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Research Landscape Map for the Our Land and Water National Science Challenge (2nd Edition)

Report for OLW | R McDowell, C Saunders, J Turner, P Mudge, D Houlbrooke, C Tanner

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Summary

The development of a second edition of the Research Landscape Map (RLM) for the Our Land and Water National Science Challenge (the Challenge) has delivered three components: 1) a rich understanding of the current research landscape particularly work that has the potential for medium to high impact to help achieve the Challenge mission; 2) the determination of research gaps, and 3) informed where linkages should exist between Challenge programmes and existing research.

Research providers, funders and stakeholders were asked to supply briefs of all research programmes (live as of July 2015), larger than $50K per annum, which delivered outcomes complementary to the original Challenge strategy. Independent assessors collated the briefs and scored the projects according to their likely impact in helping to meet the Challenges mission. The process followed a transparent approach that accounted for differing opinions of how well organisations and independent expert assessors scored impact. Outputs from the scoring and mapping exercise are available to all, helping providers and stakeholders ascertain what research is going on, but also to integrate research with the Challenge.

The second edition of the RLM has an inventory of 226 research programmes. Compared to the first edition of the RLM a number of factors were noted:

- Overall, there is less investment, especially as sources such as the PGP wind down, but this is being partly compensated by an increase in Challenge and industry funds; note that industry are only funding Theme 2.
- The distribution of funds within the biophysical sciences (Largely Theme 2) has changed a lot with increases in investment in precision agriculture/horticulture and water quality limits and mitigations, and reductions in all other areas.
- Both Themes 1 and 2 have shown significant increases in collaboration, and see value in 'building capacity' and 'knowledge into action' as principal enablers to achieving outcomes. Theme 3 also sees value in these enablers, but sees significantly more in 'connecting with society' and 'vision mātauranga' than Themes 1 or 2.
- The number and investment in programmes scored moderate to very high likely impact towards the Challenge mission was similar to the first edition of the RLM. This was fuelled by an increase in the number of SSIF-programmes. In contrast there was also an increase in the proportion of programmes scored low to very low impact with funded by MBIE. This suggests CRIs are aligning more funds towards the Challenge mission, but that proposals submitted to MBIE are not.

Using impact as a measure of alignment to the Challenge mission, research gaps were identified relative to the original strategy. Additional lines of inquiry may result from other processes. However, the identification of gaps should not be interpreted as a license for inclusion in the revised Challenge strategy.

1. Introduction

The Our Land and Water National Science Challenge (OLW-NSC) maintains a research landscape map (RLM) of existing research of relevance to the Challenge strategy[1]. The Challenge has a mission:

"To enhance primary sector production and productivity while maintaining and improving our land and water quality for future generations".

To achieve this mission the Challenge looks through a value chain "lens" and works in the following strategic areas under three themes.

The **Greater value from global markets** theme aims to:

1. Develop mechanisms that increase the value of the New Zealand brand;
2. Equitably distribute value from consumer to producer along the value chain; and
3. Incentivise and reward sustainable land use practices.

This is set against work in the **Innovative and resilient land and water use** theme to:

4. Understand processes (e.g. attenuation of contaminant transfer) within our land and water resources;
5. Classify and model their performance and potential response to management; and
6. Derive new production systems that create headroom to meet objectives.

Finally, to ensure this occurs work in the **Collaborative capacity** theme aims to:

7. Create the social capital to understand and address land and water issues; and
8. Develop the tools to meet objectives across space and time that result in better, faster and more enduring community decisions by individuals, communities and regulators.

From here these themes are referred to as themes 1 to 3, respectively.

The specific aims of the map were:

- Obtain a snapshot of recent/current projects in each of the Challenge's themes
- Identify current level and sources of investment (2015 onwards)
- Determine relevance of each project assessed as the likelihood of achieving a significant impact towards the Challenge mission within 5-10 years.
- Track metrics to measure success, such as the level of alignment, and inform Challenge key performance indicators.
- Inform research gaps for the Challenge to potentially fill in a revised Challenge strategy for submission to MBIE on the 4th of July, 2018.

[1] http://www.ourlandandwater.nz/assets/Uploads/Addendum-to-the-Challenge-Strategy-July-2017.pdf

2. Methodology

With limited resources there is a need to assess impact and alignment to the Challenge mission. There exist a number of methodologies with which relevance can be assessed, each with advantages and disadvantages (Morgan, 2014). It should be noted that this **does not** constitute an assessment of the quality of the research or its potential impact on the primary sector in areas that do not so directly align with the Challenge mission.

To construct a research landscape map, the following project inputs were requested from a number of organisations (Table 1). These inputs were:

1. Identifiers (organisation name, project titles, funding sources, and magnitude).
2. Timeline (start and end dates).
3. Objectives.
4. Achievement measures.
5. A project's use (1 = very low, 5 = very high) of the Challenge Enabling Themes: Big Data, Building Capacity, Connecting with Society, Turning Knowledge into Action, and Vision Mātauranga (see Appendix I).
6. The organisation's assessment of impact towards the Challenge mission (1 = very low, 5 = very high).

Table 1. List of organisations from which data was sought and inputs supplied (or not = x).

Government	Input	Industry	Input	NGO	Input	Provider	Input
MfE	NA[1]	ExportNZ	×	Fish & Game NZ	√	AgResearch	√
MPI	√	NZ Winegrowers	√	Forest Owners Association	×	Landcare Research	√
MBIE	NA	Synlait	×	Forest & Bird	NA	NIWA	√
Regional Council Special Interest Groups	√	Sustainable Business Council	×			Plant and Food Research	√
Envirolink	√	ANZCO	×			Scion	√
GWRC	NA	Ngāi Tahu Farms	NA			Aqualinc	√
ECan	NA	ZESPRI	√			Univ. Otago	×

WRC	NA	Silver Fern Farms	×	ESR	√
ES	NA	Horticulture NZ	√	Univ. Auckland	×
HBRC	NA	QualityNZ	×	Massey Univ.	√
Waikato River Authority	NA	DairyNZ	√	Lincoln Univ.	√
DoC	√	Beef+Lamb NZ	NA	Lincoln Agritech	√
L&WF	×	Fonterra	√	GNS	√
NZAGRC	√	FANZ	NA	Waikato Univ.	√
		Ballance Agri-Nutrients	NA	MOTU	√
		Ravensdown	√	Victoria Univ.	√
		FAR	√		

[1] Not applicable as organisation felt data input via other provider.

