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Indicators for the future
Lessons from Next Generation Systems

Our Land and Water Challenge

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Indicators and Next Generation Systems

Dear Caroline

As per our contract received 4 July 2017, please find attached our report on Next Generation Systems, a research programme in the Our Land and Water National Science Challenge. The report investigates use of the indicators for high-performing farms as determined by rural entrepreneurs and researchers in Next Generation Systems.

This is the seventh in a series of publications produced by the Indicators Working Group, chaired by Vicki Compton of the Ministry for Primary Industries. Please note that this report should be read in conjunction with the restrictions in Appendix C.

We hope that this report can help Our Land and Water better understand its potential impacts.

Yours sincerely

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Executive summary

Key findings from this project

There are a lot of potential indicators for the primary sector

Indicators are relevant variables, measured over time and/or space, that provide information on something of interest and that allow comparisons to be made. Primary production – farming, horticulture, forestry, fishing and so on – occurs in a social, cultural, environmental and economic context. It is complex, and so has many phenomena of interest.

PwC held a structured workshop with five lead researchers from the Next Generation Systems programme in the Our Land and Water National Science Challenge. The workshop produced a long list of potential indicators that covered many aspects of primary production, including the people, ecosystems, production, infrastructure and changes over time, as well as links to surrounding communities and to value chains.

The high-priority indicators are common ones

The workshop also included a focusing and prioritisation activity. It identified some key indicators that participants felt would be useful. They were:

- dollar-value indicators – profits, EBIT, production per hectare and per unit of input, and variability/volatility of revenue or earnings
- connectivity indicators – business connections and networks, local money flows, and indirect and induced impacts
- water quality indicators – macroinvertebrate community structure, swimmability and contaminants.

Researchers highlighted these indicators at the end of a process designed to emphasise farming systems and the wide range of possible indicators. Nevertheless, these selected indicators are, for the most part, common ones for describing farm system performance. The connectivity indicators are less common, but can be assessed using well-known techniques such as Social Network Analysis and macroeconomic input-output modelling.

Good indicators are difficult to find or create

The Indicators Working Group, which produced this report, has identified six criteria of good indicators and used them for a series of indicators projects. The workshop discussed these criteria with respect to the selected indicators.

The NGS researchers found flaws with all of the selected indicators. Some indicators are well-defined but too costly to collect widely. Some are less well-defined but relevant. Others, even the common dollar-value indicators like EBIT (earnings before interest and taxes) were acknowledged as only partly valid, capable of capturing only some aspects of performance.

It is useful to have both a systems view and a focus on indicators

The work of the NGS and this report take both a systems view and an analytical view of primary sector enterprises. Both perspectives are useful. The systems view reminds people involved in research, business and land management about the large number of stakeholders and the wide range of potential impacts. The analytical view can monitor and evaluate performance according to a number of metrics or indicators. It

can also improve the research by encouraging researchers and stakeholder to be precise about the impacts they are targeting or the effects they are observing.

This work adds to our understanding of indicators

This report presents the seventh and final project for the IWG since 2017. The projects have investigated communities, modelling, and other research from the perspective of indicators. This work with the NGS contributes to the understanding in the IWG about the use and application of indicators.

NGS is interesting for a few reasons. It involves researchers working with entrepreneurial farmers and land managers. They are able to report on thinking that crosses between research and business. NGS also has a well-developed idea of indicators and has applied them to an evaluation and prioritisation exercise. Finally, it takes an open view of possible land use rather than an industry view, because of its focus on system transformation. The particular perspective of NGS adds to our understanding of the use of indicators in the primary sector.

Introduction

This report is part of ongoing work on indicators

The Indicators Working Group (IWG) started in 2017 as an initiative by the Our Land and Water (OLW) National Science Challenge (the Challenge) to improve the use of indicators. OLW has two key goals, which are to:

- enhance primary sector production and productivity
- maintain and improve our land and water quality for future generations.

Indicators – measurements of outputs and impacts – will play an important part in guiding and evaluating those changes. For this work, we define an indicator as a relevant variable, measured over time and/or space that provides information on a larger phenomenon of interest and allows comparisons to be made.

PwC on behalf of the Challenge runs the IWG, which includes representatives from central government, the science sector and agricultural industries. The IWG supports the use and development of agri-environmental indicators by:

- coordinating work programmes on indicators and data
- disseminating results
- driving specific projects on the use of indicators in agricultural practices.

