification 2 (REC2), quarter million mapping programme (QMAP).

Box 8.1: A list of improvements to Crown information, as suggested by councils.

- **National groundwater monitoring programme:**[69] Increase spatial coverage and improve timeliness and availability of data analysis.
- **NZLRI:**[70] Increase spatial resolution and updates, including integration with datasets such as S-map, and add site-specific soil and land information.
- **LCDB:**[71] Improve spatial resolution and update frequency in regional catchments, particularly for wetlands, and modified land uses.
- **River Environment Classification 2:**[72] Improve resolution and integrate more up-to-date catchment and climate data to enhance river classification accuracy and integrate monitoring data and fine-scale spatial datasets.
- **NZ river maps:**[73] Improve alignment with higher-resolution and up-to-date datasets, including climate, land use and water monitoring data.
- **Freshwater ecosystems of New Zealand geo-database:**[74] Improve spatial resolution and incorporate updated monitoring data and mātauranga Māori inputs.
- **New Zealand tsunami database:**[75] Improve local-scale modelling and incorporation of site-specific data for regional catchments to better reflect lagoon and coastal dynamics. Improve integration with updated hazard, climate and monitoring data.
- **New Zealand threat classification:**[76] Improve integration with spatial species distribution and monitoring data.
- **National vegetation surveys:** Improve spatial coverage and increase density of vegetation plots represented in the National Vegetation Survey Databank.[77] Integration with spatial mapping, remote sensing, and updated monitoring data would improve restoration and ecological trend analysis.
- **Wetland information:**[78] Improve spatial resolution and completeness of wetland mapping, particularly for small and modified systems such as drains and ephemeral wetlands. Integration of updated monitoring data and mātauranga Māori inputs would support targeted restoration.
- **Topographic data and maps:** Improve spatial resolution, increase update frequency, and include higher-accuracy elevation and hydrographic data (e.g. LiDAR-derived features). Improve integration with real-time datasets and updated infrastructure information.
- **Aerial imagery:** Central government should coordinate a programme and increase funding for regional aerial imagery acquisition to provide regular (every three years) acquisition for the country.
- **Climate change projections:** Provide timely updates of regionally downscaled projections with each Intergovernmental Panel on Climate Change assessment.
- **LiDAR:** National funding for five–six-year repeat acquisition cycle for the entire country.
- **Drinking water:** Integrate water abstraction and quality data held by territorial authorities and the Water Services Authority –Taumata Arowai with councils' environmental data, and standardise source IDs.

69 ESNZ, 2026c.
70 MWLR, 2026c; National Environmental Data Centre, 2026.
71 MWLR, 2025b.
72 ESNZ, 2026f
73 ESNZ, 2026d.
74 DOC, 2026a.
75 ESNZ, 2026e.
76 DOC, 2026b.
77 MWLR, 2026d.
78 For example, update information from a 2017 desktop study by DOC (ECan, 2017b).

Summary

These examples give a sense of where we currently stand in terms of environmental information, including specific datasets available to support decision making on key challenges, and the sort of improvements that could enable better decisions in the future.

They do not pretend to paint a comprehensive picture of all information available to support decision making. However, the commonalities across the different locations and environmental challenges show that there is a convincing need to improve:

- existing data quality – this means looking at sampling frequency, monitoring duration, spatial coverage, and resolution, as well as the maintenance, validation and calibration of equipment
- integration of available data into a coherent, standardised framework.

These common data issues hinder evidence-informed decisions. Council staff across the three locations have highlighted a long list of desired improvements to respond to these common data quality and integration issues – many of which have also been raised independently in the earlier chapters of this report. These include:

- regular land use mapping
- increasing the update frequency of datasets – in particular, 5–6-year repeat LiDAR and 3–5-year repeat satellite or aerial imagery acquisition
- standardising data practices within and across organisations and regions where appropriate – councils highlighted that this should include typologies and collection methods where practical, including for ecological and administrative classification systems used with environmental data and in environmental reporting (i.e. standardised naming conventions and descriptions for data feature attributes)
- improving the spatial consistency and completeness of datasets
- increasing the monitoring frequency of various programmes
- improving the integration of data and data management systems, including standard data sharing agreements between agencies negotiated at a national level to avoid duplication and differences
- having some datasets collected and managed at the national level (e.g. LiDAR, land use and satellite data)
- ensuring that key national or regional datasets are open source.

