WHITE PAPER:

Aotearoa New Zealand Artificial Intelligence

A Strategic Approach

NOVEMBER 2021

Artificial Intelligence Researchers Association

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ABOUT THIS WHITEPAPER

The present paper was prepared under the leadership of Prof Albert Bifet, Prof Richard Green, Dr Daniel Wilson and Prof Mengjie Zhang. It is based on discussions with Associate Prof Alistair Knott (University of Otago), Prof Stephen Cranefield (University of Otago), Prof Michael Witbrock (University of Auckland), Dr Paul Geertsema (University of Auckland), Prof Michael Winikoff (Victoria University of Wellington), Prof Gill Dobbie (University of Auckland), Associate Prof Te Taka Keegan (University of Waikato), Prof Eibe Frank (University of Waikato), Prof Bernhard Pfahringer (University of Waikato), Prof Ruili Wang (Massey University), Prof Albert Yeap (AUT), Dr Kristin Stock (Massey University), Associate Prof Patricia Anthony (Lincoln University), Dr Alvaro Orsi (PlantTech Research Institute), Dr Danielle Lottridge (University of Auckland), Dr Linley Jesson (Plant and Food Research), Dr Thomas Li (University of Canterbury), Dr Giulio Valentino Dalla Riva (University of Canterbury) and Jannat Maqbool (University of Waikato).

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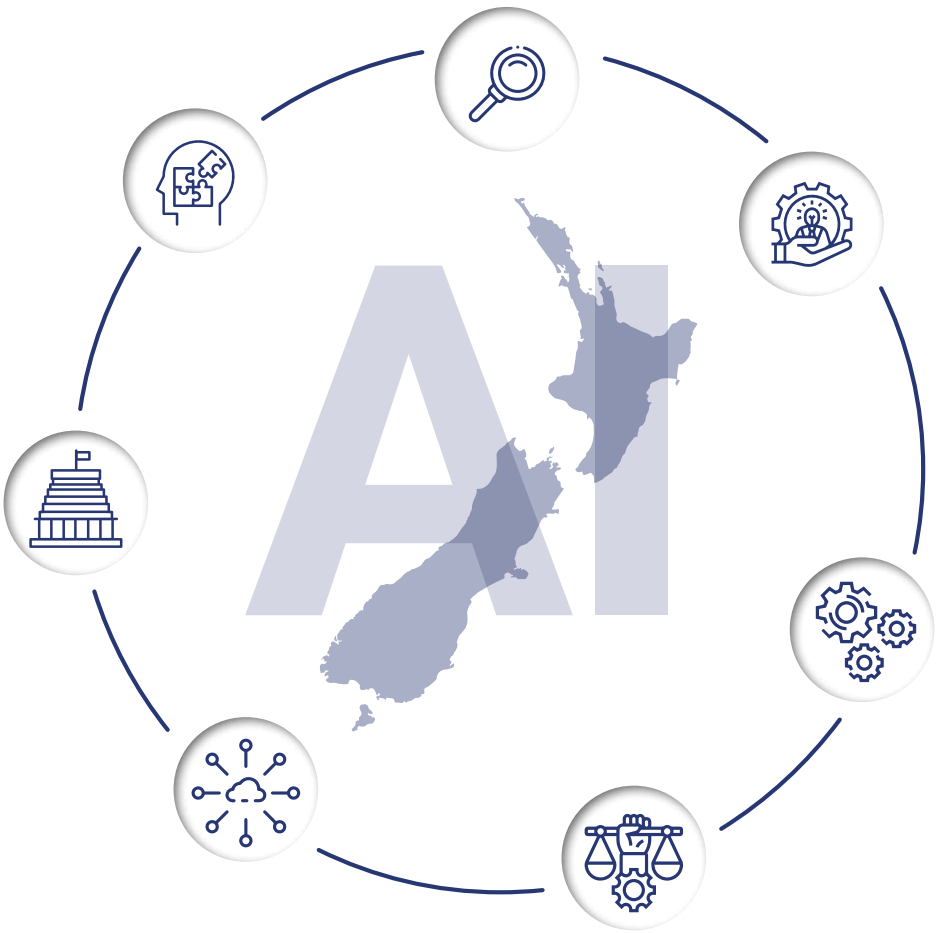

AI

EXECUTIVE SUMMARY

Artificial Intelligence (AI) is profoundly changing how we live and work. The cumulative impact of AI is likely to be comparable to other transformative technologies such as electricity or the internet. As a result, it is imperative that we take a strategic approach to realising the potential benefits offered by AI and to protecting people against the potential risks.

In this whitepaper, we discuss current AI capabilities in Aotearoa New Zealand and offer recommendations for establishing Aotearoa New Zealand as a research centre of excellence and trust in AI. Our discussion is informed and guided by the framework for developing a national AI strategy set out by the World Economic Forum [1].

It is important to invest in AI imbued with characteristics and values important for Aotearoa New Zealand such as sustainability, fairness, equality, data sovereignty, Te Tiriti obligations, multiculturalism, intergenerational thinking, people and whānau first, and holistic thinking. Otherwise, we risk being relegated to users of overseas technologies developed by countries with different values.

Our vision is that by 2030, Aotearoa New Zealand will have a community of cutting-edge companies producing and exporting AI technologies, supported by a strong network of researchers involved in high-level fundamental and applied research. Our main recommendations are:

Scientific Research: Increase funding for public AI research by developing a network of new research centres, hubs, and programmes in basic and applied AI research.

AI Talent Development: Augment capacity to attract, retain, and train domestic and international AI talent.

Industrialisation of AI Technologies: Create programmes to encourage private sector adoption of AI technologies, including investments in strategic sectors.

Ethical AI Standards: Create a task force to establish standards and regulations for the ethical use of AI, including culturally appropriate AI.

Data and Digital Infrastructure: Create an effective national data infrastructure with open data partnerships and datasets, while enabling and supporting Māori data sovereignty obligations, as well as commitments to create test environments and regulatory sandboxes. AI needs a good data infrastructure to be successful.

AI in the Government: Government leading the adoption of AI in administration, healthcare, infrastructure and regulation in ways that give effect to Te Tiriti o Waitangi.

Inclusion and Social Wellbeing: Use AI to promote socially inclusive growth and encourage an AI community that is inclusive of diverse backgrounds and perspectives.

It is important to consider the strategic implications of AI for Aotearoa New Zealand. If we do not invest in AI research and adoption, we lose the ability to compete effectively with dominant platform firms domiciled in large markets such as the US, China and the European Union (EU). This situation risks Aotearoa New Zealand losing the ability to tailor AI to our local needs, priorities and ethical standards, and not being independent in terms of technology or data sovereignty.

While acknowledging the research that is being done outside of the universities — for example, with respect to culturally safe AI — there is currently a strong AI research base with potential benefits for Aotearoa New Zealand that are not currently being realised by the application of AI in our industries. The main message of this whitepaper is that we must invest in leveraging our strong AI research base to increase the competitiveness and productivity of Aotearoa New Zealand in a manner that suits our needs and priorities. Building and strengthening mechanisms that efficiently disseminate AI expertise from research to industry has the potential to significantly increase productivity and prosperity for all of Aotearoa New Zealand.

1. INTRODUCTION

AI is attracting greater attention as more people become aware that AI will change how we live and do business. Google CEO Sundar Pichai claims that AI will profoundly impact the world, even more so than electricity or fire [15]. The transformative power of AI will affect every sector – from agriculture to healthcare, manufacturing, logistics and retail.

There are many definitions of AI. The whitepaper "On Artificial Intelligence – a European approach to excellence and trust" from the European Commission characterises AI as "a collection of technologies that combine data, algorithms and computing power" [23]. This simple account of these essential AI components makes clear that advances in research and innovation in these three areas is vastly increasing the potential of AI. A common definition is that AI systems perform tasks that would require intelligence if they were done by a human. One subfield of AI is Machine Learning (ML), which is focused on building algorithms that can learn from data for themselves. Within that, Deep Learning (DL) is a subfield of ML using artificial neural networks with feature learning.

> **"The main message of this paper is that universities and research institutes have very strong AI research that has a huge breadth and potential"**

Aotearoa New Zealand research is very well known internationally due to open source software. Academics in Aotearoa New Zealand have created R and Weka, two of the most successful open source AI tools of all time. All main universities and big companies worldwide have been utilising R and Weka for many years. Every data scientist and AI researcher and practitioner in the world recognises the power of R and Weka. However, the involvement of locally-based researchers in Weka and R is largely unknown in Aotearoa New Zealand, and the impact to our economy has been surprisingly small.

