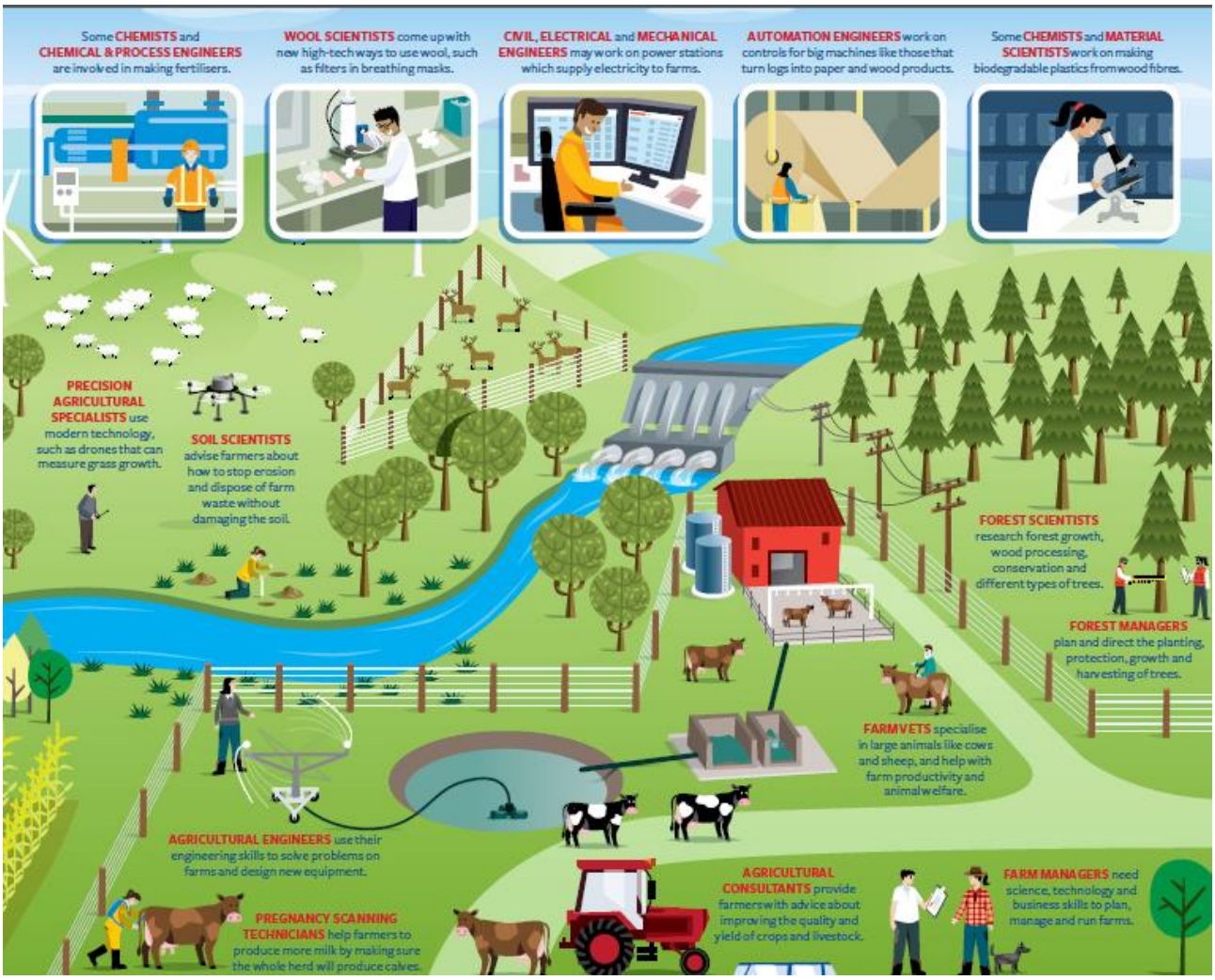
Improving Communication of Primary Industries Research, Science, Technology and Innovation



Kylie Phillips

Kellogg Rural Leaders Programme 2016

Foreword

I am passionate about seeing New Zealand's Primary Industries better utilize all the scientific research that is underway, to create more value from our natural resources. I believe that building awareness of research, science, technology and innovation in our younger generation will improve knowledge transfer in the future and will help farming continue to future generations of New Zealanders.

I grew up on a 400ha sheep and beef farm in the Waikato, and was a boarder at Epsom Girls Grammar School. I studied Food Science at the University of Otago (BSc with Honours) and stayed on to complete my PhD. I worked as a Research Scientist at Fonterra and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) before joining Campbell Arnott's in Sydney as a Senior Researcher in Sensory and Consumer Science. I returned to New Zealand to take up a role as Sector Manager - Biological Industries in the Science Investment branch of the Ministry of Business, Innovation and Employment. This role opened my eyes to the Primary Industries research, science and technology being invested in by the New Zealand Government and reignited my passion for our land and the opportunities it enables. During the Kellogg Rural Leaders Programme I took up a new role at Zespri as Innovation Leader - Fruit Physiology, Taste & Quality.

"Creativity is inventing, experimenting, growing, taking risks, breaking rules, making mistakes and having fun" — Mary Lou Cook

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Acknowledgments

A huge thank you to the Ministry of Business Innovation and Employment (my previous employer) and Zespri (my current employer) for supporting my participation in this programme.
Thank you to all the people I interviewed and discussed my topic with and my fellow Kellogg participants and staff for making the journey so enjoyable, challenging and rewarding. Thank you to my family and friends for your support and encouragement to step up as a leader and embrace new challenges.

Executive Summary

By the year 2020, over $1.6 billion of New Zealand taxpayer money will be invested in science and innovation per annum. What share will Primary Industries have of this investment?

"With the coming of the fourth industrial revolution - fundamental change to our daily personal and professional lives from the combination of physical, digital and biological technologies - the primary sector will find itself at the centre of change."

Ian Proudfoot, Global Head of Agribusiness, KPMG 2016

The aim of this project was to understand what the benefits might be of improving communication of government-funded Research, Science, Technology and Innovation related to the New Zealand Primary Industries and how this could be achieved. Ten stakeholders from a wide range of areas in the science and innovation ecosystem were interviewed and findings were related to literature and initiatives already underway in New Zealand. Benefits of improving communication include:

- Attracting science and innovation talent to the primary industries and building future capability
- Positive engagement with the public ensuring social licence to operate
- Building New Zealand's international reputation as an innovative country - to attract skilled migrants, build partnerships with global experts, and be seen as a trusted producer of safe, premium food and fibre products
- Improved cross-sector collaboration and learning
- Faster and more advanced innovation in industry from research, science and technology uptake

To achieve sustainable growth in New Zealand Primary Industries, attracting and retaining a diversity of talented people is critical. Recommendations from this report for key stakeholder groups include:
Government:

- Improve the *New Zealand Story* Business Toolkit information on science and innovation
- Government funding agencies could publicise their science and innovation investments more
- Include a section on the quality of the communication plan in assessment criteria for government science funding

Research Organisations:

- National Science Challenges could increase their focus on engaging school children in science and innovation (and the government could incentivise or reward them for doing this)
- Universities and Crown Research Institutes could include positive public engagement in their promotion criteria for staff (likely if the government funding criteria changes)

Primary Industries:

- Industry associations or businesses could develop more graduate programmes with a science and innovation focus to create career pathways for attracting talented young people
- Businesses could sponsor employees and their research providers to visit schools to talk about science and innovation being invested in and the future career opportunities in their sector
- Industry could investigate how to collaborate on opportunities of the fourth industrial revolution

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Introduction

"With the coming of the fourth industrial revolution - fundamental change to our daily personal and professional lives from the combination of physical, digital and biological technologies - the primary sector will find itself at the centre of change."

Ian Proudfoot, Global Head of Agribusiness, KPMG in New Zealand
2016 Agribusiness Agenda - Thriving in exhilarating times

Over $1 billion of New Zealand taxpayer money is being invested in the science and innovation system. The 'Innovative New Zealand' Budget 2016 package included an additional $410.5 million government investment in science and innovation over the next four years. This is one of the largest single investments in science and innovation in New Zealand's history and means that by 2020, the annual cross-government investment in science and innovation will have increased to approximately $1.6 billion per year. This investment is aimed at delivering on the vision of the National Statement of Science Investment and supporting the Business Growth Agenda, which seeks to grow business investment in research and development (R&D) to over 1 per cent of gross domestic product (GDP) (Ministry of Business, Innovation & Employment, 2016).

The National Statement of Science Investment outlines the vision for 2025:

"A highly dynamic science system that enriches New Zealand, making a more visible, measurable contribution to our productivity and wellbeing through excellent science."

Sir Peter Gluckman, Chief Science Advisor to the Prime Minister, outlined four major reasons why a government must invest in science:

1. Cultural (the basic human drive to know more about the world) and reputational – to be perceived as an innovative country that other innovative countries want to interact with. Contributing to global knowledge is increasingly a tool of diplomacy, national identity and vision.
2. To meet society's needs for knowledge so individuals, companies and NGOs can make better decisions using scientific knowledge e.g. support higher education and human capital development, the adoption or regulation of new technologies, balancing conservation and development drivers. As offshore markets demand information around sustainability and biosecurity, private sector stakeholders (including farmers and local government) need information to demonstrate reliable production that fulfils these needs.
3. For the State's own needs as a major end-user of knowledge in virtually every domain, e.g. natural hazards identification and management, cybersecurity and defence science, biosecurity measures and regulatory safeguards (eg food safety, agricultural chemicals), environmental science for decision-making by central and local government. Science plays a growing role in trade dispute resolution and negotiations and in diplomacy.
4. To promote science-based innovation for social, environmental and economic benefit (Gluckman, 2015).

A National Strategic Plan for Science in Society, "A Nation of Curious Minds – He Whenua Hihiri i te Mahara" was launched in 2014 with the aim of helping all New Zealanders engage with science and technology. The plan is intended to initiate a discussion about how stakeholders can collaborate and leverage existing and new activities to enhance public engagement with science and technology. Outcomes for the project over the next ten years are:

- more science and technology-competent learners, and more choosing science, technology, engineering and mathematics (STEM)-related career pathways
- a more scientifically and technologically engaged public
- a more publicly engaged science sector
- a more skilled workforce and more responsive science and technology.

One aspect of Government science and innovation investment is the Ministry for Primary Industries Primary Growth Partnership (PGP), which invests in long-term innovation programmes in partnership with industry to increase the market success of the primary industries (see figure 1, industry-led and contestable space). Around $727 million of government and industry funding has been committed to 21 PGP programmes to date, over their lifetime (Ministry for Primary Industries, 2016a). Programmes include education and skills development, R&D, product development, commercial development, and technology transfer.

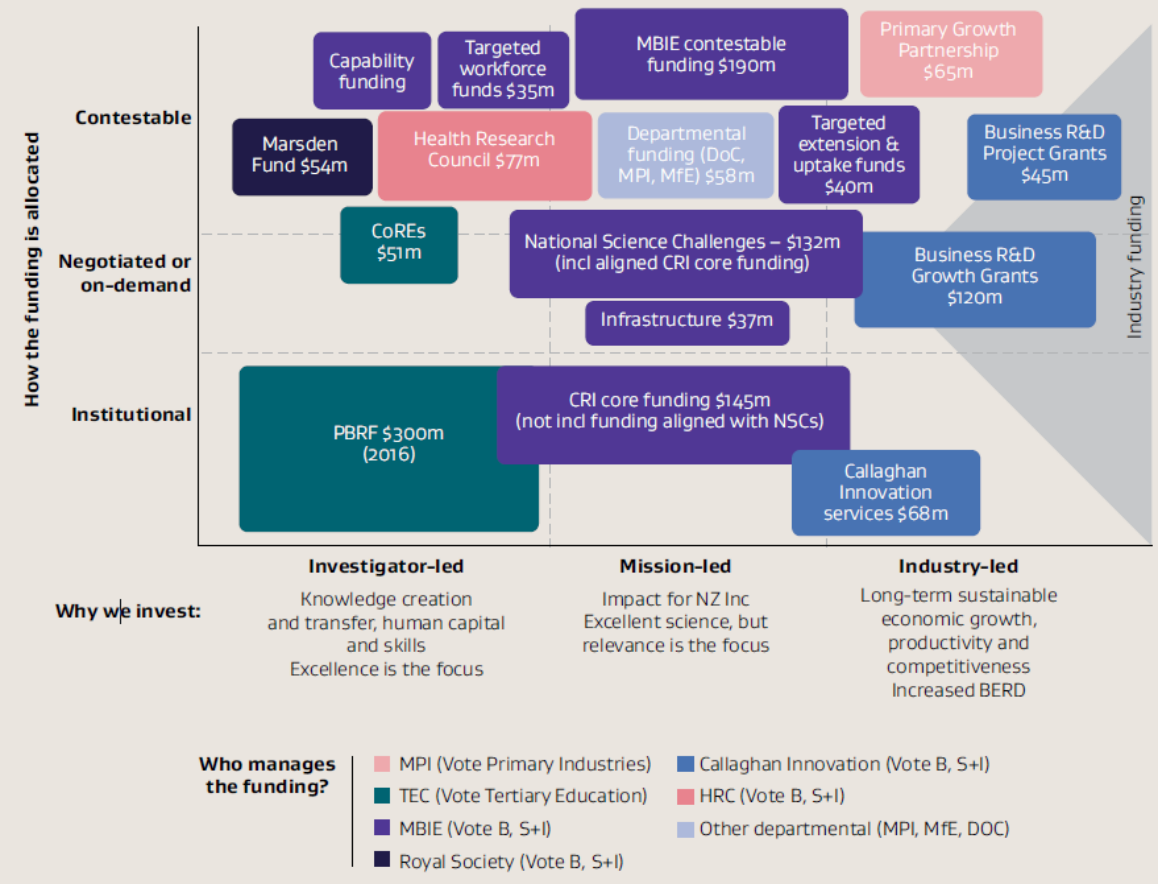

Figure 1. Summary of the Government's main investment mechanisms for Science and Innovation (Ministry of Business, Innovation & Employment, 2015).

"The beginning of the Fourth Industrial Revolution highlights that we are moving into a new era of opportunity to grow the wealth and prosperity of all New Zealanders. Our ability to thrive in these exhilarating times and realise the opportunities created will depend on how we respond to the evolving needs of those who consumer our food, beverage, fibre and timber products." Proudfoot KPMG-Agribusiness-Agenda-2016-Vol1

Proudfoot outlines the huge opportunity that new technology creates for New Zealand in the fourth industrial revolution which goes beyond computers and automation to a more complex cyber physical system (Figure 2). In this fourth revolution, we will build on past developments and new technologies will combine the physical, digital and biological worlds, including wearable devices, 3D printing, Internet of Things embedded sensors, unmanned land and sky vehicles and augmented intelligence. New technology will be developed faster, cheaper, and be more accessible across the world (Schwab, 2016).

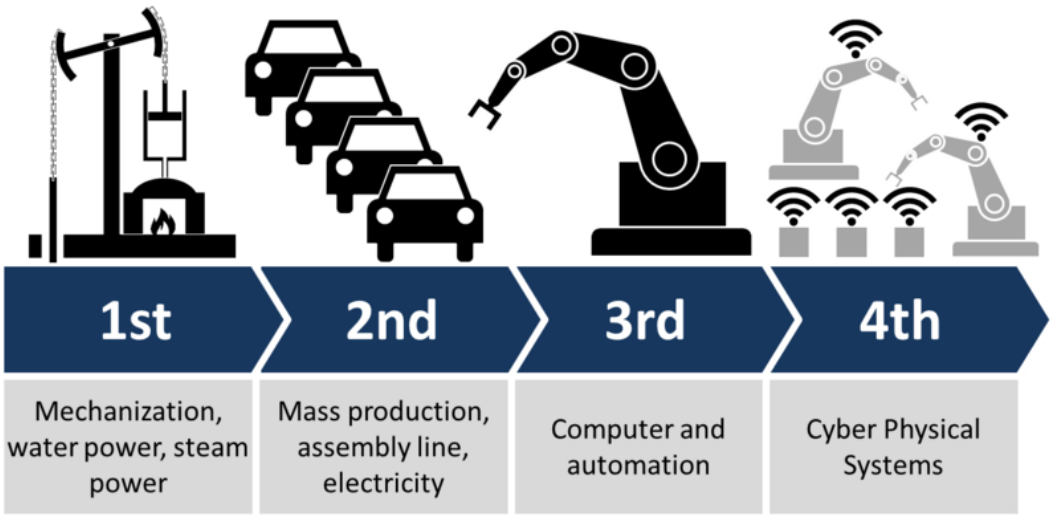

Figure 2. The Four Industrial Revolutions (Christoph Roser, 2016)

A study analysing four iterations of the Business Operations Survey (2005, 2007, 2009 and 2011), reported that factors including firm size, high perceived quality, investment/research and development capability, major technology change, application of formal IP protection and new export markets are systematically and positively related to innovation. External issues, such as those related to geography, market structure, business environment, had little influence. At the firm level, innovations in NZ are highly dependent on the firms' internal ability to develop new technologies and market demand. The (very small) size of firms does matter in NZ, which lacks a major 'home market' or a major trade block on its doorstep, such that ultimately, government may need to be involved to maintain a viable scale for domestic R&D (Hong et al 2016). Data from the 2013 survey showed that applying for government funding was at the bottom of the list of activities to support innovation undertaken by New Zealand Businesses, while acquiring computer hardware and software was the activity most commonly conducted (Figure 3).

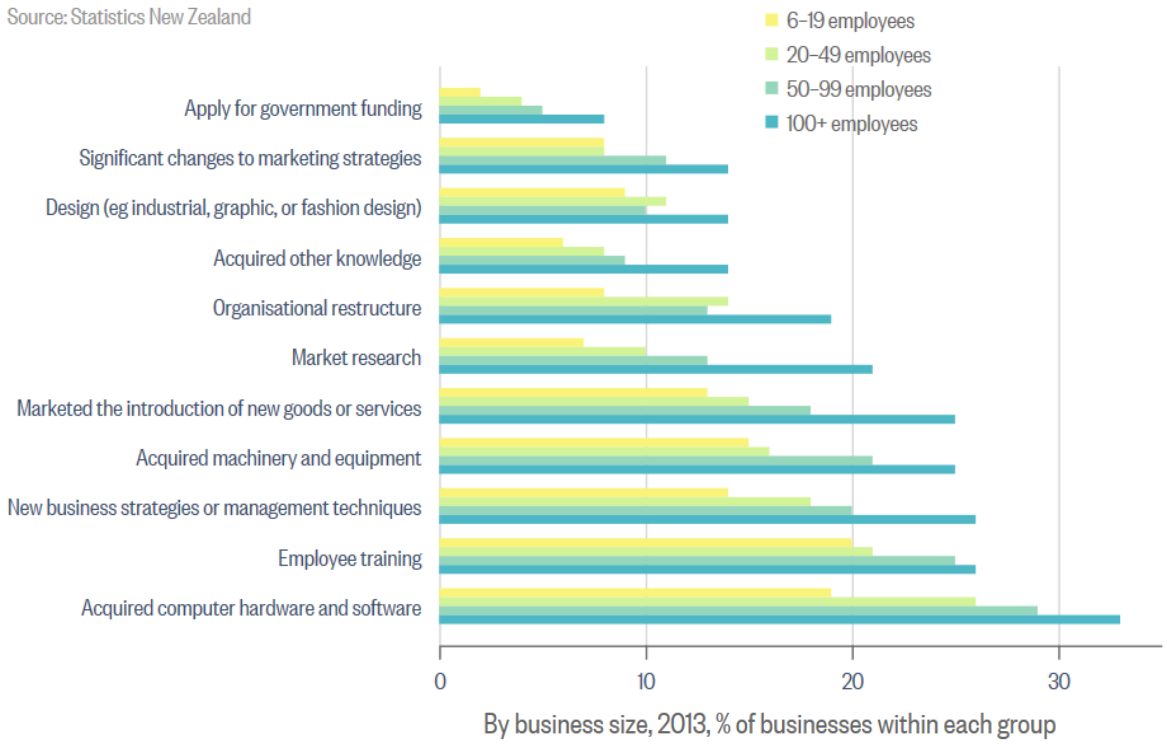

Figure 3. Activities to support innovation undertaken by New Zealand Businesses in 2013 (Statistics NZ)

A study on the impact of government assistance through R&D grants on innovation output for firms in New Zealand found that receipt of an R&D grant almost doubles the probability that a firm introduces new goods and services to the world, while its effects on process innovation and any product innovation are relatively much weaker. These findings are broadly in line with recent international evidence from Japan, Canada and Italy which found positive impacts of public R&D subsidy on patenting activity and the introduction of new products (Jaffe et al 2015).