Some of these improvements can be achieved through greater use of technological advances, such as remote sensing, high-frequency monitoring, and eDNA. However, many of the desired improvements involve system-level and data management changes, such as standardising data collection methodologies and metadata.

There are numerous benefits to improving the currently available environmental information system, including reduced duplication and cost for councils and users of the system (e.g. developers or infrastructure providers), more efficient management of data and monitoring networks, reduced time spent cleaning and reconciling data, and increased transparency.

While technological improvements can unlock new and additional environmental information, their use comes at a cost. For example, high-frequency monitoring can provide great resolution and real-time data for decision making, but the upfront cost and the upkeep of telemetered sites are significant, as sites need to be visited regularly to maintain and calibrate equipment and ensure data quality. As a result, few technological upgrades are simply a matter of one-off deployment. Any proposed improvements need to be subjected to a rigorous business case to determine what monitoring technique is best suited to each particular purpose.

9

Sticky pig fern, *Hypolepis rufobarbata*

Did Budget 2026 solve the problem?

This report has been developed during a period of significant policy flux. Resource management and science system reforms are probably the most visible changes. But proposed changes to the structure of local government could also have profound consequences for the way environmental data are collected and managed. The publication of *A federated system to improve environmental information* was an interim output of this report. [1] It was released to help ensure that environmental information was not lost sight of in reform processes and to encourage the Government to pursue federation to address many existing issues.

Budget 2026 crystallises how the Government intends to implement its resource management reform by laying out, at a high level, what and how it will invest to achieve its desired outcomes. It includes investing $294 million over four years to support the implementation of the new planning system.[2] Given this significant investment, it is timely to examine what it covers and whether it addresses the issues with New Zealand's environmental information system identified in this and my earlier reports.

The announcement includes an investment of $41 million over two years to design the digital foundations of the new planning system. These foundations include national data standards, an e-Plan viewer, and the core system architecture needed to support the new planning system over time.[3] Other areas to be addressed with the funding include the implementation of national instruments; guidance to assist councils, businesses and communities in transitioning to the new system; and the development of a new planning tribunal. Crucially, there is a $61 million investment in priority datasets to support the planning system to be delivered over four years, and an additional $7.4 million of investment to support the New Zealand Flood Map.[4]

Ultimately, this investment should be judged on the outcomes that it actually delivers. However, several comments can be made on how the Budget announcements align with the discussion in this report.

First, the Government's investment in digital and data, as part of the resource management reform, is to be welcomed. It is an acknowledgment of something I have been saying throughout my tenure as Commissioner; that without investment in solid data foundations, simply changing the policy landscape will not generate the benefits the Government is trying to deliver. This is a trap New Zealand has fallen into too many times to count.

1 PCE, 2025a.

2 Bishop et al., 2026; Willis, 2026.

3 Bishop et al., 2026.

4 Grigg, 2026. The New Zealand Flood Map was the only data investment named at the time of writing (Willis, 2026, p.11).

Second, the Government has signalled the first step towards developing a federated system to facilitate the sharing and use of information. It is my understanding that the centralised digital planning platform will be built on top of this underlying data architecture, which will enable greater federation of information. Specifically, the inclusion of work on standards and core system architecture is important. These building blocks will be critical to enabling interoperability of environmental information from different sources and ensuring it is used to its fullest potential.

As this work proceeds, the Government should take the opportunity to study the recently released draft Australian National Environmental Standard for Data and Information.[5] The standard proposes a set of national principles that ensure data and information used in decision making is representative, transparent, comparable, reusable and ethical. Such standards appear to be a practical way to address the issue of what comprises 'best available information', as well as improving interoperability.

