Science New Zealand

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Submission on
Te Ara Paerangi – Future Pathways
Green Paper on Science Sector Reform

Submission to the Ministry of Business, Innovation and Employment
(FuturePathways@mbie.govt.nz)

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Contents

Part A: Overview, Summary and Recommendations

Science New Zealand Inc

Science New Zealand is an incorporated society comprising the seven Crown Research Institutes (Crown-owned companies) as members, and Callaghan Innovation (a Crown agency) as an associate member. The CRI CEOs form the Board of Science New Zealand.

Science New Zealand was established in 1992 shortly after the CRIs were created, to assist the CRIs in their statutory mission: to benefit New Zealand. It supports the contribution of CRIs to the current and potential economic, environmental, social and cultural wellbeing of New Zealand, including via being a vehicle for communication and cooperation amongst the CRIs and working with other entities in the RD&I system across public and private sectors.

This submission has been developed collectively by the CRIs' governance and management under the Science New Zealand umbrella. Individual CRIs, and Callaghan Innovation, will provide additional submissions.

Overview

Science New Zealand welcomes the publication of *Te Ara Paerangi – the Green Paper on Science Sector Reform.* It provides a significant opportunity to reflect on New Zealand's research, science and innovation system and how it might be improved to better contribute to a sustainable, productive and inclusive future for New Zealand.

The Boards and Senior Management of CRIs have given considerable thought to these matters. In September 2021, prior to the launch of the Green Paper, Science New Zealand published two papers: *Pathways to the Future* and *The Value of CRIs in Aotearoa New Zealand's Science System Today.* They are attached as part of this submission.

There are some excellent aspects to the current system – not least that it produces high quality research and has high productivity. New Zealand's science underpins the nation's prosperity and wellbeing through both its domestic application and in supporting the reach and influence of New Zealand globally.

There is, however, much room for improvement, as reviews in recent years have noted. The system is overly complex and hard to navigate; inefficient competitive processes do not add value and deliver uncertain outcomes; it has a proliferation of entities, many of which rely upon the research staff of the major research organisations but with added layers of structure and governance; and does not yet adequately reflect a Te Tiriti-based relationship.

Furthermore, as *Te Pae Kahurangi Report* noted, *[New Zealand] appears 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.* [1]

It is our view that an effective science system for New Zealand will be more certain, less time consuming, more accountable, more effective and more efficient, sufficiently resourced to deliver on the goals, and have greater emphasis upon outcomes that deliver impact for the good of New Zealand, domestically and globally.

[1] Te Pae Kahurangi, July 2020, Positioning Crown Research Institutes to collectively and respectively meet New Zealand's current and future needs. MBIE https://www.mbie.govt.nz/assets/te-pae-kahurangi-report.pdf

It will reflect the distinctive nature of New Zealand's society, support the Te Tiriti relationship and be inclusive of mātauranga Māori and te ao Māori.

It will acknowledge that its purpose is to support achievement of the nation's aspirations in an increasingly dynamic world. So it will include and engage all New Zealanders in its design and delivery, and be strongly globally connected. It will understand that the people and infrastructure comprising the RS&I system are part of a much broader system at both national and international levels, involving social, economic, cultural and environmental values, actors, issues and priorities.

Key perspectives

The Science New Zealand response is shaped by three key perspectives:

i) A system-wide review, with clear process. The review must be truly system-wide. While the CRIs are a critical component of the science system, as *Te Pae Kahurangi* noted[2], they are only part of a much wider system which is well beyond Vote RS&I. The review needs to encompass the role of education (at all levels), training, immigration, societal engagement with science and innovation, and the role of tangata whenua.

The process must be robust and transparent. At all points of consultation, decision-making and implementation, there needs to be clarity on problem definition and the main options; present a cost-benefit or other appropriate analysis, and only then move to recommendations. People knowledgeable about the system should be involved from the outset.

ii) Clarity on why New Zealand invests in research, science and innovation. New Zealand invests in research science and innovation to improve outcomes and opportunities for New Zealanders in a dynamic world. To do so, the system must enable research-led knowledge to flow through the system to end-users. While New Zealand is highly productive in creating new knowledge, it is the application of science research in the hands of end users (such as industry, government departments and agencies, and Māori) that generates social and economic transformation.

Therefore the focus of the renewed RS&I system must be on the vertical integration of researchers and end users, more so than on the horizontal connections between research providers. The latter is of benefit only if it serves the former.

iii) A clear purpose for each element of the system, with the ability to deliver. Every element of the system should have a clear purpose and be enabled and empowered to deliver on that purpose. This will drive efficient and effective collaborative and cooperative behaviours necessary for the science research and its application and to enable people to flourish. *Pathways to the Future* provides more insight on this approach.

Role of science in helping New Zealand achieve its aspirations

It is the CRIs hope that the Te Ara Paerangi process can accelerate the necessary step-change in research-led innovation and the contribution science research can make to achieving the aspirations of New Zealanders.

A robust and productive science system, including the contribution of mātauranga Māori, is essential for creating a better future for New Zealand, economically, environmentally, culturally and socially. Research, development and innovation are also at the heart of the

[2] ibid

nation's transition to a low-carbon future and adaptation to the effects of climate change. As well as its utilitarian role, science helps develop and evolve New Zealand's distinctive place in the world, thus contributing to national pride.[3]

Science research, development and innovation has three interacting layers. It is these three working together that deliver positive, enduring impact that makes the difference for New Zealand:

- the creation of new knowledge;
- using new and existing scientific knowledge to create new products/services, new businesses, improved processes and/or improved policies and regulations;
- applying and scaling the outputs of development to lift productivity, increase incomes, enhance the environment and produce positive social outcomes.

The New Zealand science system comprises a broad range of organisations, from government agencies and universities through to corporate R&D departments and deep tech start-up companies. The CRIs are positioned right in the middle of this system, mandated specifically to undertake, promote and disseminate research for the benefit of New Zealand. It is this mission that drives all they do.

Aspects of the current system are not working optimally. Economic growth has been driven more by working harder and longer than by innovation-led gains in productivity. A major exception, is the food and fibre sector with a longstanding science-based productivity base.

Now is the time to leverage the nation's strengths and maximise impact from its research, science and innovation resources, to focus on how best to achieve the outcomes New Zealand wants.

System opportunities include the following:

- better strategy setting – currently fragmented with Government, Māori, Industry and Research entities each developing strategies separately, when genuine partnership would be more effective;
- better enabling research and development through to end users, and to support the start-up of new companies and new sectors;
- better engagement of Mātauranga and Māori than current science funding arrangements allow;
- more active engagement of all parties in encouraging and developing the R&D workforce New Zealand needs;
- and ensuring the appropriate infrastructure to support them in whatever part of the New Zealand economy they work.

Developing a national overview agreed by all stakeholders

The research, development and innovation system is poised to help build a more productive, sustainable and inclusive future. Government is committed to raising the R&D investment to 2% of GDP by 2027. While New Zealand's national workforce is small and the R&D investment at about half the OECD average, it is highly productive: producing more than double the number of outputs per researcher, and per dollar spent, than the OECD average.

Government policy has strongly encouraged collaboration between research organisations. The objective is to increase sharing between knowledge creators, in expectation that this horizontal integration will transform New Zealand's economic, environmental, social and cultural wealth and well-being.

[3] Briefing for the Incoming Minister of Research, Science and Innovation, November 2020, MBIE Website: https://www.mbie.govt.nz/dmsdocument/12533-briefing-for-the-incoming-minister-of-research-science-and-innovation

While such horizontal integration has value, CRIs propose that substantially greater opportunity lies in increasing the vertical collaboration between the knowledge creators and those who apply and scale the outputs of the knowledge development. (In practice, this is a two-way exchange). This is done well in only a few places.

Industry collaboration with CRIs is significant, and although New Zealand's overall private investment in RD&I is relatively modest, the share of industry investment into New Zealand's government research institutions is the highest in the OECD. Global science and mātauranga Māori collaborations are beginning to show real value. New Zealand needs to broaden these successes.

A central recommendation from the CRIs is that New Zealand should create a Research, Development and Innovation Council (RDI Council). This would consist of a 'quadruple helix' of Government, Māori, Industry and Research, working collectively to co-design the transition pathways to a sustainable and prosperous future. The Council would have responsibility to collectively identify National Priorities for investment.

The National Priorities will be delivered through Missions: substantial, vertically-integrated initiatives that are outcome-based and time-bound. These will accelerate research into impact through deliberate connections between research and its users. Each member of the quadruple helix will be empowered to support the Missions; and will be accountable for delivery. This will involve changes to the way that Māori, Industry and Research are funded to deliver nationally important outcomes

Concepts used in this submission

Pathways to the Future introduced concepts that recur in this submission:

- *PRO* (Public Research Organisations) - used instead of CRIs, reflecting that CRIs are one form of public research organisation and reaffirming that CRIs are both open to change and have a track record of instigating change;

- *Quadruple Helix* – the bringing together of government, business/industry or sector, Māori and research organisations to increase the effectiveness of RS&I investment through improved focus and prioritisation;

- *Vertical integration* – increasing the flow of new and existing knowledge through the system, from knowledge creators to end users (i.e. vertically) through the quadruple helix members working together effectively to deliver on agreed strategies.

Summary and recommendations

Submission structure

The topics are addressed in the order they are presented in Te Ara Paerangi. Many are necessarily interlinked: for example, institutional and funding structures need to be focused on delivering and ensuring accountability for beneficial outcomes in Priority areas; infrastructure and co-location are linked with workforce and institutional structure; and matters pertaining to Māori are critical to all. So the recommendations are also interlinked.

The recommendations are at a high level and must be considered within the wider context of the RS&I system beyond Vote RS&I. Science New Zealand welcomes the opportunity to work through these recommendations during further stages of this process.

Priorities

Setting of National Priorities will allow New Zealand to align resources more effectively around declared areas of national importance. This is absent from the New Zealand system, following repeal of the Foundation for Research, Science, and Technology Act 1990 by the Research, Science, and Technology Act 2010.[4]

The number of National Priorities should be relatively few. Importantly they will not cover all that a country of New Zealand's sophistication should expect to have available from the science system.

Recommendations:

- that the Government establish an independent Research, Development and Innovation Council (RDI Council) comprising key stakeholders from Māori, Industry, Government, and Research communities (the quadruple helix), enabling a holistic view of the wider RS&I system. This need not be a full-time, permanent body.
- One of the roles of the RDI Council is to set a small number of National Priorities advancing the well-being of New Zealanders;
- the National Priorities should be framed as outcome based, time bound Missions (like the Kennedy moon-shot mission);
- the Council should set the targets and identify participants in the Missions;
- the Missions will replace existing mechanisms so as to drive vertical as well as horizontal alignment of effort to achieve National Priorities;
- the RDI Council should regularly review the National Priorities;
- the organisations responsible for delivering the Missions will be held accountable for the outcomes.

[4] Research, Science, and Technology Act 2010

Te Tiriti, Mātauranga Māori, and Māori aspirations

Māori need to be engaged as Te Tiriti partners in the science system. That is a foundation point for the Science New Zealand recommendations and commentary in response to all the topics in Te Ara Paerangi. The response also recognises that New Zealand is developing a "by Māori, for Māori" approach in many aspects. CRIs also acknowledge the multiple and diverse forms of engagement they have with Māori: individuals (including as staff and directors), iwi, hapu, Māori incorporations and businesses.