Additional notes to guide organisations in the input of data included:

- Projects were included in the mapping exercise if live as of 1 July 2015.
- The magnitude of funding was calculated as total value for the project (and per annum). For on-going Strategic Science Investment Fund (SSIF)-funded projects, the end date was assumed to be June 30th 2018. Funding sources were divided into: Government – via the Ministry for Business, Innovation and Employment (MBIE) and including Challenge funds; Government – via other sources including MPI's Primary Growth Partnership and Regional Council funds; Industry related funds such as the Foundation for Arable Research or the Fertiliser Association of New Zealand; Non-Governmental Organisations such as Forest and Bird; Commercial companies; University funds such as the Performance Based Research Fund; and other.
- If more than one Theme was targeted, organisations were asked to split funding across the relevant Themes.

Once collated, an additional assessment of programme impact was made by the Science Theme Leadership team plus an independent assessor from Manaaki Whenua Landcare Research. The independent assessor filled a gap in expertise, but had also been involved in the first edition of the map and hence knew the process.

Data for impact was analysed via a REML (restricted maximum likelihood; Genstat Committee, 2015) procedure with organisations and independent assessors coded to determine:

1. Are there are differences between an organisation's assessment of impact and those of the independent assessors?
2. Do the independent assessors score organisations differently?

The output from the second question was used to adjust impact and therefore provide an integrated assessment how much 'moderate to very high impact" research is delivering towards the Challenge mission. However, we recognise that the assessment is still subject to several caveats including the quality and level of the information supplied (i.e. was there enough to judge impact).

Information is presented at the Theme level, to keep compatibility with the outputs of the first RLM, and also towards each of the eight strategic areas. Due to the large size of Theme 2 projects were also mapped (in the accompanying spreadsheet) into one of 10 categories: 1) Plants for production; 2) Animals for production; 3) Water allocation and irrigation efficiency and production benefits; 4) Climate and climate change effects; 5) Precision Agriculture and Horticulture; 6) Soil quality and erosion; 7) Water quality, limits and mitigations; 8) Farm systems; 9) Catchment systems and attenuation; and 10) Aquatic biodiversity and cultural values. Impact to these categories was not assessed, but have been used by other stakeholders in the assessment of research strategies (McDowell et al., 2016).

Direct comparisons between the first and second edition of the RLM were made using a non-parametric tests, such as a Kruskal-Wallis for the comparison of medians and a χ^2 for the comparison of frequencies.

3. Outputs

As indicated in Table 1 data was received from 93, 75, 66 and 88% of government (central + regional), industry bodies, non-governmental organisations, and providers, respectively. This compares well to that received in the first RLM (93, 53, 66 and 88%, respectively), although there were differences in who responded; for example, the Universities of Otago and Auckland responded in the first edition, but did not to the request for the second edition, however, Victoria University and Aqualinc responded to the request for the second edition. The total number of programmes were 22, 172 and 32 for each respective theme; less than the first editions numbers (51, 243 and 66). As an indicator of the level of information provided, data for annual investment and current objectives were provided for 94% of programmes, up from c. 90% in the first edition.

3.1 Metrics

Generalised thematic-based metrics were derived for:

1. The magnitude of investment by source (e.g. industry vs government – MBIE vs CRI SSIF funds;
2. The degree of collaboration within a project to other groups;
3. The frequency with which enabling themes significantly contributed to the outcomes of a programme; and
4. The likely impact (scored 1 = very low to 5 very high by providers) that an enabling theme contributed to outcome of a programme - new for the 2nd edition.

These metrics are intended to be used to indicate changes during the lifetime of the Challenge. Metrics are reassessed every two years. At the high (Theme) level, it is unlikely that more frequent assessment would be able to highlight specific areas of research requiring realignment.
The hypotheses are that with time the degree of collaboration and use of Challenge enablers would increase, and that the magnitude and distribution of investment sources would change and become more aligned with the Challenge Themes.

3.1.1 Investment

The total annual investment along with the relevant funding sources is given in Figure 1 apportioned according to each organisation's assessment of alignment. In Themes 1 and 3 the major source of funding was from MBIE. Challenge funding (counted as subset of MBIE funds) comprised about 20, 15 and 6% of Themes 1, 2 and 3, respectively. Crown research institute SSIF and industry funding were also a significant source of investment in Theme 2. When broken-down further, the majority of 'Govt – other' funding was sourced from some programmes funded out of the Ministry for Primary Industries' Primary Growth Partnership and the New Zealand Agricultural Greenhouse Gas Centre. The study of greenhouse gasses (GHG) is not within the scope of the Challenge, although adapting to climate change is. Hence, while included in Figure 1, a more representative figure for Theme 2 was $76M. Compared to the first edition, the magnitude of annual investment is 27 ($3.6M), 6 ($5.2M), and 30% ($2.6M) less for each respective theme. A comparison by each sub-category is also given in Table 2 (with and without GHG research). The main source of the decrease has been fewer funds from Govt-other as Primary Growth Partnerships mature, but also SSIF (Table 3). However, increases are noted in MBIE (largely due to Challenge investments) and Industry funds.

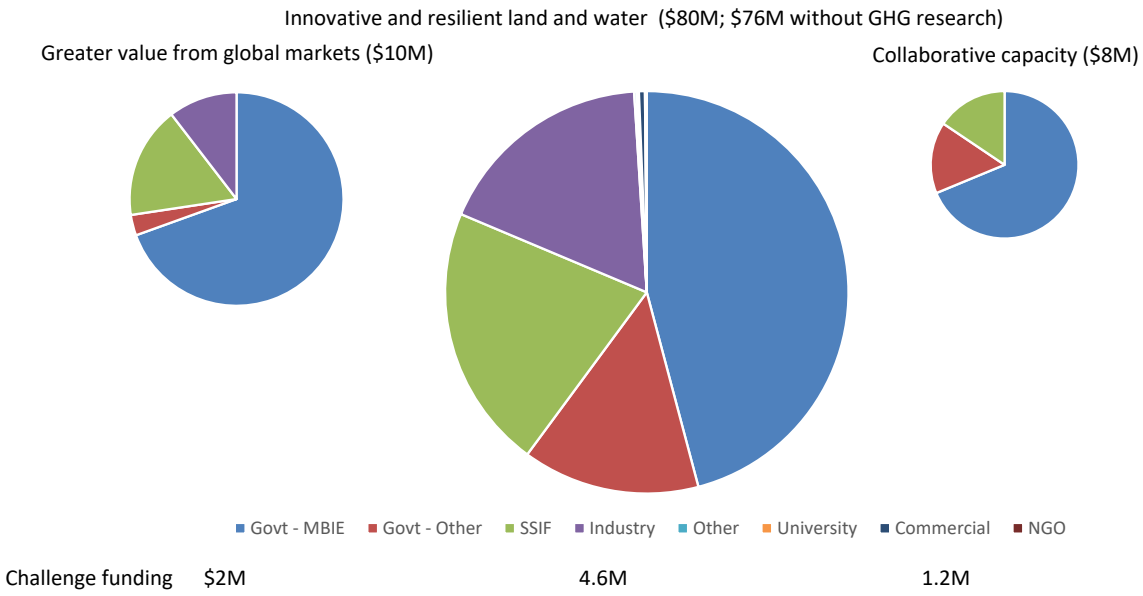

Figure 1. Total annual investment and funding sources apportioned to each Theme. The size of the pie chart is indicative of the magnitude of annual investment.