This report is the result of the seventh and last of the specific projects in the portfolio of the IWG's work.

The purpose of the research reported here was to work with the Challenge-funded Next Generation Systems (NGS) programme to investigate indicators for high-performing farms as determined by rural entrepreneurs. Identifying high-performing farms and investigating them is the work of NGS. IWG was working with researchers in NGS to draw out what they have learned about indicators and put it in the context of the whole IWG programme of work. The scope of work did not include primary research with farmers or land managers, or analysis or review of any data collected by NGS. This report should be read in conjunction with the Restrictions in Appendix C.

The IWG applied an indicator focus to the NGS programme

Next Generation Systems is a research programme in OLW and sits in the Theme 'Innovative, resilient land and water use'. NGS aims to support system change and transformation in New Zealand land use. Researchers are working with land managers and primary sector business by taking a systems view of their activities. They work to understand the systems in which the farms and enterprises operate, including the spatial, social and commercial systems. At the same time, NGS researchers have developed and used a multi-criteria decision-making (MCDM) approach that includes specific criteria for assessing the performance of primary sector enterprises.

NGS is connected to both a systems view and an analytical view of their partners' land uses. It is a good candidate for closer inspection with a focus on indicators. The IWG has been through a two-year process of:

- defining the criteria for good indicators
- investigating indicators for use in community discussions and integrated bio-economic modelling
- considering their application for evaluating progress on economic and sustainability goals.

The Group therefore has some expertise to investigate and evaluate the use of indicators by NGS.

The main activity for this investigation was a workshop with five lead researchers from the NGS programme. In the workshop, PwC guided participants through a series of activities. The first activities encouraged participants to take a systems approach and to describe one of their research projects holistically. The later activities shifted the focus to an analytical approach, to centre the discussion on possible indicators that could be relevant for the different projects. The workshop arrived at a discussion about possible indicators and their feasibility, with some key indicators captured on a collective list. Details about the workshop method and participants are provided in Appendix B.

This report presents potential indicators from NGS and further information about the research

The IWG has focused on reporting potential indicators for use across the three main groups of stakeholders: research, government and industry. This report starts with a discussion of the indicators that were elicited in the workshop. The discussion first catalogues the full list of indicators, and then presents the results of a more focused evaluation using six criteria for good indicators.

The report also presents the results of the more holistic, system-level activities from the workshop. These results provide context for the indicators, and also provide more information about the work in NGS. As part of that discussion, the existing work in NGS on criteria for evaluating land-use options is reviewed. The criteria are themselves another source of potential indicators.

As a result, this report contains two groups of potential indicators. The first group is a full reporting of many possible indicators and criteria that have been suggested, which collectively demonstrate the complexity of the issues targeted by NGS and OLW. There is much detail, which can support a focus on context and nuance. These long lists can be found in Table 1, which records results from the workshop, and Figure 3, which presents the MCDM criteria from prior NGS research. The second group is a short list of prioritised indicators, found in Table 2. While there are some caveats to the prioritisation, they are an unsurprising list of key indicators that are relevant across the stakeholder groups.

Indicators from NGS

This chapter presents lists of indicators

This chapter presents and evaluates the indicators discussed in the workshop run by the Indicators Working Group for senior researchers in Next Generation Solutions. The focus is on the indicators, rather than the NGS research or the systems thinking that supports the programme. The next chapter goes into more depth about the research.

The chapter presents a catalogue of all the indicators suggested by the workshop participants, developed in a structured brainstorming exercise. It then presents a shorter list of selected indicators that resulted from reflecting on and evaluating the long list. This chapter also presents two tools that were useful in the discussion. One tool is the AgResearch Resilience Framework, which is useful for taking an analytical approach to describing a system. The other tool is a set of criteria for good indicators, which the IWG has been using to evaluate indicators. The lists and tools provide insight into the use of indicators for NGS and the broader rural sector.