Views from Māori will be presented by various groups during the Te Pae Kahurangi process. That should continue or, in some instances, commence discussion. At this time, therefore, Science New Zealand limits its recommendations to the following:

Recommendations

- Māori and Mātauranga Māori should be valued and enabled via authentic partnership;

- Government and the science and innovation system should engage with Māori to understand the changes they require the Crown to make so that Māori are empowered to take a full partnership role in both the establishment of National Priorities and the development of Mission strategies;

- Existing institutions and leadership should be actively encouraged and supported in making change to better enable Māori partnership and leadership in ways reflective of Māori needs and values.

Funding

Science New Zealand proposes a layered approach which will enable top down selection of critical areas to fund and equally important bottom-up investment to generate new ideas and applications. National Priorities will only be one part of the national investment.

The layers:

- Base funding to cover core national science capability and infrastructure (e.g. long-term data collection, biosecurity, communicable diseases etc)
- Appropriate funding to meet National Priorities
- Contestable for blue sky ideas.

The system needs a higher percentage of funds providing long term stability.

- This will support capability development and enable research organisations to build stronger relationships with sectors, including Māori. Partners will have confidence in the ability of the research organisation to commit and deliver.
- This approach is consistent with the vertical integration proposal, enabling integration of development of science knowledge, exchange of science knowledge, and application / commercialisation (as outlined in *Pathways to the Future*)[1]
- It enables New Zealand to develop and retain core capability of enduring value – not least the current, emerging and future human talent which is the basis of the science research and application endeavour.

The institutional purpose and accountability mechanisms will ensure the necessary dynamism that matches capability to the research and application which the nation needs. It avoids entrenching existing capability.

Competitive funding to support a contest of ideas will continue to be important. It enables new entrants and provides a testing ground for new ideas which may then flow into operational activity and other end user outcomes. The direct and indirect costs of bidding, however, do need to be lowered. There are various ways this can be done.

The RDI Council mechanism will better enable all parties to understand who the beneficiaries are, and who is willing to pay. As a participant in the quadruple helix National Priority setting process, the government will have a clearer view of the needs, who pays and therefore a reason for the government to fund a priority.

Recommendations:

- Base funding needs to cover all the research and capability the citizens of New Zealand expect public research organisations (PRO) to undertake or provide;
- To deliver on the National Priority Missions, key research providers need to be resourced commensurate with the expectations over the duration of the Mission;
- Each of the key organisations needed to support National Priority Mission strategies should be empowered and enabled to act rather than be reliant upon contestable funding mechanisms;
- PRO should be adequately resourced through institutional funding to empower and enable them to deliver on the commitments they make as part of the National Priority Mission strategy;
- PRO should be adequately resourced commensurate with the expectations the Crown has of them in other respects;
- The Government should have a funding pool accessible via contest, to generate new ideas and enable new entrants;
- Repayable grant mechanisms should be expanded to support emerging sectors and companies in selected areas, including those incubated within or using foundation research provided by PRO.

Research Institutions

Diversity offers strengths

To meet New Zealand's future goals and aspirations the country needs a cohesive national system with a range of types of institutions, each serving a distinctive purpose. While some overlap is both inevitable and useful, the core purpose of each should be clear.

Each of the major types (universities, CRIs or future PRO, and industry/sectoral research organisations) need to be enabled to undertake their core purpose. They can then leverage their distinctive and complementary roles while being closely connected to each other.

The different types of organisation have very different purposes, cultures, reward incentives and management approach. This is reflected, at a general level, in the networks, drivers and focus of staff. Such differences are a strength in a system which values diversity.

For example, a CRI coheres around its institution's mission (set out in the CRI Act 1992 and the Statements of Core Purpose), and develops the platform to enable that. Universities

cohere around the purposes set out in the Education and Training Act 2020 (such as to be primarily concerned with more advanced learning; research and teaching closely interdependent; a wide diversity of teaching and research; academic freedom; critic and conscience of society) and staff have autonomy to pursue research within those bounds. Industry research organisations focus their staff and infrastructure on research of direct benefit to that sector.

Structural change and organisational form

When reviewing potential change to research institutions the review needs to consider two closely related but separate matters:

- Structural change to the RS&I system;
- Organisational form of the research organisations.

In both cases, a robust and transparent process is needed. This should articulate the problem, set out options and evaluate them carefully. People with in-depth knowledge of the system, including end users, need to be involved from the outset.

Company model

There has been much commentary on removing CRIs from the Companies Act. CRIs note that the Companies Act is not in conflict with the requirement to "benefit New Zealand" as set out in the Crown Research Institutes Act 1992.[5]

The company model has on occasion been misunderstood, both inside and outside the CRIs, as 'profit maximising'. It was intended, however, and has generally been implemented, as working for financial sustainability.

It is instructive that the CRI Act uses the phrase 'financial viability' whereas the State-Owned Enterprises Act requires SOEs to "*operate as a successful business and, to this end, to be .. as profitable and efficient as comparable businesses that are not owned by the Crown.*"[6]

The company model has given the CRIs:

- access to good governance and management,
- the insight of directors focused on the CRI purpose and role in the national system,
- imposed financial diligence, operational effectiveness and efficiency,
- required staff to work with end users,
- ensured a focus on customers,
- independence in a way valuable to social trust in the science and advice of CRIs,
- ability to use the balance sheet to acquire, maintain and develop assets of national importance.

Co-location

CRIs are co-located in more than 20 sites around New Zealand, with CRIs, other research organisations (public and private), universities and iwi entities. Some are for historical reasons; more recently there has been purposeful relocation.

[5] Crown Research Institutes Act 1992 www.legislation.govt.nz/act/public/1992/0047/latest/
[6] State-Owned Enterprises Act 1986 https://www.legislation.govt.nz/act/public/1986

Co-location may be a factor in collaboration and access to shared infrastructure but is not essential to either, as shown by multi-campus universities, CRIs and other research organisations in New Zealand.

Purposeful co-location is valuable when it is supported by a strategic purpose and a long-term commitment to the arrangement. Co-location should focus on enabling vertical flow of knowledge through to end users (and the reciprocal engagement with knowledge creators), and all three layers of the RD&I system.

Consideration of co-location should engage end-users in the design and decision-making. This may accelerate the co-location of PROs and end-users, as already exists with many CRIs as a vital means of connecting research to impact.

The CRIs recommend a transparent robust policy process be used to consider co-locations. This will involve problem definition, listing of main options, evaluation and cost-benefit analysis. The vertical integration model prioritises enhancing the flow of knowledge creation through to end users.

The importance of regional sites in enabling close engagement with widely dispersed end users should not be underestimated. This applies to many of New Zealand most significant sectors. Regional sites also greatly assist in better enabling relationships with iwi, hapū, Māori incorporations and businesses.

Recommendations

- When reviewing potential change to research institutions the review needs to consider two closely related but separate matters:
    - structural change to the RS&I system and
    - organisational form of the research organisations

- In both cases, a robust and transparent process is needed. This should articulate the problem, set out options and evaluate them carefully. People with in-depth knowledge of the system, including end users, need to be involved from the outset;

- As mission-focused PRO, CRIs should continue to have the objective ("benefit to New Zealand") and principles as set out in the CRI Act 1992;

- CRIs should be structured around their core purpose: to deliver science research which is useful, usable and used to benefit New Zealand. As mission focused PRO the focus needs to be aligned with developing a more productive, sustainable and inclusive New Zealand. This requires close engagement with existing and emergent sectors, as well as maintaining close linkages with blue-sky research. The capability they steward will evolve, as will the challenges and opportunities for New Zealand;

- There should be a review of the alignment of PRO with end users to ensure that the major end user groups have a simple and clear alignment to an appropriate PRO. This may involve creation of a new PRO if there is a gap. The RDI Council could be used to identify gaps;

- The institutional form of each PRO should prioritise engaging with their relevant sector's end users. The engagement should be consistent with science independence and integrity, long-term sustainability of human capability, assets and

infrastructure, and accountability. This approach will reinforce the proposed vertical integration which enables maximum flow between knowledge creators and end users to deliver the agreed outcomes;

- Co-location policy development should be subject to transparent, robust processes; and include all parts of the quadruple helix.

Workforce

New Zealand needs a diverse, inclusive and competitively-rewarded workforce, with the research and innovation skills and resources to deliver outcomes for the good of New Zealand.

The workforce and their employing organisations need long-term certainty and stability in resourcing their missions (both National Priority Missions and other activity). As people are the key resource for a research organisation, the current workforce needs a high degree of certainty that their investment into skills and knowledge will be appropriately protected and rewarded.

Similarly, the potential future workforce will be influenced in their choice of study, career and employer by perceptions of how workers of today are valued. The projected increase in R&D investment to 2% of GDP by 2027 implies a significant growth in the STEM-trained workforce (an implied 29,000 FTE increase). If young people do not see a viable and rewarding career path, too few will stay with the necessary study or enter the science workforce. To attract and retain the best people requires rewards and support commensurate with other professions.

- There needs to be significantly enhanced investment in increasing Māori interest in gaining science qualifications; developing Māori research opportunities, including Māori-led and initiated research; and developing non-Māori staff to be capable and comfortable in working with Māori and mātauranga Māori.

- The RDI Council should have a role in considering the capability needs of New Zealand at a systems level. This involves looking at future capability needs some decades ahead and how that capability is to be acquired. That is a separate role to the more immediate task of bringing more graduates into the science system.

- Attention needs to be given to the role of Government in prioritising skills and training (at ITP and universities) applicable to New Zealand's aspirations, and to a balanced immigration policy that attracts and retains skilled migrants that can help New Zealand achieve its aspirations.

- Attention needs to be given to ensuring a STEM-based career is attractive – both in terms of potential career paths and for appropriate reward and support commensurate with other professions.

- PRO need to continue their significant contribution to developing New Zealand's science workforce. CRIs mentor or co-supervise some 450-600 graduate students each year in disciplines New Zealand needs, and provides opportunities for the students to work on issues and challenges critical to New Zealand.

Research Infrastructure

Institutions are best placed to determine their need for small to medium infrastructure and the resources to obtain them.

The system discussion centres on purchase, ownership, maintenance of and control of access to large-scale infrastructure: should this be centralised or distributed?

It is preferable to have such infrastructure in the organisations which are responsible for both capex and opex, provide professional management of the equipment or asset and the associated capability, training and technical support for users, and maintenance. Separating these elements can undermine the effective utility of the asset to the nation.

The company structure of CRIs ensures that capital expenditure and operating expenditure implications are linked in the decision-making process, thus focussing on efficient use of assets from purchase through to end of life. Rather than being a hinderance, the company structure encourages CRIs to offer use to other potential users, with appropriate protocols for access (such as outcome-based merit).

There is, however, an infrastructure resourcing gap which Government needs to address. That is, how to provide, maintain and renew facilities necessary for proof of concept and similar work which is beyond the research investment phase but prior to full-scale commercialisation. These assets are often best placed alongside or within research organisations and industry partners.

The RDI Council should have a role in developing a national infrastructure strategy. This will build upon its members diverse knowledge of sectors and of likely future needs.