The World Economic Forum (WEF) recently released the whitepaper "A Framework for Developing a National Artificial Intelligence Strategy" [1], in which they propose a framework to help the teams responsible for developing national strategies to ask the right questions, follow best practice, identify and involve the right stakeholders in the process, and create the right outcome indicators.

Inspired by the WEF framework, this whitepaper proposes a set of key dimensions and recommendations on establishing Aotearoa New Zealand as a reference in excellence and trust in AI research worldwide. The main message of this paper is that universities and research institutes have very strong AI research that has a huge breadth and potential to enable our people and economy to prosper.

In what follows in section one of this paper, we provide some background on the state of AI research in Aotearoa New Zealand, its distinctiveness, its connections with the rest of the AI ecosystem, and its potential to benefit our country. In section two, we apply the WEF framework to examine the key dimensions of a national AI strategy for Aotearoa New Zealand. We then provide key recommendations to realise a vision of Aotearoa New Zealand as an exemplar in excellence and trust in AI worldwide.

1.1 WHY INVEST IN AI RESEARCH IN AOTEAROA NEW ZEALAND?

Aotearoa New Zealand has the capability of becoming an important hub of AI research globally. Indeed, Aotearoa New Zealand could attract people from Silicon Valley and other global advanced technological centers, and create an innovative international ecosystem of AI. Currently, Aotearoa New Zealand is seen as one of the best countries to live in, due to its values, greenness and response to the COVID-19 pandemic. Additionally, Aotearoa New Zealand AI research is very well known internationally, and our researchers are leading the world in a number of areas, such as evolutionary learning and stream data learning and image vision applications for primary industry and environmental monitoring.

There are three main reasons to invest in AI research in Aotearoa New Zealand:

• **To create AI imbued with characteristics and values important for Aotearoa New Zealand, while recognising our bicultural and multicultural society.** The decisions that AI systems will make are a reflection of their creator's values and beliefs. This is why it is so important when it comes to AI research, to design systems that prioritise local values and ways of being, and not solely commercial goals.

• **To ensure that profits from AI innovations remain onshore.** The report "The Impact of Artificial Intelligence on Jobs and Work in New Zealand" [13] considers various possible future scenarios, some where AI leads to a net creation of new jobs in Aotearoa New Zealand, and some where it leads to a net displacement of jobs. They consider two scenarios of the latter kind – one where the profits from AI flow offshore, another where they remain onshore in some measure. If profits remain onshore, the Government would be better able to support those whose jobs have been displaced: on this basis, they argue that the Government should be proactive in finding and investing in AI-focused niches in which local companies can be successful. On the prospect of AI taking people's jobs, some of the more comprehensive AI strategies take this topic very seriously (e.g. the recent OECD blog series [16] on what national AI strategies have to say about AI and work). Supporting local AI research and development rather than buying AI solutions from overseas will improve the social benefits of broader national AI adoption.

• **To improve productivity.** One of the main economic issues in Aotearoa New Zealand is low productivity. The paper "Productivity by the numbers" [14] by the New Zealand Productivity Commission claims that, post World War II, our country has gone from being one of the most productive economies to one of the least productive in the OECD. Our people work more hours but produce less than most OECD countries. Innovation in AI is key to lifting productivity by automating tasks with low and high economic value.

If Aotearoa New Zealand does not invest in AI research and adoption, we will lose the ability to compete effectively with dominant platform firms domiciled in large markets such as the US, China and the European Union (EU). This situation risks Aotearoa New Zealand losing the ability to tailor AI to our local needs, priorities and ethical standards, and not being independent in terms of technology or data sovereignty.

> **Aotearoa New Zealand has the capability of becoming an important hub of AI research globally.**

1.2 AI IN THE NATIONAL CONTEXT

In recent decades, researchers in Aotearoa New Zealand, particularly the universities, have been carrying out fundamental research in AI, including in both of the high-level research streams of *symbolic AI* (see Table 1) and *subsymbolic/computational* AI. A large portion of the research on the subsymbolic AI side is in machine learning, or ML (see Table 2).

Deep Learning is also an important and active research area. Deep learning is a subdomain of ML that consists of artificial neural network-based ML as well as other techniques (see Table 3). All of this fundamental AI research is vitally important as it provides the theoretical and algorithmic base that underpins and powers AI applications.

Table 1. Examples of fundamental research areas in Aotearoa New Zealand in *symbolic AI.*

knowledge representation and knowledge-based systems	agent and multi-agent systems	constraint programming
reasoning and logic-based systems	planning and scheduling	web intelligence

Table 2. Examples of fundamental research areas in Aotearoa New Zealand in *subsymbolic AI* (mainly machine learning).

supervised, unsupervised, semi-supervised, and reinforcement learning	instance-based learning	induction learning
connectionist learning	evolutionary learning	statistical kernel-based learning
Bayesian and probability-based learning	data stream learning	one/few-shot learning
transfer learning and domain adaptation	feature selection/construction and dimensionality reduction	deep learning

Table 3. Examples of fundamental research areas in Aotearoa New Zealand in *deep learning* (a subdomain of machine learning).

convolutional neural networks and variants	recurrent neural networks	deep-stacked autoencoders
deep belief networks	deep generative adversarial networks	variational autoencoders
deep reinforcement learning	deep PCA nets	deep forest learning
deep genetic programming		

Another active area of fundamental AI research in Aotearoa New Zealand is explainable/interpretable AI/machine learning (ML), including explainable models and visualisation, and data-driven AI, including AI/ML-based on data science and data engineering. Furthermore, AI ethics, implications and relevance to public policies are also major research topics in the humanities, social sciences and law disciplines.

There is a large category of local AI research between fundamental and applied AI research consisting of computer and machine vision and image processing, natural language processing and understanding, and audio, speech and signal processing, and robotics. In most universities, they are essential aspects of AI/ML/Data Science and engineering.

Local AI applications have been focused on primary industry such as agriculture, aquaculture and open ocean/blue economy, environmental/ earth science, geology and disaster management, chemical and material science and engineering, biological and biomedical sciences, as well as marine biology and genomics, public health and medicine, neural science/psychology and drug discovery, cybersecurity, biosecurity, food and water resources, networking and the Internet of Things (IoT), tourism and knowledge travel, sustainable and renewable energy, finance and economics including GDP and CPI prediction, tax, banking, and insurance, and linguistics and languages including natural language processing of te reo Māori.

Among many of these fundamental AI research areas and key applications, Aotearoa New Zealand has been playing an important leadership role in the world in at least the following aspects:

- ML tools such as Weka and R
- Evolutionary learning and optimisation
- Data stream learning/mining
- Image and vision computing applications to primary industry
- Automated design of deep neural network architectures and other deep models
- Feature selection/construction and dimensionality reduction
- Dynamic scheduling and combinatorial optimisation
- Indigenous data sovereignty
- Oversight of government uses of AI and algorithms [11]
- Oversight of harmful content on social media [17]

> **“Aotearoa New Zealand’s AI academic community has built a solid global reputation both through researchers working in Aotearoa New Zealand and our people undertaking AI research abroad.”**

Our universities have been collaborating with various partners in AI/ML projects. These partners include: all seven Crown Research Institutes (CRIs); Māori organisations; regional research institutes – such as the PlantTech Research Institute and the Bragato Research Institute; and other national research institutes such as Callaghan Innovation and the Cawthron Research Institutes. These projects in primary industry and high-value manufacturing enhance economic value, the environment, and health outcomes.

Aotearoa New Zealand is playing an important leadership role in AI internationally in the area of AI approaches to dealing with the COVID-19 pandemic. In particular, Michael O'Sullivan at Te Pūnaha Matatini in Auckland is co-leading a GPAI (Global Partnership on Artificial Intelligence) project on 'AI-powered immediate response to pandemics' [18]. Aotearoa New Zealand is widely respected internationally for its response to the pandemic – perhaps one reason why our country has taken a leadership role in this GPAI project.

