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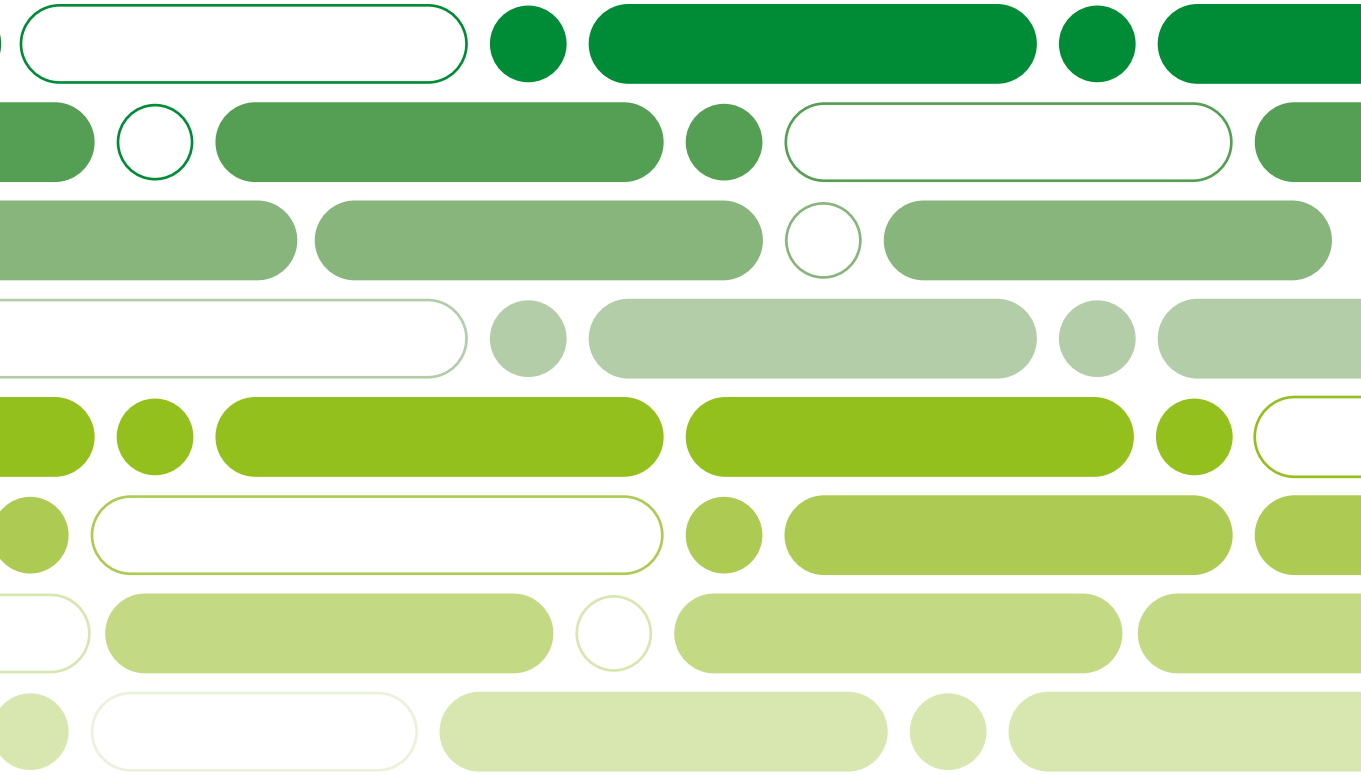
Te Kāhui Atamai Iahiko o Aotearoa

ARTIFICIAL INTELLIGENCE FOR THE *Environment in Aotearoa New Zealand*



An analysis of opportunities and benefits of applying artificial intelligence to support environmental sustainability in Aotearoa New Zealand.

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AI Forum members and other organisations who participated in the research survey. Your responses helped us to build a robust understanding of the AI for the environment ecosystem in Aotearoa New Zealand.

Lead report coordinator and research team leader, **Matt Lythe** of Lynker Analytics.

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The many AI, data and environmental sector practitioners, leaders, researchers, and business people we interviewed for this report.

About this Report

The purpose of this report is to help create a shared understanding of how artificial intelligence (AI) can be applied to a range of environmental issues in Aotearoa New Zealand. At its centre is ensuring that te taiao (the environment, the natural world) is nourished and its mauri (life force and vital essence) is kept in balance.

This report provides an overview of the current state of AI for the environment in Aotearoa New Zealand, and what a thriving future could look like. It also outlines the challenges to increasing uptake, and proposes areas for future focus.

About the AI Forum

The Artificial Intelligence Forum of New Zealand (AI Forum) is a purpose-driven, not-for-profit, non-governmental organisation (NGO) that is funded by members. We bring together New Zealand's community of artificial intelligence technology innovators, end users, investor groups, regulators, researchers, educators, entrepreneurs and interested public to work together to find ways to use AI to help enable a prosperous, inclusive and thriving future for our nation.

The Forum holds an evidence based approach, focusing on addressing challenges to realise opportunities.

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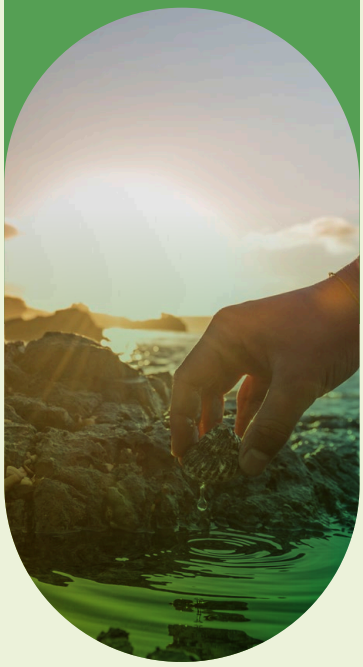

Introduction

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FOREWORD

Artificial Intelligence Forum of New Zealand

Megan Tapsell Chair, AI Forum

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Te Kāhui Atamai Iahiko o Aotearoa

The application of intelligence in any form is the foundation to our ability to make an impact on Aotearoa. As we apply intelligence to the ways in which we use and develop our land, technology plays an important and increasing role. As this report was developed a Te Ao Māori view was undertaken, and this whakataukī underpins how we would like to see Artificial Intelligence applied to the Taiao/ Environment in Aotearoa.

Manaaki whenua, manaaki tangata, haere whakamua. Care for our land, care for our people and we can progress positively.

Through this report we imagine an Aotearoa where artificial intelligence (AI) and advanced data collection methods are seamlessly combined with human expertise to ensure our environment is healthy and can sustain us physically, economically and spiritually for generations to come.

The report incorporates research and the expertise of many people in the field to explore the huge possibilities for AI to assist with the collection, analysis, and modelling of environmental data at scale. It provides an overview of the current state of activity, and looks at the opportunities, barriers, and areas of action we need to take to realise a thriving ecosystem. This research was conducted at the request of the Ministry for the Environment (MfE) and Statistics New Zealand (Stats NZ), who have an important role in the environmental and monitoring system in Aotearoa New Zealand.

As Natasha Lewis, Deputy Secretary, Joint Evidence, Data and Insights Group at MfE puts it "Much needs to be done to improve our understanding of the environment and the impact of our decisions and activities. The challenges in the current system are well documented and we need to focus now on solutions to address those challenges, including the opportunities for emerging technology".

Rachael Milicich, Deputy Chief Executive for Insights and Statistics at Stats NZ also noted "We can see the importance of understanding the role of emerging technologies in supporting Aotearoa New Zealand to grow an effective evidence base of data and statistics. It's crucial that we have high-quality data to enable the effective use of AI for addressing our environmental challenges".

There are already some exciting applications of AI to support the environment being developed by businesses, researchers, government agencies and non-profits. However, there is work to do to ensure a sustainable and thriving AI for the environment ecosystem. This includes building capability and talent pipelines, ensuring datasets are accessible, and aligning the funding landscape.

There is a particular opportunity for mātauranga Māori to be embedded in AI for the environment approaches and systems. The people we spoke to for this report acknowledged the importance and opportunity of weaving Māori perspectives into our AI for the environment systems, but there is still a way to go to operationalise these approaches more broadly.

We are proud to launch this report which is a first step to consolidating the current state, opportunity and, crucially, the steps we need to take to realise a thriving AI environment to support the environment.

Tēnā rawa atu, ngā mihi nunui ki nga kaitiaki, ngā tangata matatau, ngā kaitautoko katoa o tēnei pūrongo.

I would like to acknowledge the researchers and writers of this report, everyone who has shared their expertise and experience along the way.

Ngā mihi mahana

Key Highlights

From climate change to the loss of biodiversity, Aotearoa New Zealand's interconnected environment is facing unprecedented strain. This is starting to have a substantial and recurrent impact on our health, wellbeing and economic prospects.

The development and broad implementation of AI for the environment is likely to have **significant return on investment in Aotearoa New Zealand**, in the shape of benefits to our industries and economy and improved human health and social cohesion.

Work currently underway on AI for the environment in Aotearoa New Zealand has clear concentrations in a couple of areas: **preserving and bolstering biodiversity, and understanding the impacts of changing land use.**

Challenges to growing the AI for the environment ecosystem include: silos and fragmentation between different parts of the field, the expense and changes in practice required to operationalise AI projects within an organisation, and access to sufficient high quality data.

AI for the environment can help in a number of compelling ways:

- processing big data and providing near real time information.
- more accurate predictions and modelling.
- answering specific questions to support decision-making and identify where to put effort.
- detecting and labelling features of interest in data collected from sensors.
- finding new insights from historical data.

Species recognition or identification, data analysis, and remote sensing are three of the most common techniques used in AI for the environment projects undertaken in Aotearoa New Zealand.

However, we are not yet fully exploiting this new technology. AI can play a major role in an enhanced and more active environmental monitoring system delivering data and insights at a national scale.

There is an opportunity for mātauranga Māori to be built into AI systems in a way that respects the unique connection that tangata whenua have with the land and the environment.

Laying the groundwork for a more coherent environmental data ecosystem is a big opportunity, and essential for growing the field. This includes filling data gaps, developing and cementing approaches for Māori data and the environment, and adopting and implementing appropriate rules, standards and guidance.

Summary Recommendations

New Zealand's environment is in a precarious state. It faces multiple threats and is besieged in numerous ways, mostly as a result of human actions. These threats include thousands of species threatened or at risk of extinction, shrinking wetlands, a warming climate leading to more regular droughts and extreme rainfall events and decreasing water quality.

Also data on the state of the environment is fragmented and reliant on monitoring systems designed mainly to support regional needs. AI technology provides an important part of the solution to this problem. To best enable the AI for the environment ecosystem to maximise its positive impact for New Zealand the following recommendations have been developed. **The full recommendations page 44.**

1. Build a Coherent Environmental Data Ecosystem

- Deploy AI alongside other new technologies to enhance environmental data collection.
- Develop a national environmental open data framework.
- Consider where and how mātauranga Māori may be incorporated within Government AI systems.
- Coordinate the development of standards and best practices for environmental data management.