Addressing the issues discussed in chapter 3 (e.g. commercial constraints and the management of sensitive data) and the resourcing of those operating in the system will also be important. The Government has indicated that this work will continue, with further investment considered in future budgets, subject to detailed business cases. This ongoing investment is critical.

However, the key enabler to improved data sharing is something the Government cannot directly buy – trust. Greater trust can be fostered through investment in systems and standards, but ultimately it comes down to the relationships between the institutions that collect and manage information and those affected by its use. It remains to be seen whether the arrangements proposed in both the resource management and local government reforms will improve on the current levels of trust or simply perpetuate the status quo.

Third, the proposed investment in data and practical tools to improve planning decisions is sorely needed. Prioritising investment in data on soils, land use, LiDAR, biodiversity and natural hazards would make sense based on the discussion in chapter 8. Too often, the Government has set down change in legislation and national direction without the required investment in the information that councils and others need to actually implement the policy. The first cab off the rank is the New Zealand Flood Map, which includes work to integrate existing modelling and to develop a new model to fill gaps where local information is not available.[6]

There are, however, several risks to be managed that will require some critical thought and dedicated foresight. The most important thing to emphasise is that the planning system is only a part of New Zealand's environmental management system. The planning system is a very significant element of it, but the two are not synonymous.

Framing investment solely around the implementation of the new planning system risks creating trade-offs between, for example, immediate implementation and long-term, broader environmental system improvements. This risk is particularly high given that decisions are being made at pace. Prioritisation is always necessary, but path dependency is also a real risk.

The new digital planning system, as envisioned by the Government, should form a module within a wider federated environmental information system. This is because there are many cases in which the transfer of environmental information is not directly relevant to planning but still has significant value. Biosecurity planning and operations are an example. Without this long-term vision, we will not unlock the full potential of federation and leave environmental and economic gains on the table.

Trade-offs will also arise when investing in supporting environmental data and information if it is framed only in terms of planning outcomes.

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5 Department of Climate Change, Energy, the Environment and Water, 2026.

6 Bishop et al., 2026.

While a significant portion of the announced $68.4 million is to be spent on building up the underlying information base, it will not be enough to address everything that is needed. A myriad of trade-offs will need to be considered when deciding which domains to invest in, which elements within those domains to focus on, and which aspects of specific datasets to prioritise. As a result, if the sole purpose of data investment is to support the planning system, we are likely to miss opportunities in other parts of New Zealand's environmental management system.

In some cases, dramatic improvement can be achieved through significant one-off investments. For example, it is estimated that obtaining full geographic coverage of farmable land with New Zealand's digital soil map S-map would require a one-off investment of around $25 million over 10–15 years. An additional $8–15 million would be needed to extend coverage to all of mainland New Zealand.[7]

However, one-off investments are not the end of the story. Datasets require ongoing maintenance and continuous updates, driven in part by New Zealand's dynamic landscape and by evolving resource use. For S-map, ongoing investment is likely to be in the order of a million dollars per year.[8] Given that the current budget announcement only covers four years, clearly a longer-term commitment is needed.

The budget also fails to address a more fundamental and structural issue concerning the way environmental information is funded in New Zealand. It continues the status quo in which outputs are likely to be purchased predominantly from existing research organisations such as the Public Research Organisations (PROs). This continues the money-go-round where the Government is, in effect, paying itself.

If we are looking for a system that is more accessible and allows greater reuse of information, that will make collecting, managing and providing it more expensive. It is entirely appropriate that the Government invests in this work. After all, it is often the largest consumer and beneficiary of such information.

Research organisations are keenly aware of the importance of environmental information to New Zealand, its considerable public value, and the intellectual property challenges it is creating. The renewed commercial imperatives signalled in the science system reform (and specifically for the PROs) risk increasing the costs of generating and accessing environmental information. This could potentially place it beyond the reach of many users.