Aotearoa New Zealand's AI academic community has built a solid global reputation both through researchers working in Aotearoa New Zealand and our people undertaking AI research abroad. In terms of activity, Aotearoa New Zealand ranks 19th in the world in the number of all-time AI related scientific publications per capita and 44th in the number of all-time AI related scientific publications (source: www.scopus.com).

A new association of AI researchers, known as the Artificial Intelligence Researchers Association, was established in 2021 (to complement and work with the AI Forum, government, tech sector and industry). It already has more than 315 active research members from universities, CRIs, Regional Research Institutes, and private research organisations from across the country. The Association's first annual event was held at Hobbiton on 9 April 2021 (https://www.ainz.ai/). Over 30 senior researchers from around the country presented at the inaugural workshop on a broad range of topics (see Table 4).

This association will provide a more research-based perspective on AI, with this paper as its first outcome. As the Artificial Intelligence Forum of New Zealand (AI Forum) is mainly focused on industrial applications of AI, there is a need to have a strong research organisation to give an expert view of the research in AI.

Table 4. Sample of presentation topics from AI Researchers Association event, 9 April, 2021:

deep learning	explainable AI	adaptive problem solving
evolutionary learning and optimisation	computer vision and image processing	ML for data streams
feature selection and big dimensionality reduction	transfer learning and domain adaptation	planning and scheduling
automation	cybersecurity	fake news detection
autonomous systems	ethics	natural language processing

1.3 DATA SOVEREIGNTY AND MĀTAURANGA MĀORI

For Māori and Indigenous people worldwide, data is a taonga – something that is highly prized. And there is growing concern among Indigenous communities that the use of their data by external parties could lead to stigmatisation and further economic, cultural, and physical harms. Additionally, without clear frameworks and guidance, the increased adoption of AI could exacerbate existing inequities or create new harms. The Global Indigenous Data Alliance (GIDA) provides an international forum for Indigenous peoples to collectively progress their data sovereignty and governance goals. As a first step, GIDA has published its CARE Principles (standing for Collective benefit, Authority to control, Responsibility and Ethics) to provide the first international framework for the ethical use of Indigenous data [24]. In Aotearoa New Zealand, Te Mana Raraunga, the Māori Data Sovereignty Network, advocates for Māori rights and interests in data, underpinned by Te Tiriti o Waitangi and the UN Declaration on the Rights of Indigenous Peoples (UNDRIP). The guiding principles for Māori data sovereignty – that Te Mana Raraunga promote – are described in their charter document [25]. To support the operationalisation of Māori data sovereignty principles, members have developed a Māori Data Audit Tool [26]. This rōpū also advocates for culturally safe use of AI.

“For Māori and Indigenous people worldwide, data is a taonga – something that is highly prized.”

The national AI strategy has an opportunity and an obligation to align with and incorporate the work of these agencies and affiliated researchers, and to facilitate activities relating to culturally safe AI methods that respect and observe Māori data sovereignty. For instance, there have been some interesting discussions about how federated learning could be used to allow Māori datasets to contribute to training international models without compromising data sovereignty. Indeed, most of the points made earlier about why further investment in AI research in Aotearoa New Zealand is important also apply to why we should invest in Māori-led research.

In a traditional sense, mātauranga Māori refers to the knowledge, comprehension or understanding of everything visible or invisible within the universe and how it is interconnected through whakapapa and whanaungatanga. Mātauranga Māori recognises that each part of a system is related and must work together to achieve its objective. If one part of the system is broken, it will affect the performance of the whole system. In AI, this can mean the system of an AI product or ecosystem or the impact that new and fast-growing technology will have on the whole of the society it grows from. In this case, society must recognise that the essential components of wellbeing that make up a functioning human society align and support one another. If one part of the system fails, the whole system will fail. AI created in ways that respect UNDRIP and Te Tiriti obligations provide an opportunity for Aotearoa New Zealand to make distinctive contributions to globally relevant AI issues.

1.4 AI INTERNATIONAL CONTEXT

AI development has increasingly become a national objective for countries worldwide. The US and China are the main frontrunners, with China having the ambition to become the global leader in AI research by 2030 [8].

In 2020, the US National Science Foundation (NSF) created five new AI institutes at the cost of US$100 million, aimed at advancing technological innovation and bolstering the economy: NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography; NSF AI Institute for Foundations of Machine Learning; NSF AI Institute for Student-AI Teaming; NSF Molecule Maker Lab; and NSF AI Institute for Artificial Intelligence and Fundamental Interaction.

In the UK, the Alan Turing Institute was created in 2013 with a £600 million investment as a National Centre to promote advanced research and translational work in algorithms and the application of data science.

Australia announced in May 2021 that it would invest AU$1.2 billion in their digital future, with AU$124.1 million of that directed towards initiatives in building AI capability, including a National Artificial Intelligence Centre.

Table 5 shows some national AI strategic investments of different countries. All developed countries are strongly investing in AI.

Table 5. AI Funded Strategies [2].

Country/ Region	Release Date	Official Strategy	Funding (July 2018 US$ exchange rates)
Australia	May 2018	Australian Technology and Science Growth Plan	AUD$29.9 million (US$21.6 million)
Canada	March 2017	Pan-Canadian Artificial Intelligence Strategy	C$125 million (US$95 million)
Singapore	May 2017	AI Singapore	S$150 million over five years (US$91.5 million)
Denmark	January 2018	Strategy for Denmark's Digital Growth	DKK 75 million in 2018, followed by DKK 125 million each year to 2025 (US$11.7 million, US$19.5 million)
Taiwan	January 2018	Taiwan AI Action Plan	NT$36 billion over four years (US$1.18 billion)
France	March 2018	France's Strategy for AI	€1.5 billion over five years (US$1.75 billion)
EU Commission	April 2018	Communication Artificial Intelligence for Europe	Increase annual investment in AI to €1.5 billion by end of 2020 (US$1.75 billion)
United Kingdom	April 2018	Industrial Strategy: Artificial Intelligence Sector Deal	£950 million from government, academia, and industry (US$1.24 billion)
South Korea	May 2018	Artificial Intelligence R&D Strategy	₩2.2 trillion (US$1.95 billion)

In the remainder of this section, we briefly review other nations' AI strategies. The CIFAR (a Canadian-based global research organization, formerly the Canadian Institute for Advanced Research) published a report ("Building an AI World – Report on National and Regional AI Strategies" [2]) comparing several national strategies. Their findings were as follows:

- According to eight areas of public policy, AI strategies were proposed for specific areas of impact: scientific research, talent development, skills development, industrialisation, ethics, data and digital infrastructure, government services, and inclusion
- AI strategies can be categorised generally into four main types: research and talent, industrialisation, comprehensive, and guiding
- Although the AI strategies do not share the same strategic priorities, scientific research and industrialisation are top priorities for all of them

The report used a heat map (Table 6) to show the relative importance of the following eight areas of public policy for each strategy:

Scientific Research: The creation of new research centres, hubs, or programmes in basic and applied AI research or a commitment to increase existing funding for public AI research.

AI Talent Development: Funding to attract, retain, and train domestic or international AI talent, including funding for chairs and fellowships or creating AI-specific Master and PhD programmes.

Skills and the Future of Work: Initiatives to help students and the overall labour force develop skills for work, such as investments in STEM (science, technology, engineering, and mathematics) education, digital skills, or lifelong learning.

Industrialisation of AI Technologies: Programmes to encourage private-sector adoption of AI technologies, including investments in strategic sectors, funding for AI start-ups and small and medium-sized enterprises (SMEs), and strategies to create AI clusters or ecosystems.