2. Build Capabilities and Relationships

- Invest in increasing the institutional understanding of AI in businesses and Government.
- Increase the exposure of AI specialists to environmental challenges and environmental scientists to AI.
- Increase collaboration within the AI for the environment ecosystem.

3. Increase and Align Funding to Support Impactful Projects

- Target funding to accelerate AI for the environment uptake.
- Align funding with measurable environmental impacts.
- Target funding to outcomes of national importance.

Our Focus Areas

In this report we focus on five key environmental outcomes for Aotearoa New Zealand where AI can deliver meaningful solutions.

Key Environmental Outcomes

01
Preserving and Bolstering Biodiversity

This includes protection of native plants, animals and ecosystems in land, freshwater and marine environments.

02
Understanding Impacts of Changing Land Use

This includes changes to vegetation across the country and the use of land in urban areas.

03
Reducing Pollution From Our Activities

This includes substances or kinds of energy (noise, light, heat) that are harmful to the environment.

04
Protecting our Freshwater and Marine Resources

This includes how we fish and the taking of water from waterways for various purposes.

05
Climate Change Mitigation

This includes reducing greenhouse gas emissions and mitigating the effects of climate change for Aotearoa New Zealand.

These outcomes align with the themes in *Environment Aotearoa 2019*, which provided a comprehensive overview of the state of the environment in Aotearoa New Zealand.[1] The most recent synthesis report, *Environment Aotearoa 2022*, did not find significant change in these themes while also putting environmental change in the context of our lives as individuals, families (whanau), and communities. Both of these synthesis reports recognise that most of the key environmental challenges we face have developed over long time frames and that there are gaps in knowledge, data and understanding that can prevent people from making informed decisions about issues.

These include:

- missing data that prevents us from knowing what is happening where and when
- limited knowledge about the effects of human activities that relate to decision-making
- incomplete understanding of the impacts on our wellbeing and what we value.[2]

While the focus of our research is on five environmental outcomes, we acknowledge there are many additional environmental areas that could also be supported with the use of AI.

Aotearoa New Zealand's Environmental Reporting Series

Under the Environmental Reporting Act 2015, the Secretary for the Environment and Government Statistician must publish a report every six months on a particular environmental domain, as well as a synthesis report every three years, and from now moving to every six years. The two most recent synthesis reports, *Environment Aotearoa 2019* and *Environment Aotearoa 2022* present an overall summary of the health of our environment.

The 2019 report addressed nine priority environmental issues and summarised the purpose of the report as providing 'evidence to enable an open and honest conversation about what we have, what we are at risk of losing, and where we can make changes'.

The 2022 report is framed on the nine stars of Te Kāhui o Matariki, each representing a different aspect of the environment and people's connection with it. It presents a commentary, supported by Māori knowledge (mātauranga Māori), science, and indicator data, with this purpose in mind.

Photo Credit: Chris WIlliams

Part One

12 The AI for the Environment Landscape

Photo Credit: Chris WIlliams

Understanding and Monitoring the Environment

Introducing the Environment Te Taiao

> *"In traditional Māori knowledge, the weather, birds, fish and trees, sun and moon are related to each other, and to the people of the land, the tangata whenua. It is truly an interconnected world – a vast family of which humans are children of the earth and sky, and cousins to all living things."*
>
> Te Taiao: Maori and the Natural World[3]

Our natural world holds people, plants, animals, soils, freshwater, seas and skies.[4] All aspects of the environment are interconnected, including between people and nature. Changes in our environment can have far reaching impacts, both positive and negative on ecological integrity, public health, economic wellbeing, culture and recreation.[5]

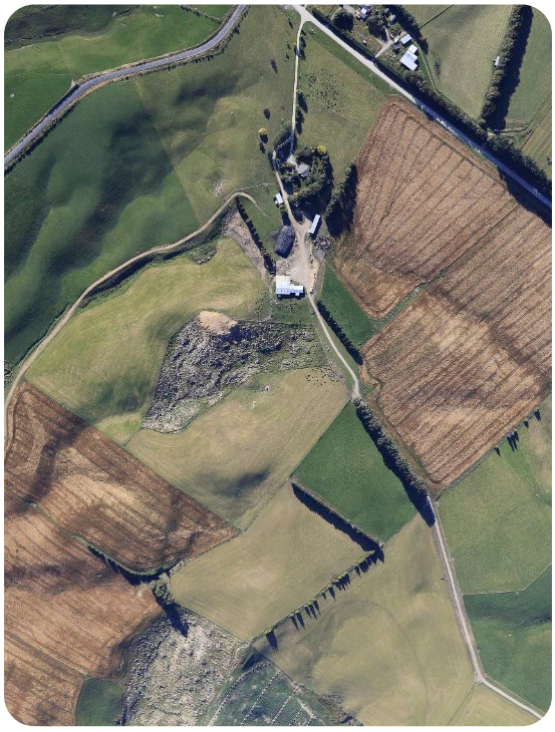
This report examines the application of AI to many aspects of the environment te taiao including the air, freshwater, marine, atmosphere and climate, and land domains. It also explores the biodiversity and ecosystems these domains support.

Current State of the Environment

Our interconnected environment is facing unprecedented strain in a range of areas including climate change, land use change and intensification, natural resource use, air and water pollution and the loss of biodiversity.[6] Conserving, stewarding and protecting the environment is essential to ensure human and non-human life is supported and able to flourish in the future. Many of these pressures will continue to have an impact for years to come, leaving a legacy impact on the wellbeing of future generations.

At a Glance:

- 90 percent of seabird species (86 of 96) and 82 percent of shorebird species (14 of 17) are threatened with extinction or at risk of becoming threatened[7].
- Trophic level index (an aspect of ecosystem health) was poor or very poor at 46 percent of modelled lakes[8] while around 800,000 (approximately 15 percent) of New Zealanders have water supplies with potentially hazardous nitrate levels.[9]
- The national average temperature has risen by 1.13 (±0.27) degrees Celsius since 1909, at an average rate of 0.10 degrees per decade. That rate was 0.31 degrees Celsius per decade in the past 30 years.[10]
- In 2019 our net greenhouse gas emissions were 26.4 percent higher than 1990.[11]



How we Currently Monitor the Environment

This section takes a closer look at the current approaches to understand the environment in Aotearoa New Zealand. This includes the national monitoring and reporting system, as well as more localised approaches. By examining current systems, we can better understand how AI can help efforts to support and understand the environment.

The National Environmental Monitoring and Reporting System

Monitoring is required by a range of legislative tools, and supports the work of each regional council and the people they serve. However, local and central government's approach to environmental monitoring is fragmented, with a variety of standards and methodologies in use for regional data collection.

Regional environmental monitoring data is included in the national level reporting system. This reporting is carried out at regular intervals by Statistics New Zealand (Stats NZ) and the Ministry for the Environment (MfE). It aims to provide a diagnosis of the health of the environment, so decision-makers have an evidential basis for comparing issues.[12] The environmental reporting system is intentionally separate from policy, funding and regulatory responses to address environmental issues.

The Ministry for the Environment explains that "environmental reporting is an objective exercise in which we present information on our environment. Developing responses to address environmental issues is more subjective and open to debate. It involves the Government, stakeholders and society as a whole making judgements on what we value most and what trade-offs are acceptable."[13]

There are significant gaps in the current data and knowledge available about aspects of the environment. In his 2019 report *Focusing Aotearoa New Zealand's Environmental Reporting System*, the Parliamentary Commissioner for the Environment outlined a range of issues with the reporting system and made supporting recommendations.

> *"To say that we have designed a national environmental reporting system would be to overstate its coherence. It has been more a case of cobbling together what we have to hand, trying to solicit the willing engagement of a wide range of stakeholders and putting the hat around to try to plug some of the many gaps."*
>
> **Simon Upton**,
> Parliamentary Commissioner for the Environment, 2019[14]

Photo Credit: Darryl Ward

Considerable work is currently underway on aspects of the monitoring and reporting system. For example, public engagement for an update to the reporting system and Environmental Reporting Act has recently been completed. The Ministry for the Environment notes that this work will include "exploring how mātauranga Māori, data, evidence, knowledge and science could be shared, collected, managed and protected in environmental reporting".[15]

Local Approaches

In addition to the national monitoring and reporting system, there are many areas where place-based local monitoring takes place for the benefit of particular communities. These processes may not form the wider picture of the environment compiled by the government.

MĀORI APPROACHES TO UNDERSTANDING THE ENVIRONMENT

As tangata whenua people of Aotearoa New Zealand, Māori have strong traditions and cultural practices for the stewardship of environmental and natural resources, including an inter-generational focus. A rich body of mātauranga knowledge relates to understanding the natural world and its mauri life force.[16] This knowledge is place-based observation of the environment, and a holistic view of the ecosystem and humans' place within it. A mātauranga Māori-centred understanding of the environment tends to use indicators relating to observable states and wellbeing descriptors (for example the clarity of river water, or whether people feel a sense of calm and enrichment when they are in the area) rather than the biophysical markers of other scientific methods.

LOCAL KNOWLEDGE AND CITIZEN SCIENCE

Local communities contribute to projects to help understand or protect their local environment, either informally or through the concerted effort of nonprofits and community groups.[17] These citizen science projects can include individuals monitoring their local environment using sensors or other recordkeeping practices, and sharing data in order to build understanding and support environmental decision-making. In addition, different regions have strong bodies of local knowledge gained through everyday interactions. This knowledge may be related to weather patterns, growing conditions, tides and watersheds, and wildlife behaviours and populations. Currently, these local practices don't always feed into national-scale environmental reporting. However, there are opportunities to strengthen connections between local and national systems for the benefit of everyone.

SPOTLIGHT

Citizen Science

Combining people power and technology in citizen science projects.

Citizen science — public participation in scientific research — is carried out by many groups and communities around Aotearoa. Citizen science projects may include monitoring water and soil quality, and collecting data on wildlife populations. These projects empower communities and support a broad range of positive environmental outcomes.

AI can be used to drive and support community efforts in many ways including access to expertise. For example, to identify species spotted in a certain area. It can also help facilitate environmental reporting, for example a chatbot can provide an easy way for people to report environmental pollution or wildlife incidents to the relevant authorities. Machine learning can also provide easy-to-understand information about the impact of people's activities, including environmentally-focused efforts like planting, trapping and beach cleanups and other activities like farming, forestry or fishing. The increasing availability of open source resources, user-friendly tools and online courses will aid the accessibility of AI technology for communities and environmental organisations. Complementary tools including cameras, acoustic recorders and other sensors can work with AI to further support and accelerate local initiatives.

Images provided by wildlife.ai

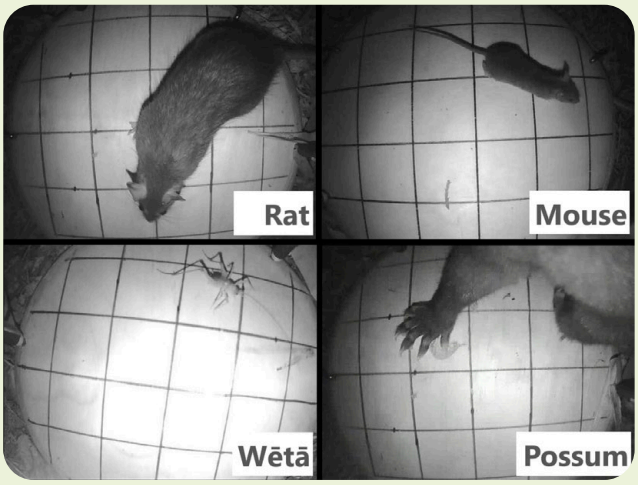


image provided by wildlife.ai

Wētā Watcher

PARTNERS: Wildlife.AI in association with Te Kotahitanga o Te Atiawa Trust, Indemic Ltd., Taranaki Mounga and the Department of Conservation.

Monitoring and learning about insects and reptiles is an essential part of preserving biodiversity. However, their small size and camouflage skills make them difficult to monitor, leading to information gaps. Wildlife.AI, working together with community groups and local students, are designing and field testing a system called Wētā Watcher to help solve this problem. The Wētā Watcher device records videos of ground-dwelling invertebrates and herpetofauna (lizards/geckos) in their natural environment. As an animal crawls under the Wētā Watcher device, their movement triggers the camera, which records a short video. A machine learning algorithm in the device identifies the animal and sends a signal to the cloud, with information about the species, the date, and the location. This information is captured and collated and can be used to help community groups and wildlife managers to know where the animals are, and better learn how to prevent species loss. The device is designed to be low-powered, open source and 3D print available, making it convenient to use in remote or wooded areas, and more readily available to communities.

AI for the Environment

In this section, we explore AI as a tool to support the environment in Aotearoa New Zealand. This section also outlines the areas where AI can help efforts to support the environment, the global context and the opportunity for Aotearoa New Zealand.

What do we mean by Artificial Intelligence?

Artificial intelligence (AI) can be defined as the theory and development of computer systems that can perform tasks that normally require human intelligence, such as visual perception, speech recognition, and decision-making.[18] Among the multiple tasks associated with AI, the ability of computers to "'learn' patterns from data (machine learning) is arguably the most relevant today. This report focuses on narrow AI – that is, AI programmed to perform a singular or limited task – which is currently in broad use across research and commercial domains. Further definitional details can be found in the AI Forum's 2019 report, *Towards our Intelligent Future - an AI Roadmap for New Zealand*.

About Machine Learning

In most cases, the type of AI we are discussing in this report is machine learning (ML). There are over 100 types of ML algorithms and their use depends on the tasks involved. A comprehensive overview of ML algorithms and their use is beyond the scope of this report, however several examples are detailed as follows.

Deep Learning is a type of ML model based on artificial neural networks that can be used to overcome complex environmental challenges. Examples of environmental applications include automatically processing thousands of wildlife images to monitor animal populations,[19] modelling the global impacts of climate change,[20] and tracking illegal wildlife trade on social media.[21] Deep learning is of particular relevance to this report as recent improvements in these algorithms, and their broadly open source policies, have led to a widespread use across the environmental sector.

Other types of ML models that can support environmental analysis include **Support Vector Machine** (SVMs) models, which can help unravel underlying distributions and patterns from high-dimensional data.[22] Also, **random decision forests** which provide well supported predictions for datasets with large numbers of independent variables.[23]

Explainable AI (XAI), a toolbox to better understand ML models, is also increasingly relevant. Explainable AI can help minimise common risks and unintended consequences while also producing easier to understand environmental predictions, classifications and interrelationships.

AI Is Well-suited to Support the Environment

Compared with traditional approaches of collecting, processing and analysing information, the features of AI systems – like providing fast data analysis at scale and drawing inferences from complex interconnected processes – can provide benefits in our efforts to address a range of environmental issues.

For example, remote sensors can collect data from multiple and diverse sources. This data can be processed automatically and stored in the cloud enabling global insights across multidisciplinary teams and highly reproducible outputs which supports multi-temporal analysis.

Photo Credit: Chris Williams

Key Areas Where AI Can Help Efforts to Support the Environment

AI can help accelerate the understanding of, and action towards, positive environmental outcomes. There are several key ways for AI to support the environment in Aotearoa New Zealand, including:

Processing Big Data and Providing Near Real Time Information

AI can process large quantities of data and perform complex mathematical calculations in short periods of time. This enables users to quickly gain insights about the state of the environment. Using ML and combining data from multiple sources can also help uncover hidden patterns and relationships in the environment.

Applications may include:

- early detection of invasive species, or disease and stresses in native species.
- creation of robust longitudinal historical data describing the environment across areas such as land use, ecosystem services and erosion.
- faster reporting and enforcement of illegal activities like fishing, trade of wildlife and waste dumping.

More Accurate Predictions and Modelling

AI models can also outperform the predictive power and inference of common statistical tests used in the environmental sector. They can combine data from multiple sources, for example, cameras, acoustic recorders, weather stations or satellite monitoring systems. This enables national scale, holistic and multidisciplinary insights to guide environmental management and the development of regulations. AI models can also standardise ways of collecting data and reduce human-induced bias.

Applications may include:

- presenting potential impacts of different climate policy options on urban and rural areas.
- understanding the potential behaviour of species that do not have significant data collected about them.
- building 3D spatial reconstructions from light detection and ranging (LiDAR) or multiple images to reveal changes on topology/ hydrology and assess the overall health of forest ecosystems.
- wildfire science including fire detection, fire susceptibility and fire behaviour prediction.

Answering Specific Questions to Support Decision-making and Identify Where to Put Effort

Techniques such as augmented intelligence can enhance human decision making by gathering many types of structured and unstructured data. Data can then be presented in a way that provides human users a holistic view in response to specific questions. This is particularly useful for resource allocation and in time-constrained and multidisciplinary areas. For example biosecurity, environmental disaster response, and policy development, monitoring and enforcement.

Applications may include:

- identifying when predator control is required in a certain area, or when to adjust fishing quota limits.
- guiding the design and development of new infrastructures in ways that minimise negative environmental impacts.
- combining cultural, social and environmental information to identify high priority conservation areas.

Detecting and Labelling Features of Interest in Sensor Data to Improve Monitoring and Analysis

AI is an effective tool for processing raw data collected from satellites, aerial survey systems, unmanned autonomous vehicles (UAVs), camera traps and acoustic recorders. AI can transform raw data into relevant environmental variables for further analysis. The analysis of data from remote and autonomous sensors can expand the area and time sampled when collecting environmental information, and help to scale human expertise.

Applications may include:

- monitoring species diversity and behaviour (both pests and native species).
- understanding changes in land use over time using computer vision and analysis of historic aerial photographic records.
- tracking composition and quality of soil and waterways at finer scales.

Gaining New Insights From Historical Data

Computer vision, text recognition and natural language processing (NLP) methods are efficient ways to extract new knowledge from various forms of archived media. These techniques can help with processing information from written text or audio files into computer readable data, and the analysis of that data. This can help build a deeper picture of changes in various aspects of the environment in the preceding century or longer.

Applications may include:

- processing of data in handwritten ship logs to understand changes in ocean conditions.
- performing sentiment analysis on handwritten fieldwork dairies to extract insights about flora and fauna over time.
- analysis of existing recordings from native bush areas to identify sections where there are native bird calls.

It is expected the opportunities of AI for the environment, and the risks that accompany them, will change over time as technology evolves. In its 2018 report, *Harnessing Artificial Intelligence for the Earth*, PricewaterhouseCoopers (PwC) notes that current applications of AI to support "earth challenges" largely use supervised or semi-supervised learning to make sense of large real-time datasets. It notes that "future applications will likely involve more systems propelled by autonomous decision-making where AI acts independently, thus creating new opportunities and risks."[24]

The Benefits Extend Beyond the Environment

The development and broad implementation of AI for the environment will have a significant return on investment in Aotearoa New Zealand. The benefits will extend to our industries, economy, and improved human health and social cohesion.

AI for the environment aligns with many of the wellbeing domains of the Treasury's Living Standards Framework 2021, including environmental amenity, subjective wellbeing and health. It also contributes to all four aspects of the wealth of Aotearoa as outlined in the Living Standards Framework: the natural environment (primarily), social cohesion, physical and financial capital and human capability.[25]

MAUI63

FOCUS AREA: Preserving and bolstering biodiversity

MAUI63 is a nonprofit developing an AI-powered tracking drone to autonomously find, follow, and uniquely identify Māui and Hector's dolphins. Māui dolphins are found only off the west coast of Aotearoa's North Island. They are one of the world's rarest subspecies — with only around 63 dolphins alive today.

Currently, there are big gaps in our understanding of Māui dolphin behaviour and territory. The greatest threats the dolphins face are location-related — contact with fishing boats and nets, toxoplasmosis, or problems related to changing ocean temperatures. However, traditional monitoring techniques only allows for Māui dolphins to be surveyed for a few weeks, every few years.

MAUI63 aims to change this with the support of key partners including the World Wide Fund for Nature (WWF), Aware Group, Microsoft, Moana, Department of Conservation (DOC), Sanford and the Ministry for Primary Industries (MPI). Together, they are designing an autonomous monitoring system to find and follow dolphins. The system consists of a long range camera equipped drone that records video footage. This aerial footage is reviewed using object detection models that quickly identifies dolphins in the ocean. The first machine learning model developed by the team can detect Māui and Hector's dolphins with ~96 percent accuracy compared with a trained person manually tagging images, at 1,000 times the speed. Future machine learning models in development aim to identify the unique fins of each individual dolphin so specific dolphins can be spotted and monitored over time.

The information obtained by the MAUI63 system has the potential to help stop the decline towards extinction of these unique dolphins. The up-to-date data they provide will allow policy makers to accurately update restricted ocean zones, ensuring fishing boats steer clear of the dolphins to help ensure their safety. This partnership between a conservation nonprofit, the fishing industry, and government points towards an exciting future of collaboration, where AI can be designed and deployed with benefits for all.

Maui63.org

Globally, AI may be able to remove waste in a circular economy for food worth $127 billion a year.

There is currently limited data about how AI for the environment contributes to economic outcomes in Aotearoa New Zealand. However, we can explore examples globally to help understand the potential. For example, research by the Ellen MacArthur Foundation and Google estimates the potential value that can be unlocked by using AI to help design systems that reduce waste in a circular economy for food is up to $127 billion a year by 2030. This value will be realised through opportunities in farming, processing, logistics and consumption aspects of the product life cycle.[26]

In Aotearoa New Zealand, some of our largest industries rely on a thriving environment for their long term viability. For example, the food and fibre sector, which includes many of our primary industries, is expected to contribute $50.8 billion in the year to June 2022.[27] However the Environment Aotearoa 2022 report found that highly productive land was becoming less and less available and that New Zealand was risking its current food production systems becoming unsustainable in the future. Prior to the Covid-19 pandemic, annual tourism spending totalled $41.9 billion a year.[28] Additionally, research suggests that time spent in nature has direct, positive effects on human health and wellbeing,[29] and the health impacts of pollution and extreme weather events have a significant economic cost.

The Global Context of AI for the Environment

Countries are at different stages of the development and implementation of national AI strategies and policies. According to research from the Organisation for Economic Cooperation and Development (OECD), 21 countries have released national level AI strategies as of 2021, however only seven of these include the environment or climate change as an area of focus for AI.[30]

An analysis of these strategies finds a varying degree of detail.[31] The Australian report identifies the environment as a major area for AI work and the French AI strategy has a clear focus on the environment, including specific ways to address issues. Likewise, China's AI strategy mentions sustainability and the environment, including specific plans for the use of AI for environmental protection. Meanwhile, the United Kingdom's (UK) AI Sector Deal only lightly touches the subject, including examples of open environmental data.

There has been significant work produced by international AI organisations and consultancies to identify opportunities and challenges presented by AI for the environment. In 2018, PwC published *Harnessing Artificial Intelligence for the Earth*, which was developed alongside the World Economic Forum (WEF) and other partners.[32] The

report outlines opportunities for AI to support six global 'earth challenges' aligned broadly to the themes covered by this report. In 2021, the Global Partnership on AI published *Climate Change and AI: Recommendations for Government Action*, examining the potential applications of AI for climate outcomes in a global context.[33] The report concluded that AI brings significant opportunities to accelerate strategies for climate change mitigation and adaptation, across multiple areas including energy, land use and disaster response. The report also highlighted that lesser resourced regions, including those in the southern hemisphere are likely to suffer the most from both climate change and digital transformation of the global economy.

Currently, several global technology companies including Google and Microsoft are making significant contributions to AI supporting environmental outcomes and sustainability focused AI services. For example, Microsoft's Planetary Computer combines large volumes of global environmental data with application programming interfaces (APIs), enabling users to answer global questions about the data, and making the answers available to conservation stakeholders. Google's Environmental Insights Explorer (EIE) is a freely available platform using a range of data sources and modelling capabilities to help cities measure and analyse emission sources. The platform provides actionable data to help cities identify strategies to reduce emissions. This includes air quality, building, transportation and tree canopy data, plus rooftop solar potential.

The recently announced Multi-Mission Algorithm and Analysis Platform, jointly developed by the National Aeronautics and Space Administration (NASA) and the European Space Agency, is another example of an initiative collating data and applying AI to make a difference to at-risk ecosystems.[34] The open source project collects data on the biomass of forests across the planet from a variety of sources including satellite instruments, the International Space Station, and airborne and ground surveys. AI is then developed and refined by a team of global scientists to combine these heterogeneous data sets and make them interoperable.

Building Climate Friendly AI Systems

While AI systems can have positive impacts on the environment, their use can also have negative impacts. During our interviews we heard how New Zealand has an opportunity to be world leading in the development of green AI technology. This includes systems that use minimal amounts of energy. While beyond the scope of this report, it is an important consideration for those developing AI, including government and other organisations.

The Global Partnership on AI's (GPAI) report *Climate Change and AI: Recommendations for Government Action* summarises AI's climate impacts in three categories:

- the energy use associated with computation tasks. For example, training AI algorithms and developing and running hardware.
- the potential for AI to facilitate activities associated with high greenhouse gas emissions like oil and gas extraction.
- deeper systems level effects from AI being widely adopted. For example, the potential of self-driving cars to increase reliance on individualised transport options.[35]

The GPAI report's recommendations for addressing the negative climate impacts of AI include avoiding direct funding from governments for AI applications that counter climate goals.

Current State of AI for the Environment in Aotearoa

In Aotearoa New Zealand, AI is currently being used to support the environment in a number of exciting ways, with a diverse range of projects from groundbreaking fundamental research to fully operationalised AI-based systems.

Participants include businesses, university researchers, Crown Research Institutes (CRIs), government agencies, not-for-profit and non-governmental (NGO) organisations. In this section, we provide an overview of the current state of AI for the environment in Aotearoa.

Overall Maturity and Shape of the Field

Across our ecosystem, there is plenty of interest in the potential for AI to help improve our understanding of the environment, enhance measurement systems, model complex inter-connected environmental systems, surface new insights, and accelerate work to support and care for our natural world.

However, many of these projects are in their initial research and development (R&D) phases. A relatively low proportion of the projects are already in operation and having an impact, indicating that the field is still nascent.

During our research, we documented 60 projects that specifically aim to improve environmental outcomes. These projects provide representative examples of existing R&D and production systems. They provide insights about current capabilities, capacity and distribution across the public and private sector, application area, and overall end user utility of AI for the environment.

A relatively low number of projects have been operationalised across Aoatearoa New

Photo Credit: Paul Sutherland Photography

Zealand and many remain or only ever existed in a R&D phase. The nascent nature of the field also presents an opportunity to grow and scale a robust, holistic, broad-based AI for the environment ecosystem that reflects the values and cultures of Aotearoa New Zealand.

In their AI maturity model, consulting firm Gartner describes five levels from Level one: awareness to Level five: transformational.[36] We estimate the overall state of Aotearoa New Zealand's AI for the environment ecosystem is Level two: active. At this level, there is active experimentation, mostly taking place in a data science context. This is largely the case in Aotearoa New Zealand, although there are some advanced outliers. For example, some research organisations with deep experience using advanced computer analysis of environmental data are at a higher stage of maturity, as are some businesses which have AI and data science at their core.

In organisations focused on improving environmental outcomes, a significant barrier to integrating AI is limited capacity and capability to operationalise projects. The nascent understanding of future opportunities where AI might support their work is a further barrier.

For companies intending to develop AI tools, funding is a notable barrier. This reflects the primary outcomes of the technology, environment and social, are likely to be non-financial.

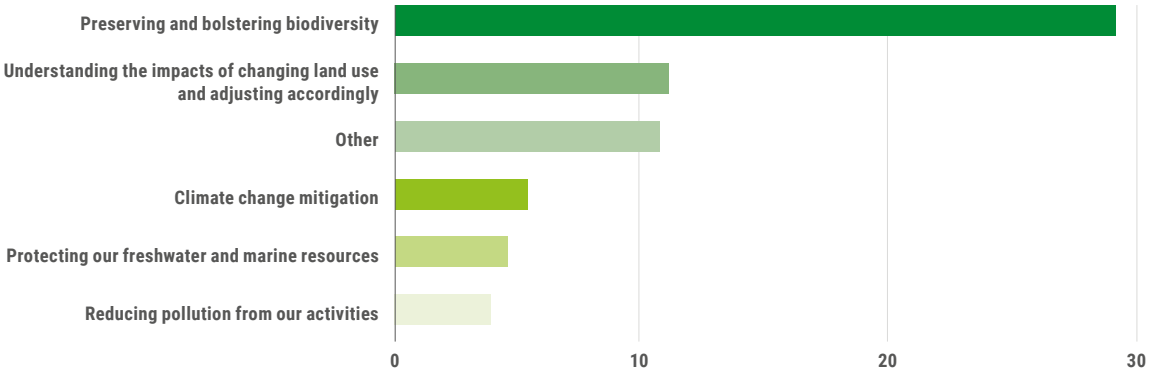
Areas Where Work is Concentrated

Our research identified 60 AI for the environment projects – 26 through our online survey and the remaining 34 through our interviews and wider research. The following summary indicates the concentration of work and applications currently gaining momentum. However, this summary is not complete or definitive.

Projects by Primary Environmental Outcome

As shown in the chart below, work underway on AI for the environment has clear concentrations in two of the five environmental outcomes.[37] Currently, there are 27 projects aiming to preserve and bolster biodiversity and 11 projects that aim to understand the impacts of changing land use. We note that approximately half of the projects aim to contribute to two or more environmental outcomes and we have subsequently categorised them by the primary area of focus.

Figure 1: Primary environmental outcome to which current AI for environment projects contribute



Source: AI Forum of New Zealand, 2022

Table 1: Main types of AI for Environment projects

	Preserving and bolstering biodiversity	Understanding the impacts of changing land use and adjusting accordingly	Climate change mitigation	Protecting our freshwater and marine resources	Reducing pollution from our activities	Other	TOTAL
Species recognition or ID	19			1			**20**
Data analysis	3	2	3	2		8	**18**
Remote sensing	3	8	2	1	1		**15**
Image processing	2	1			1		**4**
Support						2	**2**
Unsure					1		**1**
TOTAL	**27**	**11**	**5**	**4**	**3**	**10**	**60**

Source: AI Forum of New Zealand, 2022

Main Types of AI Projects

Current projects engage a range of AI capabilities, concentrating in a few areas. For example, species recognition or identification is often used for projects that focus on preserving biodiversity. Data analysis and remote sensing are other common features of projects, and are used across almost all of the theme areas. Table 1 above classifies projects only under one type, but we acknowledge that data analysis is deeply embedded in other types, such as remote sensing and species recognition.

Snapshot of Current Initiatives

This summary details some of the projects underway in the AI for the environment landscape.

Preserving and Bolstering Biodiversity

Most projects supporting this outcome use AI in conjunction with data capture technologies. This includes drones, Internet of Things (IoT) sensors, audio recording devices or camera traps to help identify the location, abundance or behaviour of different native and pest species.