Table 2. Sub-categorisation of theme 2 (Innovative and Resilient Land and Water Use) for the first and second editions of the Research Landscape Map.

Theme 2 (sub-categorisation)	First RLM	Second RLM (inc. GHG research)	Second RLM (no GHG research)
Plants for production	13,238,035	9,354,915	7,478,425
Animals for production	6,769,818	730,049	730,049
Water allocation and irrigation efficiency and production benefits	11,601,115	6,800,908	6,800,908
Climate and climate change effects	5,691,937	3,808,890	2,030,757
Precision Agriculture and Horticulture	4,092,754	15,124,695	14,615,895
Soil quality and erosion	9,279,587	6,856,140	6,856,140
Water quality, limits and mitigations	8,396,896	17,305,828	17,055,828
Farm systems	10,310,954	6,061,566	6,061,566
Catchment systems and attenuation	6,295,175	9,827,131	9,827,131
Aquatic biodiversity and cultural values	5,550,984	4,168,515	4,168,515

Table 3. Changes in major funding sources in each theme.

Theme / Funding source	First RLM	Second RLM (inc. GHG research)	Percent decrease[1]
Greater Value from global Markets			
Govt - MBIE	3,811,755	6,664,399	75%
Govt - Other	2,248,564	300,000	-87%
SSIF	4,150,787	1,627,000	-61%
Innovative & Resilient Land and Water Use			
Commercial	3,725,935	386,437	-90%
Govt - MBIE	25,481,363	36,721,719	44%
Govt - Other	14,301,246	11,379,226	-20%
Industry	11,392,523	14,121,711	24%
SSIF	24,418,856	17,012,453	-30%
Collaborative capacity			
Govt - MBIE	5,064,322	5,179,418	2%
Govt - Other	3,525,496	1,183,000	-66%
SSIF	2,483,374	1,172,198	-53%

[1] Positive number indicates an increase in funding relative to the first RLM.

3.1.2 Collaboration

The frequency and number of collaborators as indicated by each theme is given in Figure 2. By difference, the proportion of projects with no indicated collaboration was 45, 18, and 4% for Themes 1 through 3 respectively and less than in the first edition for Themes 2 and 3 (34, and 43%, respectively), but similar for Theme 1 (45%). A Kruskal-Wallis test indicated that the median number of collaborators had doubled ($P<0.05$) for Themes 2 and 3 (now both 2), but stayed the same for Theme 1.

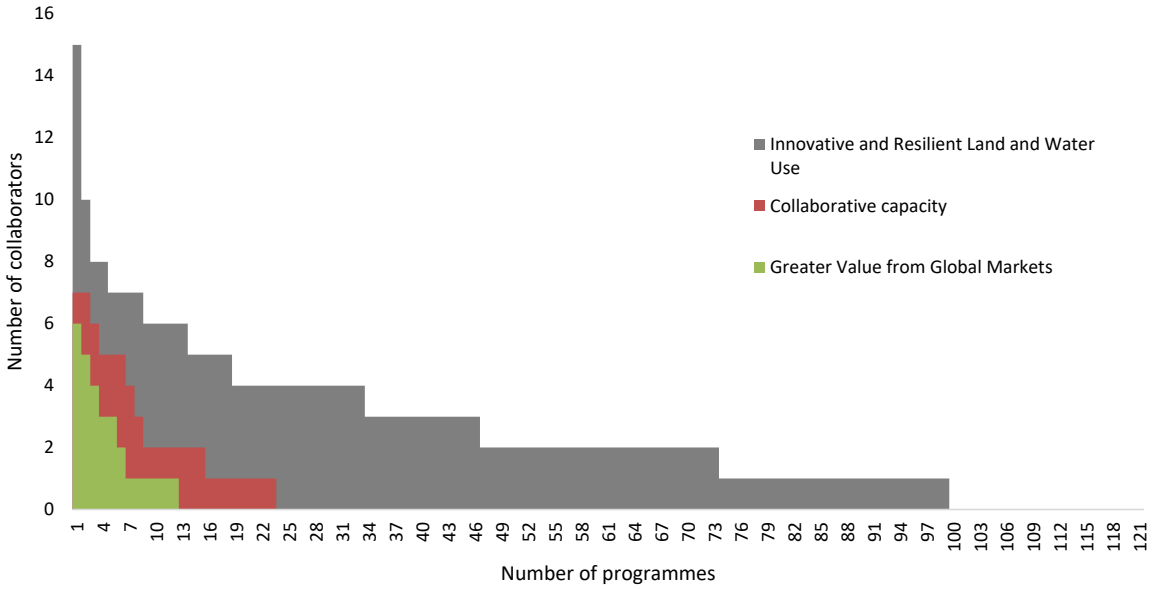

Figure 2. Histogram showing the number of collaborators within projects for each Theme as indicated by organisations.

3.1.3 Use of enabling themes

Data for the mean frequency of the use of enablers within projects (by Theme) is given in Table 4. A description of each of the enablers is given in Appendix I. The analysis of the data indicated a significant increase in the use of enablers in both themes 1 and 2, while the frequency remained similar in theme 3. In addition, providers also considered all enablers in the second edition of the RLM, not just a few as per the first RLM.

Providers assessed the relative importance of enablers to deliver outcomes. Mean scores for each theme are given in Figure 3. A score of 3 (out of 5) is considered of moderate importance. A Kruskal-Wallis one-way analysis of variance indicated that providers considered ‘connecting with society’ and ‘vision mātauranga’ to be more important to the delivery of outcomes in theme 3 than in themes 1 or 2. The low level of use of some enablers could represent the level of understanding of an enablers, or that some programmes (and the disciplines used therein e.g. Theme 2) require fewer enablers to deliver outcomes.