Recommendations:

- Infrastructure policy development should be subject to transparent, robust processes; and include all parts of the quadruple helix;

- The RDI Council should have a role in developing a national infrastructure strategy, bearing in mind the relationship of usage, capex and opex.

Part B: Setting the context

Context and implications for Te Ara Paerangi

1. New Zealand desires to be more productive, sustainable and inclusive.[7] It wants its people to have life-long educational opportunities, enjoy an equitable society and quality natural environment, and work that is productive, fulfilling and high-value. It desires to be a model global citizen, encouraging a stable world order with robust international law and regulatory systems.

2. New Zealand has many attributes which give confidence that the nation is not only able to address the many challenges of the modern world but is also able to identify and realise the opportunities they create for the nation and its people.

3. These attributes include being an open, liberal democracy; a stable and open trading economy with strength and depth in established economic sectors, particularly in food and fibre and with fast-developing technology and services sectors; an evolving role of tangata whenua in the social, economic and political arenas; being multi-cultural and thus linked to all parts of the globe; a soundly-based reputation for ease of doing business and low corruption; being good partners in regional and world forums; a well-educated population; a good health system; environmentally conscious; and a high quality – and in some cases, world-leading - science research capability.

4. Further, New Zealand has unique characteristics arising from demography, geography, ecology, social and economic history and national values which enable a distinctive set of approaches to the challenges and opportunities the country (and world) faces.

5. At a high level, many of the challenges are not unique to this country. Examples include climate change, environmental concerns, natural hazards, social and economic inequity, the role of first peoples in the social and political construct, diversifying an economy and preparing people for the changing nature of work and sources of prosperity and well-being.

6. New Zealand has multiple advantages arising from its strengths. They advantage the value of our physical exports and offer immense potential in an increasingly services-based, weightless, global economy. New Zealand has shown it can be adept at helping shape rules, regulations and systems of countries and global organisations in areas of national importance, such as trading regimes, marine law, human and animal health. More will be needed in this dynamic space.

A broad view of the RS&I system is needed

7. Science research – including the social sciences - underpins all parts of the national endeavour: public and private sectors, not for profits, community, Māori (iwi and hapu), individuals and whanau.

8. Societal support for science research is linked to people collectively seeing their aspirations heard and that they have a mana-enhancing role in shaping the priorities and resourcing. This requires close, substantive and respectful engagement, to understand why they want to invest in science, and their priorities. A critical element is in ensuring that the science system itself aims to be equitable, diverse and inclusive – exemplifying New Zealand's values.

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[7] He Tirohanga Mokopuna 2021, The Treasury's Combined Statement on the Long-term Fiscal Position and Long-term Insights Briefing, Treasury Website: https://www.treasury.govt.nz/system/files/2021-09/ltfs-2021.pdf

9. Because science research is so fundamental to all aspects of New Zealanders lives, and will shape future possibilities, change needs to be extremely well considered and alert to indirect consequences. While some level of disruption can be the cost of attaining a better system, it is prudent to be clear about how change may play out in an extremely complex system in which highly mobile people, and societal trust, are the principal assets.

10. The Te Ara Paerangi review must be far broader than Vote Research Science & Innovation and consider wider implications in some detail. The process will need to consider education and training, infrastructure, policy settings across government (including immigration), funding and societal changes to ensure a cohesive system appropriate to the mid-21st century. While the Green Paper commences a useful discussion on some of these issues, the review needs additional, substantive consideration of these other matters from other perspectives.

11. Each area raised for discussion in the Green Paper needs its own transparent, robust policy process. At all points of consultation, decision-making and implementation, the review must be clear on problem definition, the main options, present a cost-benefit analysis, and only then move to clear recommendations. People knowledgeable about the system should be involved from the outset.

12. As Crown-owned entities with the statutory purpose of delivering benefit to New Zealand, and active in many of the critical areas of challenge and opportunity, CRIs are committed to serving the current and future needs of New Zealand. In the 173-year history of government-owned research organisations in New Zealand there have been many institutional and funding arrangements. The core purpose, however, has remained constant: to specifically benefit New Zealand through excellent research and its translation into impact through close relationships with users.

13. Science New Zealand acknowledges that Māori have a central and essential role in framing the future. While this submission is informed by discussions with Māori staff and partners in research and application, the CRIs cannot speak on their behalf. This submission offers some thoughts as a contribution to the korero.

The purpose for science investment

14. New Zealand undertakes less than one percent of the world's research. This, by itself, cannot sustain the aspirations of the population. So it needs to engage globally to access others' research, technology and applications; and it needs to resource knowledge creation, application and capability (including vital human talent) specifically relevant to national needs. This has led to the evolution of a high quality, highly productive, diversified science research system that is globally engaged.

15. Clarity of the purpose or goals of research investment must come before establishing priorities. The science system review largely considers the vital question is: "what are the priorities for research, and how should they be resourced?" The beginning point, however, should be: "what is the purpose of science research?" That question will be answered differently by the public sector, private sector, and others (such as Māori and not-for-profits).

16. Understanding the different parties 'why' for RS&I will better enable identification of priorities and expectations and how the system could maximise its scarce resources (people, infrastructure and societal support). It will help determine where the optimum decision point for investments should sit (e.g. central, or much closer to beneficiaries of the research and co-investors); how authentic partnership with Māori is reflected in

organisational and funding arrangements; and how institutional arrangements are attuned to purposes.

The Government purpose in investing in R&D

17. Government invests in R&D to deliver outcomes. Goals include:
    a. developing a world-class, effective and efficient public sector (health, education, social services, culture and heritage, environment and conservation, infrastructure provision);
    b. building a more capable private sector, including through developing human capital suited to creation of intellectual capital and its realisation;
    c. incentivising the private sector to favour investment into R&D;
    d. ensuring researchers and research institutions are globally linked and engaged;
    e. encouraging blue-skies or curiosity-driven research which will develop human capital, and may create intellectual capital of value to the nation;
    f. enabling research which is more directly applicable to developing or implementing government policy;
    g. undertaking scientific measurement and data collection to support the implementation of government policy and regulation;
    h. developing and retaining diverse research capability needed to respond to natural and other disasters.

18. Government has an enabling role with the private sector. This includes helping provide appropriately skilled graduates, tax incentives, access to high risk patient capital for investment in technology development, and de-risking early stage research and innovation pathways (especially in areas where New Zealand has comparative advantages).

19. Government has a primary role in areas where it is the sole or largest customer, often enabling wider access to the research outputs. This includes quality assured information and analysis for policy makers; long-term monitoring and data collection and evaluation; and responsiveness to events (such as pandemics, natural disasters, biosecurity and environmental challenges). New Zealanders have seen value in having a critical mass of capability (people and infrastructure) in areas vital to national wellbeing, and available as and when the government requires it.

20. A national strategy will assist to identify current and future capabilities, and how they are to be acquired, supported and developed. Science research, like all markets, is subject to the vagaries of fashion and market sentiment which can leave some important areas under-resourced (too few people; insufficient infrastructure and investment); or the extremes of being abandoned or over-crowded. Internationally, governments favour state-owned institutions as a guarantee in having the necessary base level of resource.

Private sector purpose in investing in R&D

21. The private sector purpose for RS&I is, broadly speaking, to ensure a return on investment for its stakeholders (or, in the case of industry good groups, their members). This can include consideration of social, cultural and environmental matters. Their purpose therefore prioritises RS&I which can protect market share or develop new products and processes.

Roles of Organisations within the System

22. The purpose of each type of organisation drives which research type they prioritise, the areas of research and the breadth and depth of those areas. Table 1 shows where research is conducted and Figure 1 shows who funds it.

Table1: Where research is conducted

	$$	% of total spend[8]
Higher education (universities and polytechnics) • predominantly basic (or blue skies) research	1,082m	24%
Government (central and local) sector, CRIs and Callaghan Innovation • focused on mission-led research and application	758m	17%
Private sector including businesses, industry and other research organisations • focused on experimental development (application of research to a specific problem).	2,709m	60%

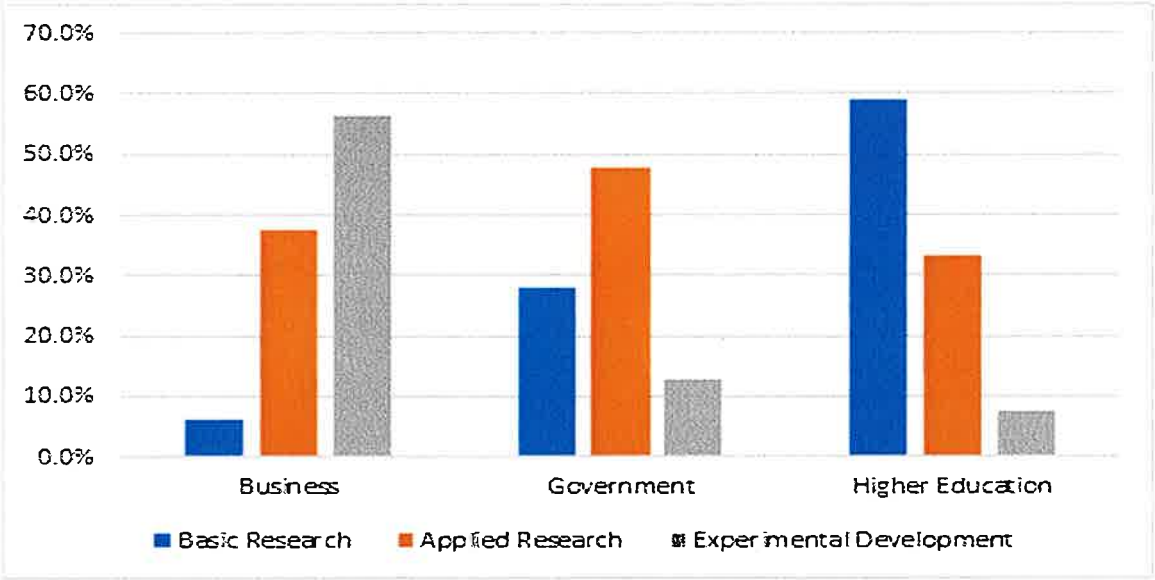

Figure 1. Type of research and development expenditure by sector (percentage of total research carried out by sector).[9]

23. The Draft Research, Science and Innovation Strategy (MBIE, 2019) states:
*"it [*the government's science investment system*] is designed and maintained to support a range of research, development and innovation activity, from blue- skies investigation to applied R&D. All of this activity is important and needs to be supported in balance across the system."*[10]

24. Science New Zealand proposes that more work is done to better establish the balance that is necessary to deliver on the national aspirations. This work should be done by engagement with all sectors, with priorities agreed between government, research organisations, businesses/sectors and Māori ie a quadruple helix of key actors.

25. In 2007, CRIs, universities and independent research organisations presented a report to the then Minister of Research Science & Innovation, recognising that this balance is dynamic. The Report reaffirmed the need for investigator-led research (not least because it is important for the training of new researchers). It recommended however, that for a period increases in the national spend should be weighted towards mission-

[8] Research and Development in New Zealand 2020, StatsNZ Website
[9] Research and Development in New Zealand 2020.
[10] Draft Research Science and Innovation Strategy, 2019, MBIE *op.cit.*

led and user-led research as that delivered more immediate impacts, including economic. The objective was to grow a bigger pie of national investment.

26. The OECD found in their review of the New Zealand Innovation System in 2007:
"Historically, the New Zealand economy has been shaped by the exploitation of natural resources through agriculture, forestry and fishing, and associated processing and service activities. More recently, agri-food related biotechnology, tourism and film making have emerged as new industries able to exploit natural comparative advantage. The importance of land-based activities has shaped New Zealand's innovation and R&D system."[11]

27. Almost a decade and a half later, Te Pae Kahurangi (July 2020) continued to note:
"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."

Mission led research: a government research institution role

28. Mission-led research will be essential for New Zealand to reach its potential. By mission-led is meant outcome focused science and its application to solve real world problems.

29. The main providers of *mission-led research for New Zealand benefit* are the Crown-owned CRIs and Callaghan Innovation. Other research organisations in specific mission-led research spaces are not Crown-owned and thus not subject to Crown direction (although many are heavily dependent on government funding). Examples include Cawthron Institute (a focus on elements of marine science) and Malaghan Research Institute (health science); or levy-funded bodies such as DairyNZ and BRANZ.

30. The CRIs were established in 1992 from various government owned research organisations, principally the Department of Scientific and Industrial Research (created in 1926 but with constituent parts going back to 1865) and the Ministry of Agriculture and Fisheries research centres (going back to1864).

31. The CRI Act (1992) states the purpose and lead principle of every CRI:
"To undertake research; that research undertaken by a CRI should be undertaken for the benefit of New Zealand."

32. The CRIs remain distinctive through their mandate:
    a. to be relevant and responsive to New Zealand's unique economic, environmental, social and cultural requirements;
    b. to work on the issues of the day; especially those which others cannot or will not;
    c. to take the research through to impact that makes a difference for New Zealand;
    d. to look beyond the present to the future challenges and opportunities for the nation;
    e. to help the nation be prepared for natural, public health or other emergencies, and to be immediately available to help the nation at those times, and when government directs.[12]

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[11] OECD Reviews of Innovation Policy: New Zealand, 2007. OECD Website: https://www.oecd.org/newzealand/oecdreviewsofinnovationpolicynewzealand.htm
[12] The Value of Crown Research Institutes in Aotearoa New Zealand's Science System Today, 2021, Science New Zealand Website: https://sciencenewzealand.org/publications/the-value-of-crown-research-institutes-in-aotearoa-new-zealands-science-system-today/

33. The CRIs have operated as companies since 1992, in a deliberate decision by the then Minister of Research, Science and Technology, Hon Simon Upton, to make them responsive to end users. This model has on occasion been misunderstood, both inside and outside the CRIs, as 'profit maximising' whereas it was intended, and has generally been implemented, as working for financial sustainability (the CRI Act requires 'financial viability').

34. All institutional models have pluses and minuses, but the company model has given the CRIs access to good governance and the insight of directors, imposed financial diligence, allowed independence, ensured a focus on customers, and the ability to use their balance sheets to acquire and maintain an asset base to support their tasks.

35. The CRIs are effective and efficient in converting RS&I investment (in people and infrastructure) by the public, private and other sectors into outcomes which are valued and used.[13]
    - When the private sector commissions external research, it spends three of every four dollars with CRIs and Callaghan Innovation.
    - New Zealand is consistently in the top two in the OECD for publicly owned R&D entities being commissioned by the private sector.

36. The partnerships have resulted in new products and services in traditional industries which have added significant value in export earnings; underpinned new industries and incubated globally-leading companies. (See *The Value of CRIs Report*, annexed)

37. Te Ara Paerangi states that CRIs receive 80% of their revenues, collectively, from government. This overlooks important distinctions between revenue gained as grant funding, contestable funding or commercial contracts:
    - about 26% is from MBIE Strategic Science Investment Fund (SSIF). SSIF is available to some non-government research organisations as well and so is institutionally agnostic;
    - about 23% comes from non-SSIF MBIE contestable funding (e.g. from Endeavour or Marsden Funds);
    - the balance of CRI revenues from government sources comes from commercially tendered contracts which are open to any potential provider. This includes government departments' operational research i.e. commercially tendered but not necessarily for commercial benefit (e.g. fish stock assessments).

38. This mixed model of revenue has many advantages, including the close relationship with users which has made CRIs the principal providers of research when business commission externally. The balance, however, between short term, at risk funding and long-term funding needs to ensure that the core purpose for which the government established the research organisation is viable.

39. The CRIs concur with the Te Pae Kahurangi Report which concluded, in a section titled: *The research undertaken by CRIs remains important to New Zealand's future:*

> *"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;*
>
> *"The areas of research covered by CRIs remain highly relevant…"*

[13] ibid

> *"... changes to the operating model for CRIs [are needed] 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."*

40. The institutional form, governance and management of government research organisations varies around the world, often reflecting the political, social and economic histories of their countries. The CRIs were established to have a high level of independence from direct government control, yet an equally high level of accountability through professional boards to the shareholding Ministers. It was considered that, along with a strong sectoral focus, this would ensure both efficiency and effectiveness.

41. The level of governance independence was also a strong signal to society that the science research was free from political pressures. It enables society to have confidence that science-based input to policy is robust, rigorous and independent.

42. The CRIs were explicitly not to be State-Owned Enterprises (SOEs). The CRI mandate is to undertake research to benefit New Zealand, with the financial requirement stated simply in the CRI Act 1992 as: "to be financially viable". This contrasts with the State-Owned Enterprises Act which requires SOEs to "*operate as a successful business and, to this end, to be .. as profitable and efficient as comparable businesses that are not which owned by the Crown.*

43. The Government as owner sets the surplus expected from CRIs; which in recent years has largely shadowed the cost of capital charge levied upon government departments as part of the national public service accounts framework. Surplus ("profit") is reinvested into the people and infrastructure to ensure New Zealand retains and develops the capabilities the nation requires.

Māori and CRIs

44. Māori relationships with Crown science research organisations and researchers pre-date the formation of CRIs in 1992. However, the relationships have been more actively pursued at an institutional level since then, often building on those started with individual scientists. CRIs and Māori, especially iwi and hapū share an interest in, for example, natural assets, the natural environment and primary production. From these areas, innovative products and services have been developed to diversify the economic and social opportunities for Māori.

45. The relationships continue to evolve, and CRIs are changing as a result. CRIs acknowledge that there is still much for the Crown and its entities to do to advance the Te Tiriti commitments and to enable a 'by Māori, for Māori' approach. There is more active partnering with Māori; more projects initiated and led by Māori; greater focus on supporting improved outcomes for Māori; and active inclusion and promotion of the value of mātauranga Māori. CRIs look to play their role as part of an authentic partnership between the Crown and Māori.

Databases and collections

46. Databases and collections underpin long term strategic activities focused on outputs which are useful, usable and used. They – and the science capability wrapped around them - support evidence-based policy and operational decisions by government,

businesses and communities. The collection, maintenance, analysis of data and its connection to policy decisions is integral to evidence-based policy development in long-term areas such as fisheries management, conservation, health and water quality. Government, business and communities need access to good data and good science to evaluate the prospective policy impacts.

47. The CRIs maintain, update and curate New Zealand's major databases and collections for a wide range of areas vital to New Zealand's economic, environmental, social and cultural interests. Many of these databases and collections also underpin the monitoring, evaluation and validation of New Zealand's international obligations.

48. The collections and most databases are available to researchers throughout the science system. In some instances, there is public availability within 24 hours of accession. Having them close to their major users ensures ongoing utility and relevance.

49. Over time, however, these essential elements in the national science capability have been underfunded, causing holders to subsidise them internally (at cost to other functions) or, for some non-CRIs, to offload them to other institutions (such as museums). The review needs to consider dedicated investment into these holdings, to maximise their value to all users.

Major assets and infrastructure

50. Most forms of science research, development and innovation require substantial assets and infrastructure. These are held in multiple places and by different types of organisations in the public and private sectors. Databases and collections are one form.

51. Others include research vessels, high performance computing, specialised laboratories and associated equipment. Science research equipment can be very expensive and relatively short-lived before becoming outmoded. Many pieces of kit are common across labs in different organisations, but in practice are highly customised for particular uses.

52. As part of the system design CRIs are custodians of much of the nationally significant assets and infrastructure. Maintaining them and the associated capability for the benefit of the nation is a key responsibility of boards and management, with the assets held for use in current research programmes and for use in times of national requirement.

53. For many such assets, the CRs are themselves the major users, so the placement increases research efficiency and effectiveness. Access is open to researchers in other institutions and encouraged. The close relationship of the assets with users maximises use, identifies issues and avoids the purchase of 'white elephants'.

54. CRIs do, however, see some benefit in reviewing the access protocols for all significant assets and infrastructure across the system, and the underlying funding support (if the future system still runs with significant short-run funding). Some major assets held by CRIs already run merit-based access protocols, utilising a range of merit criteria. Some would-be users however point to funding as a barrier to their use of the assets, and instead use overseas based assets. This has the effect of further reducing the financial viability of New Zealand-owned assets.

Disaster preparation, response and recovery

55. CRIs are essential to New Zealand's preparation for, response during and post-event recovery from disasters and emergencies. The CRIs are the primary providers of long-term research for disaster mitigation and emergency management including events such as floods, droughts, volcanic activity and earthquakes, pandemics, biosecurity incursions, and infrastructure failure.

56. As Crown entities, CRIs integrate with the responding government agencies to make their knowledge and insights accessible pre, during and post events. The Crown also has the power to direct CRI activity where required (such as in national emergencies) and, as the owner, provides expectations to the Boards for long-term planning.

A broader perspective: towards a better RS&I system

57. The CRIs as institutions have been reviewed, individually and collectively, many times since being established in 1992. These reviews are in addition to annual audits, select committee reviews, project and programme reviews, specific area financial reviews (such as a balance sheet review), infrastructure reviews, investment process reviews (including a review of Core Funding in 2017) and impact reviews.

58. CRI Boards and management internally assess their efficiency and effectiveness, and review priorities and use of resources. This includes seeking advice from end users and research and innovation partners or science advisory panels of eminent practitioners in relevant fields from New Zealand and abroad. This has resulted in strategic shifts in all CRIs over the past 30 years.

59. CRIs have a track record of recommending major institutional changes. These include the disestablishment of one of the original 10 CRIs, the merger of two others to form Plant & Food Research, integration of a CRI with a university (which, when further assessed by officials was found to not be viable due to purpose, cultural and financial reasons), and restructure of IRL (which became part of Callaghan Innovation). This indicates a strong commitment by successive boards and management to put aside institutional protection and consider how the purpose of the CRI fits into the national needs. Current boards and management are approaching the Te Ara Paerangi review with similar commitment.

60. In 2009 the *Crown Research Institute Taskforce*, chaired by Sir Neville Jordan was commissioned by the Minister of Research, Science, and Technology, Hon Wayne Mapp. Its report, *'How to enhance the value of New Zealand's investment in Crown Research Institutes'*[14] was released in March 2010.

61. The Taskforce Report found:

> *"Collectively, CRIs are a rich repository of science capability and have a proud research tradition. They are to be commended for their achievements and the contribution they have already made to New Zealand. As the opportunity for change gathers momentum, we have a unique chance to build on their particular strengths and successes."*

62. Importantly, the Taskforce placed CRIs within the wider RS&I context. The Report recommended significantly increased discretionary funding (later formalised as Core Funding), and a specific purpose statement for each CRI. It also recommended significant changes to the policy and purchase functions of central government, noting

[14] CRI taskforce Report, 2009, MBIE Website: https://www.mbie.govt.nz/assets/7502750043/how-to-enhance-the-value-report-of-the-cri-taskforce.pdf

how these functions provided the structure for an effective national RS&I system and needed to work together. This recommendation resulted in the creation of an integrated Ministry of Science & Innovation (later disestablished and its functions transferred to the Ministry of Business, Innovation and Employment - MBIE).

63. The 2019-20 MBIE report *'Te Pae Kahurangi: Positioning Crown Research Institutes to collectively and respectively meet New Zealand's current and future needs'*[15] made similar comments: endorsing the value of CRIs but concluding that *"aspects of the current system are not working well"*. It identified *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.*

64. In 2021, the Productivity Commission published *New Zealand firms: Reaching for the frontier.* The report looked at the economic contribution of New Zealand's most productive "frontier firms", and the environment in which they operate. The Commission found that the New Zealand science system is not business friendly and is complex, lacks depth and is inwardly focused.[16] It noted, however, that land-based CRIs in particular attract a substantial proportion of their revenue from industry sources, saying that this suggested a close relationship between business and researchers.

65. The Productivity Commission recommended:

> *"Government investment should be focused on areas of existing or emerging economic strength and competitive advantage. A small country can excel in only a limited number of areas that can get to critical mass and support sustained world-class competitive performance."*

66. The Productivity Commission also noted a lack of consistency of policy across parts of government, with ostensibly overarching policy on research science and innovation unconnected to strategies from other parts of government. The Commission recommended a comprehensive review of New Zealand's innovation policies.

67. The Te Ara Paerangi review is an opportunity to consider these perspectives and open a richer discussion than has emerged through previous, CRI-focused, reviews.

The strategic opportunity for New Zealand: a strong resilient and high-value economy

68. For more than a century successive governments, and others, have argued the case for diversifying the economy. At times, proponents have declared traditional primary sectors to be sunset industries. Today, it is recognised that these sectors have been an economic lifeline for the country in times of global turmoil such as the Global Financial Crisis and the Covid-19 pandemic.

69. Te Pae Kahurangi noted:

> *"the food and fibre sector 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."*

[15] TPK Report, 2019, MBIE Website: https://www.mbie.govt.nz/assets/te-pae-kahurangi-report.pdf
[16] New Zealand firms: Reaching for the frontier, April 2021, Productivity Commission Website: https://www.productivity.govt.nz/assets/Documents/Final-report-Frontier-firms.pdf

70. The return from science and innovation investment in the traditional sectors has been consistently high, aided by developing and applying new products (such as the gold kiwifruit) and new technologies (such as harvesting and data sensing) and by reducing input costs and lessening environmental impact.

71. At the same time, new and existing knowledge and skills have transferred from the traditional sectors into new areas. The Productivity Commission noted research showing that new economic areas are more likely to emerge, embed and be successful when firms build on existing capabilities in their innovation ecosystems.

72. Te Pae Kahurangi identified environmental research as *"now probably more central to New Zealand's future than in 1992. Threats to national resilience are increasing in diversity and frequency. CRIs have collectively built deep capabilities in these areas."*

73. Economic, environmental, social and cultural wellbeing goals require New Zealand to have a more diversified economy. The application of science and technology by business is a critical driver of economic growth and, in New Zealand, government research organisations have been, and remain, instrumental to both the research and its application. Until the New Zealand economy substantially changes, this is likely to continue.

74. The CRIs are strong advocates for such change, to complement existing areas of economic and social strength. The CRI model is a strong candidate for helping develop and work alongside new and emerging sectors of the economy and societal challenges. CRIs are utilising and advancing technologies such as robotics and AI and developing advanced manufacturing capability that is world-leading in some areas.

75. The CRIs concur with the view expressed in the Te Pae Kahurangi Report:

> *"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.*[17]

Meeting the Challenges and Opportunities of the Future

76. Te Ara Paerangi is a once in a generation opportunity to reshape the New Zealand science and innovation system to make it fit for the middle of the 21st century and beyond and enable it to best serve the wellbeing of all New Zealanders. CRIs are a critical part but not the sole actors in this system.

77. The review needs a system approach which incorporates all policy, purchase and provider entities as well as end users more generically. It needs to ensure that change is well considered for potential impacts across the whole of the system, given that RS&I is a complex integrated system with multiple actors having their own objectives, but reliant upon others. In particular, it needs to ensure that the principal purpose of each part of the system is well-defined before attempting to develop priorities.

[17] Te Pae Kahurangi Report, Op Cit

Part C: Response to the Te Ara Paerangi issue areas

PRIORITIES

Setting Government Research Priorities

78. This section should be read in conjunction with commentary in Part B, specifically *Developing a national overview agreed by all stakeholders*; and *The purpose for science investment.*

79. New Zealand is a small economy with limited resources to invest in science. To avoid inefficiency and ensure the country's most pressing needs for science are met, resources need to be effectively aligned around the purpose of the research (why each of the stakeholders is making the investment and then the priorities). For example, one purpose for the government's RS&I investment is to create and transfer to the private sector human capital suited to intellectual capital creation and its realisation - thereby building a more capable private sector. System actors (e.g. research organisations, businesses and sectors, Māori) need to determine or signal which areas of human capital development they wish prioritised.

80. Currently there is no overall prioritisation of New Zealand's science investment. The draft Research, Science and Innovation Strategy (MBIE 2019) laid out some criteria for identifying where investment would be useful but avoided prioritisation as such. Previous mechanisms, such as having sector based pools of funding, the Statement of Science Priorities issued biannually by the Ministry of Research, Science and Technology (MoRST), and the Foundation for Research Science and Technology (FRST) portfolio system (where funding was allocated in impact outcome areas called portfolios and research priorities within each portfolio were set by industry or sector led panels), have been discontinued.

81. Several government agencies including MPI[18] and MfE[19] have science strategies but, while indicating areas they consider important, they do not explicitly set out priorities and show how they are matched to funding. Meanwhile, the government's principal RS&I funder asks bidders to consider government strategies without indicating how much weight this adds to approving a project.

82. The National Science Challenges were chosen by a two-step process: public consultation followed by an expert panel chaired by the then Prime Minister's Chief Science Advisor, Distinguished Professor Sir Peter Gluckman. The NSC were explicitly to address areas of priority to New Zealand; however, the money invested in each one is relatively small and it is questionable whether they have been able to focus on their initial purpose of 'additionality' of research as opposed to priming existing research. Nonetheless, they may have some useful lessons in areas such as collaboration building, funding allocation and engagement with Māori.

83. The Science New Zealand discussion paper, *Pathways to the Future*[20] set out a potential mechanism to identify priorities for the system.

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[18] Ministry for Primary Industry Science Strategy, 2015, MPI Website: https://www.mpi.govt.nz/dmsdocument/10172-MPI-Science-Strategy-Rautaki-Putaiao
[19] Our Science Strategy Rautaki Pūtaiao, 2018, MfE Website: https://environment.govt.nz/assets/Publications/Files/our-science-strategy.pdf
[20] Pathways to the Future, 2021, Op. Cit.

84. CRIs recommend that the Government sets up a Research, Development and Innovation Council comprising key stakeholders from Māori, Industry, Government, and Research. This body would develop the criteria for establishing a small set of National Priorities, and establish 'Missions' that would be agile, dynamic, respected and mandated and allow funding to be allocated effectively. The National Priorities would be reviewed periodically.

85. An independent RDI Council covering a broad range of stakeholders would allow for long term, enduring priority areas to be set, and ensure that the priorities were focused on solving issues of importance to all New Zealanders, and set with a deep knowledge of the needs of New Zealand. It would be independent of the political cycle but allow for political engagement.

86. The Council would set clear priorities. It would not be an allocator of funding. Its aim is to bring together the key stakeholders so that they develop and share a common agenda. Key criteria for allocating priority funding would be collaboration of the relevant science groups and connections to end users to ensure delivery of outcomes from the science. The funding assigned to a 'Mission' needs to be sufficient to see those outcomes delivered and allow them to be of significant scale. Participants would be accountable for delivery.

87. This process should bear in mind the insight from Dr David Skilling who has characterised most sector initiatives by government as delivering a 'sub-therapeutic dose.'

88. Dr Skilling is quoted in the Productivity Commission Report:

> *To make progress, the right materiality of ambition is required (percentage points of GDP, not a few extra million dollars of exports); a focus is required on the cluster as opposed to very specific activities; and a structural, whole of government policy agenda is needed (skill, infrastructure, research, FDI attraction, and so on) rather than some financial support. This should be done properly or not at all. And importantly, choices will need to be made in terms of what not to do.*

89. The National Priority areas would not cover all of the work done within the science system, but rather a subset of the work that is currently a priority and needs focus and alignment to be best achieved. This will leave a pool of unprioritised funding to generate new ideas and potential new areas for Missions.

90. This process will also help determine where the optimum decision point for investments is – e.g. is it central or better made much closer to beneficiaries of the research and co-investors.

Priorities - recommendations

- that the Government establish an independent Research, Development and Innovation Council (RDI Council) comprising key stakeholders from Māori, Industry, Government, and Research communities (the quadruple helix), enabling a holistic view of the wider RS&I system. This need not be a full-time, permanent body;
- One of the roles of the RDI Council is to set a small number of National Priorities advancing the well-being of New Zealanders;
- the National Priorities should be framed as outcome based, time bound Missions (like the Kennedy moon-shot mission);
- the Council should set the targets and identify participants in the Missions;
- the Missions will replace existing mechanisms so as to drive vertical as well as horizontal alignment of effort to achieve National Priorities;
- the RDI Council should regularly review the National Priorities;
- the organisations responsible for delivering the Missions will be held accountable for the outcomes.

TE TIRITI, MĀTAURANGA MĀORI AND MĀORI ASPIRATIONS

91. This section needs to be read in conjunction with the other topic areas, as the role and importance of Māori is integral to understanding and progressing each.

92. Māori aspirations are holistic and long term in nature, combining goals for the environment, employment, social well-being and technology advancement. The CRIs long term strategic vision focus on benefit to New Zealand, and national presence with regional distribution fits with these aspirations. CRIs have Iwi and other Māori relationships going back decades, are working to build their Māori workforce and unlocking the unique, innovative potential of Māori knowledge, people and resources.

93. The CRIs look to the evolution of the science system to strengthen the ability of government research to meet Māori aspirations on a Te Tiriti basis.

94. Government assigns specific funding for Māori centred projects through the Vision Mātauranga Capability Fund. While other MBIE bidding processes also include relevance to mātauranga Māori, the primary hurdle is a 'science excellence' bar largely measured on academic criteria. In contrast, much Maori-initiated work has a strongly applied, impact-driven focus. Many Māori therefore find winning MBIE investment in Māori goals via these mechanisms as elusive. The systemic bias undercuts the ability of CRI and Māori to partner in seeking funds for such work.