The increased costs of generating and accessing environmental information could undermine the ability of research institutions to deliver the robust evidence base required for effective environmental management and decision making and weaken the intrinsic link between research and development and environmental wellbeing. The way research funds are spent under the Government's new Science Investment Plan will need to be carefully considered if real improvements in environmental information are to be realised.[9]

7 BSI, pers comm., 30 June 2026. The additional area includes the DOC estate and other mountainous lands.

8 BSI, pers comm., 30 June 2026.

9 The Science Investment Plan 2026–2036 was released on 10 June 2026 (MBIE, 2026c).

10

Silvaticum, *Polystichum silvaticum*

Conclusions and recommendations

I have already made a number of recommendations about environmental information that remain to be taken up. To pull these all together along with the findings of this report, I make the following recommendations.

Recommendation 1: The Minister for the Environment should develop a long-term environmental information plan for New Zealand that sets out the steps required to:

- implement a federated information system
- improve the use of existing data
- unlock the potential of innovative technology.

This should include addressing issues of trust, access, sharing, privacy, data sovereignty, ownership of information, and technological uptake.

Any such plan should be developed in close collaboration with those who, in addition to central government, are key users of environmental information – namely, regional and territorial government, the environmental research sector, iwi/Māori and the private sector (especially infrastructure providers and land-based industries).

But the Government also has to start by getting its own house in order.

There is a clear case for improving New Zealand's wider environmental information system. It needs better leadership and governance. It needs to join up a mass of currently fragmented systems. And it needs investment in technologies that can unlock existing and new data streams. This is not a question of innovation for the sake of innovation. It is about developing an environmental intelligence capability that can support industries and populations that are increasingly exposed to the rising costs of environmental breakdown.

More environmental information that is more accessible and better integrated will not solve the environmental challenges that New Zealand faces. But it will put us in a better position to do so. Sometimes, better information can put difficult problems in a different light and help us to find new ways forward. However, our most difficult environmental challenges are not the result of technical shortcomings. They are human and political, and they won't be solved by lots of new data. In short, better information is necessary, but not sufficient to guarantee progress.

Despite a widespread appreciation of the importance of better environmental information, we have been woefully inadequate at prioritising, coordinating and adequately resourcing what is needed to succeed. Recent announcements by the Government of its intention to invest in the digital and data foundations of a new planning system and the development of a common operating picture for emergency management are good starting points.[1] They are an acknowledgment that without investment and solid digital and data foundations, simply changing the policy landscape will not generate the benefits that are claimed for the reforms.

Organising information around a federated system has clear benefits and will enable information to flow more easily between agencies and individuals.[2] The recommendation in my 2025 note to set up a federated data system appears to have been taken up, given Budget 2026 announcements.[3] It is important to remember that a federated data system has many benefits beyond the planning system.

What appears to be missing, however, is a recognition that much of the foundational environmental information (e.g. topography, landscape factors and natural hazards) on which that policy reform relies will not, in the first instance, be available. Trying to develop spatial plans without high-quality bio-physical information about the space those plans are supposed to apply to will almost certainly see poor decisions being taken. Given decades of underinvestment in environmental information this is to some degree unavoidable. We need to understand the environment we're living in. Planning should ideally follow from that. We cannot stop progress in the meantime, but we should try to minimise any future regrets.

A key question to be answered is whether we have the capabilities in place to make the most of technological innovation and to implement system change to improve environmental outcomes. Based on the current evidence, my answer is no.

Ultimately, this comes down to a lack of leadership. There is no champion advocating for and driving change across the entire environmental system. Such leadership must come from the government as both the largest consumer and beneficiary of environmental information. The government needs to position the New Zealand environmental information system as critical infrastructure, given that our society and, even more markedly, our biological economy are absolutely dependent on a resilient, well-functioning environment. Understanding the state of that environmental 'infrastructure' can generate real economic value. If we don't think about environmental information in this way, history will repeat itself and any reforms to improve the way we manage our environmental impacts will yield mediocre results at best.

In my view, New Zealand needs an agency with the expertise and remit to oversee, coordinate and implement an effective environmental information system. Such an entity would be responsible for providing strategic direction and ensuring that the right tools – such as national data standards – are available and adopted by all parties across the environmental data supply chain.[4] It also needs to be a centre of expertise that other organisations can draw on.