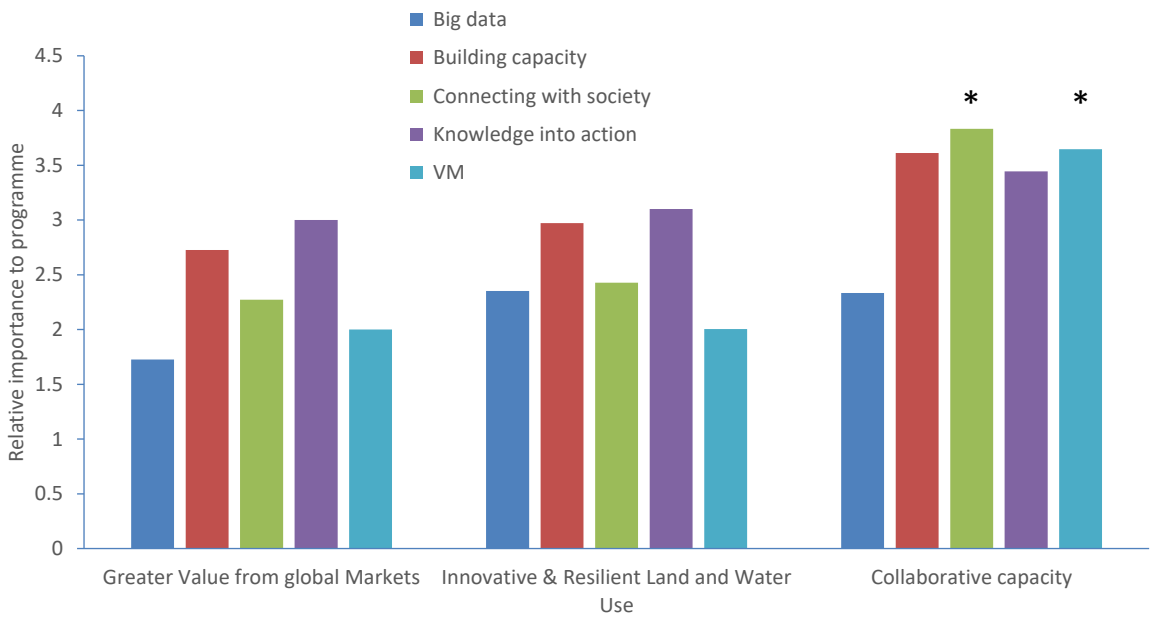

Figure 3. Relative mean importance of enablers to the delivery of outcomes for programmes in each theme. The asterisks indicate the enabler was deemed significantly more important.

Table 4. Frequency (percentage) of programmes that considered enablers aided in the delivery of outcomes in the first and second Research Landscape Map (RLM). Difference is the result of a χ^2 test between the frequency of all enablers in the first and second RLMs.

Theme	RLM Edition	Number of programmes	Big data	Building capacity	Connecting with society	Knowledge into action	Vision mātauranga	Difference
Greater Value from global Markets	1	48	1	8	2	13	1	<0.001
	2	22	50	50	50	50	50	
Innovative & Resilient Land and Water Use	1	226	10	20	2	14	3	<0.001
	2	172	73	73	72	73	72	
Collaborative capacity	1	67	9	24	37	43	28	0.51
	2	32	56	56	56	56	53	

3.2 Relevance assessments

In order to assess the impact of current work to the Challenge strategy and mission, scores for impact need to be adjusted for consistent over or under assessment. The collated outputs indicated that for all three Themes the scores provided by organisations was different (P<0.001; usually greater) than that given by a group of independent assessors (Figure 4). However, independent assessors tended to score projects for some organisations differently, albeit to a lesser degree (P<0.01) (Figure 4). The adjusted scores therefore represent a mean with the organisation included as another independent assessor. Care should be taken in interpreting the results of the scores for individual organisations. Whereas some providers contributed a wide range of projects to the Research Landscape map, others providers were narrower in their focus. Where providers were more inclusive there are likely to be a larger number of projects that are less directly aligned to the Challenge, lowering the average score. Hence, a high or low average score should not be taken as a measure of the organisation ability to deliver impact to the Challenge.

Adjusted scores were used to filter programmes that were of moderate or greater relevance (i.e. scored ≥3). By Theme, the numbers of programmes of moderate or greater relevance were 9, 73 and 13 for Themes 1, 2, and 3, respectively. Data for investments in all projects according to adjusted relevance is given in Figure 5. The annual level of investment for projects of moderate or greater relevance was 4, 50, and 6 million dollars for Themes 1, 2, and 3, respectively. Therefore, there are 6.0, 30, and 2 million dollars per annum spent on projects that are projected to have a low to very low relevance on one or more of the Challenge Themes (Figure 6). The distribution of funding sources for low to very low scored projects differs to that seen in Figure 1 for total annual spend. The greatest funding source of low to very low scored projects for all themes is Govt-MBIE. This contrasts with the first edition of the RLM which identified a majority of investment in low to very low scored programmes as sourced from CRI SSIF funds. This might indicate a strategic shift in funds towards the Challenge mission and a lack of alignment to the Challenge for MBIE-proposals, it may also indicate investment by CRIs and MBIE in areas that have impact in other aspects of primary sector growth or environmental management.