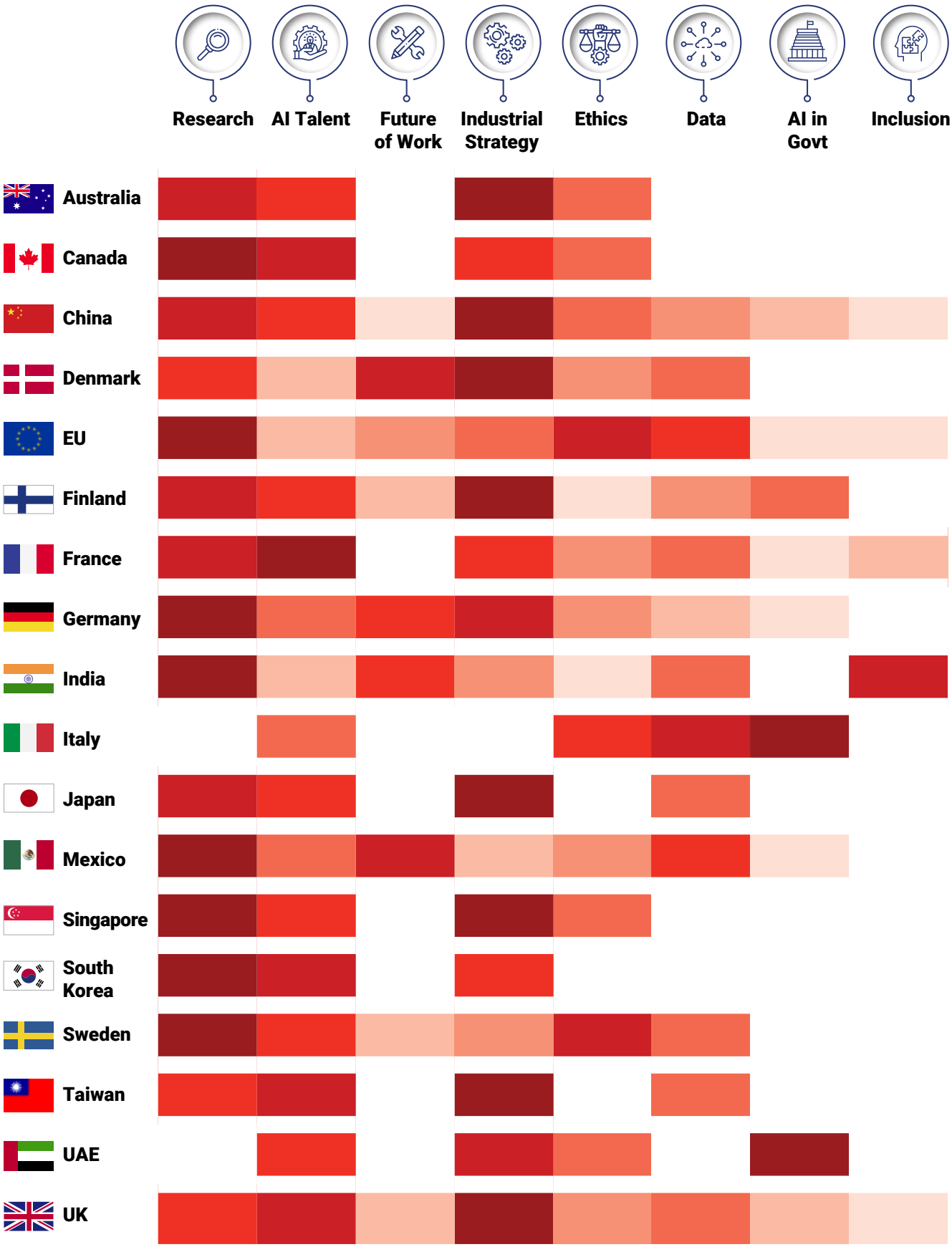
Ethical AI Standards: The creation of a council, committee, or task force to create standards or regulations for the ethical use and development of AI. This area also includes specific funding for research or pilot programmes to develop explainable and transparent AI.

Data and Digital Infrastructure: Funding for open data partnerships, platforms, and datasets as well as commitments to create test environments and regulatory sandboxes.

AI in the Government: Pilot programmes that use AI to improve government efficiency, service delivery, and public administration.

Inclusion and Social Wellbeing: Ensuring that AI is used to promote social and inclusive growth and that the AI community is inclusive of diverse backgrounds and perspectives.

Table 6. AI Strategies Heat Map [2].



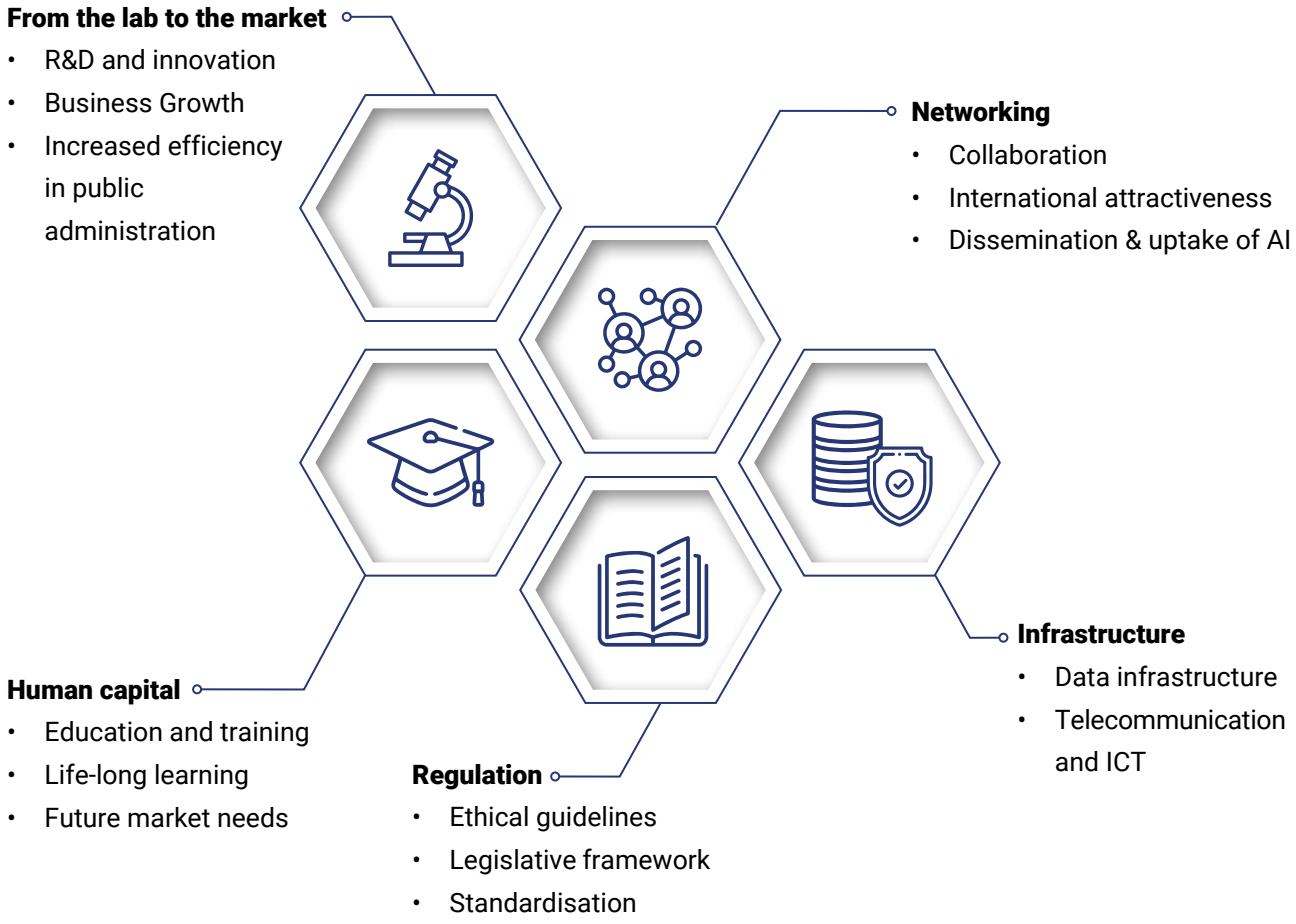
It is interesting to see that all strategies are unique in the areas they prioritise, but there are several similarities:

- Research or industrialisation is the most important area for almost all of the national strategies, indicating that most strategies focus on basic and applied research or on the application of AI technologies in the private sector
- Only five national strategies touch on all eight policy areas, while seven are quite focused and touch on four areas or less
- Inclusion and the future of work are the lowest and second-lowest priority policy areas, respectively
- All of the surveyed strategies omit mention of the importance of Indigenous data sovereignty (which provides an opportunity for Aotearoa New Zealand to be world leading in this space)

In 2021, the European Commission and the OECD published the report "AI Watch – National strategies on Artificial Intelligence: A European perspective" [7], which provides information on the latest policy developments and trends in AI policies for research and development, jobs and skills.

Figure 1 provides an overview of the relevant policy areas for AI and the key objectives they propose to unleash the full potential of AI in Europe.

Figure 1. Overview of relevant policy areas for AI from JRC – European Commission [7].