In my 2025 note, I suggested that the Ministry for the Environment (MfE), Stats NZ, or Toitū Te Whenua – Land Information New Zealand (LINZ) could plausibly be the lead agency to develop a federated system to improve environmental information. However, the landscape has changed since that note was released. MfE has been merged into the broader Ministry for Cities, Environment, Regions and Transport (MCERT). This is a mega policy ministry. In my view, operationalising an environmental information system needs to happen in an agency much closer to users and draw on a fundamentally different set of competencies than those normally found in Wellington head offices.

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1 MfE, 2026a; Mitchell, 2026; National Emergency Management Agency, 2026.

2 It will also mean that principles such as FAIR (Wilkinson et al., 2016) and CARE (Global Indigenous Data Alliance, 2026) can be followed.

3 PCE, 2025a.

4 It would need to work in tandem with the Government Chief Digital Officer and Government Digital Delivery Agency to leverage ongoing digital work and procurement in the public sector, and the Government Chief Data Steward.

While Stats NZ and LINZ, the government's technical experts in statistics and property and location services, respectively, are not policy agencies, they lack the breadth of expertise in environmental information needed to drive real change on the ground. Their expertise and collaboration will, however, be important to any designated lead agency.

Another factor to consider is that if the environmental information system is to be trusted, its independence is critical. Policy agencies are, by definition, under direct ministerial control and have a central role in determining priorities. But once those priorities are set (whether they govern research, data collection or monitoring), the business of carrying them out needs to be undertaken at arm's length by technically proficient staff who are trusted by all potential users. This is particularly important if private data are to be integrated into such a system. It has to be demonstrably beyond political interference.

In my view, the Environmental Protection Authority (EPA) is the logical place for this mission. In recommending this, I am building on the suggestion made in my 2022 *Environmental reporting, research and investment* report that the EPA would be the logical agency to provide oversight and leadership of environmental monitoring.[5] It is also in line with my 2024 report, *A review of freshwater models used to support the regulation and management of water in New Zealand*, which recommended a national centre of excellence to support freshwater modelling.[6]

Central government had this capability before the upheavals of the 1980s, which saw these competencies being devolved to local government (and the private sector). Nearly four decades on, the Government is setting itself up to re-centralise and prioritise its management of the environment. It needs a national-level agency to carry that through, although its operations could be embedded in the regions. The skills needed to deliver many functions are already in place in regional councils. If the Government is bringing regulatory authority back to the centre, its institutions should to some extent match that. This has been a theme in several reports I have delivered to Parliament.[7]

In my view, a properly resourced EPA is the appropriate place to build the corpus of technical skills that is needed to see that regulations are implementable and enforced, and the environmental outcomes properly monitored. The federation of our currently fragmented system, and the roll-out of technologies described in this report, requires a critical mass of highly qualified people. They need a home, and it is not a policy ministry. Neither is it a research institution (although it should have close links with the research community).

Recommendation 2: The Government should revise the mandate of the EPA to give it responsibility for the coordination, leadership and management of New Zealand's environmental information system.

5 PCE, 2022a, p.77.

6 PCE, 2024a, p.118.

7 PCE, 2022a, 2024b, 2025a, 2025b.

A key responsibility for the EPA should be to improve the pipeline of information that flows through the new environmental information system. Identifying leverage points for technological innovation and fostering their adoption will be just as important as system oversight. New Zealand possesses the technical skills but lacks the coordination, capacity and funding to implement technologies consistently and at the required scale. Such an entity could fulfil this role, including by (but not limited to):