With over $1 billion of taxpayer money being invested in the New Zealand's science and innovation system, one does wonder, are we really making the most of this investment? Are primary industries maximizing this investment? How much do various stakeholders know about where this money is going? If they knew more, what would the benefits be?

Study Question

The question being researched here is:

What are the benefits of improving communication of government-funded Research, Science, Technology and Innovation related to the New Zealand Primary Industries and how can this be achieved?

It is acknowledged that a significant amount of Research, Science, Technology and Innovation occurs within the private sector funded by businesses, however this is not in scope for this report. The term 'Science and Innovation' is used in this report to represent research, science, technology and innovation according to the definitions outlined in Table 1, and aligned with the terminology used in The National Statement of Science Investment.

Table 1. Key definitions for the purpose of this report

Research, Science, and Technology Act 2010: Purposes for which specified RS&T funding may be allocated (The Parliament of New Zealand, 2010)	Specified RS&T funding may be allocated for research, science, or technology, or related activities, for the benefit of New Zealand. These activities include (but are not limited to) any activity that— a. is likely to increase knowledge or understanding of the physical, biological, or social environment; or b. is likely to contribute to New Zealand's economic growth; or c. is likely to develop, maintain, or increase skills or scientific or technological expertise that is of particular importance to New Zealand; or d. is unlikely to be funded, or adequately funded, from non-governmental sources; or e. facilitates research, science, or technology, or related activities; or f. promotes or facilitates the application of research, science, or technology, or related activities.
Research and Development (Statistics New Zealand*)	Any activity characterised by originality. R&D should have investigation as its primary objective, and an outcome of gaining new knowledge, or new or improved materials, products, services, or processes. R&D includes buying technical knowledge or information, both from within New Zealand and from overseas. R&D excludes market research, efficiency studies, or style changes to existing products.
Innovation (Statistics New Zealand*)	Developing or introducing any new or significantly improved activity. This includes activity to improve products, processes, and methods that the business was the first to develop and those adopted from other organisations. Statistics New Zealand collect innovation data according to the definitions in the OECD Oslo Manual (2005).

*Business Operations Survey: 2015, Statistics New Zealand published 6 April 2016

Methodology

A mind map was created to illustrate the many stakeholders that are connected to and interested in science and innovation in New Zealand's primary industries (Figure 4). Participants of this ecosystem were selected for interviews (see appendix) with the aim of getting a wide range of perspectives.

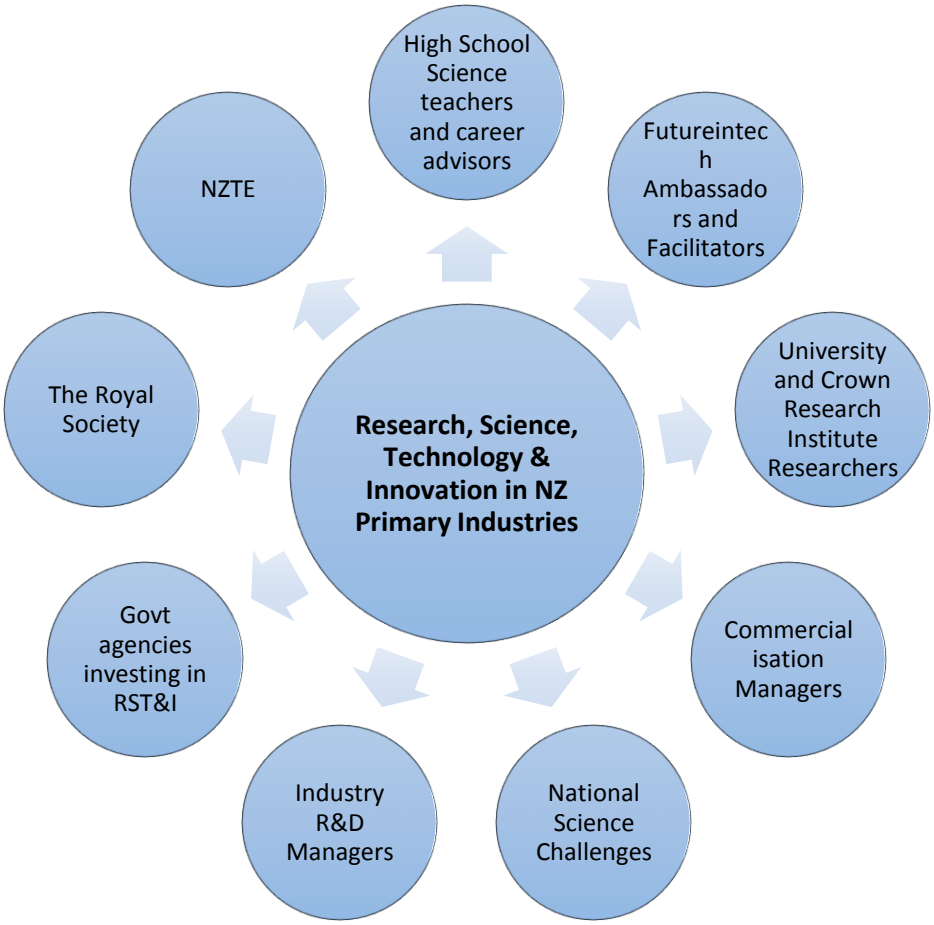

Figure 4. Stakeholders in New Zealand Primary Industries Research, Science, Technology and Innovation

Semi-structured interviews were carried out to allow the flexibility to explore topics of interest raised by interviewees, creating more in-depth interviews (predominantly in person and some on the phone). The aim of the interviews was to obtain an understanding of the factors that stakeholders in the New Zealand Science and Innovation system perceived to be important for improving communication. Thematic analysis was carried out on the data to extract the main points of interest and relate to existing literature and initiatives already underway in New Zealand. Comments made by interviewees were not attributed to names to retain anonymity and freedom of opinion.

Findings and discussion

Communication pathways

The crucial question of communication is from whom and to whom? Following the interviews, the many communication pathways within and beyond the land-based primary industries were mapped (Figure 5). Communication can occur within a primary sector (e.g. the Horticulture industry), between primary industry sectors (e.g. between Meat/Fibre and Dairy) as well as from and to outside the primary industries (e.g. from Zespri to government). All interviewees believed there are opportunities to improve communication in the primary sector, and these many channels represent the complexity and range of opportunities that could be taken up. There are different reasons for communicating the science and innovation that is happening, depending on your audience:

- Research Organisations – to develop capability in the sector, attract core funding, ensure research is fit-for-purpose and has high engagement with end users
- Government – attract more funding, ensure fit-for-purpose innovation and regulatory systems (exporting, environmental compliance)
- Public – social license to operate, build social capital with the public by sharing positive science and innovation stories, attract today's talent and future capability to the sector

Science needs to be relevant – for industry to see the value, for young people to care and this will help scientists to link the science to the benefits. Three versions of a story may be needed – to children, to industry and about the value of government funding the research to society. It is now being recognized that the softer skills will become increasingly important for scientists – they need to know and communicate their part in the bigger story of what is happening. The interdisciplinary systems approach includes science, social science, cultural and economic know-how to have an impact on economic, environmental and social outcomes for New Zealand. But what is the incentive for scientists to communicate? The implementation pathway as assessed in MBIE's annual competitive funding round does not incentivise scientists to communicate beyond academic publications (showing science excellence credentials) and end-users (for example through an industry magazine). So what about the public who are making this $1 billion investment in science and innovation? How could our younger generation benefit from this large investment?

Whose responsibility is it to communicate what is funded? On the one hand, over $1 billion tax payer money is being invested in science and innovation so the public has a right to know where their money is going. On the other hand, the ones who may benefit most from improved communication is the primary sectors themselves, so the responsibility also sits well with them. In reality it is not an either or approach, but both government and primary industries have a responsibility to, and will benefit from, improved communication via the many channels identified in Figure 5.