From a scientific perspective, there have been some efforts to analyse national AI strategies from a data science perspective, using AI [3,4].

In Fatima et al. (2020) [3], the authors built a dataset with all the relevant information on the national strategies of 34 countries. Their analysis focused on:

- Opportunities to modernise the public sector and transform industries, like health;
- Critical data and algorithmic elements that need to be managed, like data exchange and explainable AI; and
- Planning for capacity building and governance frameworks to support AI development efforts.

The authors found that most of the plans remain far more aspirational than practical since there was a conspicuous absence of metrics in any of them. They noted that metrics are vital when designing strategic plans to ensure that the various milestones, performance benchmarks, and targets are clear.

In Fatima et al. (2021) [4], the same researchers identify what factors influence the AI approach of a country, using signalling theory to decode strategic national AI plans. They discovered that countries with low technical capabilities are proactive in building ethics by design since they have to lay the foundation for technology (AI specifically).

In contrast, those with a strong AI foundation may face a challenge to re-build systems with ethics by design. This suggests that ethical AI guidelines ought to be a priority. Another main finding was that advanced research capability and data accessibility for AI is a precondition to developing a nationwide AI system.

This concludes the context-setting section of this paper. In the sections that follow, we analyse the dimensions of a national AI strategy for Aotearoa New Zealand (section 2) and propose our recommendations (section 3).

2. KEY DIMENSIONS: OVERVIEW OF A NATIONAL AI STRATEGY

The whitepaper "A Framework for Developing a National Artificial Intelligence Strategy" [1] from the World Economic Forum, proposes a framework with a set of key dimensions and recommendations to help teams responsible for developing national AI strategies. In this section, we outline the five key dimensions and propose how to customise them to the Aotearoa New Zealand context.

KEY DIMENSION 1: ESTABLISHING A STRONG RESEARCH ENVIRONMENT AND FORGING INDUSTRY-ACADEMIA INTEGRATION

The AI technology research landscape is unique compared with other scientific research sectors, with enterprises and academic research potential being equally valued. The creation of and access to open data becomes a crucial infrastructure on which AI solutions development depends. Almost all western countries have focused on investing in research – both basic and applied – through various modalities. Given the strategic focus and goals of each country, nations pursuing an AI strategy should propose a way forward to create a domestic research environment that makes use of industry-academia collaboration. The focus should be on attracting the best talent for basic and applied research and examining how the existing research incentive systems could be reformed for greater cross-sectoral integration in industry and governance.

For Aotearoa New Zealand, we propose four major goals:

- To increase the number of outstanding local AI researchers and skilled graduates
- To establish interconnected nodes of scientific excellence in universities, CRIs and Regional Research Institutes
- To develop global thought leadership on the economic, ethical, cultural, policy and legal implications of advances in AI
- To support a national research community on AI

> **"Universities can play a fundamental role in educating the next generation of AI practitioners."**

Universities can play a fundamental role in educating the next generation of AI practitioners. The main risk for companies is to think that online courses from cloud computing providers are sufficient to train their employees. There is an urgent need for professional education at the university level for people implementing AI at companies. In medicine, there is a clear preference for medical staff trained at universities, and not through YouTube videos. People also prefer to work with doctors with experience and not students. The same should be valid for AI: we need to have expert people in AI leading AI projects with a solid education in AI at a university level. It is not the same to use a car than to build a car. It is very easy to use a car or AI, but it is very difficult to build a car or a new AI algorithm or system. There is no need to have a university degree to use a car or AI, but there is a need for a university degree to build a car or a new AI system. There is a strong need for AI graduates for our big primary industry, health/(bio)medical, environmental, high-value/high-tech manufacturing as well as social, wellbeing, economics, finance, and others. Further, the professional skills required extend beyond technical skills into domains like professional ethics, which is vitally important to realise the value of culturally responsive AI, ethical AI and data sovereignty.

KEY DIMENSION 2: PREPARING THE WORKFORCE FOR THE AI ECONOMY

AI has the potential to be used in our primary industry, climate change mitigation, health sector, and high-value industry as well as social/ethical considerations to improve our economy and establish our AI economy. The Government has started paying attention and making investments in these areas, but there is still a long way to go – and great potential for impact. To maximise our national benefit, particularly in economic, environmental, health and social spaces, we need to make substantial investments to enhance our fundamental research in AI and ML and closely apply those AI/ML techniques to these areas.

Primary Industry

Primary industry is the most important industry for our economy, and AI has great potential to help make significant improvements in this sector, especially where AI/ML techniques are not extensively used.
Our national priority needs to be focused on:

- Milk and dairy industry
- Aquaculture and the open ocean blue economy
- Wine and viticulture
- Animal products, particularly cow and sheep
- Forestry
- Water resources
- Plant and horticulture industries, including fruits and vegetables
- Plant and animal disease diagnosis and processing, and biosecurity

These areas of primary industry contribute greatly to our economy, and AI/ML experts can collaborate with agriculture/aquaculture/horticulture, biological, and chemical domain experts to revolutionise current performance in primary industry.

Many of our key strengths in AI/ML can make significant contributions to these areas, particularly predictive modelling and regression, feature extraction/selection and engineering, computer vision and image processing, real-time stream mining, automated deep learning, transfer learning and domain adaptation, while planning and scheduling techniques could be used to help our primary manufacturing industry.

The Māori economy is also very relevant and important to our economy, with the Māori asset base valued at over $68.7 billion [19]. AI/ML contributions in this economy need to be cognisant of Māori data sovereignty issues, partnership, and culturally appropriate AI systems.

Climate Change and Environment

Climate change and our environment are important aspects of the Government's strategic focus, and AI can greatly help in these areas, particularly in:

- Climate modelling
- Weather forecasting in land and ocean
- Disaster prediction, particularly earthquake, volcano and tsunami
- Monitoring potential impacts of climate change in rivers and bridges
- Glacier management
- Reducing greenhouse gas emissions of transport infrastructure

These key areas will directly contribute to helping monitor and sustainably manage our environment and climate change, and will also form an important part of Aotearoa New Zealand's AI economy.

Health Outcomes

Biological and biomedical applications and public health are important to human life and wellbeing as well as the lives of animals and ocean plants. AI has started to play an important role in this area, but its potential has not yet been explored. AI/ML can make great contributions to this area, particularly in:

- Bioinformatics such as biomarker detection, DNA sequence, synthetic biology
- (Bio)medical diagnosis and treatments
- Cancer detection and diagnosis including skin cancer detection and breast cancer detection
- Public health including healthcare and nursing
- Community diseases such as COVID-19
- Neural and cognitive science
- Drug discovery

High-value Manufacturing Industry

Aotearoa New Zealand does not have a full range of manufacturing industry, but we have several key areas of strength in which AI/ML could provide immediate and great help, particularly:

- Cybersecurity (New Zealand-Australia strategic investment)
- Sustainable/renewable energy and our zero-carbon strategy
- Material and chemical engineering, including nanotechnology, electronic devices
- Superconductivity including high-temperature and low-temperature
- Blockchain
- Communication
- Mechanical/mechatronic/robotics, unmanned aerial vehicles/drones
- IoT and robotics

Social and Ethical Considerations, Vision Mātauranga and Public Policies

Social impact is an important aspect of the Government's strategic focus. The Vision Mātauranga funding policy also recognises and prioritises Māori flourishing in research. Compared with the above research and technical areas, some of the ethical issues, potential harms, and minority/equity issues are equally important but have received much less attention. AI/ML policies, techniques and collaborative practices with diverse stakeholders can also greatly help mitigate any negative impacts and improve the potential for AI that works for the wellbeing of all. In addition to the relevant areas already mentioned, other relevant key areas include:

- Culturally appropriate solutions for Māori and Pacific peoples
- Fair AI in banking and insurance, finance, GDP/CPI prediction
- Equitable AI in human resources and organisational management
- Public policymaking for socially-responsible use of AI

Carefully applying AI/ML techniques to these aspects along with appropriate frameworks and governance mechanisms will greatly enhance/improve our economy, environment, health outcomes and society. To achieve this goal and make our economy/environment/health/society sustainable and positive, we must also enhance our fundamental AI research and maintain our international reputation and leadership in key areas.