- undertaking a stocktake and assessing the access restrictions for environmental information held by research organisations and other central and local government organisations as appropriate to ensure that we know what we currently hold and how it can be accessed and reused
- further developing guidance and shared solutions to address common issues (such as data management) in the use of high-frequency water quality monitoring
- coordinating investment and capabilities in the use of cameras and passive acoustic monitoring devices for biodiversity and biosecurity monitoring. Leveraging the excellent work being undertaken in predator control, the focus should be on broader applications and integration with other technologies
- filling gaps in our taxonomic information to further improve the use of eDNA as a detection method. Work is also needed on how best to incorporate eDNA into monitoring programmes alongside more traditional monitoring approaches. This includes how it may be used to monitor outcomes under the Government's new environmental limits regime
- fostering greater collaboration between data scientists and domain experts to ensure that robust information and AI models are being used, and that the outputs represent the real world
- continuing investment in local high-performance computing environments to ensure researchers can process and make sense of growing data streams
- mandating the use of digital object identifiers (DOIs) and unique identifiers for environmental data to ensure that provenance, quality and use can be tracked and make reusing data easier.

All these tasks would depend on close collaboration with other organisations to ensure work is well sequenced and linked to outcomes. In particular, new technologies for environmental monitoring should be seriously considered across two of the four pillars that form Research Funding New Zealand – namely, the 'Technology for Prosperity' and 'Environmental Sustainability and Resilience' pillars. This is a matter requiring immediate attention as all pillars are presently developing their investment plans.[8]

One area, in particular, that requires a more deliberate and coordinated approach is the application of **remote sensing**. The coordination of remote sensing data sourcing, the validation of indices and metrics for New Zealand applications, and the identification and delivery of a set of core national value-added data products would dramatically improve our information base. The goal should be to produce nationally consistent information derived from remote sensing that is available to all. A fundamental shift rather than incrementalism is required here.

As noted in chapter 4, such national responsibilities are often vested in scientific agencies.[9] The creation of Earth Sciences New Zealand centralises a lot of the technical expertise needed to deliver such information.[10] However, to achieve this would require a fundamental shift in how the Public Research Organisations are directed and funded. In my view, it is better to keep some distance between research and the implementation and delivery of an information system that is fundamentally designed to support a regulatory system.

8 MBIE, 2026c.

9 As discussed in Cote et al. (2025, pp.85–92).

10 Although significant expertise is also housed in the Bioeconomy Science Institute and other government organisations.

As a first step, the revised EPA should procure a core set of satellite remote sensing data services for all-of-government use (including local government). New Zealand is too small, and its resources too slender, to continue to have individual organisations and agencies negotiate separately for the same or very similar information. National climate projections published by MfE (now MCERT) represent an example of such an approach. The Government is taking a national approach to the procurement of information technology systems across sectors to enable efficiency.[11] Environmental information should be treated similarly.

The revised EPA should also be the Government's key advisor on reviewing and modernising the Nationally Significant Collections and Databases to reflect both existing and new environmental information needs and resourcing. This would transform them into authoritative national datasets.

Recommendation 3: The Government should task the revised EPA to identify, source and maintain a set of critical remote sensing products for the benefit of all of New Zealand.

Finally, returning to resource management, it is uncontroversial to say that the new resource management system needs to be grounded in high-quality environmental information. However, the information base that we currently possess does not measure up to that standard. The Government is investing in some areas to improve the underlying data (chapter 9), but those data will take time to develop and disseminate. Meanwhile, regional spatial plans are required to be notified shortly after the new legislation comes into force. To minimise disruptions to the spatial planning process there needs to be transparency about the information relied on during the development of a regional spatial plan so that submitters can question its adequacy.

Recommendation 4: The Minister responsible for the Planning Bill (once enacted) should require councils to disclose the information that has been relied on in developing proposed regional spatial plans and ensure that submissions on these plans can comment on the adequacy of that information when they are notified.

11 Collins, 2025, pp.4–5.

Tufted filmy fern, *Hymenophyllum pulcherrimum Colenso*

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This report has been produced pursuant to subsections 16(1)(a) to (c) of the Environment Act 1986. The Parliamentary Commissioner for the Environment is an independent Officer of Parliament, with functions and powers set out in the Environment Act 1986. His role allows an opportunity to provide Members of Parliament with independent advice in their consideration of matters that may have impacts on the environment.

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July 2026

ISBN
978-0-473-79656-3 (print)
978-0-473-79655-6 (online)

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata