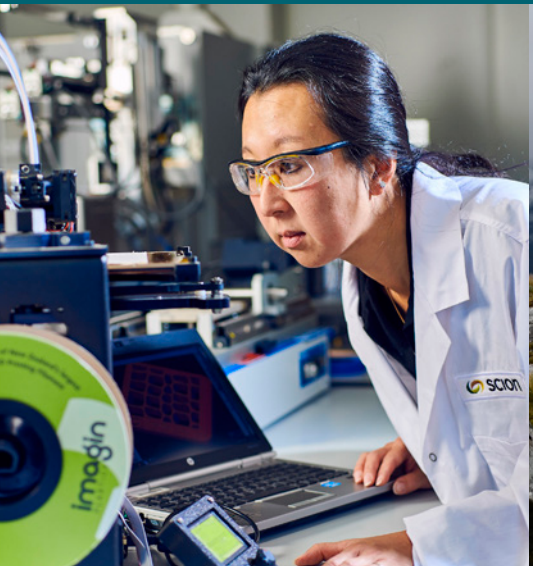
Te Pae Kahurangi

Positioning Crown Research Institutes to collectively and respectively meet New Zealand's current and future needs



E hara taku toa I te toa takitahi, engari he toa takitini

The greatest successes we will have are from working together.

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Executive summary and recommendations

1. In October 2019, the Ministry of Business, Innovation and Employment (MBIE) commissioned Te Pae Kahurangi, a review by an independent Panel, to assess how well Crown Research Institutes (CRIs) are positioned, collectively and respectively, to meet New Zealand's current and future needs.

2. Although the review focused on CRIs, many of the issues identified by stakeholders and discussed in this report apply to the wider science system of which CRIs are an important element. To the extent practicable, the scope of any changes that follow this review would usefully apply to the wider system, wherever relevant.

CRIs REMAIN A CRITICAL COMPONENT OF NEW ZEALAND'S SCIENCE SYSTEM

3. CRIs were established in 1992 as a diverse group of mission-led companies undertaking research and science services for New Zealand's benefit.

4. CRIs have contributed to New Zealand on multiple fronts, spanning breakthrough research, supporting critical sectors of the economy and society, enhancing understanding of our natural world, solving environmental challenges, building support for Māori and responding to multiple emergencies.

5. CRI leaders and teams with whom the Panel met were all committed to making a difference for their customers and for New Zealand through quality research and associated services.

ASPECTS OF THE CURRENT SYSTEM ARE NOT WORKING WELL AND THE FUTURE WILL REQUIRE AN APPROACH THAT IS MORE INTEGRATED

6. Stakeholders and, to varying degrees, CRIs themselves, identified several features of the existing operating model that are not working as well as they could, including fragmentation, overlapping activities and missed opportunities for sharing resources, as well as aspects of public funding that sometimes incentivise unproductive competition and distort choices on ways to achieve impact from new knowledge.

7. Meeting the challenges and opportunities of the future will require harnessing the collective capability of CRIs, often in partnership with other science system participants and with Māori, to tackle the complex and interdependent research challenges that are central to New Zealand's future, including in relation to:

   - climate change, water and land use
   - food, materials and energy transitions
   - increasing threats to resilience, human health and well-being.

8. CRIs collectively will need high levels of adaptability, allowing them to build new capabilities and allocate resources to emerging research priorities, unconstrained by organisational boundaries.

ENHANCING CRIs' FUTURE CONTRIBUTION TO NEW ZEALAND

9. Drawing on the views and insights of stakeholders and the CRIs themselves, the Panel has identified several areas where changes to the various components of the current operating model have the potential to deliver a future state in which the collective capability of CRIs will be better positioned to meet New Zealand's research needs.

Integrated strategy and priority setting

10. Under the existing operating model, strategy setting is undertaken on a standalone basis by each CRI, working with stakeholders, checking in with MBIE and seeking endorsement from the Minister.

RECOMMENDATION 1

The Panel recommends that MBIE and CRIs co-design an explicit process for developing and documenting an integrated pan-CRI strategy and high-level research priorities over a multi-year period, in consultation with Māori, science-using government departments and other CRI stakeholders, within a context set by science system strategies and the priorities of the government of the day.

11. The strategy and high-level research priorities will evolve through time, which will require other elements of the operating model to be configured to support ongoing adaptability and agility in refining the set of capabilities that CRIs steward, as well as the ways in which those capabilities are combined and deployed.

Customer-centric

12. Stakeholders were clear on the respective roles of CRIs in many areas but noted apparent overlap of activities in several of them, which was causing confusion for some customers with regard to who does what and how to get integrated support.

13. Current arrangements for prioritising and funding environmental and related (e.g. primary sector) research for the government are not working well.

RECOMMENDATION 2

The Panel recommends that:

- *CRIs address areas of overlap and organise to ensure the option of a 'single front door' for customers and other stakeholders who interact with multiple CRIs*
- *MBIE, the Ministry for the Environment, Ministry for Primary Industries, Department of Conservation, CRIs and Māori co-design and implement a process for prioritising and funding CRIs' environmental and related (e.g. primary sector) research for government.*

Meeting Māori and iwi aspirations

14. Māori and iwi groups are seeking partnerships with CRIs that are more integrated, Tiriti based and long term.

> **RECOMMENDATION 3**
>
> *The Panel recommends that:*
>
> - *CRIs provide a supportive environment for a growing cohort of Māori researchers*
> - *CRIs work together to build an integrated, Tiriti-based partnership with Māori*
> - *MBIE works with Māori and science system participants to ensure the system and the various funding mechanisms are purposeful, targeted and linked, to support Māori and iwi aspirations.*

Purposeful collaboration

15. Stakeholders and CRIs provided a number of examples of purposeful collaboration among CRIs and with other science system participants, but also commented that CRIs sometimes compete with one another and with other science system participants (and vice versa) in unproductive ways. A funding system that requires competing for funds to support core activities and the standalone nature of individual CRIs were cited as primary causal factors.

16. Opportunities to collaborate for national benefit sometimes appear to be thwarted by a combination of organisation-specific interests and different ways of operating.

> **RECOMMENDATION 4**
>
> *The Panel recommends that:*
>
> - *CRIs strengthen the mechanisms for, and reduce the barriers to, collaboration with each other and with other science system participants, including through adopting common practices wherever practicable*
> - *MBIE reviews the ownership and funding arrangements (discussed below) to strengthen incentives for purposeful collaboration among CRIs and with other science system participants.*

Attract and develop talent

17. CRIs have been effective in attracting and retaining scientific and supporting skills and talent, including attracting international scientists to New Zealand.

18. Stakeholders and CRIs themselves identified opportunities for CRIs to take an approach that is more integrated in some aspects of workforce development, to increase diversity at senior levels and to increase the number of Māori researchers at all levels.

> **RECOMMENDATION 5**
>
> *The Panel recommends that CRIs:*
>
> - *work collaboratively to 'build a pipeline' in areas of emerging skills' shortage, such as data science*
> - *reduce barriers to researchers moving within the science system (e.g. different employment conditions), to ensure the best use is made of scarce talent and to enhance knowledge transfer*
> - *further grow their diversity of leadership at senior levels.*

Efficient and effective use of scarce resources

19. Each CRI is working to enhance efficiency and effectiveness at the organisation level, but much less so at the collective level.

> **RECOMMENDATION 6**
>
> *The Panel recommends that CRIs collaborate to enhance value for the whole, relative to the sum of the parts, through:*
>
> - *integrated investment planning, enabling system-level allocation of scarce capital*
> - *proactively addressing and resolving areas of unproductive duplication*
> - *pooling commercialisation opportunities to diversify risk and build end-to-end excellence in commercialisation capabilities*
> - *standardising systems and processes such as contracting, intellectual property (IP) management, financial and information technology (IT) systems and sharing access to specialised capabilities such as laboratories and other science infrastructure.*

AN OPERATING MODEL TO SUPPORT THE FUTURE STATE

20. The current operating model was established almost 30 years ago, based on the prevailing view that state sector activities should utilise market mechanisms (such as competition and contestability) and commercial disciplines to the maximum extent possible. While the model has evolved somewhat, it is still based on standalone organisations pursuing their own success through delivering research that is of benefit to New Zealand.

> **RECOMMENDATION 7**
>
> *The Panel recommends a future state operating model for CRIs that is strategy led and configured to:*
>
> - *harness and focus the collective research capability*
> - *enable high levels of adaptability in the face of ongoing change*
> - *build new capabilities in response to new opportunities*
> - *collaborate beyond organisational boundaries, across CRIs and with other science system participants*
> - *partner long term with Māori*
> - *utilise resources efficiently and effectively.*

21. A further reason to evolve the current operating model is that several CRIs have faced recurring threats to their financial sustainability and lack the scale and diversity of revenue to support their current cost structures. This compromises their ability to sustain core capabilities, to plan or (at times) to consider priorities beyond survival.

> **RECOMMENDATION 8**
>
> *The Panel recommends that the future operating model be configured to ensure CRIs are organisationally and financially resilient, while remaining accountable for performance.*

Funding

22. MBIE balances multiple objectives in stewarding the main components of CRIs' public funding.

> **RECOMMENDATION 9**
>
> *Taking a CRI perspective, the Panel recommends that MBIE review funding settings with the following objectives:*
>
> - *explicit and stable funding of fit-for-purpose core and high-priority research and science service capabilities and functions, including prioritised databases and collections (as determined at a pan-CRI level), as well as emergency response*
> - *a rebalancing of CRI public funding between stable and contestable funding, in favour of the former, reducing uncertainty and transaction costs, and enabling better medium-term planning*
> - *a planned approach to relevant elements of the funding system to enable a programme of research that is more integrated, focusing on the main cross-cutting challenges such as climate change*
> - *a combination of organisational and funding arrangements that provide an appropriate level of financial stability.*

23. Given clarity of strategy and priorities, as discussed above, CRIs should have discretion as to how they deploy the relevant elements of the Strategic Science Investment Fund (SSIF), subject to maintaining accountability for performance.

Organisational form

24. The CRI Act requires CRIs to undertake research for the national benefit. The Companies Act status of CRIs creates a duty for directors to act in the best interests of the company.

25. In organising to tackle increasingly interdependent research problems, this duty is not a good foundation for a collaborative operating model for CRIs.

26. The financial and liability frameworks of the Companies Act can be a complication for CRIs in emergency response.

> **RECOMMENDATION 10**
>
> *The Panel recommends that CRIs remain as Crown Entities (with a mandate to deliver public benefit through collaboration) but are no longer subject to the Companies Act.*

Governance and structure

27. The current operating model is organised around seven standalone and separately governed organisations, all owned by the Crown. Attaining the future state will require CRIs to be governed and organised in a way that leverages their collective capability and contribution, thereby providing a stronger platform to deliver on the changes described above.

28. The Panel did not undertake a detailed evaluation of specific options, but would expect the future operating model to include some combination of changes to governance, more use of soft structures to build system capability around key research challenges, and consolidation of CRI resources into groupings that are more resilient and flexibly deployable.

> **RECOMMENDATION 11**
>
> *The Panel recommends that as part of the evolution of the various elements of the pan-CRI operating model, MBIE, in consultation with CRIs and with other stakeholders as appropriate, review governance and structure with the objective of moving to a set of arrangements that can support delivery of the future state.*

NEXT STEPS

29. The Terms of Reference for Te Pae Kahurangi specified that the Panel's report should set a foundation for:

    - CRIs to develop a collective (and any respective) response and action plan to move towards this future state
    - a second engagement round with other actors in the system to discuss any proposals that may have implications for their activities
    - any related policy work.

30. The Panel's recommendations build on some of the main themes identified in the 2010 review of CRIs and reflect experience and changes in the broader operating environment since then.

31. Several of the recommendations are linked. The overarching objective is a strategy-led pan-CRI operating model, adaptive by design and underpinned by a set of incentives that harness the intrinsic motivation of researchers to contribute to improved outcomes for New Zealand through excellence, impact and purposeful collaboration, as well as moderating unproductive competition for scarce resources.

32. If the recommendations are accepted, implementing them would involve a carefully sequenced programme of change to shift the operating model, associated incentives and consequent behaviours to those envisaged in the future state.

33. The Panel has identified a future state to work towards that can form the basis for CRIs developing a collective response and action plan.

34. The Panel has also proposed operating model changes that are MBIE's responsibility.

35. Evaluation of a package of changes to the operating model for CRIs could be coordinated with any other changes to science system settings that form part of the post-COVID19 recovery in preparing advice to Ministers.

36. A change programme oriented towards higher levels of CRI integration could incorporate opportunities for system simplification as major research platforms and programmes are reviewed.

Introduction

37. In support of the Minister of Research, Science and Innovation, the Ministry of Business, Innovation and Employment (MBIE) stewards the science system and represents the shareholder interest in Crown Research Institutes (CRIs).

38. In October 2019, following discussion with CRI Chairs, MBIE commissioned Te Pae Kahurangi, an independent review of CRIs' positioning to meet New Zealand's current and future needs.

METHODOLOGY

39. In the course of Te Pae Kahurangi, the review Panel:

- met with the Minister of Research, Science and Innovation
- met with a wide range of CRI stakeholders, including:
  - business users of CRI services
  - central and local government users of CRI services
  - Māori and iwi organisations that engage with CRIs
  - other participants in the science system, such as universities and non-government research institutes
- engaged via video conference with a panel of international scientists, each of whom is on a science advisory panel for one of the CRIs and brought insights from experience working in other national and international science systems
- undertook two-day visits with each of the CRIs
- engaged with the science policy, science investment and CRI ownership teams at MBIE
- reviewed a wide range of documents and data produced by and about CRIs and on the wider science system
- commissioned a high-level comparison of the public research institute elements in New Zealand's science system against systems in other countries from which we could potentially learn.

40. At various stages in the process, the Panel engaged with CRI Chairs and with MBIE's science leadership team, to check understanding and test emerging views.

41. The Panel would like to thank everyone who made time to share their thoughts and to thank the CRIs for their openness and commitment to supporting the review with access to key people, as well as responding to a range of requests for information.

Framework for analysis and recommendations

42. The approach the Panel has taken in addressing the Terms of Reference is to:

- briefly describe the purpose and role of CRIs within New Zealand's science system
- summarise the stakeholders' views of the current arrangements
- consider what New Zealand will need from CRIs over the next decade
- develop a potential 'future state' for CRIs to work towards, identifying several opportunities to enhance their collective contribution
- consider possibilities for reconfiguring the operating model for CRIs to provide a better platform from which to deliver this future state.

43. The Panel met with a diverse group of CRI stakeholders. Not surprisingly, stakeholders had diverse views, although with high levels of commonality on some issues.

44. The perspectives of CRI interviewees varied depending on their respective operating environments but they held similar views on many aspects of the system.

45. The Panel also engaged with Māori and iwi groups, who expressed strong and broadly consistent views on the ways the current arrangements are not delivering for them.

46. In formulating conclusions and recommendations, the Panel considered the balance of stakeholder feedback and tested this against other information sources, where possible, and with CRI Chairs, MBIE science leaders and the panel of international scientists.

47. Some stakeholder comments related to opportunities to develop a science system that is simpler and more integrated. Although this review focused on CRIs, several of the Panel's recommendations could apply equally to other parts of the system, including an approach that is strategy led, reduces unproductive competition and barriers to collaboration and fosters the sharing of resources.

COVID19

48. The extent of the effects of COVID19 became increasingly apparent during Te Pae Kahurangi.

49. Science and research have been central to the COVID19 response in New Zealand and to the search for enduring solutions. New Zealand scientists have been trusted advisors to the government and to the public more generally.

50. The implications of COVID19 for New Zealand, for the science system and for CRIs will take time to emerge, but are likely to include:

- a severe deterioration in the government's fiscal position
- the loss of some sources of government and commercial revenue for CRIs, with research budgets under pressure in most organisations, including central and local government
- a risk that under-represented cohorts in the research workforce are particularly affected by any post-COVID19 austerity measures
- ongoing restrictions on travel, requiring changes to the way international collaborations are undertaken and limiting our ability to leverage the research expertise of our international partners
- investment to enhance resilience to future pandemic risks
- a desire to use the post-COVID19 recovery as an opportunity to accelerate progress in transforming New Zealand's economic and environmental performance.

51. Supporting the post-COVID19 recovery and enhancing resilience to future pandemics will be important medium-term priorities for CRIs, as well as for other science system participants.

New Zealand's science system and the role played by CRIs

52. National science and innovation systems contribute to prosperity and well-being by generating new knowledge and new ways of doing things and by enhancing access to, and adaptation of, the knowledge and innovation created internationally.

53. Most developed economies, including New Zealand, aspire to increase expenditure on Research and Development (R&D) both in absolute terms and as a percentage of GDP.

54. MBIE's *Research, Science and Innovation System Performance Report* (2018) and the draft of the *Research, Science and Innovation Strategy* (2019) provide an overview of New Zealand's science and innovation systems.

55. Research is variously categorised as being:

    - investigator led, mission led and user led
    - basic and applied
    - Horizon 1 (leverage proven ideas), Horizon 2 (develop emerging ideas) and Horizon 3 (generate new ideas).

56. MBIE's draft *Research, Science and Innovation Strategy* (2019) identifies three underpinning principles: excellence, impact and stronger connections within and beyond New Zealand's research community.

57. Research in New Zealand is undertaken by a diverse set of entities, with major contributors including CRIs (government owned), universities (autonomous), private research institutes, industry bodies and businesses. Government departments, regional councils, Māori and iwi groups undertake research in specific areas.

COMPARISON WITH OTHER NATIONAL SCIENCE SYSTEMS

58. In comparison with other small advanced economies, New Zealand spends less than average on R&D as a percentage of GDP and has lower GDP per capita. Funding pressures are endemic to science systems and that is certainly the case for New Zealand, which, despite its relatively small economy, is attempting to sustain a broad range of science and research institutions and quasi-institutions.

59. In New Zealand, business R&D as a percentage of GDP is particularly low, reflecting factors such as the structure of economic activity (with fewer R&D-intensive sectors) and the relative paucity of large businesses. Government-funded R&D represents a higher proportion of total R&D in New Zealand than in comparator countries.

60. As part of this review, the Panel undertook a brief survey of New Zealand's institutional settings for the delivery of public research at a high level as compared with those of seven comparator countries: Australia, Canada, Denmark, Germany, Singapore, UK and USA.

61. The Panel found a wide range of approaches to what are known generically as public research institutes. All the other countries appear to leverage geographic clustering of different types of research organisations and businesses more actively, to stimulate innovation.

62. In several countries, there is closer integration between public research institutes and the rest of the research sector, expressed in various ways, such as by cross-appointment at the director level, shared ministerial responsibility or an explicitly integrated approach overall.

63. In two of the countries, an integrating national research and innovation council of some kind is chaired by the Prime Minister/ President. All seven other countries have undergone varying degrees of change in their research systems over the last 20 years, many of them focused on enabling efficiencies and better coordination across the research system.

64. The most comprehensive change has been in Denmark, which has progressively restructured and integrated its public research institutes and universities in response to the outcomes of a 2001 Research Commission.

65. Wageningen University and Research in the Netherlands was cited by multiple stakeholders and CRIs as an example of an integration between university and public research institutes that is deeper than is the case in most national science systems

PURPOSE AND ROLE OF CRIs

66. CRIs were formed in 1992 following a major reorganisation of the Crown-owned parts of the science system and the disestablishment of the Department of Scientific and Industrial Research.

67. The reorganisation reflected the dominant public sector philosophy of the day, which included reducing the role of government, separation of functions and the use, wherever possible, of market mechanisms (competition, contestability) and private sector commercial disciplines.

68. The Crown Research Institutes Act (1992) established that the purpose of CRIs was 'to undertake research'. The Act specified that research should be undertaken for the benefit of New Zealand.

69. An initial set of 10 CRIs was formed around the research and science service functions undertaken by the Department of Scientific and Industrial Research and other public science bodies at the time.

70. The Institute for Social Research and Development ceased operation in 1994.

71. In 2008, the boards of Crop and Food Research and HortResearch initiated a merger, supported by the shareholder, which created Plant & Food Research (PFR).

72. In 2010, a government-appointed taskforce reviewed the CRIs and made several recommendations, including that:

- the government provide a clear, explicit and enduring strategic role for each CRI in a *Statement of Core Purpose* (SCP)
- CRIs remain as Crown companies, to encourage efficient management, but not to be operated as for-profit commercial businesses
- the government directly fund CRIs to deliver their core purpose, with this direct funding forming a significant proportion of CRIs' total Vote Research, Science and Technology funding
- the government identify technology transfer as a core responsibility for all CRIs and discourage CRIs from investing in commercialisation of activities for profit-maximising purposes
- governance be strengthened, government consider appointing individuals to more than one board concurrently (to help boards coordinate and find opportunities for collaboration) and CRIs establish independent science advisory committees and end-user panels
- the government and CRIs agree on financial targets consistent with the requirement for CRIs to be financially viable, invest in new assets and absorb risk, with any surpluses to be reinvested in the wider science system.

73. Cabinet endorsed the overall intent of the recommendations, many of which were implemented as proposed. Statements of Core Purpose were agreed. Governance was strengthened, some cross-appointments were made and CRIs established independent science advisory committees and end-user panels. CRIs are required to be financially sustainable but not to pay dividends. CRIs can pursue commercialisation opportunities as a means of achieving impact from research. The recommendation for direct funding of CRIs to deliver on their core purpose has been only partially implemented.

74. Changes to the science system since 2010 have affected CRIs both directly and indirectly, including:

- the disestablishment of Industrial Research Limited in 2013, with the component parts being divided between Callaghan Innovation and Victoria University
- the launch of National Science Challenges in 2014
- the introduction of the Strategic Science Investment Fund (SSIF) in 2016, replacing core funding for CRIs and providing a mechanism to purchase programmes of research from non-government research institutes where that offers good value for money
- the introduction of an R&D tax credit in 2019/20 to incentivise a wide range of businesses to undertake more R&D.

WHAT CRIs DO

75. The primary focus of CRIs is research into New Zealanders' interactions with our land and environment. This reflects the importance of New Zealand's geography and ecology, the centrality of natural resources to the economy and the relationship between the environment and human health.

76. Table 1 summarises the Statements of Core Purpose for each CRI, which were established following the 2010 CRI review and have not changed since.

TABLE 1
Summary CRI Statements of Core Purpose

AgResearch	To enhance the value, productivity and profitability of New Zealand's pastoral, agri-food and agri-technology sector value chains to contribute to economic growth and beneficial environmental and social outcomes for New Zealand.
ESR	To deliver enhanced scientific and research services to the public health, food safety, security and justice systems, and the environmental sector, to improve the safety of, and contribute to, the economic, environmental and social well-being of people and communities in New Zealand.
GNS Science	To undertake research that drives innovation and economic growth in New Zealand's geologically based energy and minerals industries, that develops industrial and environmental applications of nuclear science, that increases New Zealand's resilience to natural hazards and that enhances understanding of geological and earth-system processes.
Manaaki Whenua – Landcare Research	To drive innovation in New Zealand's management of terrestrial biodiversity and land resources to both protect and enhance the terrestrial environment and grow New Zealand's prosperity.
National Institute of Water and Atmospheric Research (NIWA)	To enhance the economic value and sustainable management of New Zealand's aquatic resources and environments, to provide understanding of climate and the atmosphere, and increase resilience to weather and climate hazards to improve the safety and well-being of New Zealanders.
PFR	To enhance the value and productivity of New Zealand's horticultural, arable, seafood and food and beverage industries to contribute to economic growth and the environmental and social prosperity of New Zealand.
Scion	To drive innovation and growth in New Zealand's forestry, wood product and wood-derived materials and other biomaterial sectors, to create economic value and contribute to beneficial environmental and social outcomes for New Zealand.

77. The following paragraphs set out one way of grouping the research activities undertaken by CRIs.

Research to grow economic value from New Zealand's natural resources (principally land and water) while enhancing environmental performance

78. Several CRIs, to varying degrees, support the primary and resource-based sectors of the economy, such as meat, dairy, horticulture, viticulture, crops, forestry, fishing, aquaculture and energy.

79. The division between sectors that are supported and not supported by CRIs reflects New Zealand's economic and institutional history more than a forward-looking view of economic development opportunities. In recent years, the government has used other mechanisms to provide research support for emerging sectors of economic activity, such as through Callaghan Innovation and the recent data science investment process.

80. CRIs working with resource owners and businesses undertake research across both near and distant horizons, including through:

- privately funded science consultancy to meet the immediate needs of industry groups and individual businesses
- co-funded near-to-market research for an industry body or business
- publicly funded future horizon research to create economic potential (including through enhanced resilience and reduced environmental impact).

81. Stakeholders and customers include the government's economic agencies (e.g. Ministry for Primary Industries, MBIE, New Zealand Trade and Enterprise), a range of private sector groups (e.g. peak bodies, individual businesses), iwi and Māori businesses.

82. Commercialisation is one means to achieve impact from research and is also a potential source of revenue.

Research to help New Zealand solve environmental challenges, notably with regard to climate change, water and biodiversity

83. The primary customers and revenue sources are central and local government. The research is relevant to a wide range of groups, including iwi and Māori.

84. As in the case of the first grouping, the research spans both near and future horizons, although with fewer opportunities for science consultancy and commercialisation.

Foundational research capabilities and services

85. A common feature of national science systems is delivery of foundational science capabilities and services by publicly owned research institutes (including national laboratories). In the New Zealand context, these include:

- research-based support for national resilience to a range of threats, including natural hazards, pandemics and biosecurity
- the provision of essential science services (e.g. forensics to support the justice sector; the mapping, measurement and monitoring of natural resources)
- hosting national databases and collections and shared science infrastructure.

86. Direct customers and funding sources are predominantly from science system funding (via MBIE), other science-informed government departments and local government.

87. Provision of foundational services draws on the broader research capabilities of the CRIs, including innovating to remain at, or close to, the frontier of best practice.

Research to support Māori and iwi aspirations

88. CRIs have a specific focus on research to support improved outcomes for Māori, which encompass economic, environmental, social and cultural well-being.

FUNDING SOURCES

89. Table 2 provides comparative information on sources of funding and staff numbers across the CRIs.

TABLE 2
Sources of revenue and staff numbers

2018/19 financial year	Total revenue	Science revenue[1] sources	Public[2] revenue sources		Industry[3] revenue sources		Staff[4]
	$m	$m	$m	%	$m	%	No.
AgResearch	157	147	73	50%	74	50%	722
ESR	79	79	74	94%	5	6%	420
GNS	95	95	72	76%	23	24%	442
MWLR	85	84	74	88%	10	12%	427
NIWA	161	161	128	80%	33	20%	697
PFR	169	167	80	48%	87	52%	988
Scion	56	55	44	80%	11	20%	356
Total	**802**	**788**	**545**	**69%**	**243**	**31%**	**4,052**

90. Public revenue is a mix of the SSIF, contestable funding and contracts of varying duration with central and local government entities.

91. The private sector is an important source of revenue for some CRIs, particularly AgResearch and PFR. This enables the spreading of overheads over a larger revenue base, reduced exposure to variable public funding and more research in aggregate than would otherwise be the case, while also requiring accurate cost allocations across research programmes and the careful management of IP and the risk of any form of sector capture.

[1] Excludes non-science revenue, such as farm stock sales, rents received.

[2] From general taxation and rates: includes central and local government, tertiary institutions, other CRIs and Crown-owned entities, overseas public organisations.

[3] Includes private sector contracts, levy bodies and royalties.

[4] Headcount as at 30 June 2019, when CRIs employed 3,777 full-time equivalents.

STAKEHOLDERS RECOGNISE THE MULTIPLE CONTRIBUTIONS OF CRIs TO NEW ZEALAND'S WELL-BEING AND PROSPERITY

92. In stakeholder discussions, the Panel heard many positive comments about the contribution of CRIs to New Zealand.

93. Each of the CRIs has made important research-based contributions, including:

- core underpinning science and science services
- new knowledge in applied areas that has deepened understanding and supported innovation in both public and private sectors
- critical support in multiple emergency responses and subsequent recoveries.

94. All CRIs have committed to building partnerships with, and supporting improved outcomes for, Māori.

95. In response to clear expectations from the government and requirements built into some funding mechanisms, collaboration among CRIs and with other science system participants has increased over time. Examples include assembling 'right teams' for a variety of research purposes, participating in and hosting National Science Challenges, sharing buildings, cross-appointments and joint graduate schools.

96. CRIs host world-class scientists conducting world-class science in areas that remain critical to New Zealand's future. CRIs have continued to attract international talent, to the benefit of New Zealand.

97. The diversity of the CRI workforce is improving, with women now making up 48%, although they are still under-represented at senior levels. The ability of CRIs to offer stable employment opportunities was identified as an attractor by young researchers.

98. Independent science committees have supported CRIs' quality of research.

99. The CRI people with whom the Panel met were strongly motivated by the opportunity to make a difference for New Zealand through research and associated activities.

100. CRIs have built deep relationships with world-leading counterparts in other countries, enabling collaborations of significant net benefit for New Zealand and access to world-class science infrastructure.

101. Each CRI has built and deployed capabilities in new research technologies such as genomics, data analytics, artificial intelligence and remote sensors.

102. Mainly through Science NZ, CRIs have developed a range of collaborative initiatives, such as developing a systematic approach to measuring the impact of their research.

103. CRIs have adapted to the real-term progressive reduction in the SSIF. This has been compounded by some increases in the cost of doing business, including:

- compliance with stricter health and safety and hazardous substances regulations
- the cost of increased collaboration – investing in relationships, building shared knowledge and understanding, and negotiating partnership agreements.

104. To varying degrees, CRIs have leveraged strong research capabilities and customer relationships to build financial resilience through alternative revenue streams, such as science consultancy (fee for service) and IP-based initiatives (e.g. licensing, start-ups). This has reduced their reliance on public funding and enabled the building of strategic research portfolios.

THE RESEARCH UNDERTAKEN BY CRIs REMAINS IMPORTANT TO NEW ZEALAND'S FUTURE

105. In this section, the Panel considers the extent to which, almost 30 years after their establishment, CRIs remain an essential element of New Zealand's science system.

Does New Zealand still need publicly owned research institutions?

106. The case for publicly owned research institutes is very strong for 'natural monopoly' functions such as national laboratories, curation of national collections and databases, and national hazard-monitoring systems.

107. Beyond these core functions, governments have choices about ways to configure their science systems, such as in the purchase and delivery of basic and applied science. Agencies that are funding research seek the best value for money, including through contestable mechanisms where there are multiple potential providers.

108. As discussed above, CRIs undertake a diverse range of research and related activities, spanning national functions as well as basic and applied research. To varying degrees, the same people and teams within a CRI are deployed across the spectrum of science services to future horizon research, enabling economies of scope and deeper pools of capability than if the functions were separated out. In a small science system, these synergies are of considerable value.

Are CRIs operating in the 'right' areas of research?

109. The areas of research covered (and not covered) by CRIs reflect decisions that were made decades ago. Although CRIs have built capabilities to ensure they remain at, or close to, the frontier of best practice in the way research is undertaken, the focus remains on the same broad areas of research that were established in 1992 and formalised in each CRI's Statement of Core Purpose (2010).

110. The primary sector (food and fibre) continues to account for more than 50% of the value of New Zealand's exports and the case for continuing investment in research to support future performance remains compelling.

111. Some stakeholders noted a risk of sector bias from a national interest perspective, overweighting research in the established primary and resource-based sectors and underweighting research in newly emerging opportunities that could be disruptive to existing sectors and businesses.

112. Environmental research is now probably more central to New Zealand's future than it was in 1992. Threats to national resilience are increasing in diversity and frequency. CRIs collectively have built deep capabilities in these areas.

Conclusion

113. The Panel concludes that New Zealand continues to require publicly owned research institutes which can meet core science system needs and provide a set of research and associated capabilities that can be applied in support of evolving national priorities.

114. The areas of research covered by CRIs remain highly relevant, although care is required to ensure resources are not trapped in specific areas for historical reasons and the funding system continues to pursue best value for money.

115. The following sections of this review discuss changes to the operating model for CRIs to provide more stable funding of core research and science service functions, support resilience of the publicly owned research institutes and ensure dynamic allocation of discretionary research resources, including the building of new capabilities through time.

A compelling case for change

ELEMENTS OF THE SYSTEM THAT ARE SUB-OPTIMAL NOW ARE LIKELY TO BECOME EVEN MORE SO

116. Stakeholders identified several elements of the current system that are adversely affecting the collective ability of CRIs to meet New Zealand's research needs.

Lack of role clarity and fragmentation in some areas

117. The respective roles and areas of research focus across the CRIs are clear in many areas. However, several stakeholders expressed concern about apparent overlaps and fragmentation among CRIs (and with other parts of the science system) in some areas of research, making it difficult for stakeholders to access and harness relevant capabilities and creating concerns about inefficient use of taxpayer funds.

118. Each CRI's SCP was designed, in part, to limit overlap and duplication. The SCPs were established in 2010 and have not been updated since then. Incentives to compete (discussed below), convergence of research in some areas (e.g. plant-based protein, bioeconomy, groundwater) and the absence of a suitable mechanism for addressing emerging overlaps has likely meant an increase in duplication and unproductive competition over time.

119. Several stakeholders raised the possibility of some level of aggregation of CRIs and/or closer integration with universities as a means of addressing fragmentation and complexity across the system. No stakeholder raised the opposite argument (i.e. to further disaggregate the system), although a few noted that competition among research institutes could be a stimulus for innovation.

System complexity creates confusion and adds transaction costs

120. Successive governments have introduced new features to the science system, some of which have cut across existing accountabilities and added to the cost of collaboration. Some stakeholders cited National Science Challenges as an example.

121. Conversely, some stakeholders noted that science systems in some other countries are more complex, and that some level of complexity is unavoidable given multiple objectives and multiple participants.

Competition still gets in the way of collaboration

122. The consequences of CRIs being standalone companies, the convergence of previously separate areas of research, the 'sinking lid' on funding and the imperative to 'follow the money' appear to include:

- ongoing competition among CRIs (and with other parts of the science system)
- obstruction of otherwise net beneficial collaborations (including more systematic capability and infrastructure sharing)
- confusion and sometimes frustration for some stakeholders.

123. Funding constraints that incentivise competition between CRIs and with other parts of the science system led to MBIE strengthening the financial incentives for collaboration. Some stakeholders commented that in addition to promoting purposeful collaborations, such interventions have driven some 'tick box' collaborations in the pursuit of contestable funding (to support the delivery of organisational strategy and the retention of research capabilities) and have imposed significant transaction costs (e.g. in the set-up of some National Science Challenges).

124. Under the current settings and in the absence of significant new funding, this dynamic is likely to continue.

CRIs and universities could collaborate more deeply

125. Some forms of collaboration (e.g. shared buildings, cross-appointments) are more common between a CRI and a university than between two or more CRIs. Aspects of the way the funding system works can mean incentives to compete for funding are stronger among CRIs and among universities than across the two groups.

126. Universities have some incentive to collaborate with CRIs – for example, to increase their share of the Performance-Based Research Fund or to improve their international ranking.

127. Several stakeholders noted the potential for national benefit through deeper collaboration and potentially more integration between CRIs and universities. Potential benefits cited were increases in the mobility of the research workforce, knowledge transfer through more research students interacting with CRIs, sharing of research infrastructure (including through more regional co-locations) and the potential to improve the international rankings of New Zealand universities.

128. Stakeholders also mentioned barriers to deeper collaboration, such as different organisational forms, different employment relationships, funding pressures and the fact that the tertiary education and research, science and innovation systems are stewarded by different government agencies.

Siloed strategy and priority setting and lack of adaptability

129. Each CRI has developed strategy and research priorities based on relevant government strategies and priorities, a process of engagement with stakeholders and dialogue with MBIE. Each of the strategies makes sense within its organisational context.

130. However, stakeholders and CRIs noted that:

- strategy development and priority setting is largely siloed across CRIs
- CRIs' freedom in strategy development is limited by the proportionally reducing level of funding from the SSIF – CRIs with significant other revenue sources are better able to develop strategic portfolios of research
- the government could be clearer about its strategic expectations as owner of the CRIs
- the CRIs could be a stronger voice for research in influencing the development of government priorities.

131. The current strategy-setting process across the CRI system is not readily adaptive for situations such as driving the assembling of multi-disciplinary cross-organisation research teams or the building of new research capabilities in areas of emerging priority.

The system is not working for Māori

132. There were consistent messages from Māori and iwi stakeholders, some of which were the same as the messages from other stakeholders.

133. Māori are under-represented in the CRIs and in the science system generally. The small pool of Māori researchers and other staff in the CRIs are additionally stretched because they are often implicitly expected to assist with cultural labour. There is a risk that for Māori, CRIs will become an unattractive place to work.

134. In some areas, engagement with CRIs by iwi and other Māori organisations can be complicated where they are unsure about which CRI to approach. Stakeholders noted that CRIs run on a Western management science model, which can inhibit responsiveness to kaupapa Māori frameworks.

135. Approaches from CRI (and other) researchers can seem transactional and focused on serving the researchers' needs, rather than those of the iwi or Māori organisation. Some stakeholders commented that approaches are often related to funding cycles and that several CRIs might approach them about similar themes.

136. Some Māori and iwi stakeholders commented that in Te Tiriti o Waitangi terms, the engagement is usually consistent with Article III rather than co-creation or Article II. Māori have an intergenerational and holistic view of the environment and want to develop enduring research partnerships.

137. The issue of cultural appropriation, as embodied by Wai 262, is unfinished business for iwi and Māori. Until it is resolved, it will remain a barrier to full and open engagement. The fact that Vision Mātauranga components of the MBIE application are not assessed by Māori was also noted in this context.

138. The emphasis on Western science excellence in MBIE's Endeavour Fund means that applications for Mātauranga Māori projects usually fail at the first 'science excellence' test. It was noted that there has been no large-scale, long-term, Māori-led science programme in any CRI in 27 years.

139. CRIs invest a small portion of the SSIF in Māori-related projects. Competing priorities and skill shortages mean few Mātauranga-led projects are funded by the SSIF. Māori communities and Mātauranga Māori experts generally do not have the investment capital to co-fund research initiatives, making them less attractive for the SSIF. However, CRIs rely heavily on this community to provide Vision Mātauranga and Mātauranga Māori support for the Vision Mātauranga requirements of the Endeavour Fund.

Limits to the efficient use of scarce resources

140. Each CRI is working to improve performance; some are working through organisational transformations while others are focused on continuous improvement. All appear to be heading in the right direction within their current contexts.

141. Increasingly, opportunities for further efficiencies are likely to be at the pan-CRI and pan-system level, including maximising utilisation of facilities and capabilities such as laboratories, computational and analytical resources and expertise, and in capital and infrastructure planning more generally.

142. The current operating model is not well suited to pursuing such cross-cutting opportunities. Each CRI does things in its own way (e.g. employment contracts, contracting, IP arrangements). Organisational needs can outweigh system benefits when considering resource-sharing opportunities.

Existential financial risk

143. Apart from one-off capital injections, (core) funding from the SSIF has not increased in nominal terms for many years (until Budget 2020) and has declined as a percentage of total CRI funding. CRIs have increasingly had to rely on other sources of revenue. This has been less problematic for CRIs that are able to generate a significant proportion of their revenue from the private sector, mainly through sale of consultancy services or licensing arrangements (e.g. kiwifruit and apple cultivars).

144. The consequences of financial fragility for most CRIs include:

- compromising critical foundational science functions, including core science services, databases and collections and resilience/emergency responses
- researchers bidding for contestable funds for survival, which consumes time in meeting funding criteria but with limited prospect of success
- insufficient financial capacity to sustain a balanced portfolio of research that focuses on future horizons and to deliver on organisational priorities consistently
- incentives to pursue non-fully costed alternative revenue streams to contribute to overheads, requiring an implicit subsidy from public funding sources
- loss of talent as CRI remuneration becomes uncompetitive
- incentivising organisation-specific objectives ahead of national priorities
- some combination of excessive risk aversion and the taking of 'win-or-bust' risks, such as in commercialisation opportunities.

145. For some CRIs, financial sustainability may not be achievable under the current settings unless there is a significant and sustained injection of new public funding.

146. Overall, at a science system level, we appear to be undertaking substantially more research than we are prepared to fund properly, to the point where the resourcing of some core research functions is compromised. The absence of a pan-CRI prioritisation mechanism in conjunction with aspects of the way science funding is administered make it difficult to optimise the allocation of scarce public funds to areas of highest value over time, including to newly emerging priorities.

Aspects of the design of contestable funding have adversely affected CRIs

147. Given the real reductions in core funding from the SSIF, contestable funds have become an increasingly critical revenue source for CRIs.

148. New Zealand's main contestable funds are heavily oversubscribed (as is common internationally).

149. Many stakeholders (particularly scientists) commented that the cost, effort and time required to prepare comprehensive Endeavour bids is high, relative to their low success rates and the value of the contracts.

150. The emphasis on excellence ahead of impact in the Endeavour Fund, in conjunction with the reducing funding from the SSIF, has exacerbated the financial pressure on CRIs that focus mainly on applied research.

End-of-life buildings and equipment

151. CRIs noted that a considerable proportion of their buildings and equipment are at, or close to, the end of life. Some significant refurbishments have occurred recently or are currently underway or due to start soon. Others are urgently needed but unlikely to be fundable from existing balance sheets.

Mixed experience with shared science infrastructure

152. New Zealand has deployed a range of models for the provision of science infrastructure at a scale and cost that requires a national approach. Models include infrastructure owned and operated by a single CRI or university, or by some form of joint venture.

153. Stakeholders expressed mixed views of their experiences with this shared infrastructure. The issues include stability of funding, responsiveness of the operator, value for money, equality of access, transaction costs and funding models that require a return on investment, which results in charging arrangements that incentivise users to seek alternatives.

Research and science services for government agencies are not working in some areas

154. The feedback from stakeholders suggests that the provision of science and science services for government is not working well in priority areas such as climate change, water and biodiversity.

155. Contributory factors include:

- lack of clarity over how the science system intersects with specific policy domains (e.g. natural resources, biosecurity, health, energy)
- some government agencies (e.g. Health, Police) contracting for research and science services, but with limited ability to enter into long-term contracts or to meet the full service costs (requiring a 'subsidy' from SSIF)
- some government agencies (e.g. Ministry for the Environment, Department of Conservation, Ministry for Primary Industries) rely on funding from the science system to meet most of their science needs which, from their perspective is not working
- varying levels of capability within government departments to engage with the science system and vice versa
- the challenge of commissioning research in response to short-term Ministerial priorities
- the challenge of integrating contributions across multiple CRIs in some areas
- increasing pressure on the SSIF, along with the excellence-based approach of the Endeavour Fund, limiting the ability of CRIs to plan research programmes to meet the needs of government departments.

156. Several regional and local government stakeholders commented on the opportunity for integrated CRI leadership in developing research and science service solutions in areas of common challenge for local government bodies, rather than each council having to develop its own solution.

The Companies Act status of CRIs appears to be counter-productive

157. The governance context for CRIs is set by three pieces of legislation: the Crown Research Institutes Act, the Crown Entities Act and the Companies Act.

158. The Crown Research Institutes Act requires that research undertaken by CRIs be for the benefit of New Zealand.

159. The Companies Act requires directors to take decisions that they judge to be in the best interests of the company.

160. Stakeholder feedback suggested that while CRIs invariably undertake research for the benefit of New Zealand, the requirement to act in the best interests of the company can impede collaborations that would contribute more national benefit.

161. Some stakeholders questioned whether Companies Act status caused undue focus on financial results relative to the quality and impact of research. Others noted the increasing focus of company boards on integrated reporting rather than purely financial performance.

162. Some CRIs noted that the company form of CRIs, with the associated financial and liability frameworks, could complicate participation in an emergency response.

CRIs' approach to commercialisation is fragmented and sub-scale

163. Commercialisation of IP is one way for CRIs to realise impact from their research.

164. To varying degrees, each of the CRIs has built a commercialisation capability and is pursuing potential opportunities. Individually, CRI commercialisation portfolios lack the scale and diversity to manage risk and to build end-to-end excellence. Early-stage collaboration (particularly through Kiwinet) is effective, but less so in the later stages.

165. Some CRIs are reliant on inherently risky commercialisation activities to sustain their core activities. The need to secure 'survival funding' may bias CRIs towards retaining publicly funded IP and seeking to monetise it directly rather than making the new knowledge widely available via an appropriate mechanism.

The future will require a contribution from CRIs that is more integrated

166. Several themes emerged from discussions with stakeholders about what New Zealand will need from CRIs and the science system in the coming decade and beyond.

167. CRIs' areas of research and science services are central to New Zealand's response to complex and interconnected opportunities and challenges.

168. These include climate change; water and land use; food, materials and energy transitions (e.g. towards plant-based proteins, nutrition, bioplastics, renewables and hydrogen); and increased, evolving and interdependent threats to resilience and to human health and well-being.

169. Addressing these research challenges will require harnessing the collective capability of CRIs and other science system participants.

170. Artificial intelligence and robotics will drive innovation and labour substitution. Automated data collection and analysis, as well as enhanced data science capabilities, will be increasingly important in underpinning evidence-based policy and regulation.

171. Stakeholders had divergent views on the speed and extent of some of these transitions and hence, on the appropriate balance of different research horizons and priorities (e.g. the balance between research on undertaking a current land-based activity more sustainably, shifting to a new use for the land, or focusing on downstream processing).

172. CRIs will have a part to play in New Zealand making the most of the ubiquitous new research-enabling technologies, including genomics, data analytics, artificial intelligence, robotics, automation and remote sensors.

173. A Te Tiriti o Waitangi-based approach will underpin partnerships with Māori that are deeper and more integrated.

174. Disruption, including technological and geopolitical, will be ongoing. Much about the future is unknowable. New Zealand will need high levels of science-based innovation and adaptability from multi-disciplinary teams across the CRIs and other parts of the science and innovation systems, as well as strong international connections.

175. Funding for research will remain constrained.

A POTENTIAL FUTURE STATE

176. The Terms of Reference for Te Pae Kahurangi required the Panel to set out a future state for CRIs to work towards collectively and respectively, as well as the critical capability shifts the CRIs would need to achieve.

177. Drawing on stakeholders' views of both the current position and New Zealand's future needs for CRIs, the Panel has developed a potential future state for CRIs collectively.

178. This potential future state is one in which CRIs collectively operate to ensure 'the whole is greater than the sum of the parts'. The Panel's view is that this would require an operating model that meets the following criteria:

- being strategy led, determining pan-CRI research priorities that drive the building of research teams across organisational boundaries and the developing of new capabilities
- being customer-centric – responsive and easy to navigate for all customers and stakeholders
- working together to support Māori and iwi aspirations in a Te Tiriti-based partnership model
- putting national benefit ahead of organisational interest in purposeful collaboration across CRIs and with science system partners
- acting as a magnet for scientific and associated talent supported by contemporary research facilities
- utilising scarce resources efficiently and effectively: optimising capital spend, sharing facilities, leveraging collective scale and capabilities
- enabling a resilient system.

179. The ability of CRIs to deliver on the future state is, in part, dependent on the design of funding and ownership elements of the system within which they operate. The Panel has also developed options for changes to these elements of the operating model.

180. The following paragraphs expand on each of these dimensions.

Strategy led

181. As discussed above, CRIs undertake a diverse set of research-based activities from future horizon research to the daily delivery of contracted science services. The main gap in the current strategy-setting arrangements is in developing an integrated set of strategic priorities for publicly funded, mission-led future horizon research.

182. In the future state, CRIs are influential voices in the development of national strategies for research, science and innovation, reflecting their in-depth knowledge of the science possibilities and the opportunities and challenges faced by research users.

183. Strategy and priority setting are pan-CRI within the context of New Zealand's research priorities, including climate change, water, biodiversity, the future of food and fibre, and the building of national competence, productivity and resilience.

The future will require a contribution from CRIs that is more integrated

184. Pan-CRI strategies and priorities drive investment and resource allocation decisions, including the building of 'right teams' to tackle cross-cutting research challenges and the development of new capabilities as required.

185. Specific research programmes are developed through co-design with stakeholders and collaborators across the science system.

186. An explicit strategy-setting system, co-designed by MBIE and CRIs, strengthens the operating model for CRIs and operates at a high level, is organised around (but not limited to) CRIs' main research domains, occurs every three years or so through a process of engagement with stakeholders, reflects funding constraints and results in a documented articulation of a limited number of pan-CRI strategic research priorities. These are focused on the research questions to be answered, rather than on the way the research is planned and delivered.

187. The strategy-setting process draws on relevant collateral such as a system-level Research, Science and Technology strategy, departmental science roadmaps, sector transformation plans (or equivalent), priorities for Māori development and the priorities of the government of the day, as well as taking into account the status of related science system initiatives such as National Science Challenges.

188. An explicit strategy-setting process to determine high-level research priorities is balanced by funding mechanisms that give CRIs considerable freedom in the design and delivery of publicly funded research programmes.

189. The strategy and high-level research priorities evolve through time, which requires other elements of the operating model to be configured to support ongoing adaptability and agility in the set of capabilities that CRIs steward, as well as in the ways those capabilities are combined and deployed.

Customer-centric

190. CRIs undertake research under contract for specific customers, engage with customers/stakeholders in defining and finding solutions to research problems and, through publicly funded research, undertake research on behalf of all New Zealanders.

191. In the future state, access to CRIs is easy to navigate. Direct customers know where to go for each major area of research. The option of a 'single door' gives access to collective CRI capabilities.

192. CRIs are responsive in service delivery and problem solving, while maintaining their integrity of research and, for publicly funded research, focus on maximising public benefit.

193. Strengthening the operating model for environmental (and related) research for central government will likely require a co-design process involving MBIE, other government agencies (including Ministry for the Environment, Department of Conservation, Ministry for Primary Industries), relevant groupings of CRIs and Māori as Te Tiriti o Waitangi partners. Potential changes include:

- participation by government agencies and their chief science advisors in the strategy-setting process described above
- resolving current tensions in aspects of the funding system, including in addressing the funding implications of policy decisions that require new research (e.g. to underpin the specification of regulatory standards)
- increased research capability that is well connected to decision makers within government departments
- purposeful co-design with Māori and iwi organisations to support Te Tiriti partnership
- increased pan-CRI capability to influence departments at an early stage in the design of policy and programmes
- increased integration of research programmes across relevant CRIs.

Supporting Māori and iwi aspirations

194. In the future state, CRIs provide a supportive environment for a growing cohort of Māori researchers (in partnership with education providers and Māori businesses), offer integrated support in addressing specific research-based needs of Māori and iwi groups and businesses, and have committed to co-designed, long-term, research-based partnerships with Māori.

195. A range of possible solutions are being used to address the issues identified by Māori and iwi stakeholders and position the CRIs better to deliver on the future state. (These potential solutions were discussed and developed in a co-design kōrero between members of the Panel and Te Ara Pūtaiao.)

196. These solutions should ensure that the CRIs have increased capacity to employ and develop Māori researchers, including in partnership with education providers and Māori businesses.

197. Options with potential for high impact are:

- setting a mandatory minimum proportion of funding from the SSIF that is proportionate to the Māori population to be allocated to Vision Mātauranga and Māori-led Mātauranga Māori projects
- establishing a new strategic investment fund for CRIs to support Mātauranga Māori-led research programmes for iwi/Māori. This option would be one of the most effective ways to include Māori in research.

198. The high-impact options above support the development of a deeper, more purposeful and targeted body of Mātauranga Māori work and an environment conducive to growing Māori capability.

199. In parallel, it would be useful to consider realigning the Vision Mātauranga policy to support and align with iwi/Māori research aspirations better. It would be appropriate for Māori to lead the redesign of this policy or, at a minimum, Māori are centrally involved in the decision making around its redesign, operation and governance.

200. CRI engagement with Māori would also strengthen with multiple Māori perspectives in governance and senior management to deepen the Tiriti partnership.

201. The current under-representation of Māori in science creates a small pool of Māori who can contribute to and support CRI work in relation to te ao Māori. The re-establishment of a national Māori scholarship scheme, along the lines of the former Te Tipū Pūtaiao Fellowship, is a further option to consider.

The future will require a contribution from CRIs that is more integrated

Purposeful collaboration

202. In the future state, CRIs collaborate with each other and with other science system partners, including universities, private research institutes and businesses, when there is net benefit for New Zealand in doing so. The number of connections occurring naturally is maximised, including through leveraging co-location opportunities wherever practicable.

203. Collaborations minimise transaction costs and utilise multi-disciplinary teams that share resources and knowledge. The assessment of collaboration opportunities is agnostic as to organisational boundaries.

A magnet for talent

204. In the future state, CRIs are a magnet for scientific and associated talent, including Māori researchers and other staff.

205. The diversity of the CRI workforce reflects the diversity of the population across broad job types and levels of seniority.

206. CRIs take a deeply collaborative approach to addressing emerging shortages in specialist areas (e.g. data scientists).

207. Common employment arrangements enhance mobility among organisations, supporting the flow of scarce resource and talent to its highest value use.

208. Close links with tertiary institutions support the addressing of skill gaps and maximise the throughput of research students.

Efficient and effective in deploying scarce resources

209. In the future state, CRIs operate efficiently and effectively as a group and with partners, underpinned by commonality of practice that minimises barriers to sharing resources and collaboration.

Capital planning

210. Capital planning is centralised, to enable funding of priorities at the pan-CRI level, underpinned by a consistent approach to the development of asset management plans, an integrated view of forward capital requirements, pan-CRI optimisation of the allocation of scarce funds and full exploration of co-location and resource-sharing opportunities pre-decision.

Addressing areas of duplication

211. CRIs are proactive in identifying and resolving emerging areas of unproductive overlap and duplication between CRIs and with other science system participants.

Commercialisation

212. CRIs collectively leverage their commercialisation capabilities and opportunities to achieve scale and diversification of portfolio risk and end-to-end excellence.

Standardisation

213. CRIs adopt common (but not rigid) processes, covering areas such as contracting, IP, commercialisation, employment agreements, IT, financial and human resource systems, marketing, and health and safety for high-security facilities.

214. Benefits include higher utilisation of facilities, reduced cost of collaboration between CRIs and with other partners, flexible deployment of people and a reduction in transaction costs for customers who interact with more than one CRI.

Resilient organisations

215. In the future state, CRIs are organisationally and financially resilient, able to plan with confidence, take considered risks in search of innovation and are accountable for their performance.


EMERGENCY POLICE EMERGENCY POLICE

System settings to support the future state

216. The extent to which CRIs individually and collectively can deliver on this future state will depend to a significant degree on the characteristics of the system within which they operate. These characteristics are shaped by the way the government, through MBIE as system steward, exercises its funding and ownership functions.

FUNDING

217. In designing the various elements of the funding system, MBIE balances multiple objectives, including the need to allow for new entrants to the science system and to fund newly emerging areas of research.

218. Many stakeholders commented on the way funding arrangements often create incentives for CRIs to compete with one another and with other science system participants (and vice versa) at the expense of maximising public benefit. Several CRIs noted that the current system creates significant levels of uncertainty about future funding. This complicates medium-term planning and reduces the CRIs' scope to commit to long-term partnerships with current and potential customers, as well as affecting their capacity to innovate through targeted risk taking.

219. The Panel agrees with these comments.

220. From the perspective of enhancing CRIs' individual and collective contribution to New Zealand, some combination of the following would be beneficial:

- explicit and stable funding of fit-for-purpose core and high-priority research and science service functions, including prioritised databases and collections (as determined at an MBIE/pan-CRI level)
- a rebalancing of CRI revenue sources from contestable funding to the SSIF, thereby reducing uncertainty and transaction costs, supporting dynamic resource allocation through time and the building of new capabilities in line with strategic research priorities
- a planned approach to relevant elements of the funding system to support a programme of research that is more integrated, focusing on the main cross-cutting challenges, such as climate change
- a combination of organisational and funding arrangements that provide financial stability and resilience while retaining accountability for performance, including through the commissioning of independent reviews of research quality and of delivery against strategy, as appropriate.

OWNERSHIP

221. New Zealand needs a more integrated contribution from its publicly owned research institutes.

222. Ownership elements of the current system were not designed with integration as a primary objective.

223. Building on views expressed by stakeholders, the Panel has explored options for an operating model that is more integrated, focusing on organisational form, governance and structure.

Organisational form

224. The existing company model for CRIs is well established. Each CRI is well governed within this framework.

225. However, the company model is not well suited to cross-CRI and pan-CRI decision making, particularly for CRIs that work predominantly with the public sector and are funded accordingly. The company model is also a potential constraint on CRI participation in responses to national emergencies.

226. The Panel's view is that, to varying degrees across the CRIs, an organisational form that is designed to deal with mixed objectives, strengthens mechanisms for system-level integration and enables pan-CRI decision making is likely to be more effective.

227. The Crown entity model is flexible and could accommodate a mandate that stresses public benefit through collaboration, while retaining incentives to secure revenue from other sources and maintaining the independence and objectivity of the science and research undertaken by CRIs.

228. Many of the benefits of the current governance model could be retained, mainly by maintaining the quality of the governors – diverse boards that encompass science, business and public sector backgrounds.

GOVERNANCE AND STRUCTURE

229. The current operating model for CRIs is, by design, decentralised. CRIs have deployed various integrating mechanisms to counterbalance this decentralisation.

230. A form of pan-CRI quasi-governance is provided by CRI Chairs, who meet regularly, and CRI chief executives who form the board of Science New Zealand. However, decision-making rights remain with the individual boards and (through delegation) their chief executives.

231. CRIs have developed virtual organisation collaborations in areas of collective interest, such as Better Border Biosecurity (B3 – a multi-science agency initiative to strengthen research into biosecurity) and the Groundwater Alliance.

232. The merger of Crop and Food Research and HortResearch was intended to provide greater depth of capability in several nationally significant areas of research.

233. These initiatives, in aggregate, have not been sufficient to address problems that have emerged through time because of the decentralised nature of the current operating model.

234. Prospects of attaining the future state described above would be enhanced by governing and organising the CRIs much more as a collective than as seven standalone organisations, leveraging the fact of common ownership.

235. Several stakeholders proposed some form of consolidation of the CRIs.

Potential advantages and disadvantages of consolidation

236. The primary objective of any consolidation would be to enable an integrated operating model for CRIs at multiple levels, including strategy setting, customer-centricity, long-term partnering with Māori, optimised resource allocation, purposeful collaboration, common systems and processes, and effective utilisation of research facilities.

237. Integration within organisations is usually more straightforward than integration among organisations.

238. A smaller number of consolidated entities would have more capacity to create new component parts to add underpinning capabilities, such as in computation, data preservation, provision and governance, data science, science automation, space-based sensing, and advanced genomic and meta-genomic analysis.

239. Funding constraints would still be an issue for consolidated organisations. Compared with the current arrangements, the combining of multiple revenue streams and the ability to shift resource to the highest priorities would enable better management of risk, reduce vulnerability to single events, enable targeted investment in contemporary research facilities and enhance overall financial and organisational resilience.

240. This would need to be balanced against a likely perception by some commercial clients of a reduced focus, flexibility and agility in focusing on their needs that might accompany a combining of revenue streams.

241. Incentives for unproductive competition could be moderated by the appropriate design of funding arrangements and a purpose and set of performance measures for pan-governed/consolidated CRIs focused on public value through impact, purposeful collaboration and connection. A reason to be cautious about consolidation is the associated disruption and the tendency for large organisations to become more bureaucratic and sclerotic, and less focused, than their smaller counterparts.

242. CRIs collectively employ around 4000 people and receive an annual revenue of around $800 million. At the outer limit, full consolidation would create a large organisation in the New Zealand context, but not exceptionally so. The potential benefits of consolidating the CRIs would be greater, other things being equal, in areas of broadly aligned purpose, commonality of customers, duplication of activity and unproductive competition. As discussed above, a natural grouping of CRI activities would be into those focused on research to add economic value to natural resources (with industry groups, businesses and Māori groups as primary customers) and those focused on environmental and resilience-related research (with central and local government and Māori groups as primary customers).

243. The Panel has not undertaken detailed analysis of specific options but would expect a strategy-led operating model to include some combination of changes to governance, more use of soft structures to build system capability around key research challenges, and consolidation of CRI resources into groupings that are more resilient and flexibly deployable.

244. A logical next step would be for MBIE (as the system steward and policy advisor to the Minister), in consultation with CRIs and science-oriented government departments, Māori and other stakeholders as appropriate, to review the organisational and funding arrangements for CRIs with the objective of configuring the operating model to underpin the delivery of the future state.


Leica

Next steps

245. The Terms of Reference for Te Pae Kahurangi specified that the Panel's report should set a foundation for:

- CRIs to develop a collective (and any respective) response and action plan to move towards this future state
- a second engagement round with other actors in the system to discuss any proposals that may have implications for their activities
- any related policy work.

246. The Panel has identified a future state to work towards that can form the basis for CRIs to develop a collective response and action plan.

247. The Panel has also proposed operating model changes that are MBIE's responsibility.

248. In sum, the Panel's recommendations build on the main themes identified in the 2010 review of CRIs and reflect experience and changes in the broader operating environment since then.

249. Several of the recommendations are linked. The overarching objective is a strategy-led pan-CRI operating model underpinned by a set of incentives that, to the greatest extent possible, harness the intrinsic motivation of researchers to contribute to improved outcomes for New Zealand through excellence, impact and purposeful collaboration and moderate unproductive competition for scarce resources.