KEY DIMENSION 3: INVESTING PRIMARILY IN STRATEGIC SECTORS

Aotearoa New Zealand cannot be successful in all sectors. As such, there is a need to focus our AI ecosystems around the economy's vital industries. Spreading small amounts of resources across every sector should be avoided as it will not provide the greatest return on investment. We cannot compete in terms of funding with large countries, due to our size, making it important to focus our investment on strategic sectors. We identify four focus areas:

1. Sustainable AI
2. Responsible foundation for AI: Ethical AI and Explainable AI
3. Increasing investment from Government and industry
4. AI Education in terms of competence and expertise

As outlined in Key Dimension 2, we have identified five sectors of social application and national priorities where AI can play a role in addressing national challenges:

1. Primary industry
2. Climate change and environment
3. Health
4. High-value manufacturing industry
5. Social and ethical considerations, Vision Mātauranga and public policies

> **“ ... there is a need to focus our AI ecosystems around the economy's vital industries. ”**


SOUTH POLE
EQUATOR
VANCOUVER
BLUFF
1452 km
784 nm
LONDON
18029 km
SYDNEY
1066 nm
1975 km
TOKYO
4576 nm
8475 km

KEY DIMENSION 4: PROVIDING A SET OF STANDARDISED DATA PROTECTION LAWS AND ADDRESSING ETHICAL AND BICULTURAL CONCERNS TO IMPROVE WELLBEING AND SOCIETY

It is essential to have a unified and sustainable regulatory environment of mutual trust between data subjects and organisations that clearly explains how AI is implemented and how data can be collected, stored, processed, shared, used and potentially deleted.

Kate Crawford, a senior principal researcher at Microsoft Research, argues in her book "The Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence" [5] that political issues are more important right now than ethical issues. She asserts that AI is not simply efficient software running in "the cloud", and she looks at how AI is made, considering the natural resources that drive it, the energy that it consumes, the hidden labour throughout the supply chain, and the vast amounts of data that are extracted from every platform and device that we use every day. Her book reveals how AI is fuelling a shift toward undemocratic governance and increased inequity.

> **"Transparency can only be achieved with an explanation for each decision, as other countries are aiming to provide – making research in Explainable AI extremely important."**

Yuval Noah Harari, historian and author of the book "Sapiens: A Brief History of Humankind", explained at the World Economic Forum annual meeting in Davos, in 2020 [20], that AI risks dividing the world into wealthy elites and exploited "data colonies". He mentioned that "we are already in the midst of an AI arms-race, with China and the USA leading the race, and most countries being left far behind. Unless we take action to distribute the benefit and power of AI between all humans, AI will likely create immense wealth in a few high-tech hubs, while other countries will either go bankrupt or become exploited data-colonies. ...When you have enough data you don't need to send soldiers, in order to control a country."

In 2019, the High-Level Expert Group on Artificial Intelligence set up by the European Commission published the Ethics Guidelines for Trustworthy Artificial Intelligence [6]. They proposed an Assessment List to help assess whether the AI systems that are being developed, deployed, procured or used adhere to the seven requirements of Trustworthy AI:

1. Human Agency and Oversight;
2. Technical Robustness and Safety;
3. Privacy and Data Governance;
4. Transparency;
5. Diversity, Non-discrimination and Fairness;
6. Societal and Environmental Wellbeing; and
7. Accountability.

In Europe, the EU's General Data Protection Regulation (GDPR) [9] is focused on individual data protection. Recently, the European Commission revealed a new Proposed Regulation laying down harmonized rules on AI. When it is adopted, the regulation will have significant implications for businesses both inside and outside the EU that help make AI available in the EU. As the first of its kind, the Proposed Regulation may also influence how other countries regulate AI, similar to how the EU GDPR has influenced how other countries regulate privacy. Like the GDPR, the Proposed Regulation provides for severe penalties for non-compliance.

Our Government has developed an Algorithm Charter [11] that commits the signatory government agencies to use algorithms in a fair, ethical and transparent way. However, transparency appears to be quite weak compared with other international practices (e.g. GDPR in Europe). The aim "Maintain transparency by clearly explaining how decisions are informed by algorithms" is quite vague. It mentions only providing "Plain English documentation of the algorithm", "Making information about the data and processes available (unless a lawful restriction prevents this)", and "Publishing information about how data are collected, secured and stored". Transparency can only be achieved with an explanation for each decision, as other countries are aiming to provide – making research in Explainable AI extremely important. It has also been argued [22] that in some cases a right to explanation is a consequence of existing human rights. Additionally, this Charter does not fully address important considerations, such as Māori Data Sovereignty. Te Mana Raraunga, in their submission on the draft Algorithm Charter, stated that "an 'Algorithm Charter' is insufficient to protect Māori rights and interests. Regulation that includes mechanisms for accountability and redress is necessary. Such regulation would need to include Māori data governance at all levels" [27].

Researchers at the University of Otago made some specific proposals in their 2019 report on Government Use of AI in New Zealand [10]. In particular, they suggested that the Government regularly publish a register of all the 'predictive algorithms' that are in use in its departments, along with information about their accuracy on unseen datasets, as a way of concretely addressing the transparency issue.

Additionally, Te Kotahi Research Institute authored a report for the Digital Council with recommendations to increase transparency in AI and to give effect to Te Tiriti o Waitangi. Their recommendations include [28]:

1. Build Māori Data and Digital Capacity within both Māori communities and across networks of Māori practitioners.
2. Develop robust equity assessment protocols for algorithms.
3. Ensure meaningful Māori participation in Institutional algorithm self-assessment processes.
4. Support collaborative partnership in project governance and the development and use of algorithms.
5. Create a Māori values framework and tikanga guidelines to support AI design, development, use and maintenance.
6. Explore Te Ao Māori use-cases involving te reo Māori, tikanga Māori, and mātauranga Māori in AI

Some initiatives and research projects are underway in these domains but they require further investment.

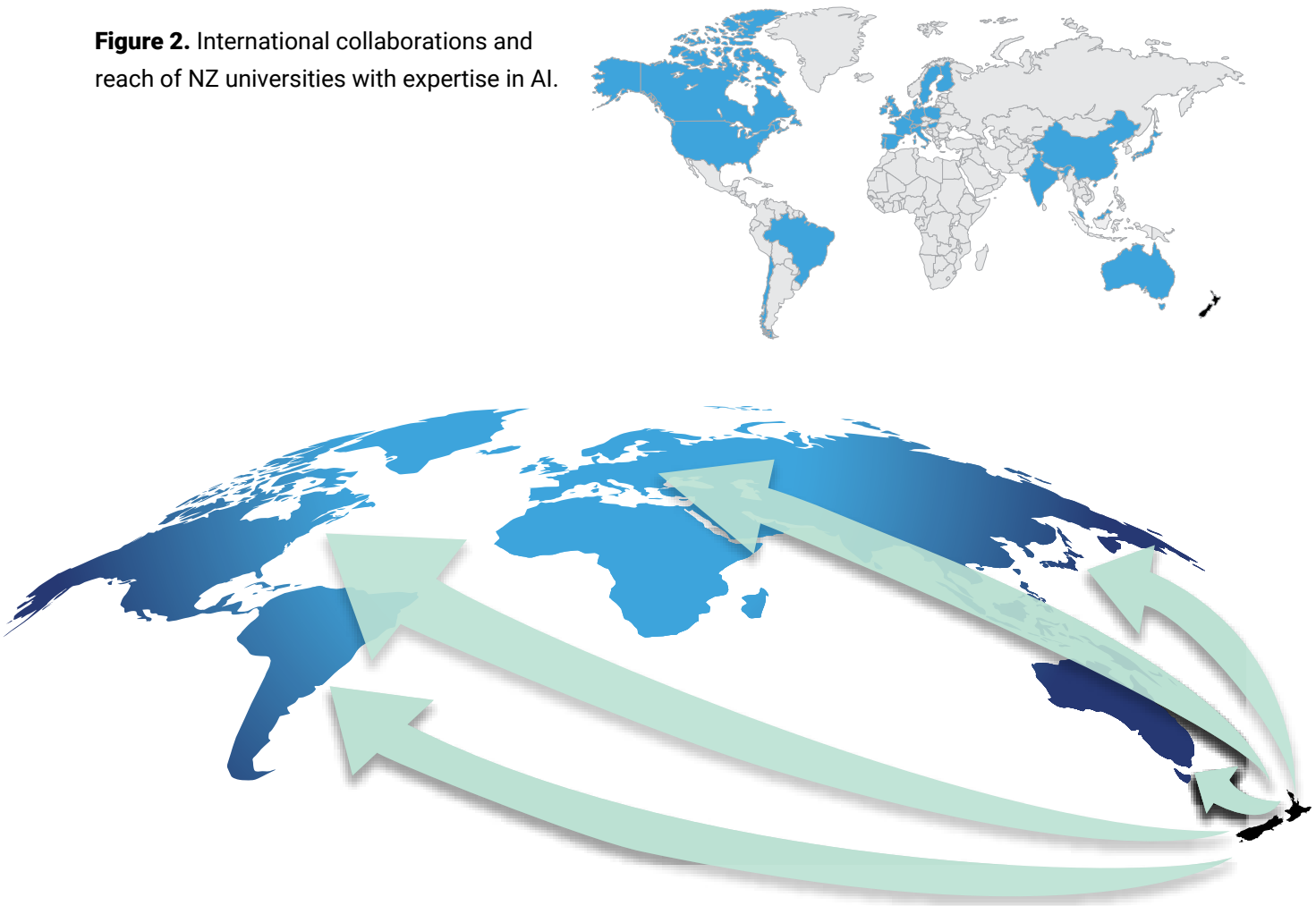
KEY DIMENSION 5: ENGAGING IN INTERNATIONAL COLLABORATION