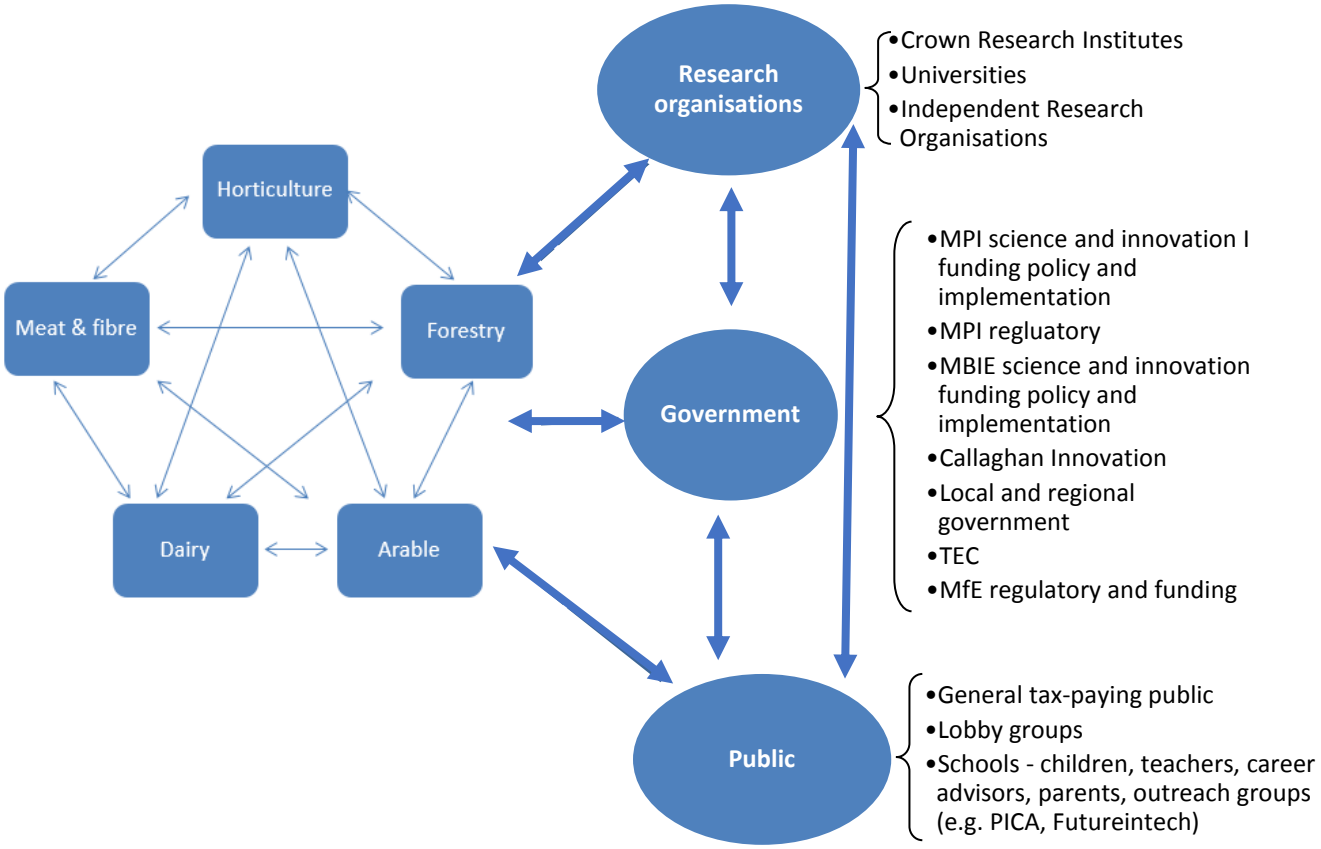

Figure 5. Communication pathways between primary industry sectors and with other key stakeholders

Landcare Research carried out a project (Millard 2016) to determine 'What is excellent science?' and concluded the key aspects of science excellence include: academic excellence, impact and adoption (finding solutions), Outcomes and Outputs, Fit for purpose/ client focus and that it delivers value to Landcare and their clients (Figure 6). Expanding on these themes, findings included:

- The Best People: Individuals, teams, institutions well placed & skilled for research, sought after practitioners with reputations for high quality work, linked internationally and domestically
- A Rigorous Approach: Well-defined, repeatable methodologies, careful implementation. Transparent and stringent peer-review. Best practice approaches. Risks identified and managed
- Optimum Results: Expansion and application of knowledge, wide dissemination, highly reliable and repeatable, strong application. International reputation enhanced Millard (2016)

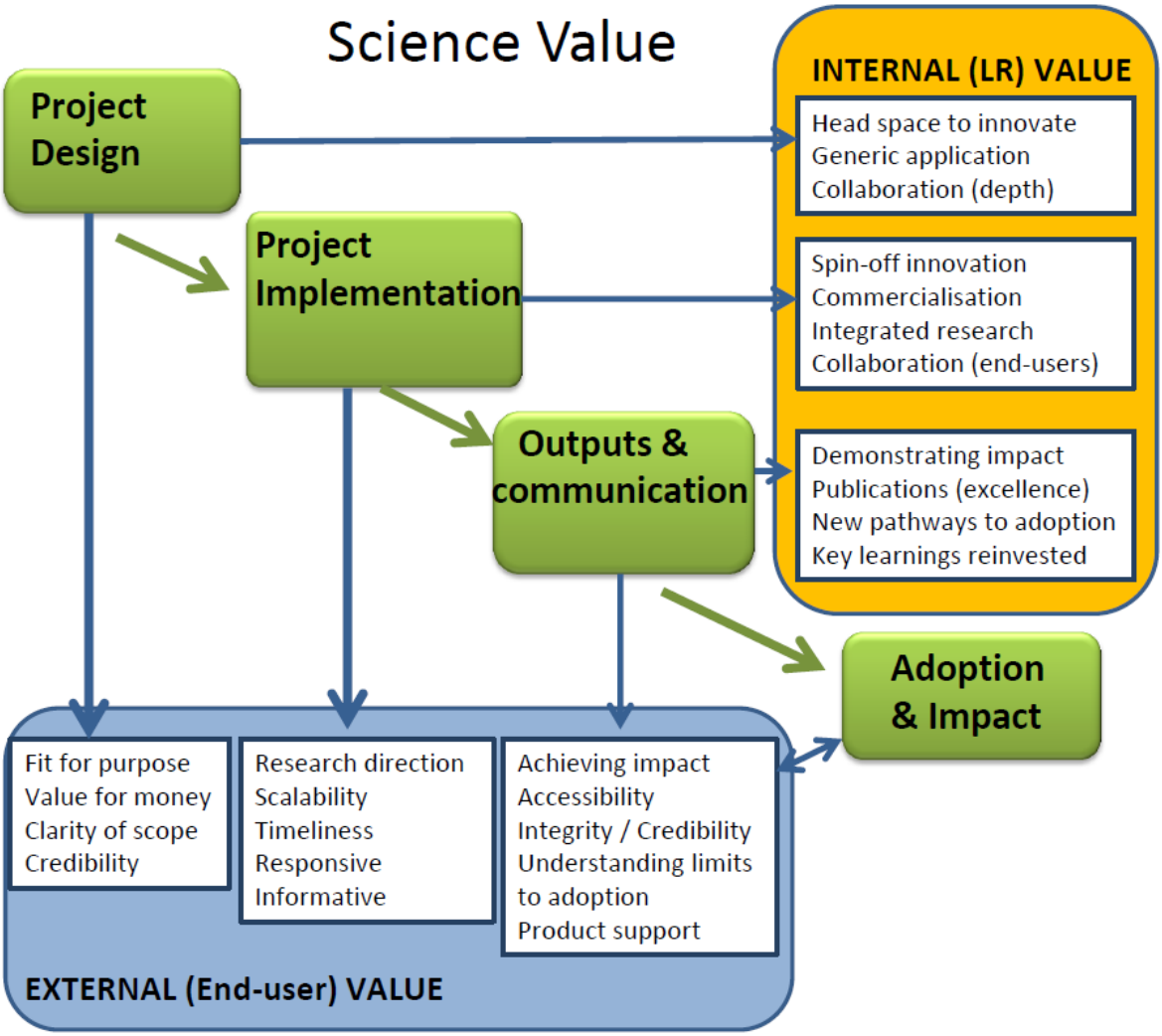

Figure 6. Science value summary by Landcare Research (Millard 2016)

Another aspect is communication within industry sectors, which is variable depending on the competitive nature of the sector. A positive example is in the young industry of sheep dairying, where Spring Sheep dairy (a joint venture between Landcorp and boutique sales and marketing company SLC), is aiming to build the whole sheep dairy industry, not just their own business through a $31.4m Primary Growth Partnership 'Sheep – Horizon Three'. Between sectors, common technology can be a useful platform for interaction and potential collaboration. For example the New Zealand Esri User Conference attracts over 500 New Zealand users of Geographic Information Systems (GIS) across organisations. The uptake of cloud services and the delivery of information to mobile devices is expanding the uptake of GIS for decisions that impact the environment, communities and economic success for businesses. Another opportunity will be the 7th Asian-Australasian Conference on Precision Agriculture in Hamilton, October 2017.

Future capability

He aha te mea nui o te ao? He tangata. He tangata. He tangata.
What is the most important thing in the world? It is the people. It is the people. It is the people.

Professor Klaus Schwab, Founder and Executive Chairman of the World Economic Forum (the International Organization for Public Private Cooperation headquartered in Geneva, Switzerland) calls for leaders and citizens to "together shape a future that works for all by putting people first, empowering them and constantly reminding ourselves that all of these new technologies are first and foremost tools made by people for people" (Schwab, 2016).

In the modern knowledge economy, a group of assets loosely termed "intangibles" is regarded as increasingly important. Firms' investment in knowledge-based capital is increasingly important in facilitating innovation and driving productivity gains - this includes intangible assets that can be broadly classified into: computerised information, intellectual property and economic competencies. Specific examples include networks, databases, software, patents and firm know-how such as management capability. New Zealand does not measure these types of assets but in some countries where these measures exist, knowledge-based capital has become much more important than physical capital in explaining productivity growth. Once a firm has successfully invested in knowledge-based capital, these assets can typically be used by multiple users at a very low marginal cost without reducing their basic usefulness. These increasing returns to scale are an important property that makes ideas and knowledge key engines of growth in 21st century economies (Productivity Commission, 2015). The 2015 Business Operations Survey found that cost and lack of management resources were barriers to innovation for over 50% of all New Zealand businesses and lack of appropriate personnel affected 45% of business (Figure 7).

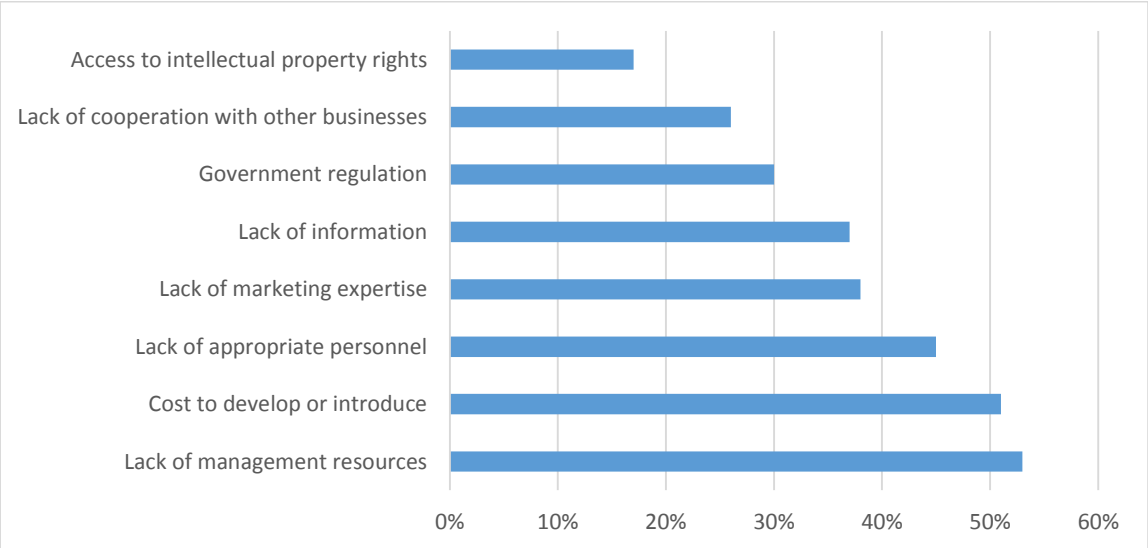

Figure 7. Barriers to innovation affecting business to a low, medium or high degree (data from Business Operations Survey: 2015, Statistics New Zealand published 6 April 2016

Many initiatives are underway to attract school children to the primary industries, including:

- Primary Industry Capability Alliance (PICA) – Grow NZ http://www.growingnz.org.nz/, Primary Industry Champions
- Science Learning Hub https://beta.sciencelearn.org.nz/topics/agriculture
- Enterprising Primary Industries Careers (EPIC) Challenge (Young Enterprise Trust, MPI and DairyNZ)
- CREST Awards e.g. Primary CREST: DairyNZ
- Futureintech (an initiative of Institute of Professional Engineers NZ)

The Ministry for Primary Industries and the Prime Minister's Chief Science Advisor (Sir Peter Gluckman) are currently developing 'The Primary Sector Science Direction', a roadmap for future science needs and opportunities for the primary sector (closely linked to the Conservation and Environment Science Roadmap being developed by MfE and DOC). In addition, the Ministry for Primary Industries outlines in their BIOSECURITY 2025 Protecting to Grow New Zealand Discussion document intended actions to promote biosecurity as a career option by:

- promoting biosecurity as a career choice in schools through the Enterprising Primary Industries Careers (EPIC) challenge and the Ambassadors programme;
- working with the schooling sector of the Ministry of Education to develop resources for teachers and learners to support understanding of biosecurity principles and concepts for learning contexts, as part of schools' implementation of the national curriculum at primary and/or secondary levels;
- working with the secondary-tertiary sector of the Ministry of Education to connect with secondary-tertiary leads and the Primary Industry Training Organisations, who actively promote Vocational Pathways for all learners from school to further study, training or employment across primary industries, and to other economic sectors;
- working with Careers NZ to develop career pathways for roles across the biosecurity system, and to promote these through careers education and advice at secondary schools and tertiary institutes;
- working with tertiary institutes to improve formal training options to enable students to specialise in a range of biosecurity disciplines and to gain critical transferable and technical skills (Ministry for Primary Industries, 2016b).

Futureintech shares the career experiences of New Zealand's technologists, engineers and scientists ('ambassadors') to help school children decide if a job like theirs is right for them. However, these ambassadors are concentrated in the main cities, so rural school children are not reached by this programme - for example, less than 1% of the 831 Futureintech Ambassadors currently operate in the Northland region. In addition, the ambassadors speak about their current jobs, but today's jobs are not the careers that today's children will be entering into in 10 years' time - particularity in the primary industries where value-add processing, automation and robotics are becoming increasingly important (Grimmond et al, 2014). The Futureintech partnership with the Ministry for Primary Industries has resulted in new web content focused on the technology, engineering and science skills that are needed for the future growth of Growing & Harvesting, Processing & Commercialisation and Supporting &

Protecting in the Primary Industries. An A2 poster for Year 5 to 8 classrooms has also been produced (figure 8) showing students the range of technology, engineering and science-based jobs that are important in farming, fishing and forestry.

However, Futureintech needs more ambassadors from the primary industries in the regions to reach rural schools. The Government's Regional Growth Action plans could also include more engagement with organisations such as Futureintech to encourage youth to study disciplines that are crucial to the growth of the primary industries in the regions. For Zespri, attracting talent to the kiwifruit industry is important as the average age of growers creeps over 60 years. A barrier for succession planning has been that children of grower parents do not see opportunities for a 'modern career' in the horticulture industry, so young people seeing the science and innovation on orchard and throughout the supply chain is hugely valuable in attracting future capability. There are also opportunities for maximising value from the government's $1 billion investment in science and innovation, by encouraging (or requiring) researchers who receive public funding to communicate their project vision with the public or speak at schools. Engaging with school children is a useful way to engage a community as parents generally like to hear about what their children are learning at school. Currently, schools contact Futureintech when they want a speaker, however an ideal situation would be that primary industry employees proactively contact Futureintech when they have some time available to go out to schools and promote careers in science, engineering and technology. Storytelling has been observed as a powerful way to engage school children, when ambassadors share their personal career journey that others can relate to and what they envision the opportunities are for the future, including a call to action. Another important feature is relating the career to their everyday lives or things they enjoy, such as the robotics development in the forestry industry being like some aspects of computer games.

Figure 8. Poster for Year 5 to 8 classrooms on careers in the Primary Industries

Social licence to operate/ Positive engagement with the public

A united voice of the primary industries is often presented when fighting issues in the public realm or with government, but the question was posed how often is there a united voice for a positive reason? If there should be three positives for every one negative then the primary sector has a long way to go to increasing the positive: negative story ratio. A New Zealand study on the challenges of science journalism found that communication advisors and scientists believe most media outlets (excluding public service media) report science poorly, and the journalists interviewed indicated that restructuring and staff cuts have placed them under increasing pressure. Smaller newspapers more frequently print press releases verbatim, whereas metropolitan newspaper journalists are likely to continue resisting use of such public relations material (Ashwell 2016). There are huge opportunities with social media that the primary industries could take advantage of in communicating the science and innovation that is being invested in to support environmental outcomes, e.g. reducing greenhouse gas emissions, reductions in nitrate leaching and other environmental issues.

Research organisations often do press releases when new funding is won, for example the Plant & Food Research Press Release *New funding shows big support for primary industries:*

> "Plant & Food Research has been awarded more than $30 million in funding for four projects as part of the Ministry of Business, Innovation & Employment's Endeavour Fund……..The largest allocation of Plant & Food Research's funding has gone to a five-year project aimed at developing new sensing tools for accurately predicting fruit maturity and storage performance. This will assist with optimising fruit quality at export market destinations, providing a competitive advantage to New Zealand through higher returns and preserving the country's reputation as a reliable supplier of fresh fruit".

In response to this same funding announcement, Scoop.co.nz published an Act Party Press Release entitled *Government announces $209m in corporate welfare*

> "This is Steven Joyce doling out eight flag referendums' worth of corporate welfare to research programmes that should be funded by industry groups and private investors," says Mr Seymour. $14 million alone has gone to a study on the storage life of fruit. Even if this is a worthwhile study, surely it's not the taxpayer's job to fund research on behalf of private growers?"

The public need to see the benefits and positive stories about science, and that it is ethically and appropriately carried out, in order to build trust and credibility. Research related to Genetic Engineering is a good example where scientists need tacit approval of the community. Although the definition under the RS&T act which governs MBIE funding is very broad, each year applications are assessed based on the assessment criteria published every year. Participants questioned whether the criteria actually incentivize the right behavior? Unfortunately, in many cases scientists are dis-incentivised to engage with the public with regard to promotions and research funding. An example is Dr Michelle Dickenson who has not been promoted beyond senior lecturer in Engineering at the University of Auckland, despite her numerous accolades for engaging outside the academic realm:

- Member of New Zealand Order of Merit
- Women of Influence award for science and innovation in 2016

- Sir Peter Blake Leadership in 2015
- Prime Ministers Science Media Communication Prize and the New Zealand Association of Scientists Science Communicators Award in 2014

Michelle strongly believes that "science should be open, transparent and a topic of conversation over the dinner table, not just the lab bench, and her vision is to create positive role models in the world that our children can aspire to be like" (Dickinson, 2016). An interviewee agreed with this concept that New Zealand needs 'science and innovation heroes' who are well known, trusted and respected, to inspire the next generation of scientists and technologists, and positively engage with the public.

One paper focused on understanding if, and how buzzwords such as 'public engagement in science', 'responsible innovation', 'green technology', or 'personalised medicine' shape the technoscientific landscape. Buzzwords are used by science policy makers, industrial companies in their advertisements, scientists in their research proposals, and journalists, and surround emerging technologies such as genomics and nanotechnology. Based on a case study of the phrase 'public engagement in science', the paper described buzzwords as linguistic technologies, capable of generating matters of concern and playing an important role in trying to build consensus; setting goals and agendas; and creating unstable collectives through noise (Vincent 2014).

Older generations of New Zealanders usually had some family connection to a farm, even if they lived in the city. One of the big sociocultural changes in New Zealand is that now there are increasing numbers of urban New Zealanders and migrants that have no connection to farms and may never have visited a farm in their life. However, in some way every tax payer does own some New Zealand farm land through Landcorp, and invests hundreds of millions in primary industry science and innovation. This an opportunity for positive engagement but there are also risks. A positive example of science engagement with the public is Zespri, who use scientific evidence of kiwifruit's health benefits to underpin consumer communications around the world. A project with joint government and Zespri investment is a High Value Nutrition National Science Challenge contestable project, where Plant & Food Research in partnership with Zespri are investigating whether New Zealand kiwifruit afford protection against glycaemia by reducing glycaemic response, by maintaining healthy energy metabolism and by retarding the systemic long-term effects of glycaemia (Plant & Food Research, 2015). Telling the stories of science and innovation in the primary sector isn't a one-off, it's an ongoing conversation that needs to be repeated, developed and enriched.

International reputation

Internationally, New Zealand is seen as a high profile country-of-origin for quality food and beverages, with competitive advantages in its land (quality production systems) and its brand (quality consumer perceptions). However *The Land and the Brand* report (Saunders et al, 2016) identifies six aspects that would facilitate the agri-food sector's continued growth and commercial success in globalised markets:

- The importance of industry leadership
- Private-public partnerships

- Effective science and innovation systems
- Market awareness
- Responsive skills development ecosystems
- Cooperative investment to support value chain enhancements

New Zealand being perceived as a vibrant, knowledge-rich, innovative country is advantageous for the attraction of highly skilled migrants and multinational companies. One interviewee clearly stated that "the problem is communication – there is great science and innovation happening in New Zealand but we are not good at talking about it". The New Zealand Story, for example has limited information on science research currently happening in New Zealand – a slide entitled "An Integrated R&D System" just lists the Crown Research Organisations, Universities and Research Associations. There is a great infographic on describing achievements of New Zealanders (figure 9) but none of currently world-leading scientists.