Researchers catalogued potential indicators

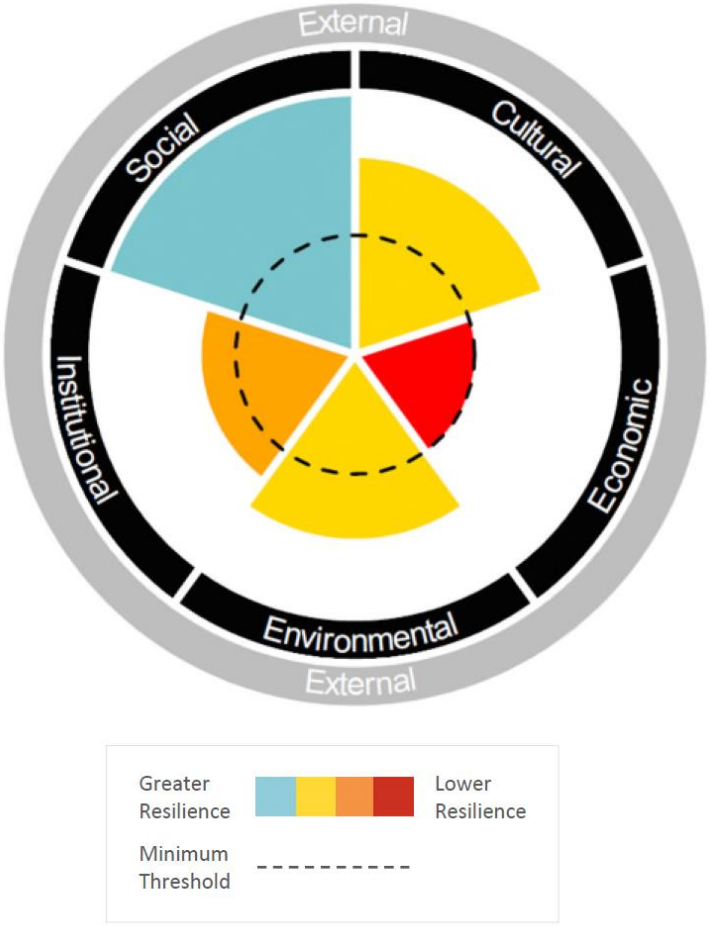
One of the activities in the workshop provided participants the opportunity to catalogue indicators to describe the performance of the farming systems they researched. This was an individual brainstorming exercise. To provide some structure, it used the AgResearch Resilience Framework. This section briefly presents the Framework and then reports the indicators suggested by participants. The Resilience Matrix worksheet used in the workshop is provided in Appendix B.

AgResearch Resilience Framework

AgResearch and PwC have developed a Resilience Framework as part of ongoing work to understand and describe resilience in rural communities. The Framework was produced in the Resilient Rural Communities research programme, funded by AgResearch to investigate the linkages between farms and communities. The Framework has been described elsewhere (Fielke, Kaye-Blake, & Vibart, 2017). It has been used to create structured descriptions of research projects (Fielke, et al., 2018) in a manner similar to attempts to normalise case study research (Colinet, et al., 2014). It has been the basis for community-based research on measuring resilience and the use of indicators (Payne, et al., 2018) and provided an organising framework for a retrospective of rural research (Brown, Kaye-Blake, & Payne, 2019).

The main infographic for presenting the Framework is shown in Figure 1. It contains six dimensions of resilience. The first five are cultural, economic, environmental, institutional and social. They are depicted as wedges in a circle, to indicate that they are both separate qualities but also form part of the whole of resilience for a system. This approach to depicting resilience highlights an important research question: whether more of one type of resilience (eg social resilience) can compensate for less of another (eg economic). The sixth dimension is external, which includes things that are external to the system being studied but affect or constrain it. The colours and sizes of the wedges in the infographic depict another aspect of resilience. Systems, such as households, communities or regions, are often described as being more or less resilient. This usage suggests that resilience can be described by its amount or quantity, represented by the size and colours of the wedges. The centre of the infographic also has a small, dotted-line circle. It represents the idea that there is some threshold of minimum resilience. Resilience literature suggests that some households or communities are not resilient. If a system falls below that threshold, then it can be considered ‘not resilient’ or vulnerable. Graphically, its resilience would be inside the small circle. In summary, the infographic captures several key ideas about resilience: separability, substitutability, quantification and thresholds.

Figure 1 The AgResearch Resilience Framework



Not included in Figure 1 is the idea of scale. Resilience research explores the different physical or geographic scales at which resilience operates. It might be personal or individual; it might concern the household or farm; it might encompass a community, region or watershed; or it might focus on larger national and global scales. Smaller scales can be nested in larger ones, and there can be interactions across scales. For the AgResearch Resilience Framework, the focus is generally on three scales: the farm household and the nation at the extremes, and the intermediate scale (community or region) in between.

The six dimensions and three scales can be combined to form a matrix, as shown in Appendix B. This matrix is a structure for focusing on each dimension and scale, one at a time. In prior work, the matrix was used to evaluate a programme of research by comparing the focus of individual pieces of research with the aims of the whole programme (Kaye-Blake, Dickson, & Stapley, 2017). This exercise indicated areas of emphasis for the programme and identified potential gaps for achieving its goals.

Workshop results

For the workshop, the Resilience Framework matrix provided a tool for prompting researchers to consider different aspects of their research and for eliciting possible indicators. The indicators that participants suggested are catalogued below, organised by scale and then dimension.

Table 1 Suggested indicators for Next Generation Solutions

Scale and dimension	Suggested indicators
Farm and household	
Social	Intergenerational respect, succession planned, jobs for our people, hours on tractor, sporting events attended, employment increased, employment diversity, employment quality (good incomes), 'good quality' jobs
Cultural	Succession planned, engagement with iwi, contribute to values, connections to land through business/employment, whakapapa and protection of wahi tapu and tikanga/story included in business and employment
Economic	Farm revenue/profitability, production per unit of land, production per unit of nutrient, return on investment, EBIT (earnings before interest and taxes), water use efficiency, maintain/grow earnings, okay to include investments in social and cultural growth (ie per cent of profit invested in social, cultural or other), earnings, diversity of portfolio, income from farm
Environmental	Water quality (measures); greenhouse gas (GHG) emissions; leaching losses; soil health; Trophic Level Index (TLI) for water; swimmability; water quality quotas; per cent carbon sequestration; meets and exceeds environment standard for N, GHG, sediment, phosphorus (P)
Institutional	Community engagement/inclusion of farming family, processor, meat companies
External	Improved local environmental quality, story used as marketing value-add, new product categories, connection through value chain
Community/region	
Social	Family valued/accepted in community, support industries, employment opportunities, whakapapa of business connections (business network) – nodes and strength
Cultural	Iwi, cultural impact assessment
Economic	Regional farm prosperity, cash movement through region, regional GDP
Environmental	Water quality (outcomes), GHG emissions, stream and river nutrient studies, water use efficiency, sediment losses, nitrogen (N) losses, N use efficiency (NUE), biodiversity
Institutional	Supply chain support of stainless steel
External	Improved catchment quality, regional marketing initiatives
National	
Social	New farming systems seen as exemplars, jobs, happiness, wellbeing
Cultural	Māori story
Economic	Industry growth, reduction in commodity boom and bust, steady growth in gross domestic product (GDP)
Environmental	Water quality; GHG emissions; meets and exceeds environment standard for N, GHG, sediment, phosphorus (P)
Institutional	–

Scale and dimension	Suggested indicators
External	International markets demand products

There are a few observation to make about the indicators proposed:

- The farm household scale had the most indicators proposed, while the community/region had fewer and the national scale had the fewest. To some extent, this is likely to be the result of the kind of research in NGS: future-focused farming systems. Nevertheless, this pattern leaves open the question of how indicators can be used to link farm-level changes with national-level policy and reporting.
- The economic and environmental dimensions had the most indicators that were readily quantifiable: dollars, indexes, efficiency measures, percentages, amounts.
- Many of the social indicators were linked to employment. Especially at the household level, some indicators focused on good jobs: enough jobs with diversity of opportunity and good incomes.

Researchers created a short list of key indicators

Criteria for good indicators

The list of suggested indicators in Table 1 provided the basis for further discussion and another workshop activity. The aim was to move from a broad list of aspects of the systems that researchers considered important, to a list of fit-for-purpose indicators. To inform that discussion, the workshop included a presentation on prior work on criteria for good indicators. This work was one of the first pieces of research conducted by the Indicators Working Group, and has underpinned all of the subsequent work. The aim is to keep bringing the conversation back to these criteria, in order to ensure that potential indicators are robust, useful and fit for purpose.