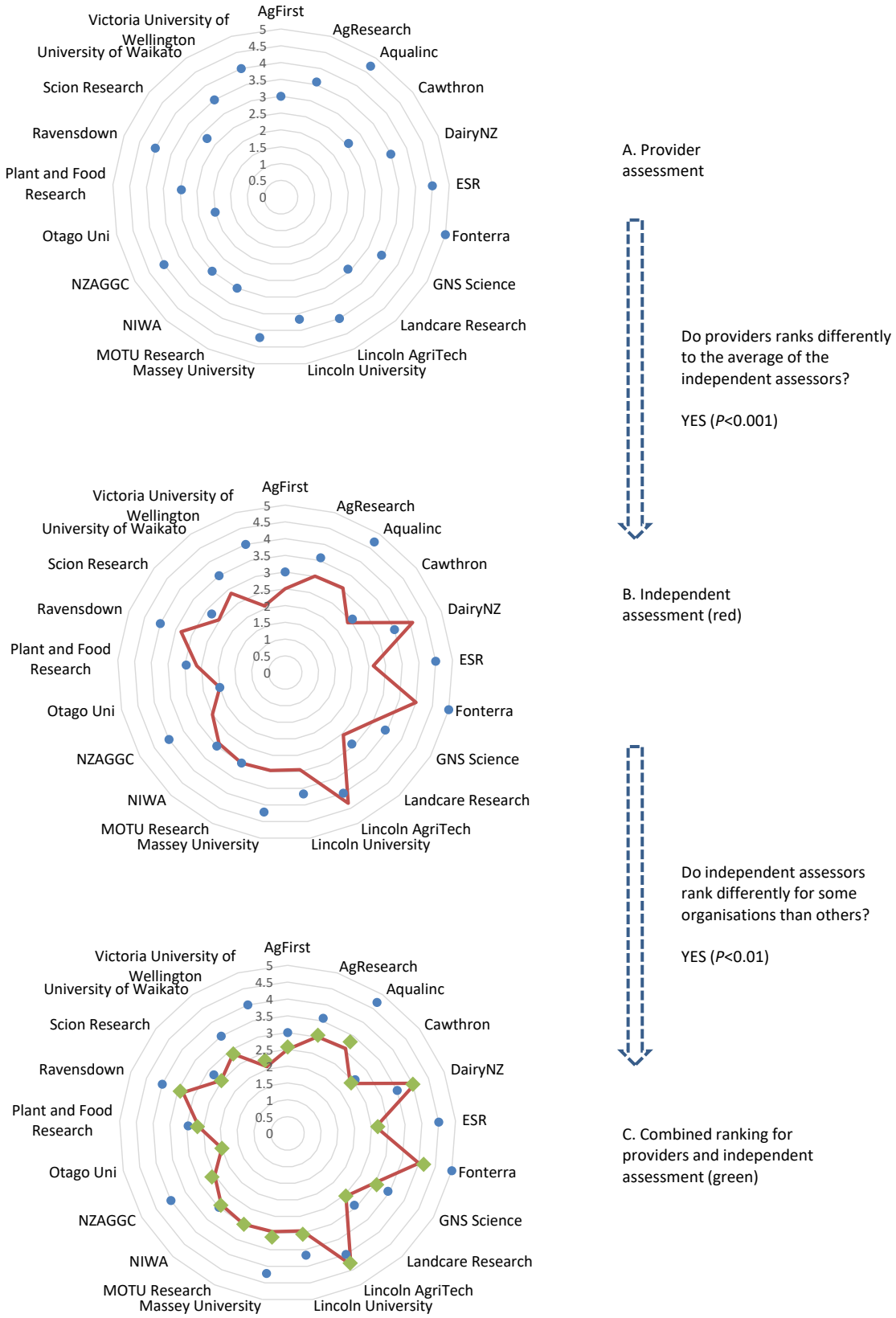

Figure 4. Mean scores for all programmes by organisation as contributed (A) (blue circles), (B) the independent assessors (red line), and (C) for both after adjustment (green diamonds).

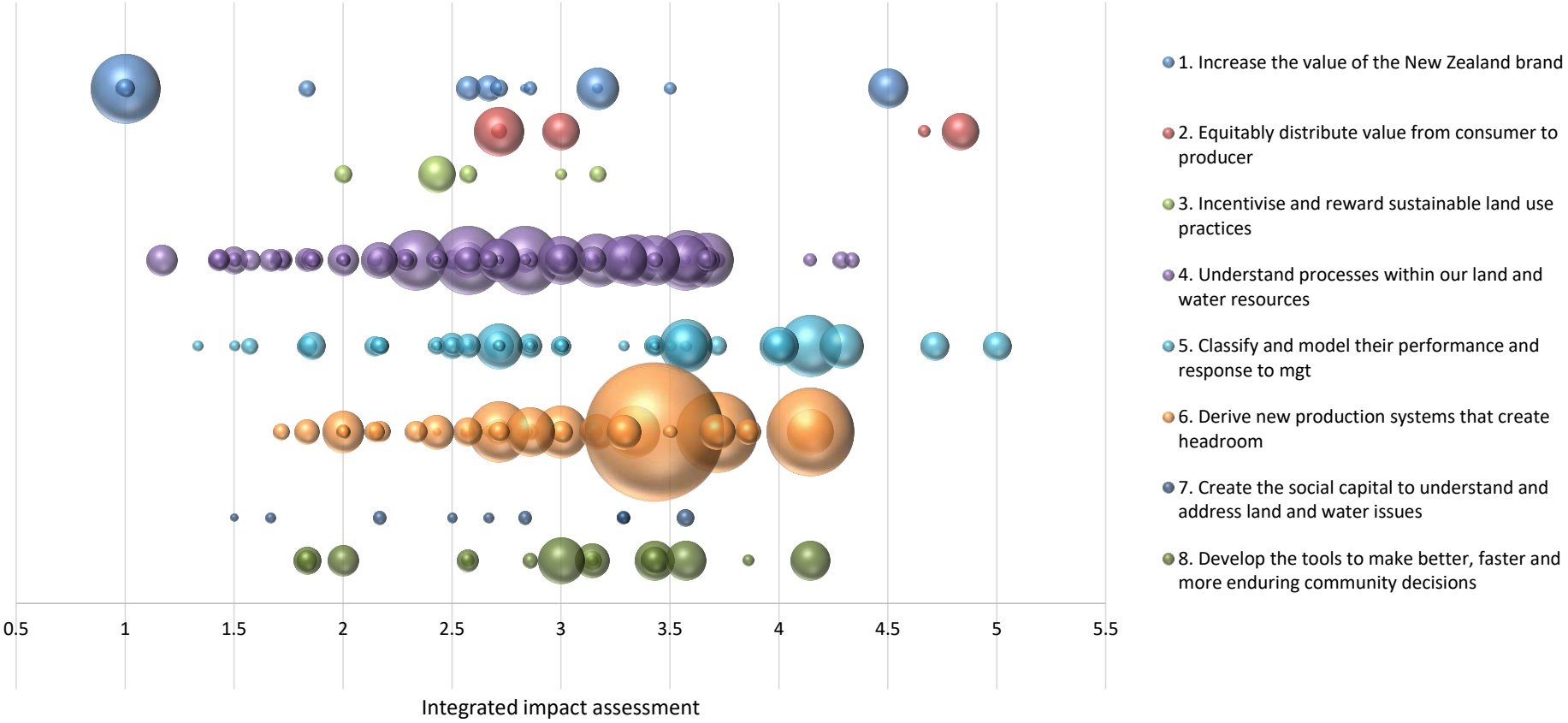

Figure 5. Integrated impact assessment (horizontal axis) and the magnitude of investment for each programmes (represented by the size of the bubble) according to their fit to strategic areas in the Challenge.

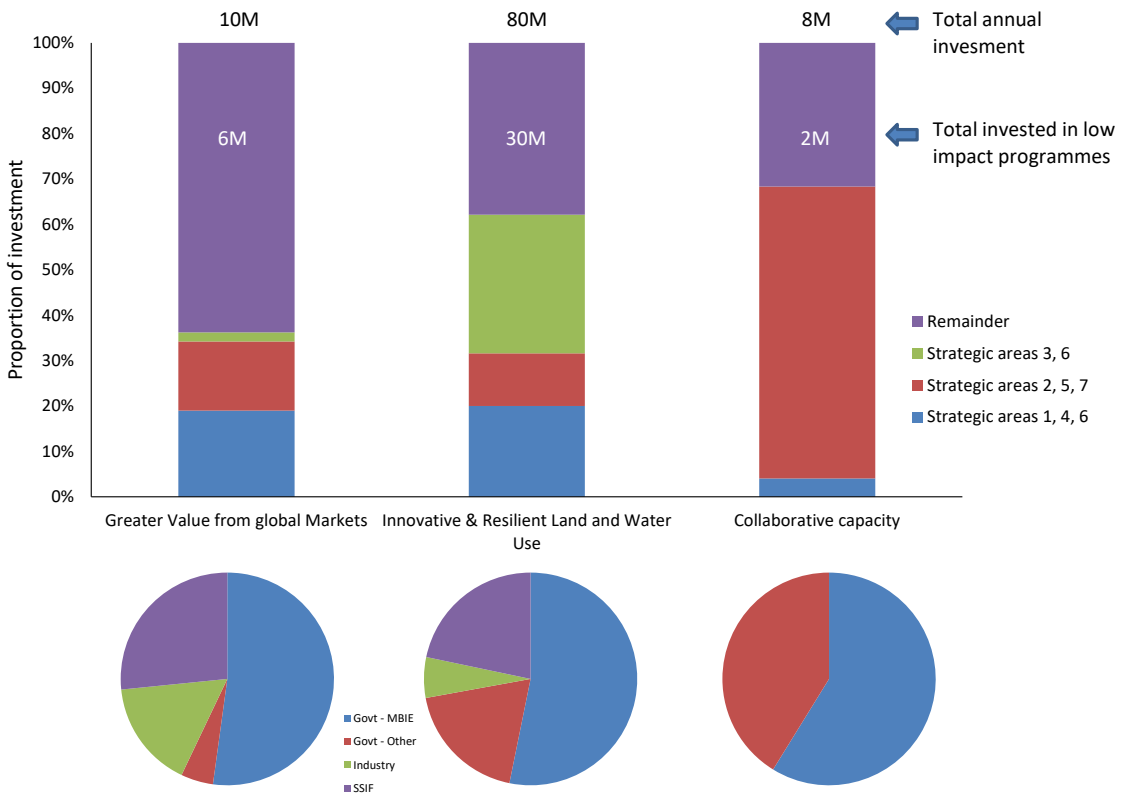

Figure 6. Mean proportional spend by theme and strategic area for moderate to very-highly scored programmes (top). The difference from the total annual spend gives the proportion spent on low to very low scored programmes for each Theme, and is broken down further by funding source (bottom).

4. Research gaps

Data for this edition of the RLM were consulted to see if any of the potential programmes listed in the revised Research and Business plan (to 2024 and itself informed by the Challenge Strategy) were being done. Unless the Challenge strategy (and therefore research areas) changes, the following potential programmes were not found in the data forming the RLM and therefore still exist as research gaps.

Table 5. Determination of potential programmes identified as still a research gap compared to the original strategy (see Appendix II).

Theme	Strategy area	Potential programme (revised research and business plan)[1]	Outcome from analysis of RLM data (gaps explained in footnotes[2])
Greater value from global markets	Develop mechanisms that increase the value of the New Zealand brand	1. Realising the value of the New Zealand story in key markets. 2. Capturing the value of cultural attributes.	**Yes – gap**. To be a component of gap 1 exploring what attributes enable Maori to gain better value beyond the NZ story.
	Equitably distribute value from consumer to producer along the value chain	3. Integrate value chains with sustainable land use practices	**Yes - gap**, if focused on implementing a transition to value chain
	Incentivise and reward sustainable land use practices	4. Quantifying and tracing the true value of sustainably produced products	**Think-piece** that combines 4 and 5 to see if rewarding sustainable production for better resource use can be decoupled from land value?
Innovative and resilient land and water use	Understand processes (e.g. attenuation of contaminant transfer) within our land and water resources	5. *Resource use efficiency and the value of ecosystem services*[1].	
	Classify and model their performance and potential response to management	6. Landuse suitability (Development and extension), collaboration with Deep South NSC 7. Modelling seed funding stage 3 (full integration)	**Yes – gap** **Yes – gap**
	Derive new production systems that create headroom to meet objectives	*8. New production systems and technology* 9. *New production systems utilizing gene editing*	**Think-pieces** to explore how 1) technology can be used to trace and prove sustainable production on larger farms with fewer people, and 2) how new technologies (e.g. molecular) can help derive the generation of functional foods with low environmental footprint?
Collaborative capacity	Create the social capital to understand and address land and water issues; and	*10. Long-term collaboration and incentives for change*	**Think-pieces** to explore how long-term collaboration can be used to incentivize and manage trade-offs with producing sustainable products, and to examine what are the best incentives for the right value chain and their relevance to policy?
	Develop the tools to meet objectives across space and time that result in better, faster and more	*11. Vision mātauranga - Extending micro-economic models nationally*	**Think-piece** to explore how to move the micro-economic models to different regions given the barriers of different

	enduring community decisions by individuals, communities and regulators.		ownership structures and objectives etc?

1 Potential programmes in italics are listed as needing a think-piece to build the evidence base before assessing it further.

2 – Potential gaps are summarized as:

Gap 1 & 2: What is the difference in value between producing a NZ brand or emphasising attributes associated with NZ?

A key issue facing NZ exporters is the difference between a New Zealand brand and exporting products based on NZ attributes and the potential difference in value of these. There is a lack of knowledge in how consumers in different markets value country of origin products compared to the value of the attributes that are associated with products. This is important for NZ exporters as to extract maximum value from the market. This gap also addresses the potential difference between value created from New Zealand made and Made in New Zealand. This is important as many of our ingredients for products such as infant milk formula are sourced from overseas and also some companies such as Zespri source from around the world to meet market demand.

Gap 3: How do we transition to an optimal Value Chain by facilitating uptake, changing culture and business models?

A key issue affecting the transition from supply chains to value chains is the change required both in culture and the business model. The culture change involves the change in vision of the key sector leaders and managers. This requires research into how these changes can be facilitated and the key ethnographic factors behind culture and its development. The change in business models requires research into the different types of modes and their relative application and success across different sectors. Exemplars could provide the key to facilitating change and providing confidence in their application.

Gap 4 & 5: Improving resource efficiency and clarifying the value of production

Think-pieces are proposed on how the estimated financial value of production from a value chain can be assessed via ecosystem services or other method to decouple sustainable production from land value by incentivising sustainable land and water management practices and maximising resource-use efficiency across land- and water-scapes.

Gap 6: Landuse Suitability (development and extension) and climate change (potentially in collaboration with Deep South).

Following the development of Landuse Suitability concepts and the regional application of a LUS tool, a second phase of work would look to extend the current concepts and tools nationally using the principles of co-design. Work is needed to better incorporate economic, social and cultural indicators within LUS tools. There is potential to extend the existing collaboration with Deep South to look at adaptation to climate change.

Gap 7: Modelling seed-funding

Dependent upon the success of stage 2, additional funding may be made available to extend and help uptake of the interoperable modelling framework to Regional Councils and any other interested parties.

Gap 8 – New Productive systems and technology

Think-piece to incorporate technological innovations into mainstream farm decision making. Technologies such as the Internet of Things (IoT) and low cost sensors have the ability to create a digital landscape that together with the utilisation of big data and artificial intelligence drive our productive systems towards on-farm automation delivering high value products with verifiable credentials.