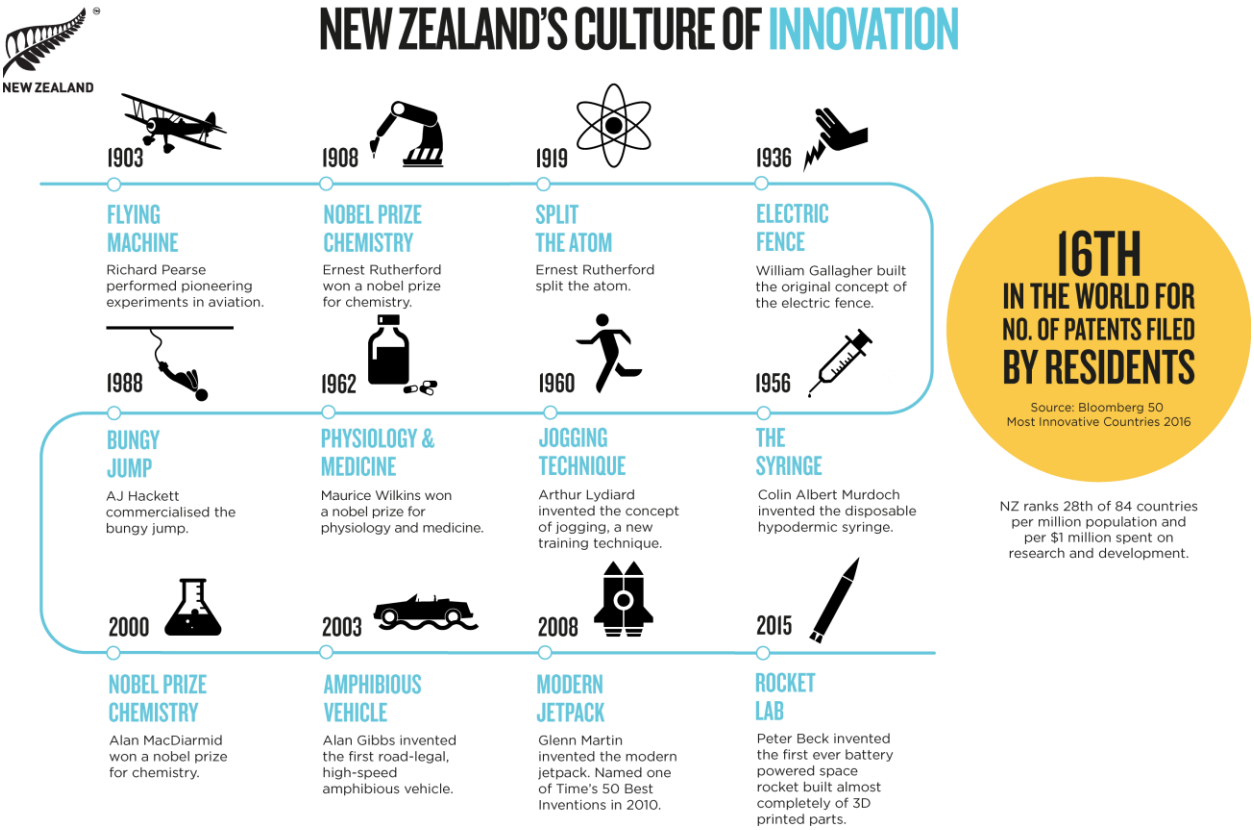

Figure 9. The New Zealand Story Infographic on *Culture of Innovation*

With Professor Ian Yule as the new President of the International Society of Precision Agriculture for 2018-2020, Craig Mackenzie honoured as the 2016 World Precision Farmer of the year and the 7th Asian-Australasian Conference on Precision Agriculture in Hamilton 2017, New Zealand is well placed to be recognised as leading this field of science and innovation. The story of precision agriculture improving

environmental and financial sustainability of farming through maximising nutrient and irrigation efficiency is also a very positive message for the public to hear about.

For Zespri, their investment and expertise in science and innovation (e.g. in health/nutrition benefits, and systems to ensure food quality and safety) is a crucial part of the business story for selling to customers, who then sell on to consumers. With New Zealand having such a large proportion of our export income based on food, being recognised as world-leading in the science of food quality and safety is crucial. The New Zealand Food Safety Science and Research Centre launched in May 2016 promotes, coordinates and delivers food safety science and research for New Zealand. A partnership between government, industry organisations and research institutions, the research conducted aims to protect and enhance New Zealand's international reputation as a trusted producer of safe food. The centre will also link to and collaborate with related international research platforms.

In a NZ Institute of Economic Research report, two key opportunities were outlined to promote Global Value Chain (GVC) participation in order to boost Domestic Value Added (DVA) as a share of exports for agriculture and Food and Beverage (F&B):

1. The national innovation system - changes suggested include:
    - Provide grants or co-funding to thriving F&B exporters or consortia for them to scope and purchase research they expect will strengthen their comparative advantage (and hence market power) in GVCs.
    - Include more explicitly, or weight more heavily, GVC impacts as one of the criteria for assessing Primary Growth Partnership and other funding schemes' applications. This will help to ensure research contributes to enhanced GVC participation.
    - Explicitly shape the research activities, performance measures and incentives of Centres of Research Excellence and other research institutions towards business-facing programmes that promote New Zealand firms' participation in GVCs with the aim of boosting DVA.
    - Further examine whether the intellectual property regime facing New Zealand firms appropriately manages the inherent tension between incentivising innovation and disseminating knowledge along GVCs. This includes exploring potential actions to protect business secrets rather than formal IP protection.
2. Industry institutions (the linkages and co-operation among private sector firms, government, educational institutions and other industry), changes suggested include:
    - Collaboration among firms can be a contributor to GVC success – this is a proxy for the upscaling approach to upgrading in GVCs. This includes collaboration by cost sharing or joint investment in offshore marketing, branding or market intelligence. This has occurred recently amongst firms in the New Zealand wine, craft beer and seafood industries. There may be value in evaluating the success of these initiatives to identify lessons learned and promoting these findings to other industry associations.
    - A 'GVC Influencers Fund' or similar could be designed that allows officials to work closely with industry to promote linkages into international production networks and facilitate exchanges with international GVC decision makers.
    - Establish offshore 'GVC Ambassadors', perhaps akin to the New Zealand Special Agriculture

Trade Envoy role, sourced from the public and private sector. Their role would be to foster better links for New Zealand businesses with other major GVC players and to monitor (including via social media) the constantly shifting links within and between the GVC markets in which New Zealand firms participate (Ballingall & Destremau, 2016).

Cross-sector collaboration and learning

Interviews highlighted that it is increasingly important to improve collaboration between primary industry sectors for these key reasons:

- New technology uptake
- Positive engagement with the public
- International reputation

A positive example of New Zealand Primary Industries collaboration was the co-funding of a Lincoln University Agribusiness and Economics Research Unit report by AGMARDT, ANZCO Foods, Beef+Lamb, Fonterra and Zespri entitled "The Land and The Brand". The report assesses the contributions that the agri-food sector has made to the wellbeing of New Zealanders over the decades and in the present day, and outlines how industry-led initiatives and private-public partnerships might build on the sector's historical successes for ongoing economic prosperity into the future (Saunders et al, 2016). Another good example is the Te Hono Movement, a growing group of New Zealand agribusiness leaders who are exploring new ways of thinking and doing. Te Hono Movement started in 2012 as the New Zealand Primary Sector Bootcamp at Stanford University and now has an alumni of over 180 influential leaders representing 80% of the New Zealand primary sector, who have built a strong foundation of trust, respect and knowledge. Te Hono mindset comes from a greater concept: Hono Tangata, Hono Whenua, Hono ki te ao – strengthening relationships by linking to the people, the land and connecting to the world. The movement is business led, government partnered and has a clear vision:

> *From price taking to market shaping. Transforming the primary sector to realise the opportunity for Aotearoa, New Zealand to be recognised for our natural environment and products, as world leaders in innovation – a place to prototype and amplify, and the quality of our relations with the rest of the world.* (Te Hono Movement, 2016)

Developing a shared language helps diverse stakeholders to co-operate across disciplinary and institutional boundaries by bridging cultural differences and building trust, however this takes time and resources (Botha et al, 2014). A shared vision and strategy at governance level were identified as key attributes for successful collaboration. When parties contribute financially and with people at governance level then fundamentals can be agreed up front and a collective understanding of the issue or opportunity established. A good example of this is in the Canterbury region where six industry sectors came together with the Regional council to characterise and quantify good management practices. Another useful catalyst of cross-sector collaboration in New Zealand primary industries identified by an interviewee was people moving between industries – both by taking up new roles or through secondments between research organisations and industry.

Many New Zealand businesses engage in innovation-related cooperative activities, defined by Statistics NZ as:

> *Active innovation participation with another organisation or individual. Includes collaborative arrangements for innovation. Each party should bring exclusive knowledge or expertise to the cooperative arrangement. Partners do not necessarily gain immediate commercial benefit from the cooperative arrangement.*

Data from the 2013 Business operation survey showed that over 40% of New Zealand businesses had joint marketing or distribution cooperative arrangements for innovation, while less than 30% had joint R&D cooperative arrangements (figure 10). In the services sector, the significance of formal R&D in the innovation mix is particularly low (about 35% of total expenditure on innovation) compared with businesses in both the primary and manufacturing sectors where R&D spending is around 80% of overall innovation expenditure (Productivity Commission, 2015).