Aotearoa New Zealand needs to engage internationally with other countries to access their expertise and capabilities within academia and industry. We must develop a plan to establish international collaborations, especially in terms of research, accessing technology developed in those countries, and creating new technologies in collaboration with them. It will be very important to contribute to global efforts towards regulation and governance. The German AI strategy has specific plans to use international cooperation in the development and regulation of AI, to which Aotearoa New Zealand ought to make a distinctive contribution.

To close this section of the paper, we summarise some of the research, international collaborations and application strengths at our universities, which demonstrates a solid base for increasing our country's international AI research profile and contribution.

> **“It will be very important to contribute to global efforts towards regulation and governance.”**

Figure 2. International collaborations and reach of NZ universities with expertise in AI.



University of Auckland

Researchers at the University of Auckland specialise in multi-agent systems, game theory, social network analysis, heuristic search, automated problem solving, ML, computational sustainability, cheminformatics, spatio-temporal data mining, adversarial learning, data stream mining, multi-label classification, natural language processing, natural language understanding, machine reasoning, knowledge representation, deep learning, computer vision and image processing, speech processing, and robotics. The fundamental AI research is applied in areas like agriculture, horticulture, construction, smart cities, healthcare, environmental science, sustainability and renewable energy, and cybersecurity. The Researchers have extensive international collaborations through projects with Beijing Institute of Technology (China), Beihang University (China), Southwest University (China), Chinese Hong Kong University (China), Harbin Institute of Technology (China), Shanghai Jiao Tong University (China), University of Tasmania (Australia), National University of Singapore, Nanyang Technological University (Singapore), Universidad Carlos III de Madrid (Spain), RIKEN Institute (Japan), University of California at Santa Cruz (USA), Aalborg University (Denmark), Royal Holloway University of London (UK), University of Alberta (Canada), Institute for Study of Learning and Expertise (USA), Carnegie Mellon University (USA), Josef Stefan Institute (Slovenia), Johannes Gutenberg University Mainz (Germany), TU Munchen (Germany), Monash University (Australia), RMIT (Australia) and IBM Research.

University of Otago

The University of Otago is co-leading a project on government oversight of social media recommender algorithms, coordinated by the Global Partnership on AI's Responsible Use of AI working group, led by Yoshua Bengio, and funded by CEIMIA, Montreal's International Centre of Expertise on Artificial Intelligence. The aim of the project is to develop methods that allow the government of a given country to ask social media companies about the effects of their recommender algorithms on citizens of that country, with a focus on harmful effects, such as the consumption or production of terrorist or violent extremist content. The technical part of the project aligns closely with this year's Christchurch Call workstream, which Ali Knott also helped to draft. The 2021 workstream focuses on a study of social media platform algorithms, as agreed at May's Christchurch Call summit. The AI and Law in New Zealand project, funded by the New Zealand Law Foundation, is hosted at the University of Otago and co-led by Ali Knott, Colin Gavaghan and James Maclaurin. This project has two parts, each informed by a national and an international workshop. The first part looked at Government Use of AI in New Zealand [10]; the second part looked at the Impact of AI on Jobs and Work in New Zealand [13]. Another output of the project was a book published with MIT Press, A Citizen's Guide to Artificial Intelligence.

Auckland University of Technology

Researchers at the Auckland University of Technology (AUT) are working on computational theories of the mind, methods and systems for computational intelligence, logic and game-playing, AI in medicine, and nature-inspired computing. AUT AI researchers have collaborations with many international organisations: Nanyang Technological University (Singapore) on mental health; Warsaw University of Technology (Poland), Dublin Institute of Technology (Ireland), University of the Basque Country (Spain), Ecole Centrale de Nantes (France), Budapest University of Technology and Economics (Hungary), Griffith University (Australia), University of New South Wales (Australia) on aeronautics and astronautics, power, renewable energy and new energy sources, sensing technologies, automation and control systems; Xinjiang University (China) and Shanghai Jiao Tong University (China) on intelligent information systems for online visual exploration and understanding and prediction of ecological and environmental problems; University of New South Wales (Australia) on learning in general game playing; Liverpool University (UK) on multi-agent logics; Temple University Philadelphia (USA) on applications of machine learning to clinical and healthcare data including brain injury data; King's College Hospital (UK) on cough hypersensitivity; Oregon Health and Science University Portland (USA), Children's Hospital of Fudan University (China), Beijing Institute of Life Sciences (China), Chinese Academy of Sciences (China) on autism, Yale University (USA) on geriatrics pediatrics and neuroscience; and Nottingham Trent University (UK) and Deakin University (Australia) on depression biomarkers.

Massey University

Researchers at Massey University are working in data processing, speech processing, image/video processing, natural language processing, geographic information science, geospatial knowledge representation and reasoning, location-based systems, and in specific application areas as agriculture, disaster management and environmental conservation. They have a wide international collaboration network, which includes Carnegie Mellon University (USA), University of Technology Sydney (Australia), Adelaide University (Australia), Peking University (China), Tsinghua University (China), National University of Singapore, Dublin City University (Ireland), Leeds University (UK), Cardiff University (UK), Ordnance Survey (UK), University of Nottingham (UK), RMIT (Australia), University of Melbourne (Australia), University of Maine (USA) and VNIT Nagpur (India).

Lincoln University

Researchers at Lincoln University are working in agent and multi-agent applications in agriculture and environment, use of ML to identify emotion and sentiment from social media text, soft computing (neural networks, fuzzy systems, ML) in complex systems, and network and data modelling for complex systems. They collaborate internationally with Universiti Malaysia Sabah.

Victoria University of Wellington

Researchers at Victoria University of Wellington (VuW) have been working on fundamental research in a range of areas of AI, ML and data science, and playing an international leadership role in evolutionary learning and optimisation, feature selection and big dimensionality reduction, automated deep learning and image analysis, multi-agent systems, categorical and ordinal data analysis, hyperheuristic and learning approaches to planning and scheduling, audio/language and signal processing, explainable AI, and autonomous agents and multiagent systems. VuW researchers have been collaborating with other universities and CRIs and successfully applying AI and ML techniques to solve application tasks in primary industry, climate change, biological and health-related areas, high-value/high-tech manufacturing such as cybersecurity and renewable energy, and ethical/ cultural AI and public policies as well as started a pipeline of training Māori researchers in AI and data science. VuW AI researchers have collaborations with many international organisations, including universities in the USA (e.g. MIT, Michigan State University, Oklahoma State University and University of Rhode Island), China (e.g. Tsinghua University, Nanjing University, Xi'an Jiaotong University, Beijing Jiaotong University, Southern China University, Southern University of Science and Technology, and Zhengzhou University), the UK (e.g. University of Warwick, Edinburgh Napier University, University of Surrey and University of Birmingham), Australia (e.g. University of Melbourne, RMIT University, UTS, Central Queensland University and UNSW Canberra), Singapore (e.g. NUS and NTU), and Europe (e.g. Delft University of Technology, The Netherlands, and University of Parma, Italy). In addition, VuW AI researchers have been collaborating with major international AI communities and societies (e.g. IEEE Computational Intelligence, Computer, and Signal Processing Societies, ACM SigEVO, ACM SigKDD, IJCAI and AAAI), chairing technical committees, and working with globally innovative companies such as IBM, Microsoft, Google, Huawei, KPMG, Xero and Weta Digital.