95. In December 2018, Science New Zealand provided the Minister of Research, Science & Innovation a report on *CRIs Māori Partnership and Co-innovation.* It reported views from Māori that the original vision of 'Vision Mātauranga' had been lost, and that the focus should be restored on unlocking the unique, innovative potential of Māori knowledge, people and resources.

96. CRIs also noted with concern that Māori can be overwhelmed by the demand for engagement and partnering from the large number of entities in the system: CRIs, National Science Challenges, universities, Centres of Research Excellence (CoREs), new Strategic Science Investment Fund (SSIF) platforms and regional research institutes. Each bring experience and models for closer engagement with Māori entities, and each increases the pressure on the limited human and other resources of Māori for engagement in specific areas.

97. A shared vision for how to have a deeper relationship and better engagement and co-innovation between Māori and government research organisations may be emerging but much more needs to be done. More can be done on developing career pathways and the employment pipeline (*see Workforce section*).

98. Some points for discussion may include:
    - strategic engagement, to increase the systematic and efficient allocation of organisations' resources;
    - building the collective capacity and progress of Māori through clear career pathways to senior leadership roles;
    - investing in mātauranga Māori research through a government investment vehicle and selection process that acknowledges the need for a distinctive approach based in mātauranga Māori, and unlocking distinctive innovation through 'science with Māori' rather than 'science for Māori';
    - ensuring that the research organisations are welcoming, receptive and reflective of Māori aspirations and practice, and are enabling of Māori partnership and leadership in ways reflective of Māori needs and values.

Te Tiriti, Mātauranga Māori, and Māori aspirations – Recommendations

- Māori and Mātauranga Māori should be valued and enabled via authentic partnership;
- Government and the science and innovation system should engage with Māori to understand the changes they require the Crown to make so that Māori are empowered to take a full partnership role in both the establishment of National Priorities and the development of Mission strategies;
- Existing institutions and leadership should be actively encouraged and supported in making change to better enable Māori partnership and leadership in ways reflective of Māori needs and values.

FUNDING

Government Funding of Science

99. Government funding for science has increased significantly since 2012. The major increases have been in the Performance Based Research Fund (PBRF - funding from TEC only accessible by Tertiary Education Organisations) and Callaghan Innovation funding for industry (only accessible by private companies, now largely a tax credit). *Respectively shown in Fig 2 as light blue second from top and dark blue at bottom.*

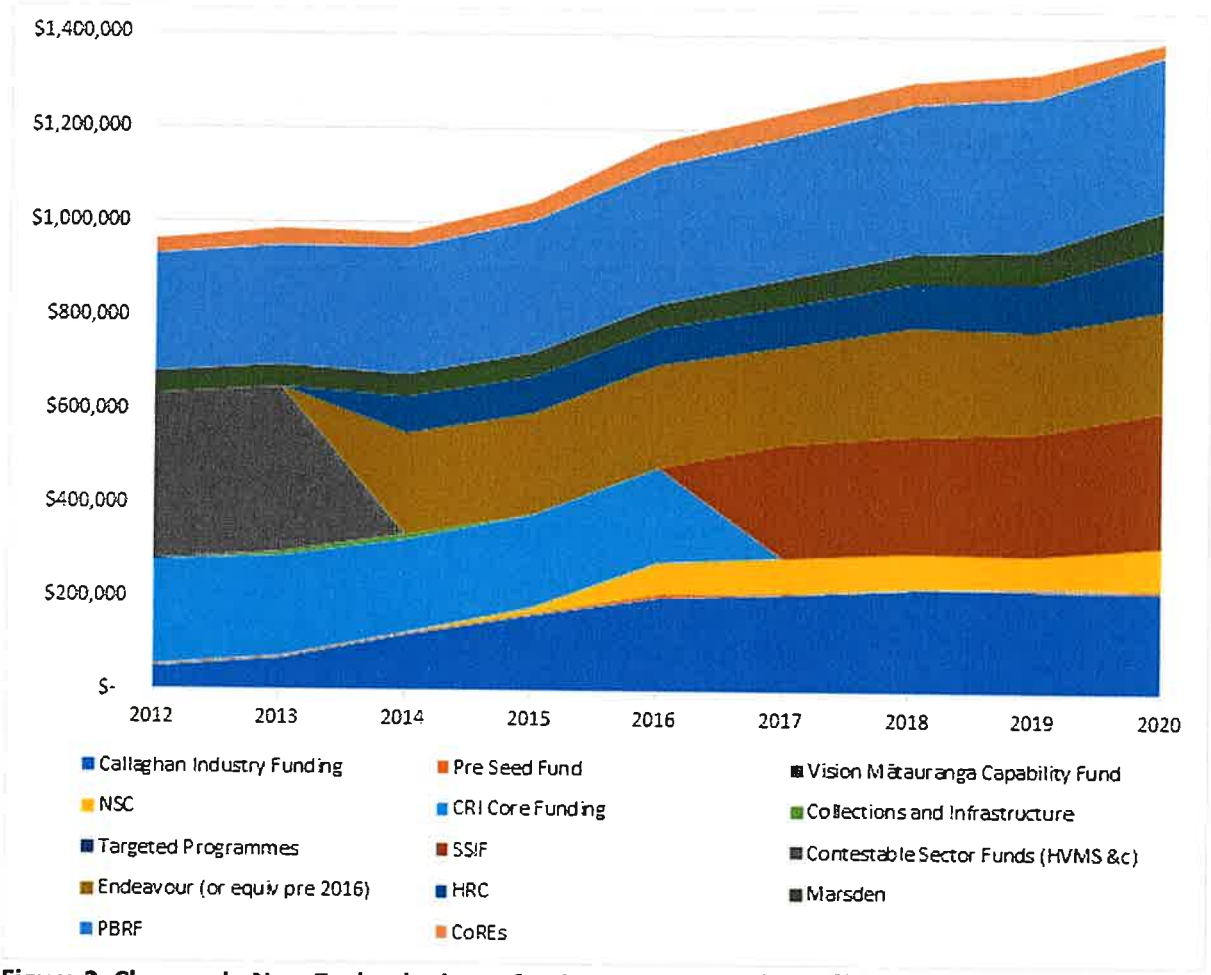

Figure 2: Changes in New Zealand science funding 2012-2020 ($,000)[21]

100. The funding is distributed via a range of separate funds. Each fund has its own unique application process, CV format (despite efforts to standardise), timetable, assessment criteria, and reporting requirements.

101. Major contracting clients in government and the private sector are under constant pressure to reduce costs. R&D expenditure is often a relatively invisible way to do so. This was particularly evident during the Global Financial Crisis (GFC) but is in practice an ongoing stratagem. Public sector R&D investment is below the generic inflation rate, let alone reflective of the higher science inflation rate (e.g. of salaries and equipment). Additional overhead pressures come from complexities around managing Requests for Proposals (RfPs), insurance, and compliance and reporting on contracts.

[21] New Zealand Treasury Estimates

Central government science investment processes

102. Prior to 2012, the contestable fund regime operated on regular sector-based funding (e.g. Biological Industries, High Value Manufacturing). Bidders competed against others in the same general area (e.g. biological research), within a set quantum of funding based upon what was coming off-contract in the area at the start of the year.

103. Not all areas were open for bidding in any one year, and in some sectors it could be several years before a sector was once again open to bids. This process guaranteed that a sector would have a dedicated funding pool, albeit at irregular intervals. It also meant a large swing in available funds at any one investment round. A loss in an investment round would not be recoverable until a future dedicated round. The home institution would have to find revenue to support the unfunded team or let them (or some other part of the organisation) go. CRIs had to balance the tension arising from having little discretionary revenue with the obligation to maintain long-term science capability of importance to New Zealand.

104. In 2012, the contestable fund was renamed (Endeavour Fund) and given a new process. It is open to proposals in any sector; bids accepted each year, with an available quantum approximately constant; and bids progress through two sequential hurdles – science excellence and then projected impact. The only strategic element is a requirement to ensure a balance across its funding, of economic (75%), environmental (20%) and social (5%) research.

105. The CRIs propose that the future system continue with the concepts of excellence and impact, but provide greater measures to ensure that these are not limited to academic definitions. Excellence and impact should be measured in ways applicable to the desired outcome.

106. The future system should also address the strategic requirements of the purpose of government investment into RS&I, of which Vote RS&I is only one (albeit important) element. The major contestable fund should be aligned with the strategic priorities of the whole of government.

CRI funding and revenue streams

107. When forming the CRIs in 1992, government recognised that the new research entities had to have some level of discretionary research funding in addition to funds won from the public and private sectors. The Non-Specific Output Funding (NSOF) was intended to enable the CRI to follow ideas which showed promise but had not otherwise been funded, and to allow some research decisions to be made by the CRI (closer to the end users and to the science advances) rather than central government. The sum was small and varied considerably from CRI to CRI due to the allocation process.

108. The 2010 CRI Taskforce endorsed the rationale for discretionary funding and provided additional reasons for its substantial increase. Core Funding (from 2012) substantially increased the discretionary sum, ranging from 7% to 38% of a CRIs total revenue.

109. MBIE commissioned a review of Core Funding in 2016 which confirmed that Core Funding was achieving its objectives. Nonetheless, the decision was made to move from part-funding the core purpose, with the CRI Boards determining its internal allocation, to central government purchase of specific capability and infrastructure platforms. Begun in 2017, the Strategic Science Investment Fund (SSIF) scope has subsequently been enlarged to include non-Crown entities.

110. At its introduction in 2012 Core Funding accounted for nearly 35% of CRI revenue across the board. As the sum has been largely unchanged, the percentage had fallen

to 26% by 2021 (Figure 3). At individual CRI level, the percentage ranges from 13% to 32%. The remaining 74% of CRI revenue is largely made up of government and commercial contracts, typically with a maximum period of one year, and contestable research grants with a maximum period of 5 years.

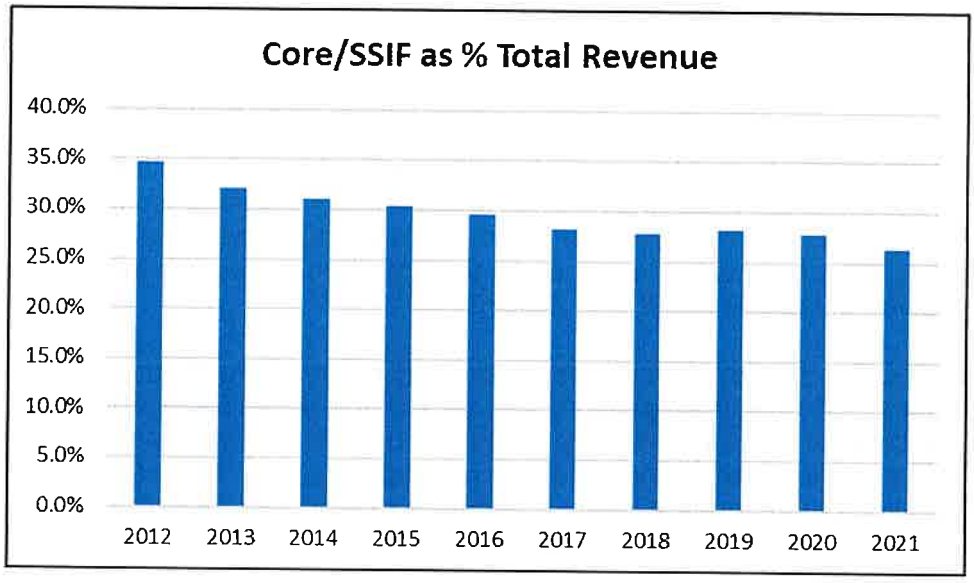

Figure 3. CRI Core (2012-2016) and SSIF (2017-2021) funding as a percentage of total revenue[22]

Impacts of funding policies and investment funds

111. The steady reduction in the real value of long-term strategic investment in research programmes and scientific infrastructure makes it difficult to maintain essential capability such as databases and collections and the ability to deliver on long term mission-led research.