Gap 9 – New production systems utilising gene editing

Think-piece examining and extending work in the soil-plant-animal microbiomes to generate high profit, verified, functional foods with a low environmental footprint.

Gap 10 – What are the drivers of implementation of collaborative decisions that result in enduring long-term outcomes and what are the best incentives and values chains to realise those outcomes?

Building on work done by the Collaboration Lab programme, a think-piece may be required to determine the specific social, cultural and economic drivers that result in successful on the ground implementation of collaborative decisions leading to enduring long-term outcomes region-by-region. The think-piece would then align these drivers with a review of different mechanisms (opportunities and barriers, including costs and benefits) and potential associated value chains to incentivise sustainable practices, including: (i) market-based instruments, e.g. the Emissions Trading Scheme; (ii) regulation, such as farm nitrate leaching limits; (iii) voluntary action, e.g. the Sustainable Land Use Initiative in Manawatu-Wanganui; and (iv) industry and publicly funded research and extension support, such as Sustainable Milk Plans in the Upper Waikato.

Gap 11 – What are the mechanisms for successfully scaling out micro-economic models?

The Mauri Whenua Ora programme is developing locally relevant micro-economic models (Pa to Plate) for enhanced social, cultural, economic and environmental outcomes to these communities in Te Ti Tokerau. We propose a think-piece to determine the key mechanisms for scaling out these micro-economic models to other regions in a way that is responsive to different regional ownership structures, community values, infrastructure and social and cultural capacity.

5. Conclusions

The development of a Research Landscape Map for the Our Land and Water NSC has resulted in three components essential in the development of a fuller and more focused research plan: 1) a rich understanding of the current research landscape particularly work that has the potential for medium to very high impact and therefore well aligned to achieving the Challenge mission; and 2) the determination of research gaps that relate to the original strategy.

There exists now an inventory of 226 research programmes which can complement the Challenge strategy and thematic-structure. Each of these projects has been assigned an impact score to help deliver the Challenge mission. This inventory will be made available to all, helping providers and stakeholders ascertain what research is going on, but also to integrate research within and outside of the Challenge.

Compared to the first edition of the RLM a number of factors were noted:

- Overall, there is less investment, especially as sources such as the PGP wind down, but this is being partly compensated by an increase in Challenge and industry funds; note that industry are only funding Theme 2.
- The distribution of funds within the biophysical sciences has changed a lot with increases in investment in precision agriculture/horticulture and water quality limits and mitigations, and reductions in all other areas.
- Both Themes 1 and 2 have shown significant increases in collaboration, and see value in 'building capacity' and 'knowledge into action' as principal enablers to achieving outcomes. Theme 3 also sees value in these enablers, but sees significantly more in 'connecting with society' and 'vision mātauranga' than Themes 1 or 2.
- The number and investment in programmes scored moderate to very high likely impact towards the Challenge mission was similar to the first edition of the RLM. This was fuelled by an increase in the number of SSIF-programmes. In contrast there was also an increase in the proportion of programmes scored low to very low impact with funded by MBIE. This suggests CRIs are aligning more funds towards the Challenge mission, but that proposals submitted to MBIE are not.

Using impact as a measure of alignment to the Challenge mission, research gaps were identified relative to the original strategy. Additional lines of inquiry may result from other processes. However, the identification of gaps should not be interpreted as a license for inclusion in the revised Challenge strategy.

6. References

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Appendix I

Harnessing the power of big data

This looks at the programme's ability to bring together heterogeneous and disparate data generated in science, practice, policy and society, into a dynamic, shared landscape of data that gets more widely used, is easily understood, integrated and analysed. It include elements of data gaps and interoperability.

Capacity building

Capacity building explores the degree with which New Zealand scientists are participating in trans-disciplinary research teams and collaborative processes, building capability through the supervision of students, mentoring new staff or replacing existing staff.

Connecting with society

Many New Zealanders remain sceptical about the value of science. Connecting with society aims to build trust and raising awareness of the value of science to meet society's aspirations around freshwater quality and the social license to operate. It incorporates aspects such as communication via existing outreach and education programmes, digital tools and social media.

Working together to turn knowledge into action

Effective uptake of research is built on a platform of knowledge (local experiential, indigenous and scientific) exchange and co-development between research and stakeholders throughout the process of generating knowledge itself and not divorced from it. The collaborative approach we propose to take will build on this trust and increase the diversity of relationships we can draw on to turn knowledge into action.

Vision Mātauranga

Māori play an active role in the management of land and water resources across New Zealand. The use of VM recognises Treaty obligations, tribal development aspirations and research that is of clear relevance and impact for Māori.

Appendix II

The plan to 2024

The next stage of the research to 2024 has a combination of existing programmes that will likely continue with some modification, and new programmes that are signalled, in a concept phase or as yet are unknown. New programmes will be informed by:

- A refresh of the Drivers matrix (foresight exercise);
- The Research Landscape Map (what's currently being done);
- Challenge workshops with stakeholders and providers (what could be done); and
- The Challenge Strategy and 20-year science roadmaps from MPI and MfE/DOC.

New programmes that are not already signalled will go through a think-piece process to develop the evidence base and research questions before progressing to an appropriate investment process (e.g. RfP, seed funding etc).

The programme logic remains unchanged unless the Challenge Strategy changes. The likely progression of existing programmes and the development of new programmes can be seen in Figure 7.

Greater value from global markets

We can get more value from our exports. Work up to and including 2019 will focus on integrating value chains, determining those indicators that are meaningful to producers and producing data on the water quality implications of our products. If we assume that participation in collaborative value chains will ensure that value is obtained and shared from consumers to producers, members of the Te hono movement aspire to realise a 20 per cent premium across the primary sector. To realise that premium, research needs to broaden from the value chain to develop the components of the New Zealand story to encourage certain land uses and land use practices, and how to communicate this into market, for selected case studies. This will draw on the research in other themes to:

- Assess the key qualities of New Zealand products under current and potential land use practices. The research will then test the value of these qualities and their New Zealand story in key markets with novel methods of communication.
    - Determine and capture the value of cultural attributes and how these can be used by different value chain methods (e.g. Mauri whenua ora's work on Pa to Plate) to equitably share value from consumer to producer and to link urban Māori with their ancestral lands.
- Develop robust and defensible standards for the authenticity and sustainable qualities of New Zealand products through various traceability options and the standardisation of disparate market reward schemes.
    - Defining the "optimal" value chain for a particular industry structure (e.g. collaborative, linear etc.) where it is clear that participants are rewarded for sustainable land use practices.
    - Defining the true cost (economic, environmental, social and cultural) of sustainably produced food using, for instance, life cycle analysis, natural capital and ecosystem services frameworks.