University of Canterbury

Researchers at the University of Canterbury have extensive international collaborations through projects with Peking University (China) on Bayesian Demographic Inference; RMIT (Australia) on Constructing Pattern Recognition Trees; Université Laval (Canada) on Deep Reinforcement Learning for Creating Game-Playing Agents; Hong Kong University and Rensselaer Polytechnic Institute (USA) and University of Montreal (Canada) on AI in Medical Imaging; University of Leeds (UK) on using AI in Video-Based Learning (VBL) culminating in the AVW-Space (online platform for VBM); University of Pittsburgh (USA) and University of Illinois (USA) and University of Pennsylvania (USA) and University of Sussex (USA) and University of Malaga (Spain) on collaboration on AI in Education; University of Milan (Italy), Urbana-Champaign (USA) and Missouri (USA), Orsay (France), ANU (Australia), Kiel (Germany), University of Cambridge (UK) on Neuromorphic Computing; Boston University (USA), Turing Centre at Eidgenössische Technische Hochschule in ETH Zürich (Switzerland), University of Queensland (Australia), University of Oxford (UK), Renmin University (China), Copenhagen University (Denmark), Georgetown University (USA), Mangalam University (India) on the philosophy of AI; Leibniz Universität Hannover (Germany), ETH Zürich on Deep Learning for autonomous robots and pose tracking;

Monash University (Australia) and ANSTO on medical imaging and AI machine learning; CSIRO (Australia), University of Melbourne (Australia), University of Rio de Janeiro (Brazil), Novitom (France), Max Planck Institute (Germany), Technical University of Munich (Germany), Norwegian University of Science and Technology (Norway), Digital Democracy Institute - Simon Fraser University (Canada), University of Montreal (Canada), American Mathematical Society on AI models for drivers of segregation.

University of Waikato

The University of Waikato's main research expertise is in AI, as seen in Microsoft Academic [21]. The University has created some of the world's most popular open source tools such as Weka, Moa and Adams. Weka has more than 10 million downloads and has been cited in more than 20,000 research and applied publications. In 2021, the University launched Te Ipu o te Mahara Artificial Intelligence Institute, which is focused on real-time analytics for big data, machine learning and deep learning. The Institute has a strong international research network, with associate members from Institut Polytechnique de Paris (France), Universitat Politècnica de Catalunya (Spain), Katholieke Universiteit Leuven (Belgium), University of Málaga (Spain), TECNALIA (Spain), Basque Research & Technology Alliance (Spain), University of Porto (Portugal), Federal University of Paraná (Brazil), Carnegie Mellon University (USA), University of Texas (USA), Blekinge Institute of Technology (Sweden), Eindhoven University of Technology (Netherlands), University of Sao Paulo (Brazil), Cardiff University (UK), Dalhousie University (Canada), Politecnico di Milano (Italy), Warsaw University of Technology (Poland), University of Münster (Germany), Université Paris-Saclay (France), University of Helsinki (Finland), University of Chile (Chile), Telefonica Research (Spain), INRAE UMR Tetis (France), Universitat de Girona (Spain), Honda Research Institute Europe (Germany), Ekkono Solutions (Sweden), ISI Foundation (Italy), Amazon Web Services (UK), and Shopify (Canada).

3. LIST OF KEY RECOMMENDATIONS

Our vision is that by 2030, Aotearoa New Zealand will have a community of cutting-edge companies producing and exporting AI technologies, supported by a strong network of researchers involved in high-level fundamental and applied research. AI will help to improve the quality of life of people through being imbued with characteristics and values important for Aotearoa New Zealand. The labour force will be highly qualified, and Aotearoa New Zealand will be at the forefront of equitable AI education for diverse stakeholders. The realisation of this vision requires investment, as well as concerted effort. We propose the following recommendations to establish Aotearoa New Zealand as an exemplar of excellence and trust in AI worldwide.

Scientific Research: Increase existing funding for public AI research with the development of new research centres, hubs, and programmes in basic and applied AI research.

- Create a network of research centres around Aotearoa New Zealand
- Double the number of researchers, lecturers, senior lecturers, associate professors, and professors (not fixed-term) in AI in three years (by 2024), and double it again in six years (by 2030), supported by a similar increase in students studying AI
- Invest in Māori AI research and Māori-led research (both pure and applied in nature)
- Increase government funding for AI research by 70% as in Europe
- Invest SSIF Fund to enhance CRI-university collaborations in AI research and local industry applications
- Organise strategic Catalyst Fund opportunities to encourage and enhance international collaborations in AI

AI Talent Development: Increase New Zealand's capability to attract, retain, and train domestic or international AI talent.

- Offer world-leading masters programmes in AI, onsite and online
- Double the number of PhD and Master by Research students in AI by 2025 and again by 2030, promoting industrial PhDs
- Introduce strategies to increase the proportion of Māori researchers and scientists
- Provide funding for 20 professorships on fundamental and applied AI
- Attract the best professors and scientists by providing better work conditions than other countries
- Create new initiatives to help students and the overall labour force develop skills for the future of work, such as investments in STEM education, digital skills, or lifelong learning
- Promote basic understanding of AI and ML among primary and secondary school students

Industrialisation of AI Technologies: Create programmes to encourage private-sector adoption of AI technologies, including investments in strategic sectors, funding for AI start-ups and small and medium-sized enterprises (SMEs), and strategies to create AI clusters or ecosystems.

- Create an AI Ecosystem with Industry Labs
- Create AI Digital Innovation Hubs for SMEs
- Help the creation of start-ups

Ethical AI Standards: Create a task force to develop standards or regulations for AI's ethical use and development, including culturally appropriate AI.

- Provide funding for research or pilot programmes to create explainable and transparent AI
- Advocate for a publicly available register of Government models, evaluated for the whole population
- Call for a wider consultation on the question of whether evaluation should also be broken down for particular groups
- Support the development and implementation of a Māori values framework and tikanga guidelines to support AI design, development, use and maintenance

Data and Digital Infrastructure: Create an effective national data infrastructure with open data partnerships and datasets, while enabling and supporting Māori data sovereignty obligations, as well as commitments to create test environments and regulatory sandboxes. AI needs a good data infrastructure to be successful.

- Map current data centres and computational infrastructure availability, usage and gaps across the wider ecosystem
- Leverage current data centres and computational infrastructure, including in the private sector, for AI models and implementation, through collaborative partnerships
- Support the development of efficient data collection, storage and compute infrastructure focusing on AI applications, through collaboration and funding
- Ensure computer science programmes across the tertiary sector include building capability toward and clear, structured pathways into the high performance computing workforce

AI in the Government: Champion government leading the adoption of AI: government administrations, hospitals, utility and transport services, and financial supervisors in ways that give effect to Te Tiriti o Waitangi.

- Maintain a register of the algorithms and models used, showing their performance on measures of bias
- Ensure collaborative partnership with Māori in project governance and the development and use of algorithms and models
- Ensure meaningful Māori participation in institutional algorithm self-assessment processes

Inclusion and Social Wellbeing: Use AI to promote social and inclusive growth and ensure that the AI community is inclusive of diverse backgrounds and perspectives [12].

- Build data and digital capacity within Māori communities and across networks of Māori practitioners

4. CONCLUSION

In this whitepaper, following the framework designed by the World Economic Forum, we discuss the research capabilities of Aotearoa New Zealand in AI, and we propose a set of key dimensions and recommendations on how to establish Aotearoa New Zealand as an exemplar of excellence and trust in AI worldwide.

It is important to also focus on the political aspects of AI, and not only the ethical ones. If Aotearoa New Zealand does not invest in research, AI will only be efficient software running in the cloud of large overseas companies. This outcome creates risk and could negatively impact our country's independence in terms of technology and data sovereignty.

The main message of this paper is that universities and research institutes have very strong AI research that has a huge breadth and potential. It is imperative to create and invest in an AI ecosystem where industry and research organisations can work together more closely for the benefit of Aotearoa New Zealand.

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AI