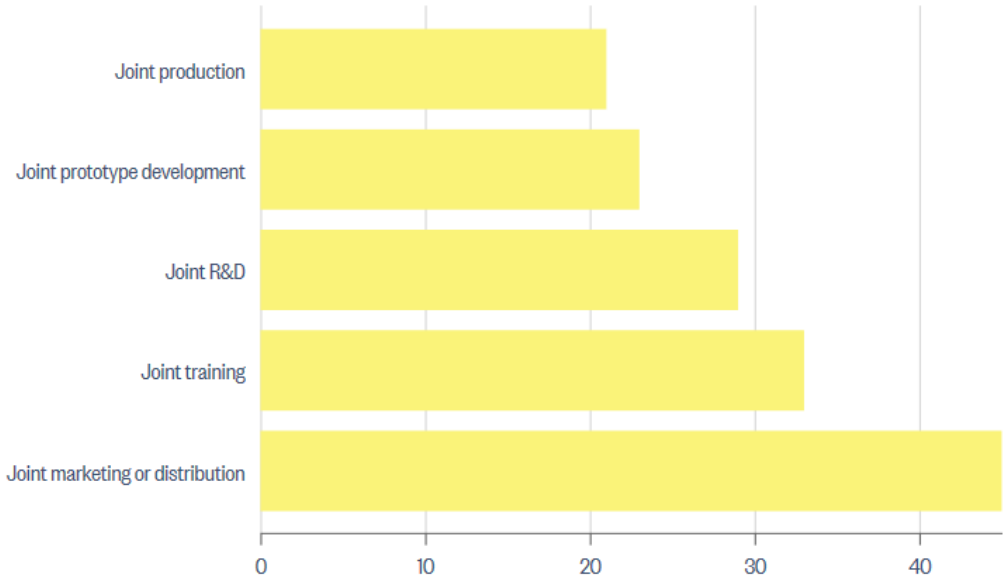

Figure 10. Innovation-related cooperation activities among New Zealand firms (2013 Business Operations Survey, Statistics New Zealand)

Cross-industry and government collaboration is not easy, for example the New Zealand Food Safety Science and Research Centre took over two years to establish. The centre was finally launched in May 2016, with Government matching the $2.05 million contribution by industry funders the Dairy Companies Association of New Zealand, the Meat Industry Association and Zespri (bringing total funding to $4.1 million per annum). Seven research organisations have been involved since a workshop in May 2014 to define how best to establish the centre - Massey University (Centre Host), AgResearch, Cawthron Institute, the Institute of Environmental Science and Research (ESR), Plant and Food Research, the University of Auckland, and the University of Otago.

The 2015 Business Operations Survey found that 26% of all New Zealand businesses reported the lack of cooperation with other businesses hampering their innovation (Figure 7). Barriers to collaboration identified through interviews included the perception or mindsets of parties such as “researchers are blue-sky” and “industry are short-term”, as well as baggage from past discrepancies or poor relationships. Lack of consensus within a sector can also hamper their engagement or collaboration with another sector. Where the is a common issue sectors tend to be more likely to work together (misery loves company) compared to when there is a shared opportunity (which may be more difficult to define). Whether there are incentives for collaborative science and innovation also hugely impacts behaviour. During establishment of the National Science Challenges, it was difficult bringing cross-disciplinary scientists together (such as social scientists with physical scientists) to work on a common mission, but the positive impact of these 10-year science programmes on New Zealand is expected to be large.

The Ministry of Primary Industries holds an annual event to bring together it's Primary Growth Partnership programmes, which is well attended by various stakeholders and included Ministry of Business, Innovation & Employment Research Partnerships in 2015. The Ministry of Business, Innovation & Employment hosted a one-off get together of it's genetics/breeding Research Partnerships in 2015 which was very well received by the sector, however this Government/Industry joint RS&T Research Partnerships funding mechanism has been put on hold by The Science and Innovation Minister since November 2015, pending outcomes of a review. The question has been raised whether better communication about the work being funded and the successful implementation of science outputs would have shed this funding mechanism in a more positive light to the Minister and government policy makers, prior to the review.

Case study on government funded research related to kiwifruit

Opportunities to improve the rates of innovation, adoption and growth in the kiwifruit industry identified by Black (2015) include:

- Improve collaboration by increasing the number and diversity of partners
- Improve networks by raising awareness of external technologies that could be taken advantage of and by developing broader geographical and discipline based networks
- More open innovation, by increasing visibility of innovation interests to help those external to the industry identify interests and improve knowledge and idea sharing
- More structure to research projects by involving end users and/or commercial partners from the start and focusing on how to deliver a commercial outcome (including the demonstration of the commercial value of results)

A case study was carried out to look at the publicly funded research that may relate to the kiwifruit industry (Figure 11). Funding comes from a range of sources including the Ministry of Primary Industries Primary Growth Partnerships and Sustainable Farming Fund, and the Ministry of Business, Innovation & Employment Endeavour fund and Research Parternships. Additional funding directly to companies

through Callaghan Innovation R&D grants has not been included as these funding amounts are not publicly available and are for the exclusive benefit of individual companies so collaboration opportunities may be more limited.

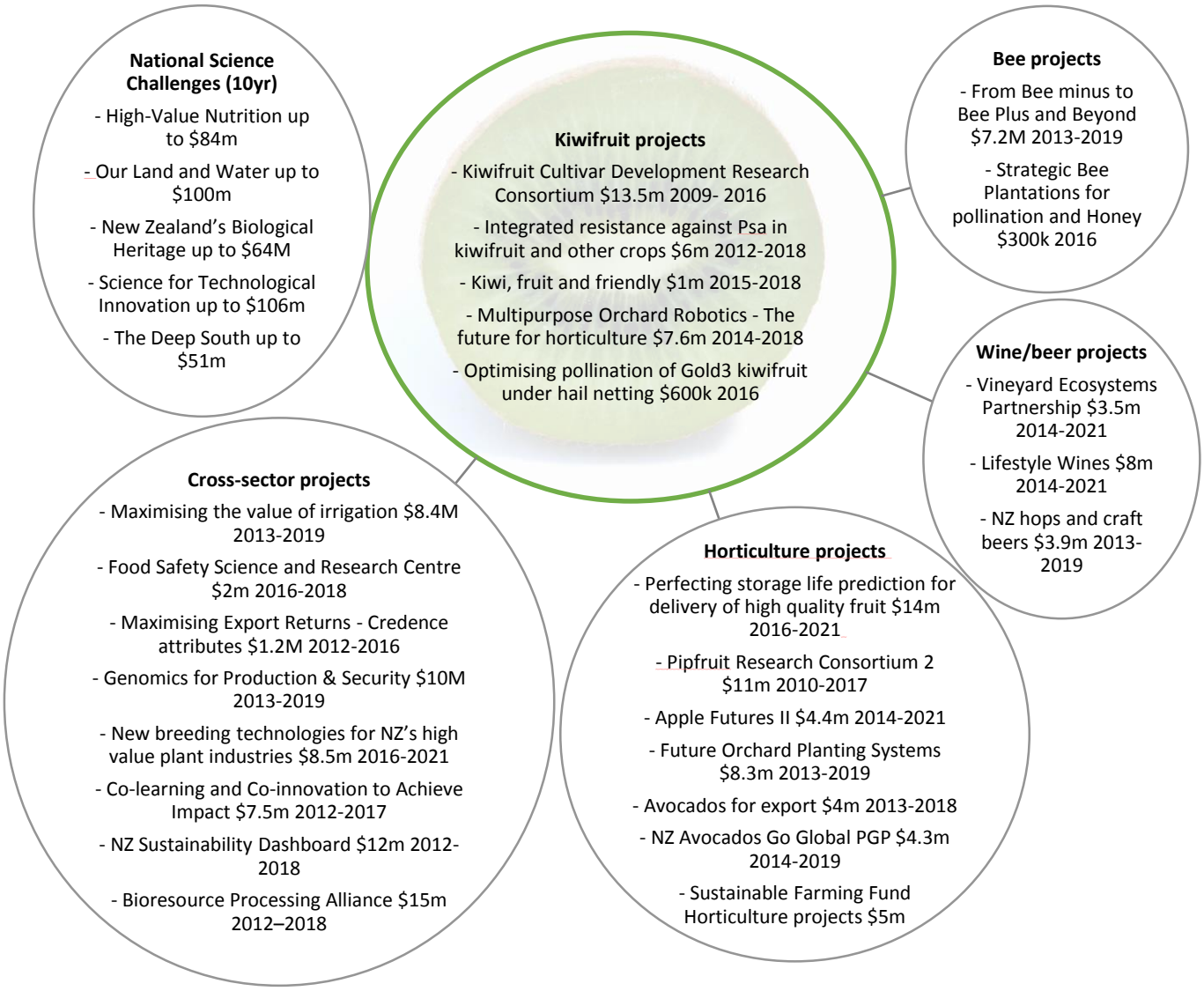

Figure 11. Government-funded research or innovation projects related to the kiwifruit industry

Sources:

- http://www.mbie.govt.nz/info-services/science-innovation/investment-funding/who-got-funded
- https://www.mpi.govt.nz/funding-and-programmes/primary-growth-partnership/
- http://www.mpi.govt.nz/funding-and-programmes/farming/sustainable-farming-fund/

Research, science and technology uptake for innovation in industry

Hendy & Callaghan (2013) reported that New Zealand produces a high number of scientific papers on a per capita basis, but conversion of ideas into innovative products or services is relatively low, possibly due to poor communication, or translation of R&D outputs and how they could benefit industry. They recommended New Zealand business need to look for opportunities for joint ventures and collaborative growth, adopting Open Innovation models rather than competing with each other.

The process of developing and implementing the 'Apple Futures' project was the subject of a case study on co-innovation – an approach to solving complex problems that engages multiple stakeholders throughout research and extension initiatives to enhance adoption and impact. Apple Futures was designed to implement applied research across a national industry, to produce export quality, ultra-low residue apples while meeting the phytosanitary requirements of over 60 countries. In 3 years it was successfully implemented on 65% of New Zealand's export apple crop with a benefit-cost ratio of 30 times the value of the investment. Key co-innovation learnings included the importance of trust amongst participants, learning together, a clear agenda for change, and monitoring and evaluating progress towards that change agenda. Features that contributed to the success of Apple Futures included:

- Cyclic communication was timely and regular with growers, exporters and all involved in pipfruit crop protection. The pilot programme demonstrated the concept and helped to manage risks.
- Learning supported by Pipfruit NZ-facilitated discussion groups that enabled growers to have direct dialogue with the trusted science team (with a track record of success) was pivotal in securing adoption (Park et al, 2015)

AgResearch is focusing on partnering with next-users to deliver research outcomes to the enduser, planning science programmes with a clear understanding of who the collaborative partners will be and their roles in achieving impact, recognising the function of innovation brokering, and monitoring and evaluating progress within science programmes. Key findings have included the need to involve an implementation group to pilot tools and processes, using facilitators to guide project teams, defining language and concepts using electronic media, videos and case studies, and on-going monitoring and evaluation. This approach has enabled AgResearch to begin the process of cultural change from a traditional linear approach to extension to a more collaborative model, with the aim of increasing the impact of science (Percy et al 2015). Results from an 18-month pilot innovative participatory programme study showed that New Zealand farmers' learning was promoted when they:

1. participated in a learning community with agricultural scientists,
2. made connections between evidence-based ideas and their own farming systems,
3. were interested in the learning focus and became part of a shared inquiry, and
4. revisited important concepts and engaged in a range of multi-sensorial activities that were aligned to important pastoral outcomes (Sewell et al 2014).