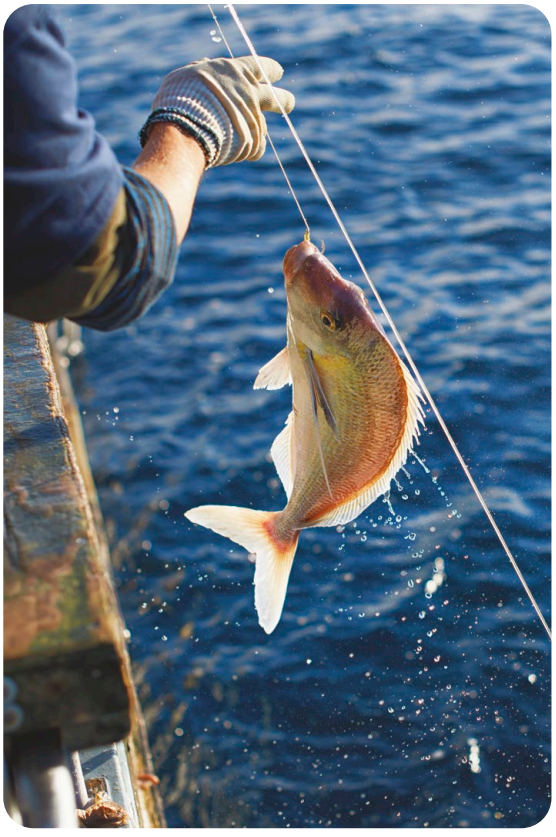


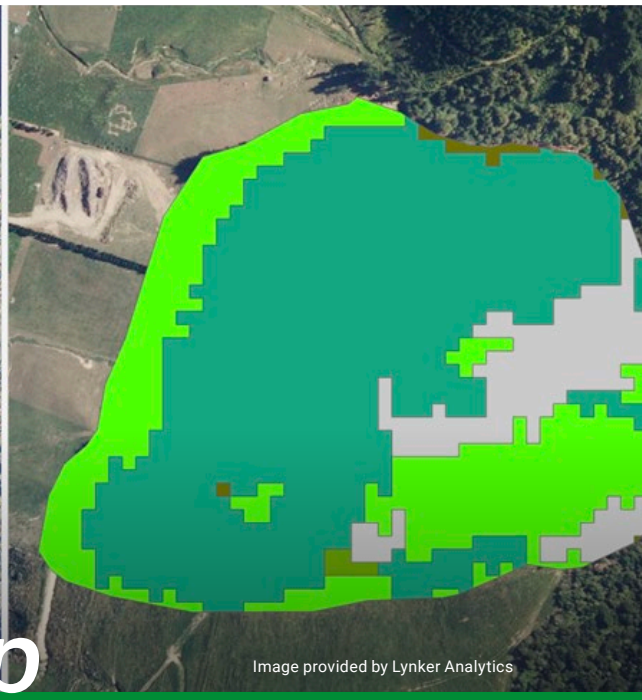
Photo Credit: Chris Sisarich

For example, ***Zero Invasive Predators*** (ZIP) uses AI software on camera lures to detect the presence of pest species in the Leith River Valley. Real-time notifications are sent to the project team. These tools are used to support ZIP's goal of completely removing possums, rats and stoats from large mainland areas.

Other projects focus on enabling the greater understanding of our native wildlife using either real-time or historic data. For example, ***AviaNZ*** is a collaboration between mathematicians, data scientists and conservation biologists to develop open source tools to analyse live audio recordings of wildlife. AviaNZ is primarily used to record birds and enable statistically reliable abundance estimates using machine learning and computer vision. Meanwhile, DOC has also focused on understanding the presence of native birds. Their collaboration with Qrious identified kiwi calls from hours of pre-recorded audio, dramatically reducing the audio that experts need to analyse.

Understanding the Impacts of Changing Land Use and Adjusting Accordingly

Most of these projects are focused on the development or application of AI tools and techniques (including computer vision, deep learning and pattern recognition) to understand specific land cover or land use and how this use changes over time. Many of the projects use current or historical aerial or satellite imagery. The ***Mountain Research Centre's Matariki*** project uses advanced computer vision to generate accurate high-resolution topographic maps to understand subtle surface elevation changes over time. The Ministry for the Environment and several local authorities have successfully used deep learning (using aerial photography, satellite imagery and LiDAR) to predict land cover, activity or the extent of ecosystem services such as wetlands. These approaches enable more frequent and wide scale observation of environmental change than previously available. The Ministry for the Environment is also leading a test case which uses AI pattern recognition tools to scan aerial imagery to identify activity or land use with the potential to cause land contamination. Contaminated land has hazardous substances on or in it and is reasonably likely to have significant adverse effects for the environment, including on the health of people. [38]



LUCAS 2020 Land Use Map

Image provided by Lynker Analytics

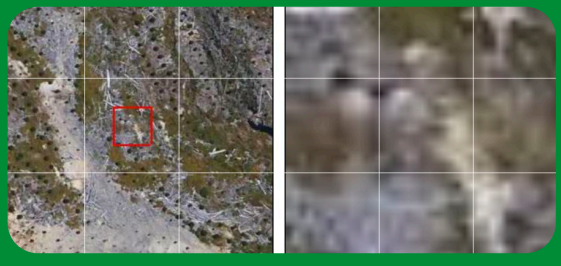
FOCUS AREA: Understanding the impacts of changing land use and adjusting accordingly

The *Land Use and Carbon Analysis System* (LUCAS) keeps track of land use change in Aotearoa New Zealand, especially in forests. Tracking changes in forest cover and grasslands is essential to understanding the impact of land use change on our greenhouse gas emissions. It also ensures land can support human habitation and contribute positively to climate outcomes.

Deforestation is an important form of land use change, with assessments conducted in New Zealand every two years to meet international reporting obligations (the United Nations Framework Convention on Climate Change and the Kyoto Protocol). However, collecting and analysing the information needed to accurately monitor changes in forest cover is technically and logistically challenging.

To help produce the 2020 LUCAS land use map, the Lynker Analytics Consortium was contracted by the Ministry for the Environment to survey and classify approximately 7,500 distinct areas of forest loss across New Zealand, to track changes in deforestation (compared to previous data). Cessna aircraft were used to conduct an aerial survey of all the areas delivering 0.25m resolution vertical aerial photography in over 99 percent of target areas. The imagery was georeferenced and then classified into land cover classes, using machine learning models. These classes included pasture, harvested land, new plantings and mature native forest.

This ***automated monitoring system*** reliably detected a range of land covers associated with deforestation, replanting and other change activities exceeding one hectare. This enabled more rapid assessment of replanting status by the Ministry for greenhouse gas reporting. LUCAS is a powerful example of how government and industry can work together to use data collection and AI tools to understand, manage and improve the health of our environment.



Climate Change Mitigation

We identified five projects with climate change mitigation as the key outcome. However, we expect a wide range of AI applications will have climate benefits, even if it is not their primary aim. AI can accelerate the process of scientific discovery about environmental systems, often by incorporating known physics-based constraints with approximations learned from data. AI can also optimise complex systems. For example, reducing the energy required to heat and cool a building or optimise freight delivery schedules. Benefits may come from making processes more efficient, reducing emissions in the process, or by understanding impacts of various activities and informing policy decisions.

Reducing Pollution from Our Activities

We identified three projects which had pollution reduction as a primary environmental outcome. Xerra Earth Observation Institute (Xerra) and Auckland Council have partnered to develop a product that automatically identifies building sites from satellite imagery. This will help council staff visit and assess sites early in their construction phase. They can then check for and mitigate issues such as sediment, stormwater runoff, changes to land stability and visual impacts on landscapes. Mahi Maioro Professionals described a project to undertake AI-based analysis of river characteristics using smartphone images. This allows for the recognition of ecological processes and river habitats to be automated, with AI improving the accuracy of the process. This project incorporates mātauranga Māori into its approach, however, it has not received funding to progress in 2022.

Image provided by Safeswim

Stay Safe in the Water

FOCUS AREA: Reducing pollution from our activities

In 2017, Auckland Council launched the Safeswim website, an initiative that empowers beach users to make informed decisions on when and where to swim. Safeswim is a partnership between Auckland Council, Watercare, Surf Life Saving Northern Region, Surf Life Saving New Zealand, Northland Regional Council and Auckland Regional Public Health Service.

Safeswim combines real-time information on the performance of wastewater and stormwater networks with data-driven predictive models. The modelling is underpinned by regular sampling to forecast water quality at swimming sites.

Generally, water quality at Auckland beaches is good, however high rainfall and other factors can lead to unhealthy conditions. Water quality sampling is a manual and time consuming process, but Safeswim augments the monitoring with multiple sources of data. Safeswim encourages people to 'check before you swim', by visiting the website to check for live information on water quality and swimming conditions.

Safeswim's predictive modelling is built using rainfall and tide data, with a historical time series of water quality testing results for intestinal enterococci and Escherichia coli (E. coli). Modelling estimates the likelihood of high pollution levels and classifies beaches as red when the risk of illness by ingestion exceeds five percent.

In collaboration with researchers from the University of Auckland, Safeswim data has been used to investigate how different machine learning techniques, including boosting decision trees and multi-layer perceptron artificial neural networks, provide much higher accuracy in terms of both sensitivity (over 75 percent) and specificity (over 90 percent) compared to common statistical methods.[39]

Safeswim is an improvement over the previous system, which had a 48 hour delay between sample collection and public reporting. More transparent public reporting has also increased public awareness about the causes of water pollution, and media coverage of water quality issues has increased dramatically since Safeswim's launch. With the help of predictive models and local knowledge, Safeswim is helping people stay safe in the water and increasing demand for public accountability regarding water quality and pollution.

Safeswim.org.nz

Protecting our Freshwater and Marine Resources

Projects in this area use a range of technology to understand the use and quality of water, and the species that live within it. Applications range from the ***Wildlife.ai Spyfish Aotearoa*** project to classify target fish species from underwater footage, to the ***Forest Flows*** research project led by the New Zealand Forest Research Institute (Scion), which focuses on developing methods to predict and optimise water use for planted forest areas. Lakewatch is a project by Xerra to develop and prototype a water quality monitoring tool which would allow regional councils to undertake real-time monitoring from satellite images.

Observations About the Current State of Play

There are a range of AI for the environment projects underway in Aotearoa New Zealand. However, many of these projects are still in development and the field of environmental AI is only beginning to display signs of future potential.

AI for the Environment Work is Taking Place Across a Number of Domains

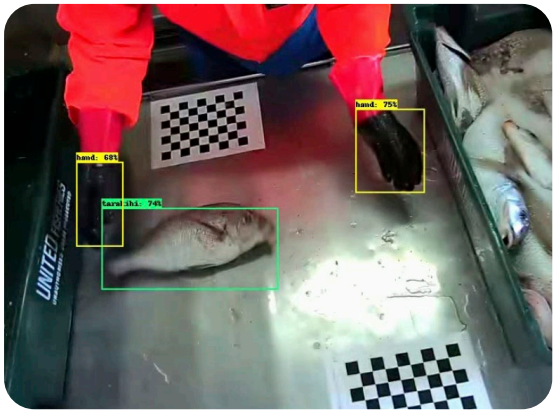
Environmental AI work is currently underway in organisations across many sectors, including government, Crown Research Institutes (CRIs), the private sector, universities, not-for-profit and non-governmental (NGO) organisations. Many projects are collaborations between one or more types of organisations. For example, businesses working with government agencies or research institutions partnering with NGOs.

Aotearoa New Zealand has a Strong Pedigree in Research

University researchers and CRIs are undertaking fundamental research on AI and play active roles in global AI research. This includes many aspects from developing ML and statistical tools, for example Waikato Environment for Knowledge Analysis (Weka) and R, to building AI-powered COVID-19 response tools.[40] The link between research and practical implementation is still emergent, but will be a vital part of ensuring Aotearoa New Zealand has a robust AI ecosystem.

AI is One Vital Tool in a Broader Data Ecosystem

AI doesn't function independently, it is a vital tool in a broader ecosystem. For example, AI often relies on large data sets, produced as part of a larger data ecosystem of collection, cleaning, management and upkeep. Increasing the frequency and consistency of data collection using complementary digital technologies (for example, IoT devices, sensors and satellites) enables better quality environmental data to be gathered. Once data is collected, it can be analysed and supplemented using AI techniques. Similarly, AI alone is not a cure-all for addressing environmental outcomes. AI can help improve decision-making, delegation of resources or understanding of the current state of the environment. However, this must be accompanied by increased investment, relationships with communities and a concerted effort on the ground.