Innovative and resilient land and water use

Moving to the concept of land use suitability will derive a new way of valuing land according to its economic, environmental, social and cultural potential. The development of next generation primary production systems, together with land use suitability to place and time land use practices and enterprises, will give us more options for achieving a range of individual and community goals. Collectively this will double the total value of production, the profitability of individual enterprises, and the achievement of objectives for targeted land and water quality metrics for an average enterprise (in the catchment) within a generation.

To ensure that this outcome is realised, work will be continued in:

- The testing and validation of the land use suitability classification scheme across spatial scales, and embedding this scheme within tools used by communities (e.g. Iwi, freshwater management units).
    - Collaboration with the Deep South Challenge on adaptation to climate change may be extended further to incorporate more attributes of resilience within enterprises to climate change shocks.
- Interoperable modelling to set the protocols and standards that enable existing and new tools to talk to one-another and provide clearer explanations of uncertainty.
    - Objectives are being set by the programme's governing group, but will include landuse suitability classification.

Think-piece processes will be used to explore:

- Extending the assessment of processes within land and water resources within the Sources and Flows programme to those that include ecosystem services and resource use efficiency (potentially with MPI).
- New production systems that use the criteria set by rural entrepreneurs and tested within the first Next Generation Solutions programme. This will likely include work examining the utility of the "internet of things" to fully automate low-paid or high-risk roles.
- The utilisation and safety of gene editing to produce the high-profit and low-environmental (and cultural) footprint primary production systems (e.g. cultured proteins) required.

Collaborative capacity

We hypothesized that collaboratively designing solutions that balance individual and collective goals, hapū/iwi non-Māori economic entities and agribusinesses and communities, takes 20% less time and resources of current adversarial approaches, such as the Environment Court. These fit-for-purpose solutions will be 10% less costly to implement, taken up 40% more widely, are 10% quicker, and result in more enduring economic, social, environmental and cultural outcomes.

After 2019, work may continue to:

- Develop the micro-economic model (Pa to Plate) within the Mauri whenua ora programme, test and extend the model to other hapū/iwi.
- Action the potential to derive tailored Maori agri-business solutions to other regions.

Think-piece processes will be used to:

- Build the evidence for longer-term economic, environmental, cultural and social outcomes from collaborative planning and management of the supply chain.
- Developing incentives, with stakeholders, to enable transformative change from these collaborative processes and to address barriers (e.g. organisational rules) to embedding processes, tools and practices in their respective organisations and communities. If merited, this work is designed to run in parallel with that in the Greater Value from Global Markets Theme on using the value chain to incentivise sustainable land use practices.

The Challenge also recognises that building social capital involves significant investment in public engagement. Areas of research will involve:

- Demonstrating the true value of the primary sector to urban sectors.
- The expanded role of citizen science in delivering high quality data.
- The role of scientists as "honest brokers" (Pielke, 2007) of solutions for individuals, industry and policy in constrained catchments.

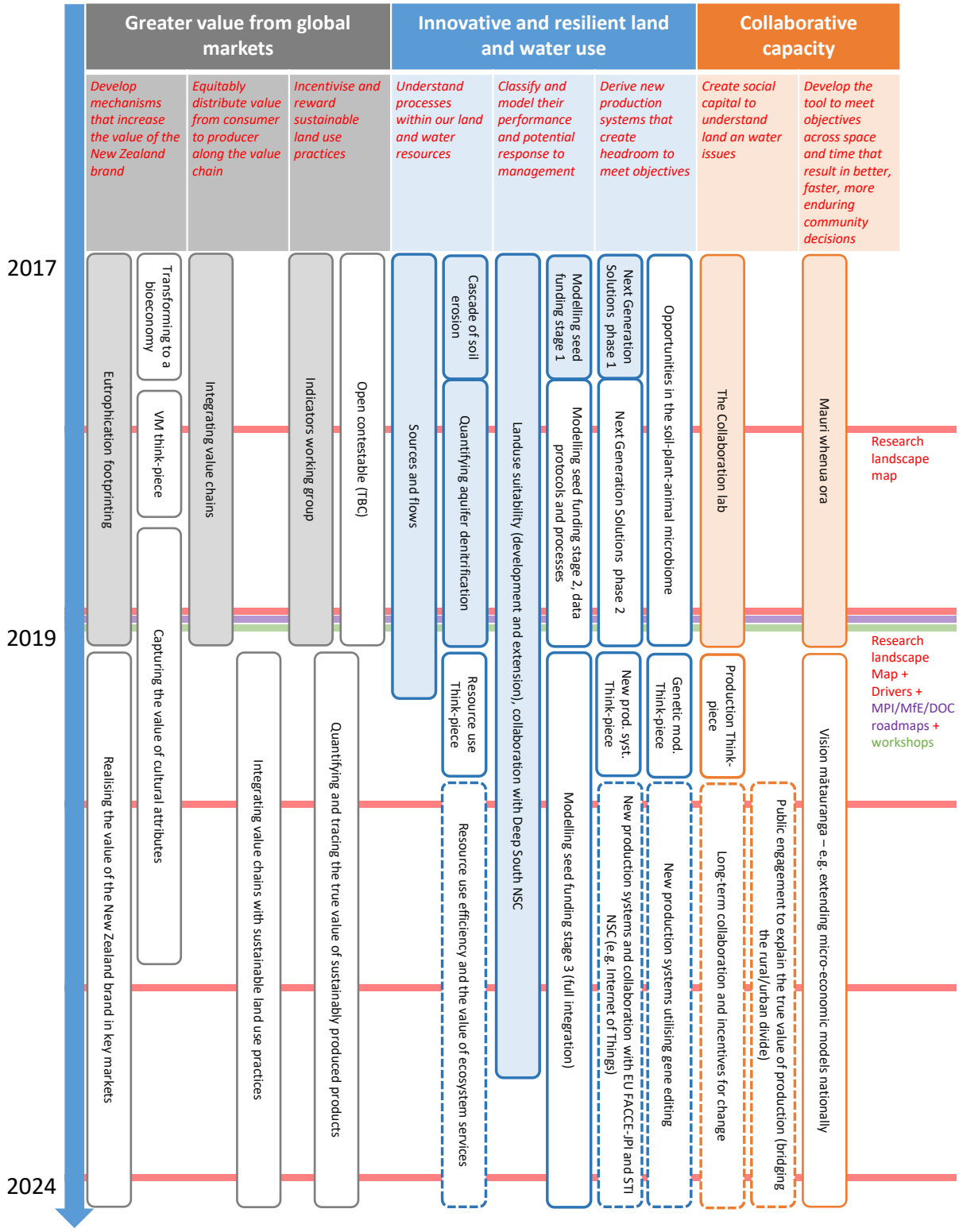

Figure 7. Long-term progression of programmes within the Challenge. Filled boxes are contracted programmes, unfilled boxes with solid lines are those tentatively signalled, and unfilled boxes with dashed lines are those programmes that are dependent upon the outcome of a pre-cursor think-piece.