112. The preponderance of short-term contracts and grants makes long term planning and delivery of research difficult, not least around staffing and professional development. This is amplified by the low success rates in current contestable funding schemes (MBIE Endeavour Funding, 12.7% and Marsden fund, 10.4% in 2021).

113. Te Pae Kahurangi noted that CRIs require *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.*

114. The contestable system also imposes significant transaction costs on organisations, and personal costs upon researchers. MBIE Departmental Science Advisers have estimated each bid costs about $500,000. While two-stage bidding processes have constrained some of the bidding costs, success rates need to be increased by either limiting the pool of eligible bidders or limiting the subject areas of proposals.

115. The lack of continuity of funding for outcome areas and low success rates make it difficult to develop relationships with partners such as Iwi, companies and sector groups because the chances of building a science programme that will provide impact for them over the long term is low.

[22] Data from CRI Annual Reports.

116. While some parts of the government funding system have had clear aims and assessment criteria over the long term (e.g. the Marsden Fund with a strong focus on academic excellence), other parts have undergone considerable change in both application assessment criteria and impact area (e.g. MSI/MBIE contestable funding).

117. In many areas specific funding schemes with defined outcome expectations but overlapping impact areas have been established, each with their own governance structure but very often drawing on the same research workforce. It is unclear that such externally mandated entities add more value than if the major employers were able to self-organise and manage the different purpose, cultures and administrative arrangements. This would deepen the relationships particularly between CRIs, universities and industry bodies. The quadruple helix process for priority-setting would support this approach.

118. Māori can be overwhelmed by the demand for engagement and partnering from the large number of entities in the system: CRIs, National Science Challenges, universities, Centres of Research Excellence (CoREs), new Strategic Science Investment Fund (SSIF) platforms and regional research institutes. Each bring experience and models for closer engagement with Māori entities, and each increases the pressure on the limited human and other resources of Māori for engagement in specific areas.

119. Reinforcing the sectoral focus of government research organisations, and allowing them to build the collaborations necessary to achieve outcomes would make it easier to identify which entity is responsible for which outcome and remove multiple overlapping ownership, governance and funding structures largely relying on the same set of research personnel.

Full cost funding

120. The science reforms of the 1990s introduced the concept of full cost funding into the New Zealand science system. To that point funding had been direct departmental funding (DSIR) or marginal funding (universities). Full cost funding was (and is) conceptually appealing because it attributes the full cost of the project to the funder of that particular project.

121. Full cost funding can make research investment more attractive through transparency: the funder is only paying for that project, so does not contribute to projects for other parties or free-ride on costs carried by other parties.

122. It also clarifies the cost of research, and where benefits fall and thus where it is useful for government to intervene (e.g. in de-risking some areas of potential economic growth where an existing industry may be unwilling or unable to contribute).

123. Full cost funding does however have some challenges - for example, in maintaining long term infrastructure and capability in an environment where there are low success rates for project grants, and insufficient dedicated or discretionary funding available for their maintenance. Loss of project funding can undermine the financial viability of existing infrastructure and capability; while gaining project funding does not immediately ensure the new infrastructure and capability is available.

124. Various patches and work arounds have been put in place to manage these issues at the cost of complexity and expense in the system. The current review process is an opportunity to look closely at the balance between full cost, marginal and institutional funding. It is a complex task, which will be linked with, inter alia, institutional arrangements, governance responsibilities, capture by industry or other sectors,

competition policy, the ability of new entrants to bid for funding, flexibility to move to new research areas, and international trade policy relating to subsidies.

Towards a better funding system

125. Science New Zealand proposes a layered approach which will enable top down selection of critical areas to fund and equally important bottom-up investment to generate new ideas and applications. National Priorities will only be one part of the national investment.

126. The layers:
    - Base funding to cover core national science capability and infrastructure (e.g. long-term data collection, biosecurity, communicable diseases etc)
    - Appropriate funding to meet National Priorities
    - Contestable for blue sky ideas.

127. The system needs a higher percentage of funds providing long term stability.
    - This will support capability development and enable research organisations to build stronger relationships with sectors, including Māori. Partners will have confidence in the ability of the research organisation to commit and deliver.
    - This approach is consistent with the vertical integration proposal, enabling integration of development of science knowledge, exchange of science knowledge, and application / commercialisation (see *Pathways to the Future*)
    - It enables New Zealand to develop and retain core capability of enduring value – not least the current, emerging and future human talent which is the basis of the science research and application endeavour.

128. The institutional purpose and accountability mechanisms will ensure the necessary dynamism that matches capability to the research and application which the nation needs. It avoids entrenching existing capability.

129. Competitive funding to support a contest of ideas will continue to be important. It enables new entrants and provides a testing ground for new ideas which may then flow into operational activity and other end user outcomes. The direct and indirect costs of bidding, however, do need to be lowered. There are various ways this can be done.

130. The RDI Council mechanism will better enable all parties to understand who the beneficiaries are, and who is willing to pay. As a participant in the quadruple helix National Priority setting process, the government will have a clearer view of the needs, who pays and therefore a reason for the government to fund a priority.

Funding - recommendations

- Base funding needs to cover all the research and capability the citizens of New Zealand expect public research organisations (PRO) to undertake or provide;
- To deliver on the National Priority Missions, key research providers need to be resourced commensurate with the expectations over the duration of the Mission;
- Each of the key organisations needed to support National Priority Mission strategies should be empowered and enabled to act rather than be reliant upon contestable funding mechanisms.

RESEARCH INSTITUTIONS

A history of change to meet changing needs

131. Government science capability can be traced back to at least 1849, when sheep inspectors were appointed to prevent the entry of scrapie into New Zealand – early bio-incursion protection agents. Government-owned science research and application capability has been critical to the science needs of the emerging nation, not least in building an economic base, developing regional prosperity, helping manage crises and emergencies and underpinning government policy development and implementation. The science infrastructure, priorities and talent have responded to changes in public sector management, as well as private sector and other sector demands.

132. From the initial investment in 1849 through to the 1920s, a variety of government agencies were set up with research functions. In 1926, in response to calls from economic sectors including dairy companies, flax industry and coal companies, the Department of Industrial Research (DSIR) was established and expanded to include physics and engineering research during the Second World War.

133. Following several years of system review which focused on separation of policy, purchase and provider functions, a policy ministry, a purchase agency and then – in 1992 – 10 provider entities (the CRIs) were established. The very small Social Science CRI was disestablished after two years with its staff joining other CRIs and universities. Crop & Food Research and HortResearch merged in 2008 to form Plant & Food Research; and Industrial Research Limited was merged into a new Crown entity (Callaghan Innovation) in 2013. The closures, mergers and reorganisations (including some not taken up) were proposed by Boards and management of CRIs.

134. The policy ministry (Ministry of Research Science & Technology) and purchase agency (Foundation for Research Science & Technology) were merged in 2011 to form the Ministry of Science & Innovation. This was then rolled into a larger ministry (Ministry for Business Innovation & Employment) in 2012.

135. Focussing CRIs on sectors rather than capabilities was a critical strategic decision agreed by both the major political parties (a change of government took place whilst the formation process was underway). In his foreword to the *Ministerial Science Task Group Report* that outlined how the CRIs should be established, Hon. Simon Upton, the then Minister of Science, said:[23]

> *Establishing Crown Research Institutes around a productive sector or oriented to people or resources, ensures that they will be focused on needs and end uses of science and technology… By establishing research institutes with full commercial powers, the ability to transfer technologies to users will be greatly enhanced to New Zealand's benefit.*

136. The focus on *needs*, end *uses* and end *users*, was intended to avoid a perceived failing of the DSIR: a focus on the scientific discipline. Rather, the focus of the CRIs was to be on research creating value for New Zealand through close engagement with sectors.

137. In response to the 2010 CRI Taskforce Report, the focus of each CRI was codified in their Statements of Core Purpose (SCP). The SCPs set out the unique purpose of each CRI and the areas in which a CRI leads and those in which it contributes. They require CRIs to work in partnership with government, industry or sectors, Māori and communities.

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[23] Quoted in Davenport and Bibby, Innovation; management, policy and practice (2007) **9**: 181-191

138. The majority of government science capability up until the formation of the CRIs was developed in response to calls for research to address problems faced by existing sectors. IRL had one of the more challenging missions, given the scale and composition of New Zealand's disparate manufacturing which is a 'sector' only in the broadest use of the term.

Government research system: purpose and principles

139. Te Ara Paerangi is an opportunity to look at whether the current set of government research agencies are those that are needed for the future, to meet New Zealand's challenges and opportunities.

140. To deliver on the challenges facing New Zealand, government research needs to cover all three areas of well-being (economic, social, and environmental). The government system needs to cover, and maintain integration across:

- Public good research — research with social value but no market value which will not be conducted by other agencies
- Strategic Research — to ensure maintenance of a range of research skills for New Zealand that can be accessed by government in the long term.
- Pre-Commercial and commercial applied research — potential for eventual economic benefits where there is market failure and to achieve value from the other categories of research as it arises.

141. Te Pae Kahurangi confirmed the continuing importance of the food and fibre sector to New Zealand's economy; and the increasing centrality of environmental research. The science and the technologies that support or emerge from these sectors are, however, applicable to multiple other sectors. These include digital and deep technologies which are enabling technologies in which CRIs have significant capabilities, and can be used more broadly. The CRIs, with other parts of the government sector, can broaden support for the digital transformation of the economy.

142. CRIs partner effectively with sectors and business because their strategic outcome focus within areas means they can build research capability and relationships with users over the long term. This long-term outcome focus needs to be maintained as the science system evolves if government research institutions are to maximise their contribution to economic growth.

143. Blue skies research and mission orientated research need to be connected, although recognising the different cultures and mechanisms that support their endeavours. Ideas that spring from but are not directly part of the mission can be explored and applicable ideas coming from blue skies research can be incorporated in delivering mission outcomes. To deliver outcomes the system must value and develop technicians, support staff and capabilities such as engineering and IT, as well as scientists.

144. The institutional form of research organisations must enable efficient and effective delivery on outcomes, in line with the purpose of the institution. The CRI structure has proved adaptive and flexible and has delivered against government priorities notwithstanding an almost constant set of system changes. Essential elements include strong links with the sectors they serve, a focus on impact as the core measure of success, improving and enhancing the long-term strategic capabilities needed by the country, and collaborating effectively with other organisations, nationally and globally.

Co-location

145. CRIs are at 50 locations around New Zealand. More than 20 sites are shared with other CRIs, universities and/or industry partners. Many co-locations have occurred because of sites inherited from predecessor organisations, rather than related to science research complementarity. Publication data shows that there is considerable collaboration between researchers in different institutions when there is a professional common interest. Distance is not a barrier in these cases.