Part Two

32 Towards a Thriving AI for the Environment Ecosystem

Reflecting our Unique Context

Aotearoa New Zealand's unique natural environment and cultural context presents specific environmental and ethical challenges. These challenges need to be considered when designing and implementing AI systems. This consideration will vary depending on the goals of the project, organisations involved and whether built from scratch or using off-the-shelf solutions.

> *"A lot of mātauranga is about the quality of the environment, and this could be put at the centre of AI systems. Ideally, you would have mātauranga Māori feed into the logic of the AI models and data systems."*
>
> Maui Hudson, Te Kotahi Research Institute

In addition, we also have the opportunity to build unique solutions that contribute to the preservation and stewardship of the environment locally, and the development of the sector globally.

In this section, we outline some considerations for implementing AI for the environment projects.

Considerations: AI for the Environment in Aotearoa New Zealand

As government, organisations, researchers, and businesses deepen their understanding and support of our environment with the help of AI, it will be important to:

- unite and align researchers and innovators across the education, public and private sectors.
- ensure our efforts are climate-friendly and use renewable energy sources, to avoid external carbon costs.
- support our economy and reward innovation.
- are equitable, inclusive and distribute benefits to all.
- consider mātauranga Māori traditional knowledge, including in the identification of environmental indicators and algorithm design.

What could our Future look like?

Incorporating these principles will result in a diverse range of AI applications and systems. For example;

- **Māori-centered projects:** AI modelling tools which have mātauranga Māori built into their logic help demonstrate the impacts of potential interventions, so communities can

make decisions about future land use and conservation projects. For example, a local iwi monitors sections of their river with sensors. The resulting data is combined with local knowledge to deepen a holistic understanding of the ecosystem.

- **Partnerships to better understand our environment:** farmers, iwi and regional councils share relevant privacy protected environmental monitoring data with government agencies. This interoperable data is combined with national satellite imaging to gain a nationwide picture of our land and climate. The government is able to make strategic funding decisions using AI and other tools. This national level data is reciprocated with communities for their own purposes and benefits.
- **AI citizen science:** Family and whānau throughout Aotearoa New Zealand use chew cards and IoT sensors with low-powered cameras in their backyards to track native wildlife and pests. Photos of chew cards and images from IoT cameras will be analysed by an AI tool. As species are identified in real time, data is added to their household dashboard. This information can then be shared to help build a picture of predator populations in their town or city.

Photo Credit: Sara Orme

"Māori have strong intergenerational science knowledge and practice in dealing with real-world problems and opportunities. And we know this knowledge continues to have immense potential, especially where it can be aligned with western science and technology."

Maria Amoamo, Merata Kawharu and Katharina Ruckstuhl
He Pou Hiringa: Grounding Science and Technology in Te Ao Māori [41]

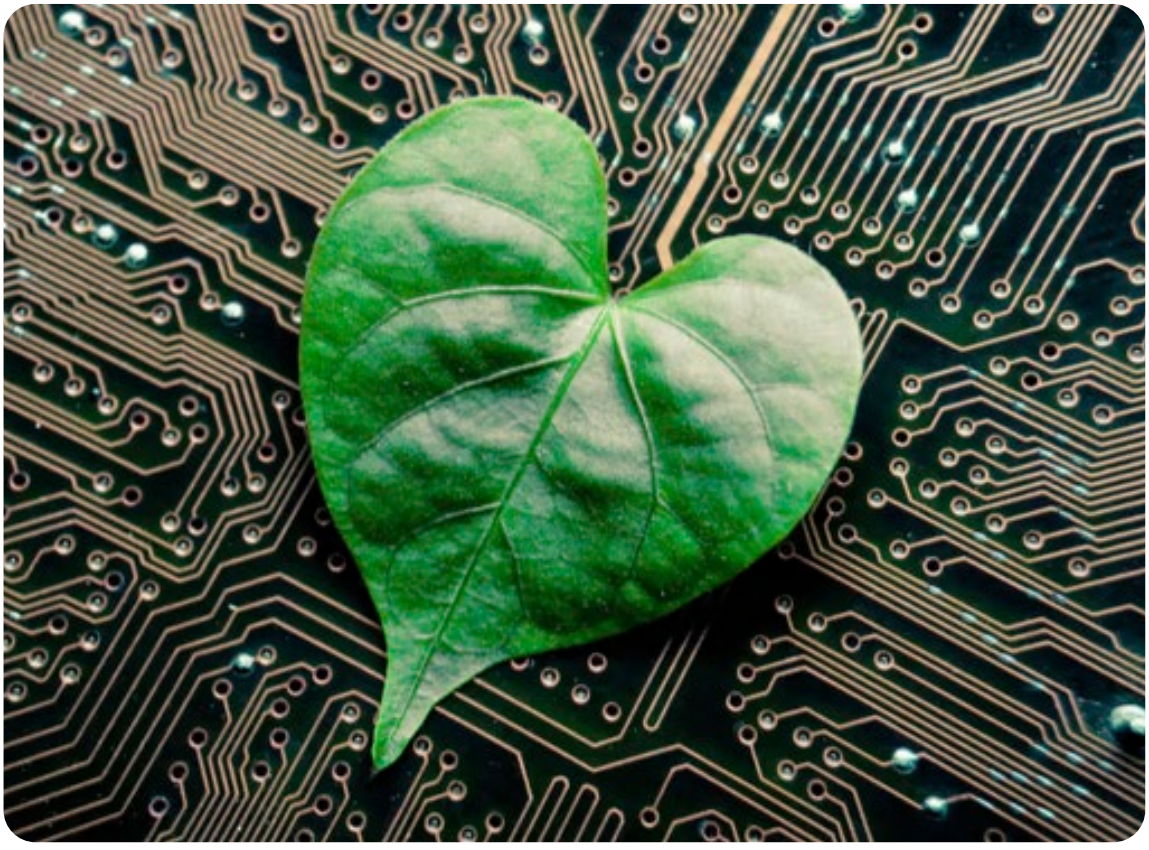
Challenges in Growing the Field

AI practitioners and environmental monitoring organisations face a number of challenges to successfully build and operationalise AI for the environment projects. Several key challenges need to be resolved in order to strengthen and expand the field.

Silos, Fragmentation and Competition

Collaboration between and across different organisations is necessary to support the development and operationalisation of AI for the environment. However, currently this can be challenging. For example, competing institutional incentives (academia's publishing requirements, intellectual property (IP) constraints and financial imperatives) can hinder successful partnerships.[42]

Government's research funding has increased significantly in the last decade. However, its distribution has led to precarity in organisational revenue for CRIs and unproductive competition across the research system.[43] This lack of coordination and collaboration can result in some replication of efforts,[44] while other areas of AI remain underdeveloped.



Meanwhile, considerable decision making and monitoring of the environment occurs in industry, especially in the agricultural sector. Partnership and information sharing is essential for developing environmental AI, but privacy, IP and regulation concerns often constrain these opportunities.

Barriers to Operationalising AI

Transitioning AI for the environment projects from research to operation can be complex and expensive. For organisations interested in implementing environmental AI projects there is a big learning curve and trial and error process. These challenges do not only apply to environmental projects – only an estimated 13 percent of data science projects make it into production.[45] Many organisations have limited resources and capability to contemplate the opportunities and potential that AI can offer.

The hype of AI can also lead people to be disillusioned when projects underperform or do not offer immediate results. While CRIs, universities, not-for-profits and NGO organisations are developing new applications there is currently a gap in scaling and operationalising them in partnership with businesses or government agencies. It is also likely that organisations will underestimate the time it takes to implement and operationalise an AI system.[46]

Our research also identified the need for better financial incentives for organisations to implement AI for the environment.

Access to Sufficient High Quality Data

Many applications of AI require large, high quality data sets to function well. Access to sufficient quality environmental data is a challenge especially in government agencies. Agencies may encounter gaps, with not enough data to properly report on the environment, while available data may not be high quality or consistent enough to use with AI applications. This is especially the case when scaling reporting to a national level.

In addition, environmental measurements and data standards are not consistent between regional bodies. As a result, comparisons are difficult and analysis is time consuming. Collecting more data, and changing monitoring and data standards to improve interoperability, is costly and complex, but is necessary to advance applications within government agencies. Currently, the National Environmental Monitoring Standards (NEMS) project, led by a steering group from regional councils and the Ministry for the Environment 'aims to ensure consistency in the way environmental monitoring data is collected and handled throughout New Zealand'.[47]

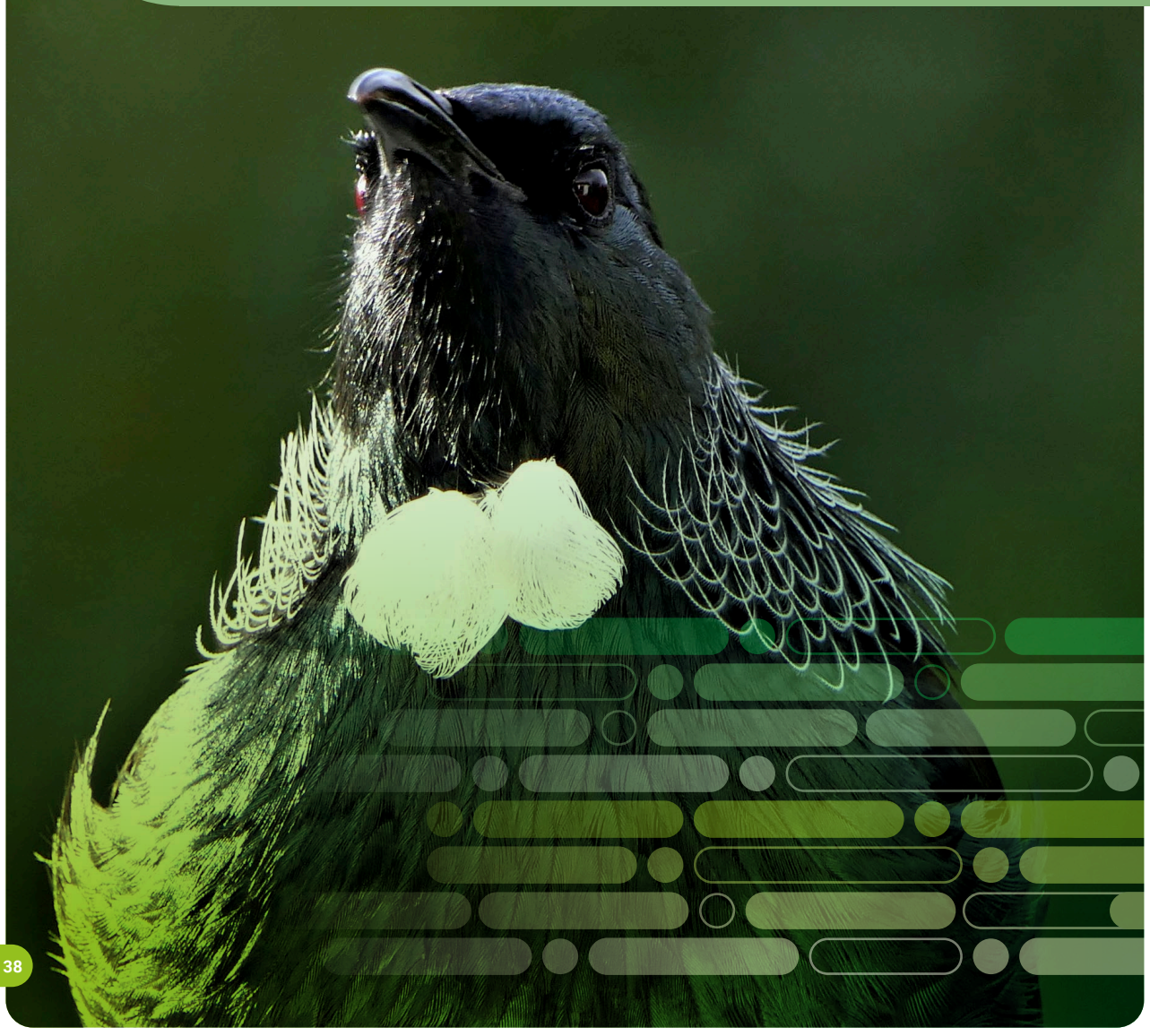
Beyond government, access to good data is essential for all AI projects. For Māori communities, enabling access to existing data or increasing culturally appropriate environmental data collection will be key to fostering Māori AI initiatives.