250. If the recommendations are accepted, implementing them would involve a carefully sequenced programme of change to move the current operating model, associated decision-making rights, incentives and consequent behaviours to those envisaged in the future state.

251. Adjustments to the operating model for CRIs could be integrated with any other changes to science system settings that form part of the recovery post-COVID19.

252. A change programme oriented towards higher levels of CRI integration could incorporate opportunities for system simplification as and when other components of the system are reviewed.


SCION

Annex One
Terms of reference

BACKGROUND

1. The Government's seven Crown Research Institutes (CRIs) comprise AgResearch, Institute of Environmental Science and Research, Institute of Geological and Nuclear Sciences, Manaaki Whenua – Landcare Research New Zealand, National Institute of Water & Atmospheric Research, Plant and Food Research, and New Zealand Forest Research Institute (Scion).
2. The 2010 CRI Taskforce reforms proposed a suite of reforms, which included increasing CRIs' focus on collaboration and efficient technology transfer and adoption with the sectors and key stakeholders it serves.
3. Each CRI has adopted a Cabinet approved Statement of Core Purpose which reflects this focus and clearly articulates the purpose, outcomes and strategic role for their organisation.
4. To ensure CRIs continue to increase their contribution to New Zealand's economic, social and environmental well-being, the CRI Taskforce proposed, and Cabinet agreed [CAB Min (10)43/5C refers], that each CRI is evaluated on a four yearly basis. A full round of reviews was completed between 2013 and 2016. This first round of rolling reviews was useful in developing individual CRI perspectives on performance and capability development.
5. For this round we are undertaking a collective review, as the Crown Research Institutes face a common set of challenges that will involve increased collaboration to secure full value from the sector. These challenges include positioning collective science capabilities for the future, the Crown's broader interest in Crown Research Institutes, and future investment – which are discussed further below.

CONTEXT

Positioning collective science capabilities for the future

6. The draft Research, Science and Innovation Strategy, Mata Ki Te Rangi (RSI Strategy) sets a focus on innovating at the frontier. Transformative science can lead to products that consumers could not have imagined, or achieve a shift in the production frontier that would not occur through incremental demand led science.
7. In parallel, emerging generic capabilities such as artificial intelligence and big data provide an opportunity to increase the impact of science. There is a scarcity aspect to these capabilities.
8. CRIs face a collective challenge around how to best develop and leverage these generic capabilities (both as inputs to their science, and as outputs in their own right) to pursue transformative science.

Defining and delivering on the Crown's broader interest in Crown Research Institutes

9. The Crown's interest in CRIs is broader than the funding and engagement that takes place through the Research, Science and Innovation portfolio. For example, CRI work supports areas such as building, environment, health, justice and the primary sectors, along with Mātauranga Māori.

10. There are opportunities to develop the wider Crown interest in CRIs at two levels. Firstly, science could both transform functions delivered by the Crown, and the economic sectors they support. Are current CRI arrangements enabling these opportunities to be pursued? Are the CRIs enabling the innovation potential of Māori knowledge, resources and people?

11. Secondly – in addition to 'transformative science' – CRIs also play a significant role in core public delivery such as water and hazard management. The arrangements within which CRIs deliver this 'science service' can be complex. Delivery often involves CRIs needing to work with each other, for example freshwater management. In addition, the service could involve engagement, funding sources and contracts with multiple core government agencies. Are these arrangements conducive to effective service delivery?

12. There is a particular opportunity for this review to explore the nature of the Crown's interest in CRIs for core public service delivery, and whether the arrangements support CRIs to optimally deliver on this interest.

Exploring challenges around future investment in footprint and capability

13. A number of CRIs are planning significant investment in infrastructure. These investment choices will have long-term (positive or negative) implications for CRI ability to collaborate moving forward.

14. In parallel some CRIs are facing challenges around maintaining medium-term financial viability. While this review is not intended to be a funding review, there is an ownership question: are Boards targeting the right long-term financial objectives for financial viability, and are these objectives matched with appropriate ownership expectations and wider system settings?

IN SCOPE

15. The purpose of the review is:

How well are the Crown Research Institutes collectively and respectively positioned to meet New Zealand's current and future needs?

16. The report will consider the following areas:

- *Strategic context – including New Zealand's needs of CRIs*
- *Current CRI positioning – including breadth of activities, institutional settings, strengths and weaknesses*
- *Role implications – collective and respective, including any key capability shifts*
- *Any implications for the system that supports CRIs*

17. The report questions in Annex One provide further detail to these areas. In addressing each area, the review will also draw on comparisons with overseas jurisdictions.

PRODUCT

18. The report product will:

- set out the context CRIs are operating within, New Zealand's needs and key future trends, issues and opportunities
- set out a future state for Crown Research Institutes to collectively and respectively[5] work towards, in the context of broader institutional settings, and the critical capability shifts it needs to achieve
- provide a more general assessment of Crown Research Institutes' collective and respective organisational capabilities and improvement needs
- set out any related system implications.

19. This report will then set the foundation for:

- Crown Research Institutes to develop their collective (and any respective) response and action plan to move towards this future state
- a second engagement round with other actors in the system to discuss any proposals that may have implications for their activities
- any related policy work.

[5] The Panel may choose to set out points relating to individual CRIs in a separate section or Annex.

OUT OF SCOPE

20. The review is Crown Research Institute focused. It is not a review of the CRI model, nor a funding review, although the findings may have implications for these areas. The report may also identify gaps between New Zealand's needs and CRI activities, but conclude that CRIs are not the right mechanism for addressing these gaps.

21. The review is not intended to be a 'report card' on current CRI performance – it will only surface these issues in order to clarify the extent of the shift needed for CRIs to position their capabilities for the future (see Annex One for the four key capability dimension areas).

PRINCIPLES

22. The report process will be:

- future focused – on future New Zealand needs, science trends, and Crown Research Institutes' adaptability to future shifts in these areas
- Panel driven – ensuring the Panel of experts bring external expertise relevant to the report
- open and transparent – ensuring that there are "no surprises" for either Crown Research Institutes or MBIE
- based on effective stakeholder engagement – balancing the opportunity for stakeholder input with engagement fatigue
- inclusive of Māori and ensuring their needs of CRIs are identified and considered
- efficient – ensuring compliance costs for gathering information is minimised
- sensitive to the need to ensure appropriate protection of information.

PROCESS FOR THE REPORT

Report Owners

23. The report owners are the Deputy Chief Executive, Labour Science and Enterprise and General Manager Entity Performance and Investment.

Panel membership

24. The Panel will comprise four to six individuals to ensure an appropriate mix of experience and knowledge is represented, including:

- previous review experience, including an ability to connect with Crown Research Institutes and challenge their thinking
- understanding of the science system and its economic contribution
- expertise in key potential capability areas
- expertise in core government service delivery needs.

25. The Panel will be expected to engage with a wide range of business users to understand their needs of CRIs.

International Reference Group

26. An International Reference Group will be available to the Panel throughout the process to provide views on:

- science trends
- comparisons with overseas jurisdictions
- Crown Research Institutes' strategy and positioning
- the Panel's draft direction of travel.

Government's Network of Science Advisors

27. The Government's Network of Science Advisors will be consulted for input into the Review on government's needs, science trends, and issues and opportunities for CRIs.

28. MBIE will ensure appropriate steps are taken to manage any potential conflicts of interest.

Report process

29. The expected review phases are:

    1. Panel recruitment, commissioning meeting with MBIE and review of background material
    2. Initial Panel meeting with board: CRI Chairs' own reflections on the landscape CRIs operate within and where they see the issues and opportunities
    3. Meeting with Minister
    4. Research into science trends
    5. Interviews with users
    6. Research into science trends and best practice
    7. Panel workshop with CRI Chairs and MBIE
    8. Individual CRI visits
    9. Interviews with collaborators and wider actors in the science system
    10. Panel workshop with CRI Chairs and MBIE
    11. Any follow up engagement necessary
    12. MBIE check in
    13. Draft Report discussion with MBIE and CRI Chairs
    14. Report finalisation, including Crown Research Institutes' response
    15. Panel and CRI Chairs' meeting with Minister to discuss report and Crown Research Institutes' response
    16. Release.

30. These phases may be refined based on discussions between the Panel Chair, MBIE and CRI Chairs. The Panel Chair will have regular 'check ins' with CRI Chairs throughout the process to test thinking and ensure no surprises. The Panel Chair will also check in with MBIE on progress.

31. The process is expected to commence mid-November, with a final report, response and action plan targeted for late May.

Administration

32. MBIE's Entity Performance and Investment Team (MBIE) will recruit and provide support for the Panel throughout the process. The key contact for the process is Alan Vandermolen, Director, Entity Performance and Investment.

33. MBIE will work with Crown Research Institutes and the Government Science Advisor network to develop background material for the report Panel, and book key stakeholder meetings. The cost of the report will be met by MBIE.

34. The report will be subject to requests under the Official Information Act (1982). The Panel's final report and Crown Research Institutes' action plan will be released publicly, with any commercial-in-confidence material withheld.

Annex One Report questions

Questions to consider in developing the report product:

Strategic context: The Crown's interest in Crown Research Institutes

- What are New Zealand's key needs and opportunities CRIs could contribute to? In particular:
  a. What is needed from CRIs to deliver against the RSI Strategy?
  b. What is needed from CRIs to address core government service delivery needs?
  c. What is needed from CRIs to support Māori aspirations?
- What trends are we seeing that the science system needs to respond to?

Current Crown Research Institute positioning

- What are the current institutional settings for supporting the breadth of CRI activities and how does this compare with overseas models?
- How well do CRI strategies align with New Zealand's key needs and opportunities?
- How well (including how sustainably) are CRIs positioning their capabilities for the future?
- How well do CRIs connect with each other and wider stakeholders in delivering on New Zealand's needs?
- What is it that CRIs currently do well, where do they need to improve and are there any barriers to improving?

Role implications

- What does this mean for the future role that CRIs could play collectively and respectively for New Zealand's key needs and in support of core government service delivery?
- What key shifts are needed across the four key capability dimensions (below) to respond to government priorities:
  d. What does this mean for the government's expectations of CRIs?
  e. What does this mean for CRI arrangements?
  f. What does this mean for future CRI capability and infrastructure?

System implications

- What might this mean for the system that supports CRIs?

Four key capability dimensions:

1. **Leadership and direction:** Purpose vision and strategy, leadership and governance, and culture
2. **Delivery for customers and New Zealand:** Understanding customer needs, value proposition, operating model, collaboration and partnerships
3. **People development:** Leadership and workforce development (including Māori workforce capability) , performance and engagement
4. **Financial and resource management:** including information management.