146. Co-location may be a factor in collaboration and access to shared infrastructure but is not essential to either, as shown by multi-campus universities, CRIs and other research organisations in New Zealand.

147. CRIs have made major re-location decisions in recent years, showing a willingness to consider long-term positioning – which may include proximity to industry or significant sector clusters as much as with academics. Sites are shared with universities at Lincoln, Massey Palmerston North, Canterbury, Otago, Waikato and with Wellington (VUW) at the Gracefield Innovation Quarter (owned by Callaghan Innovation and home to public and private sector entities). A site was shared with Auckland until the university re-located. Plant & Food Research and Cawthron Institute, an independent research organisation, are working towards a shared campus, with involvement of the local iwi, at Motueka. Scion's Te Papa Tipu Innovation Park in Rotorua includes government departments, research partners, more than 30 companies and strong community involvement.

148. When actively deciding to site share, all parties need confidence that there is a long-term commitment to the purpose of the arrangements. This can be challenging when the institutional drivers are very different. For example, CRIs are not driven by the need to attract minimum student numbers to a discipline to retain that discipline or staff capability.

Institutions – recommendations

- When reviewing potential change to research institutions the review needs to consider two closely related but separate matters:
  i) structural change to the RS&I system and
  ii) organisational form of the research organisations;

- In both cases, a robust and transparent process is needed. This should articulate the problem, set out options and evaluate them carefully. People with in-depth knowledge of the system, including end users, need to be involved from the outset;

- As mission-focused PRO, CRIs should continue to have the objective ("benefit to New Zealand") and principles as set out in the CRI Act 1992;

- CRIs should be structured around their core purpose: to deliver science research which is useful, usable and used to benefit New Zealand. As mission focused PRO the focus needs to be aligned with developing a more productive, sustainable and inclusive New Zealand. This requires close engagement with existing and emergent sectors, as well as maintaining close linkages with blue-sky research. The capability they steward will evolve, as will the challenges and opportunities for New Zealand;

- There should be a review of the alignment of PRO with end users to ensure that the major end user groups have a simple and clear alignment to an appropriate PRO.

This may involve creation of a new PRO if there is a gap. The RDI Council could be used to identify gaps;

- The institutional form of each PRO should prioritise engaging with their relevant sector's end users. The engagement should be consistent with science independence and integrity, long-term sustainability of human capability, assets and infrastructure, and accountability. This approach will reinforce the proposed vertical integration which enables maximum flow between knowledge creators and end users to deliver the agreed outcomes;

- Co-location policy development should be subject to transparent, robust processes; and include all parts of the quadruple helix.

WORK FORCE

149. To deliver benefit to New Zealanders, the research system needs an inclusive and diverse workforce with the skills and resources to achieve outcomes. This includes researchers, technicians, innovators and commercialisation / translation expertise.

150. New Zealand's need for a skilled research and development (R&D) workforce sets a considerable challenge to tertiary education and immigration policy.
    a. In 2012, when government policy was to target 40% of GDP from exports, this implied the private sector R&D workforce to grow from 8,200 full-time equivalents (FTE) to 23,000 by 2025 - an increase in new skilled entrants from 500 per annum to more than 2,500 per annum. This would require a $1.8bn per annum increase in business R&D expenditure.
    b. A commitment to having R&D investment at 2% of GDP by 2027 signals a 29,000 increase in R&D FTE of which 11,000 will be fully-trained researchers. Assuming New Zealand moves towards the international average of R&D investment split between public and private sector, the private sector FTE will need an increase of 15-20,000 people.

151. New Zealand universities produce about 440 PhD graduates annually in science, IT, engineering, agriculture and environmental studies. Many students are international. Immigration alone is unlikely to be the saviour, especially in a global war for STEM talent. The current pandemic has exposed the vulnerability of reliance on immigration for both educational and research capability, including in areas of national importance. The CRIs are facing specific workforce recruitment issues.

152. The ability of government research organisations to set their strategies and manage their staff to achieve them is important for the future of the system. In New Zealand's open employment market, staff can freely move from one employer to another. Joint Graduate Schools, secondments and shared employment contracts are also increasingly options to provide a more varied and interesting career, and to improve the system's ability to deliver impact.

153. The CRIs make a significant contribution to developing New Zealand's science workforce. Currently the CRIs partner in 14 joint graduate schools or joint research centres with New Zealand's eight universities. These entities combine research expertise, teaching, and research support with project experience in fundamental and applied research. They support a pipeline of potential recruits into CRIs and industry, giving students the experiences and skills to be useful outside of academia. There is potential to have a more formalised approach within a strategic lens of what New Zealand needs. That they exist, organised by agreement between the institutions, is evidence that despite the different purpose, cultures (including staffs' promotion incentives) and financial settings of universities and CRIs, the institutions can collaborate effectively on this important strand.

154. CRIs supervise and employ a significant number of students and post-doctoral researchers in line with this commitment. Over the last 10 years the number of PhD and other research students supervised by CRI staff has averaged 542 per annum, with approximately 75% of these being PhD students. The number of post-doctoral researchers employed across the CRIs has grown by more than 70%, from 54 in 2013 to 93 in 2020. This does not include early career researchers (i.e. within 10 years of a PhD being awarded), who are not identified as 'post-doctoral' in their employment contract. CRIs also support post-doctoral researchers to progress into research careers via university collaborations.

155. The number of Māori researchers and other staff capable of working in the Māori context or in te ao Māori research remains small across most of the science system, from both an employment and a pipeline perspective. CRIs are working hard to build the Māori science workforce, with numbers already ahead of most other institutions. CRIs are investing in developing Māori interest in gaining science qualifications; developing Māori research opportunities, including Māori-led and initiated research; and developing non-Māori staff to be capable and comfortable in working with Māori and mātauranga Māori.

156. Recruiting overseas talent remains a significant part of CRI talent strategy and attractiveness. The reputation of the New Zealand science system and the opportunity to live in New Zealand comprise a strong proposition for overseas researchers. In some years, as many as 48% of PhD recruits come from offshore (of which typically 10 points will be people with New Zealand degrees). The international exchange of human capability enables New Zealand to benefit from and contribute to a global pool of expertise.

Workforce - recommendations

- There needs to be significantly enhanced investment in increasing Māori interest in gaining science qualifications; developing Māori research opportunities, including Māori-led and initiated research; and developing non-Māori staff to be capable and comfortable in working with Māori and mātauranga Māori.
- The RDI Council should have a role in considering the capability needs of New Zealand at a systems level. This involves looking at future capability needs some decades ahead and how that capability is to be acquired. That is a separate role to the more immediate task of bringing more graduates into the science system.
- Attention needs to be given to the role of Government in prioritising skills and training (at ITP and universities) applicable to New Zealand's aspirations, and to a balanced immigration policy that attracts and retains skilled migrants that can help New Zealand achieve its aspirations.
- Attention needs to be paid to ensuring a STEM-based career is attractive – both in terms of potential career paths and for appropriate reward and support commensurate with other professions.
- PRO need to continue their significant contribution to developing New Zealand's science workforce. CRIs mentor or co-supervise more than 400 graduate students each year in disciplines New Zealand needs, and provides opportunities for the students to work on issues and challenges critical to New Zealand.

RESEARCH INFRASTRUCTURE

157. Access to large or unique infrastructure is sometimes cited as an issue. This is symptomatic of the low level of national investment, the significant R&D investment to support the major export earning sectors (food and fibre) which are spread across a large, long land mass with different climates; and that the universities have largely arisen as regional tertiary colleges rather than being specialised and thus creating attractive anchor sites for other research organisations.

158. Many CRI sites were developed in the pre-CRI era to be near research farms/orchards or sectoral end users, and reflected the need to have a diverse range of geographical locations and close engagement with end users to be relevant. Regional presence remains important, and encourages other developments using new technologies (e.g. digital hubs).

159. The company model has largely allowed the CRIs to maintain and develop the medium scale infrastructure needed to maintain their capability, such as buildings, laboratories and medium scale equipment and, in some instances larger scale infrastructure such as research vessels and supercomputers.

160. Other items, such as access to the Australian Synchrotron, have required one-off bespoke processes from government. This can encourage the managing organisations to prolong the infrastructure rather than provide the modern capability needed by researchers. This is particularly a problem in areas of rapid technological change.

161. There is considerable shared use of infrastructure across the New Zealand science system already, either because of scientific collaborations or service agreements.

162. However, the use of scientific infrastructure, particularly cutting-edge infrastructure is complex, often requiring considerable customisation to meet the needs of a specific project - which then makes it difficult to access for more general use.

163. Medium cost items, such as mass spectrometers and high performance liquid chromatographs (HPLCs) for example, can often have complex configurations of sample input devices and analytical detectors for the type of compound being worked on which make them difficult to share between labs while still having identical entries on institutions' equipment registers.

164. Purchasing major pieces of scientific infrastructure and seeing them used efficiently is a particularly acute problem for smaller science systems with limited resources. Australia prepares a roadmap of the science infrastructure that it is likely to need every five years and matches that with an investment plan released every two years.[24] National infrastructure projects, both equipment and experts, are supported by the National Collaborative Infrastructure Strategy.[25] Even so, very large infrastructure projects such as the Australian Synchrotron (of which New Zealand is a member and which is now managed by the Australian Government research organisation ANSTO) have required bespoke, one off and complex processes to get funded.

165. Co-location may be a factor in collaboration and access to shared infrastructure but is not essential to either, as shown by multi-campus universities, CRIs and other research organisations in New Zealand.

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[24] Australian infrastructure road map https://2021nriroadmap.dese.gov.au/
[25] National Collaborative Research Infrastructure Strategy https://www.dese.gov.au/ncris

166. CRIs see some benefit in reviewing the access protocols for all significant assets and infrastructure across the system, and the underlying funding support (if the future system still runs with significant short-run funding). Some major assets held by CRIs already run merit-based access protocols, utilising a range of merit criteria. Some would-be users however point to funding as a barrier to their use of the assets, and instead use overseas based assets. This has the effect of further reducing the financial viability of New Zealand-owned assets.

Research Infrastructure - recommendations

- Infrastructure policy development should be subject to transparent, robust processes; and include all parts of the quadruple helix;
- The RDI Council should have a role in developing a national infrastructure strategy, bearing in mind the relationship of usage, capex and opex.

Conclusion

Science New Zealand looks forward to engaging further with the government and others in this vitally important process. CRIs' commitment is to a more productive, sustainable and inclusive future for New Zealand, supported and enabled by science research and its application. The challenges in front of New Zealand also present tremendous opportunities for the nation. As the CRIs and their predecessors have shown, change is integral to the science and innovation endeavour – what is done, how it is done, and how it is applied. The "why" endures: to deliver benefit to New Zealand.

Attachments

From Science New Zealand, published 1 September 2021:

- **The Value of Crown Research Institutes in Aotearoa New Zealand's Science System Today**
  https://sciencenewzealand.org/publications/the-value-of-crown-research-institutes-in-aotearoa-new-zealands-science-system-today/
- **Pathways to the Future: A strategy to lift the positive impact of science on Aotearoa New Zealand's economy, environment, society and culture**
  https://sciencenewzealand.org/publications/pathways-to-the-future/