Integrating Māori and other Scientific Approaches

There is an opportunity for a range of AI for the environment projects to incorporate mātauranga Māori into their design and implementation, project partnerships and fostering Māori-led innovation. In many cases, this will require a significant shift in how technology is developed and deployed. Many organisations are aware of the need to ensure AI practices enable Māori data sovereignty and consider mātauranga Māori. However, this opportunity and responsibility requires overcoming challenges in capability, capacity and mindsets. Māori data and AI experts have limited capacity and many are already overburdened with requests to contribute to work and provide coaching on key issues.

Part Three

38 Enabling Aotearoa's AI for the environment ecosystem



From here to there...

Gaining a more substantial, mature and operationalised AI for the environment sector will involve overcoming the challenges outlined in the previous section.

However, the current low maturity also presents immense opportunities for growth and innovation for a range of organisations. Collectively, accelerating our efforts to monitor, understand and support the environment benefits us all.

Build a Coherent Environmental Data Ecosystem

As previously discussed, a thriving AI for the environment ecosystem requires appropriate, high quality data available for analysis and use. Currently, there are several aspects that need to be addressed:

Filling Data Gaps

It is essential for a thriving AI system to have appropriate, interoperable datasets. Currently, there are significant gaps in our understanding of aspects of the environment at the national level, and the data needed to build a comprehensive picture. To address this issue, a clear strategy is required for the environmental reporting and monitoring system, including clear priorities and environmental indicators.

Once data gaps can be clearly identified, a strategic plan can be made to fill them. Currently, work is underway by government agencies on aspects of the wider monitoring and reporting system. For example, updating the Environmental Reporting Act and ensuring appropriate environmental indicators are in place. This would also address a number of issues identified by the Parliamentary Commissioner for the Environment in 2019.

To fill data gaps, local and central government agencies should look beyond the current methods of data collection, and determine whether 'generational jumps' that utilise more sensors, satellite imagery or other tools can assist at scale. There are international models that exist, for example, Digital Earth in Australia, where a separate agency was established for the provision of satellite data.

We should look beyond the current methods of data collection, and determine whether 'generational jumps' that utilise more sensors, satellite imagery or other tools can assist at scale.

Not all data collection and AI projects will be carried out by, or in partnership with, the government. Beyond national and official reporting, it is important that data is readily available for local iwi, hapū and communities to understand their local areas. Where possible, agencies may help facilitate access to open data sets and opportunities to enable local data collection. Meanwhile, not all environmental data will be appropriate for all organisations to use. Privacy and other uses remain a key consideration. Ideally, access to data will be affordable, as fee-for-service approaches can create a significant barrier for smaller organisations.

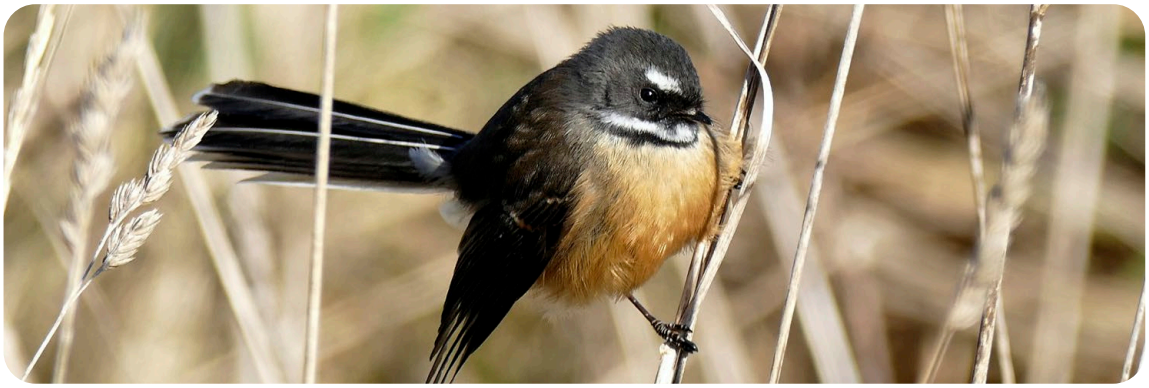
Developing and Cementing Approaches for Māori Data and the Environment

Inclusive approaches to data collection and use will look different to scientific data practices, reflecting that incorporating Māori data approaches will require a significant cultural and mindset shift. There are already a number of frameworks in place or under development. For example, Nga Tikanga Paihere is a tikanga-based framework to guide researchers using microdata in the Government's Integrated Data Infrastructure. This approach could potentially be applied to broader uses of data in ethical and responsible ways.[48] Areas where further work is needed include developing best practices for Māori data access and availability, for example whether Māori have access to nationally-collected data to help inform decisions for their communities. Consideration also needs to be given to how data is used and shared without engagement with, or permission of, local iwi and hāpu who have kaitiaki responsibilities for areas of land and water and species living there. For example, when is it appropriate for data to be gathered by satellite or remote sensors, without a physical presence on the land or in the water?

Māori data is a taonga and has whakapapa.

Adopting and Implementing Appropriate Rules, Standards and Guidance

To support interoperability and the ethical and culturally appropriate use and sharing of data, it is important to have clear guidelines that set out requirements and the path for change.



Organisations, including regional councils and other groups collecting data for the wider environmental monitoring system require support to implement these standards. This may include considering whether some data standards should be mandatory in certain contexts, funding for additional capacity and capability building, and ensuring the standards are fit-for-purpose for future use.

Building Relationships

Building Relationships Between AI Project Teams and People Affected by Their Work

To move from AI-driven insight to on-the-ground-action, requires strong, balanced, reciprocal relationships between people using AI systems to gain insights, decision makers, and kaitiaki local guardians of the land and species. Currently, decisions are often made by people who are removed from the local context. In some places, further work is required to understand where relationships could be built or strengthened to support the use of data. For example, where remote sensing techniques or satellite imagery is used to gather information about land which is under the kaitiaki of local iwi. In addition, strong relationships will also enable data-driven insights to be combined with mātauranga Māori and local knowledge to gain the best outcomes for the environment.

Increasing Collaboration Within the AI for the Environment Ecosystem

From environmental experts who have carried out monitoring for decades to those on the cutting edge of AI research, there is considerable expertise throughout Aotearoa New Zealand. This expertise can be harnessed to realise a thriving AI for the environment ecosystem.

Collectively, this means projects can leverage each other's knowledge (where IP and data considerations allow), through formal collaborations, communities of practice, or case studies which demonstrate the possibilities of AI for the environment. Some collaborations are already in place across organisations, including data communities of practices for CRIs and regional councils, and through the Time-Evolving Data Science/Artificial Intelligence for Advanced Open Environmental Science *(TAIAO)* project. There is potential opportunity for broader collaborations to further connect the environmental and technical aspects of these AI systems.

Building Capability across the Ecosystem

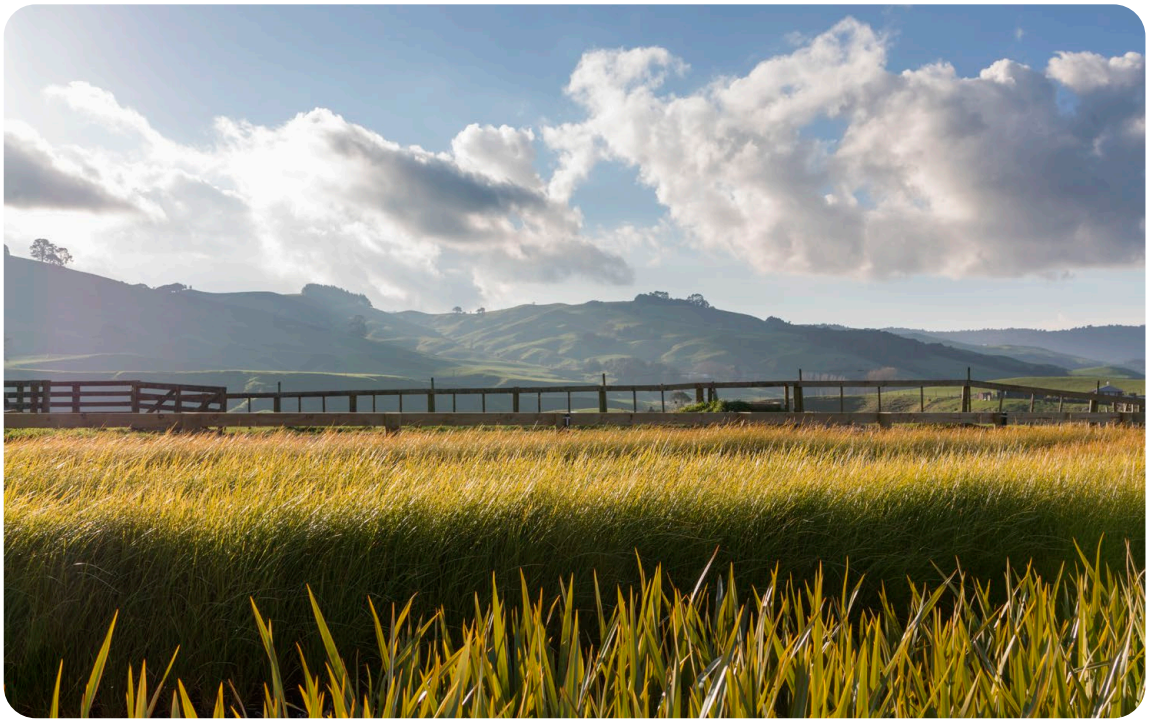
For Aotearoa New Zealand to build an AI sector that supports the environment and reflects

our culture, additional capability needs to be developed within organisations that monitor and care for the environment. This includes ensuring a basic understanding of the ways AI can support their work; building knowledge and cultural capability to incorporate te ao Māori perspectives within AI and projects; and growing internal IT capability to operationalise AI.