Annex Two
Panel member biographies

DAVID SMOL
Chair

David Smol was appointed as chief executive of Ministry of Economic Development in 2008. He was the inaugural chief executive of the Ministry of Business, Innovation and Employment (MBIE) following the merger of four departments from 2012 to 2017. During this period, David was accountable for the Research Science and Innovation portfolios, among others.

Since finishing at MBIE, David has worked in a variety of governance and consulting roles, including in the transport and regional economic development sectors, and has undertaken several independent reviews. David has an M-Phil in economics from Cambridge University and was made a Companion of the Queen's Service Order in 2018.

MARGARET HYLAND
Panel Member

Margaret Hyland is Vice-Provost (Research) at Victoria University of Wellington. She has responsibility for developing and implementing strategies and processes to achieve the University's strategic research objectives. In 2017, Margaret was seconded to the Ministry of Business, Innovation and Employment in the role of Chief Scientist.

Originally from Canada, Margaret holds a PhD from the University of Western Ontario and has spent her research career specialising in aluminium technology, and the chemistry and engineering of material surfaces. She is a Fellow of the Institute of Chemical Engineering and she was the first woman to be awarded the prestigious Pickering Medal for excellence in technology by the Royal Society Te Apārangi in 2015. Prior to joining Victoria University of Wellington, Margaret was a Professor of Chemical and Materials Engineering and Deputy Dean in the Faculty of Engineering, University of Auckland.

MICHAEL AHIE
Panel Member

Michael Ahie (Taranaki, Ngā Ruahine, Ngāti Ruanui) is a business owner and company director based in Wellington. He is Chancellor of Massey University, a director of FMG and a member of Inland Revenue's Risk & Assurance Committee. He is Chair of the board of Spring Sheep Milk Co. and the Plant Market Access Council. Michael was previously the Chair of Plant and Food Research.

Michael's past roles include senior roles with Toyota New Zealand Ltd, the New Zealand Dairy Board and Wrightson Ltd. He completed the Executive Development Programme at The Wharton School, University of Pennsylvania and received his Honours degree from Massey University.

WENDY LAWSON
Panel Member

Wendy Lawson is the Pro-Vice-Chancellor of Science at the University of Canterbury Te Whare Wānanga o Waitaha, where she has previously served as Dean of Science. She is also currently a Director of MetService, and Melbourne-based FrontierSI, and has previously served as a Director of NIWA and of Antarctica New Zealand.

Wendy is a glaciologist by scientific background, with a particular passion for remote fieldwork. Her PhD is from the University of Cambridge, and she has a Postgraduate Certificate in Public Administration from the University of Warwick Business School. In recent years, she has received a range of awards in recognition of her cross-sectoral leadership in the geospatial sector, including the 2019 NZSEA Outstanding Contribution to Spatial Award. A career highlight is the naming of a stream in Antarctica – Lawson Creek – in her honour in 1995.

MICHAEL WITBROCK
Panel Member

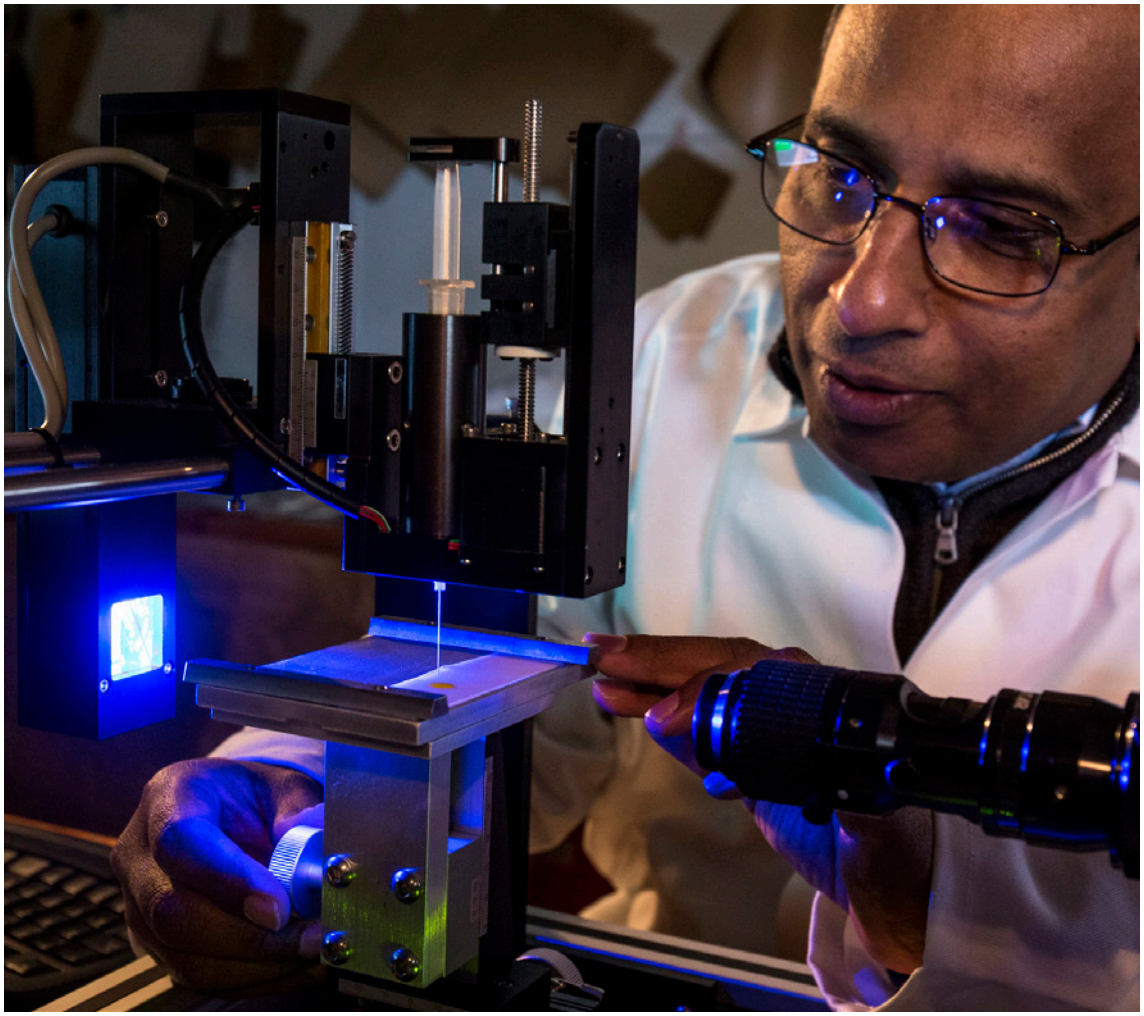
Michael Witbrock is a professor of computer science at The University of Auckland (UoA). He is building a research group, the Broad AI Lab, at the intersection of machine learning, reasoning and natural language understanding. The lab includes a focus on maximising the near-term benefit of Artificial Intelligence (AI) to New Zealand entrepreneurs and business, and more generally achieving the best social and civilisational impacts of increasingly powerful AI.

Before coming to UoA, Michael led Learning and Reasoning research within IBM Research AI at IBM's Thomas J Watson Research Center in upstate New York. He helped set IBM's Broad AI strategy at its highest levels. This followed an extended period as Vice President for Research at Cycorp, where he directed research projects in automated reasoning (including speed-up learning), automated and interactive knowledge acquisition, and machine reading, in domains as varied as counter-terrorism through to the molecular mechanisms underlying cancer. Michael has a PhD in Computer Science from Carnegie Mellon University and a BSc Hons in Psychology from Otago University.

Annex Three Stakeholders interviewed

The Panel is grateful to the following organisations/individuals who contributed insights to this report:

- AgResearch (AgR)
- Antarctica New Zealand
- Aquaculture New Zealand
- Auckland University of Technology
- Callaghan Innovation
- Cawthron Institute
- Christchurch City Council
- DairyNZ
- Department of Conservation
- Federation of Māori Authorities
- Fertiliser Association of New Zealand
- Fletcher Building
- Fonterra Co-operative Group
- FoodHQ
- Foundation for Arable Research
- Hawke's Bay Regional Council
- Health Research Council of New Zealand
- Horticulture New Zealand
- Independent – Blair Waipara
- Independent – Craig Ellison
- Independent – Ian Fergusson
- Institute of Environmental Science and Research (ESR)
- Institute of Geological and Nuclear Sciences (GNS)
- Kiwinet
- KPMG
- Land Information New Zealand
- Lincoln Agritech Ltd
- Lincoln University
- Manaaki Whenua Landcare Research (MWLR)
- Massey University
- Minister of Research, Science and Innovation
- Ministry for Primary Industries
- Ministry for the Environment
- Ministry of Business, Innovation and Employment
- Ministry of Education
- Ministry of Health
- Ministry of Justice
- Miraka
- National Institute of Water and Atmospheric Research (NIWA)
- New Zealand eScience Infrastructure
- New Zealand Forest Research Institute Limited (Scion)
- New Zealand Police
- New Zealand Trade & Enterprise
- Packaging Council of New Zealand
- Pāmu (Landcorp Farming Limited)
- Paraninihi ki Waitotara
- Parliamentary Commissioner for the Environment
- Plant & Food Research (PFR)
- Primary Sector Council
- Prime Minister's Chief Science Advisor
- Ravensdown
- Sanford Limited
- Science New Zealand
- TDB Advisory Ltd
- Te Ara Pūtaiao
- Te Rauika Māngai



- Te Rūnanga o Ngāi Tahu
- The BioHeritage Challenge (A National Science Challenge)
- The New Zealand Merino Company Limited
- The Public Service Association
- The Treasury
- The University of Auckland
- UniServices
- University of Canterbury
- Victoria University of Wellington
- Waikato Regional Council
- Zespri International

International Reference Group:

- Professor Andrew Campbell, Australian Centre for International Agricultural Research
- Bruce Mapstone, retired (formerly Chief of CSIRO Division of Marine and Atmospheric Research)
- Professor Cathie Martin, John Innes Centre, UK
- Dr Chris Pigram AM, FTSE
- Dr Liz Jazwinska, Independent Board Director & Science Strategy Advisor
- Professor Laurens Klerkx, Wageningen University
- Ulrich Schurr, Forschungszentrum Jülich

Annex Four
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NIWA