Research scientists have been challenged by the funding bodies to build greater capability for participatory approaches into their projects. Such approaches are viewed as critical to address

agricultural sustainability as they facilitate the creation of learning platforms and partnerships that have the potential to significantly transform people's behaviours. Research examining six Sustainability Farming Fund projects that used science to support sustainability and involved scientists working with end-users found that science and industry objectives are often poorly aligned. For scientists the main driver is publishable output whereas industry want applied knowledge that is easily communicated. Scientists felt they had limited skills in engaging with communities. The competitive funding system is also biased towards reports and scientific publication rather than engaging with stakeholders, which is harder to budget time and resource for. Social learning occurs slowly and incrementally so short term funding does not facilitate this opportunity. Other barriers to improved collaboration included power differentials among and between scientists, farmers, processors and supply groups, past experience, and the competitive nature of the industry. In addition when scientists are working with Māori there is a need to be respectful of Māori's unique culturally based relationship with the land and to be sensitive to protocols, perceptions and traditional/local Māori knowledge (Mātauranga Māori). Scientists felt frustrated that the funding system does not allow for the time required for relationship building and trusting partnerships to form (McEntee, 2013). Industry organisations are being engaged and seeing more funding bids before they are submitted to competitive funding rounds however there is less communication from the researchers once the funding is won, which is somewhat a concern. The competitive model encourages some patch protection making researchers less likely to share ideas.

In twenty years' time the NZ landscape could look very different. Our Land and Water National Science challenge will investigate the vulnerability and suitability of land areas for different uses, giving a menu of options and constraints under which land uses can operate sustainably. But it will still be up to the land owner/manager to decide what their farming system may look like (considering bioeconomic enterprises and beyond mono-culture). There will be an increasing divide between those who irrigate (resulting in more controlled, intensive farming) and those who do not or cannot (e.g. hill country sheep and beef farming). There is an avalanche of data generation and processing coming. In the "Growing more innovative and productive Kiwi firms" 2015 symposium, Professor Eric Bartelsman (Vrije Universiteit, Amsterdam) argued that ICT-led innovation has a long way to run and will put a premium on nimble entrepreneurship, labour-market flexibility, re-training and resource reallocation such as autonomous vehicles, universal programmable robots, data-driven expert systems, and the Internet of Things (Productivity Commission, 2015).

The potential benefits of Internet of Things (IoT) are almost limitless, saving time and resources and opening new opportunities for growth, innovation and knowledge creation (see figure 12 for a visual description). However, the success of IoT will depend on the development of the right ecosystem and addressing key issues like identification, trust, privacy and security. Secure tracking of food and water from production to the consumer is an important opportunity for New Zealand. Because IoT comprises things, sensors, communication systems, servers, storage, analytics and end user services, the developers of each of these components will need to work together to deliver easy functionality to the customer, at a price point that enables adoption.

IoT has been defined by the United Nations specialized agency for Information and Communication Technologies (ITU) Internet of Things Global Standards Initiative as:

> *"a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled. NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications." (Vermesan et al., 2014).*

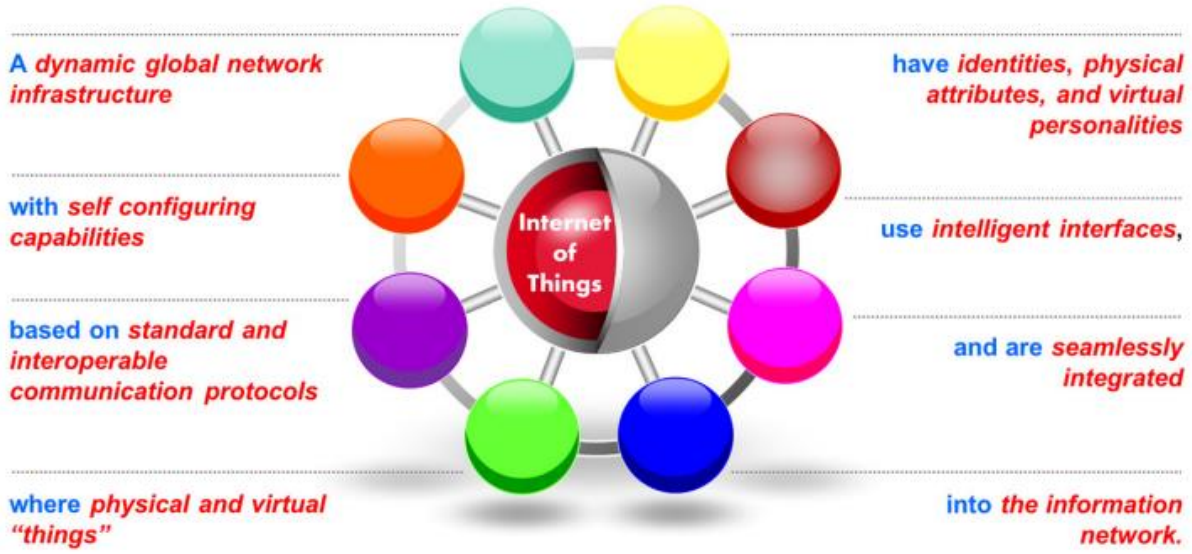

Figure 12. Internet of Things definition (Vermesan et al., 2014)

The One Hundred Year Study on Artificial Intelligence (launched 2014), investigating its influences on people, their communities, and society, defined AI as "a science and a set of computational technologies that are inspired by—but typically operate quite differently from—the ways people use their nervous systems and bodies to sense, learn, reason, and take action" (Stone et al 2016). The report outlined that AI and robotics will be applied across the globe in industries struggling to attract younger workers, such as agriculture and food processing.

Conclusion and Recommendations

There are potentially significant benefits of improving communication of government-funded Research, Science, Technology and Innovation related to the New Zealand primary industries, these include:

- Attracting science and innovation talent to the primary industries and building future capability
- Positive engagement with the public ensuring social licence to operate
- Building New Zealand's international reputation as an innovative country to attract skilled migrants, build partnerships with global experts, and be seen as a trusted producer of safe, high quality products
- Improved cross-sector collaboration and learning
- Improved research, science and technology uptake for faster and more advanced innovation in industry

To achieve sustainable growth in New Zealand primary industries, the right capability is key. Attracting and retaining a diversity of talented people is crucial to maximising benefits from the fourth industrial revolution in New Zealand. Recommendations for improving communication of government-funded Research, Science, Technology and Innovation related to the New Zealand primary industries include:

- Improve the New Zealand Story information on science and innovation in New Zealand – especially with regard to what is currently being invested in (include government investment in science & innovation and case studies of world-leading New Zealand scientists)
- Primary Industry associations and businesses could develop more graduate programmes with a science and innovation focus to create career pathways for attracting talented young people
- Primary industry businesses could sponsor employees to visit schools in rural areas important to their sector and communicate the government and their investment in science and innovation, to enable the Futureintech programme to reach rural schools and focus on future careers
- Industry could collaborate more on opportunities of the fourth industrial revolution such as internet of things, GIS and AI, e.g. the Asia-Australasia Precision Agriculture conference in Hamilton 2017 could be used as an opportunity to forge collaboration across primary industry sectors
- Government funding agencies could take a more proactive approach to publicising/promoting their science and innovation investments, and facilitating cross-sector collaboration
- The 10yr National Science Challenges could increase their focus on engaging young people in science and innovation to inspire the next generation who will be the end users benefiting from the research findings in the decades to come
- The assessment criteria used for government science and innovation funding applications could include a section on the quality of the communication plan, alongside the science and implementations plans
- Universities and Crown Research Institutes could include positive public engagement in their promotion criteria for staff (likely if changes are made to the above government funding criteria)

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Appendix

Interviewees:

Ken Taylor – Director Our Land and Water National Science Challenge (AgResearch) and Zen Gregor Senior Communications Advisor at AgResearch (Our Land and Water - National Science Challenge)
Dr Max Kennedy, Manager Contestable Investments, Science System Investment and Performance Branch, Ministry of Business, Innovation & Employment
Dr Stephen Lorimer, Senior Commercialisation Manager Victoria Link Ltd, University of Victoria
Paul McGill, Farm Innovation Manager at Landcorp Farming Ltd
Oliver Broad Communications Manager, Grower & Government Relations, Zespri
Susan Weekes, Futureintech Facilitator, Wellington area & Manawatu region
Sarah Crofoot, Policy Advisor Meat & Fibre and Environment at Federated Farmers and Young Farmers speaker in schools
Dr Kate Calcott, Futureintech Ambassador and Policy Analyst, Forestry and Plant Sector, Policy and Trade Branch of Ministry for Primary Industries
Dr Andrew Cleland, Chief Executive The Royal Society of New Zealand

Semi-structured interview questions (in person or over the phone)

Introduction: The question being researched here is *What are the benefits of improving communication of government-funded Research, Science, Technology and Innovation related to the New Zealand Primary Industries and how can this be achieved?*

- I'm interested in your thoughts on why this may be valuable and how we could improve?
- Cross-government investment in science and innovation is $1b now and will be $1.6 billion annually by 2020 – is there more value we could get from this investment?

1. **Why do you think it may be important communicate about govt spend on Research, Science, Technology and Innovation related to the New Zealand Primary Industries?**
    - Benefits? Risks? Whose responsibility is it and who benefits?
    - Talking points – international reputation, future capability, social license to operate, cross-sector collaboration, taxpayers' money

2. **What/who are good examples?**

3. **Do you have ideas about how communication could be improved? What are the barriers?**