Education initiatives are required to uplift a new generation of technologists and support capability building within Māori communities interested in using AI to support their local environment.

In the corporate sector, improving opportunities for early career AI specialists to gain relevant experience, and incentivising organisations to offer training and mentorship, will help build capability. This will help increase the number of businesses implementing AI systems. Alongside developing local capability, there remains an ongoing need to supplement this with international talent. Ensuring immigration policy is responsive and fit-for-purpose is a key part of a robust capability building plan.

Work to increase skills and capability for the wider digital sector more broadly is already underway. The *Digital Tech Industry Transformation Plan Skills Workstream Report and Draft Plan* published in 2021 includes 10 actions to build the digital skills pipeline in Aotearoa New Zealand. The Skills Plan recognises that 'our industry is suffering greatly from a mismatch of skill supply and demand, however the only way we're going to fix this long-term is if we invest in domestic development'.[49]



Credit: Paul Sutherland Photography

Building the Business Case and Incentives

In addition to government agencies and organisations dedicated to environmental protection, improving environmental outcomes will require significant action from businesses in all industries. AI can be leveraged for environmental outcomes in businesses of all types, from transportation companies using sensors to reduce emissions, to factories implementing predictive maintenance systems to minimise material waste and downtime. Both commercial and conservation outcomes can be compatible and mutually supportive. However, currently there is not always sufficient incentive for industry to invest in new technology, despite the potential environmental benefits. The key to increasing the adoption of AI in the private sector is building a strong business case and providing incentives.

Increasing and Aligning Funding to Support Impactful Projects

Additional funding for AI research and development will be an important part of growing the local AI for the environment ecosystem. The *Te Ara Paerangi Future Pathways Green Paper 2021* notes that the modern research systems in other small advanced economies have a significantly greater level of investment than New Zealand's current level, proportional to gross domestic product (GDP). The government has indicated a commitment to raising research and development expenditure. Future funding can support development of fundamental AI technology in ways that reduce duplication of effort, and where possible include incentives for research organisations to collaborate. In addition, investment is required to operationalise AI within businesses and organisations. Transitioning AI systems from research and pilot projects to fully embedded business practice is labour and capital intensive. Funding to support business uptake and integration will certainly help accelerate the positive impacts of AI for the environment.

Credit: Paul Sutherland Photography

Additional Areas for Attention

In addition to the key areas identified above, there are other issues that need attention in order to further the AI for the environment ecosystem. These include:

- **Fit-for-purpose digital infrastructure**
  This includes data storage facilities and cloud computing services, high-speed internet access across the country.
- **Looking forward to emerging opportunities**
  This includes supporting initiatives that leapfrog current technologies and being more agile in approaches to monitoring the environment and responding to a range of needs.
- **Defining the problem before jumping into a project**
  It is imperative projects begin with a clear problem definition and involve all stakeholders in the framing of the problem being addressed.
- **Climate friendly AI approaches**
  As well as using AI to support environmental outcomes, organisations are required to understand the environmental impact of AI and mitigate appropriately.

Recommendations

While there are some exciting applications of AI to support the environment currently being developed and deployed, more work is required to ensure a thriving AI for the environment ecosystem.

This report illustrates both the challenges and opportunities to leverage the benefits of advanced technologies like AI to assist in our quest for a clean, sustainable and well managed environment.

This includes ensuring the appropriate datasets are available, building critical capability, developing relationships and aligning the funding landscape.

1. | Build a Coherent Environmental Data Ecosystem

The Challenge

Data is essential for understanding, responding to, monitoring and adapting our responses to environmental challenges. High quality data is also essential if we are to leverage the benefits of AI for the environment. However, environmental data is currently scarce, fragmented and of poor quality.

The Goal

High quality, appropriate data is available for analysis and use, to support a thriving AI for the environment ecosystem.

KEY RECOMMENDATIONS

- **Deploy AI alongside other new technologies to enhance environmental data collection.** When reviewing current methods of data collection and data gaps, local and central agencies may consider 'generational jumps' through the use of AI along with more sensors, satellite imagery and other tools to help fill gaps at scale.
- **Develop a national environmental open data framework.** Given environmental data will grow in importance across multiple sectors, we recommend the development of a national scale, environmental open data collection framework. This could potentially operate externally to any single agency, and share capability.
- **Consider where and how mātauranga Māori may be incorporated within Government AI systems**. Consider the inclusion of mātauranga Māori into AI system development throughout the government's environmental monitoring, reporting and data system.
- **Coordinate the development of standards and best practices for environmental data management**. Following a gap analysis of current standards, create a repository of appropriate standards in the AI for the environment ecosystem. Establish, document and implement best practices to help guide the responsible practice and participatory design of AI for the environment solutions.

2. | Build Capabilities and Relationships

The Challenge

There is a general lack of understanding and connection between those that are monitoring and caring for the environment and those that are, or could be, developing AI solutions to help the environment. This creates issues of communication and lost opportunities.

The Goal

Strong, balanced, reciprocal relationships between those developing AI systems, using AI systems and the kaitiaki of the environment.

KEY RECOMMENDATIONS

- **Invest in increasing institutional understanding of AI in businesses and Government.** Within organisations monitoring and caring for the environment, ensure a basic understanding of the ways AI can support their work. This includes building knowledge and cultural capability of te ao Māori perspectives within AI projects. Also, growing internal IT capability so agencies can be supported to use and operationalise AI.
- **Increase the exposure of AI specialists to environmental challenges and environmental specialists to AI**. In the corporate sector, businesses can provide opportunities for early career AI specialists to gain relevant exposure and experience in environmental AI. For example, hackathons, mentorships and internships. Likewise, we should seek opportunities to expose environmental specialists to AI technologies for data collection and analysis. For example, case studies, conferences and internships.
- **Increase collaboration within the AI for the environment ecosystem.** To help realise a thriving ecosystem, the government and the AI Forum can encourage the development of communities of practice and formal collaborations. Support could be provided for projects that facilitate access to data sets or AI models where organisations and communities leverage each other's knowledge.

3. Increase and Align Funding to Support Impactful Projects

The Challenge

While there is funding distributed across the New Zealand research ecosystem for environmental and AI research, very little of it is connected to the operationalisation of the research in a real world context. The current funding ecosystem with regard to AI and the environment appears to be fragmented and not focused on scaling to impact.

The Goal

A funding ecosystem that incentivises collaboration and operationalisation of AI for the environment solutions within businesses and organisations.

KEY RECOMMENDATIONS

- **Target funding to accelerate AI for the environment uptake**. Fund programmes providing AI for the environment opportunities for the business, not for profit and research sectors.
- **Align funding with measurable environmental impacts**. Enhance strategic funding of larger scale big-impact AI programmes. Also, develop and deploy tools for monitoring, impact assessment and benchmarking of AI for environment solutions, including climate impact assessment of AI.
- **Target funding to outcomes of national importance**. Increase and target funding for research and development, to accelerate the development of AI that supports operationalised environmental outcomes of national importance.

Appendix 47

Credit: Paul Sutherland Photography

Appendix

The Research Team

AI Forum NZ

The Artificial Intelligence Forum of New Zealand (Te Kāhui Atamai Iahiko o Aotearoa) aims to raise the level of awareness and capabilities of Artificial Intelligence in New Zealand. The Forum brings together citizens, business, academia and the Government connecting, promoting and advancing the AI ecosystem to help ensure a thriving New Zealand.

The AI Forum designed, collated and edited the research.

Lynker Analytics

Experts in data infrastructure, data science and geospatial analysis, Lynker Analytics believe Artificial Intelligence (AI) and in particular deep learning holds great promise for organisations everywhere enabling knowledge to be created, distributed and acted upon faster than ever before.

Lynker Analytics project managed, analysed and edited the research.

Wildlife.AI

Wildlife.AI is a charitable trust that uses artificial intelligence to accelerate wildlife conservation.

Wildlife.AI conducted primary research, wrote technical aspects of this report and provided analysis and peer review study and report.

Antistatic

Anitistatic is a communications and research group based in San Francisco and Wellington. Antistatic brings clarity to complex issues around technology and the environment, and helps amplify the voices of people driving positive social change.

Antistatic conducted primary research and wrote the core of the report.

Methodology

This research report was written based on desktop research, survey responses, and interviews with environmental and data science experts. This section outlines the process for undertaking this survey and interviews and how the analysis was conducted.

Survey

A survey was developed by the research team to gather information about AI projects underway that are contributing, or aim to contribute, to the five environmental issue areas identified in the Environment Aotearoa 2019 report. The survey queried key environmental outcomes associated with the project, status of project development and deployment, type of AI used, and engagement with mātauranga Māori. The survey was reviewed and revised with input by members of the AI Forum, and project partners at Statistics New Zealand (Stats NZ) and the Ministry for the Environment (MfE). The survey was then distributed via the AI Forum's networks and directly to research institutions. Information regarding 26 key projects was submitted through the survey. This relatively low response is reflective of the nascent state of New Zealand's AI for the environment ecosystem and productionised systems. It is also noted that only projects with AI for the environment as a core mission were included in this research and that there are many other projects in New Zealand which also have potential positive environmental outcomes.

Interviews

The researchers conducted interviews with people who have a range of expertise in AI for the environment ecosystem. These interviews did not aim to cover all experts and organisations in the field, rather to gain an overall understanding of the current state, opportunities and challenges from a range of viewpoints.

The researchers identified a broad range of experts and organisations in New Zealand's AI for the environment ecosystem based on responses from our survey, desktop research, and existing knowledge about the field. From this list, the researchers conducted interviews with people from a range of organisations, ensuring there was representation from university research departments, businesses, Māori data experts, Crown research institutes, and government departments. Overall, researchers spoke to 19 individuals across 11 interviews. The organisational affiliations of interviewees are:

- Department of Conservation
- Dragonfly Data Science
- Manaaki Whenua
- Ministry for the Environment
- NIWA (High Performance Computing Facility)
- Qrious
- Stats NZ
- Te Kotahi Research Institute (Waikato University)
- University of Auckland
- University of Waikato

Analysis

The findings and statistics presented in the Current state of the field section were compiled from the survey submissions, interviews and desktop research. For each project, information was collected about a number of factors such as key environmental outcome, status of project development and deployment, type of AI used, engagement with mātauranga Māori, and other key features. This information was tagged to enable comparative analysis between projects.

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