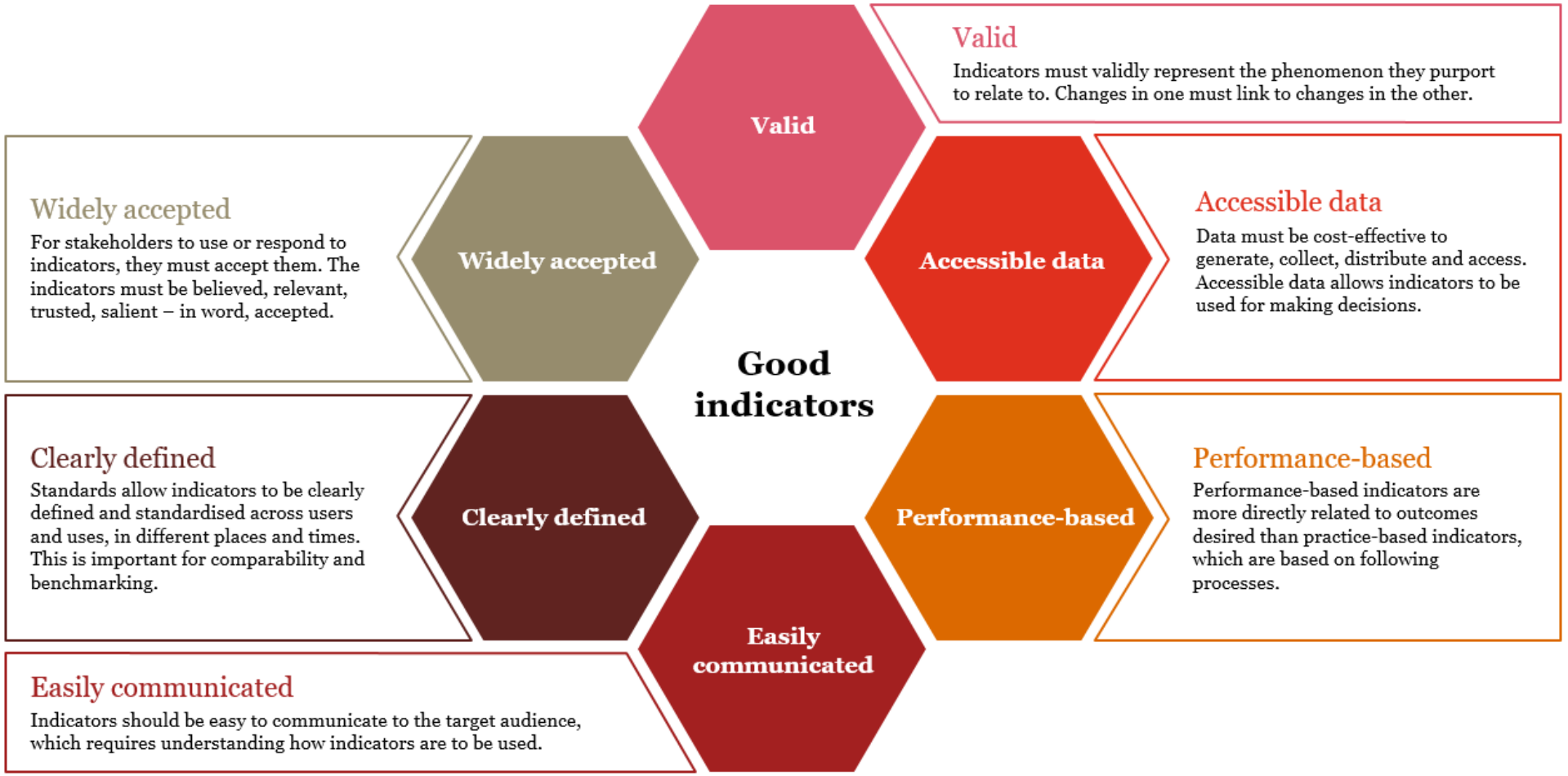
The criteria are summarised in Figure 2. They were selected after a review of a number of academic and official documents about indicators and their uses, including material from Statistics NZ and the OECD. While these sources listed many more criteria, these six cover the most important attributes of indicators. In particular, they support indicators that are relevant and measurable, and provide information about a phenomenon of interest consistently over time and space. They capture aspects of the two main themes of criteria about indicators: that they be both technically accurate and useable. PwC (2017) contains the full discussion of indicator criteria.

As shown in Figure 2, good indicators should be:

- valid
- based on accessible data
- performance-based
- easily communicated
- clearly defined
- widely accepted.

With these criteria in mind, the workshop turned to the final activity.

Figure 2 Criteria for good indicators



Selected indicators

The final activity in the workshop was a whole-group discussion about key indicators and the criteria for good indicators. Participants identified a few key indicators that they thought were important and initiated discussions about them. This activity was not designed to capture all of the indicators that had been raised during the workshop nor to exhaustively evaluate or rank them. As a result, the indicators that participants highlighted in their discussion were the ones that held their attention at the time, but should not be necessarily considered the only or most important indicators for NGS.

Table 2 presents the results of the discussion. There are several points to make about the indicators selected.

- The discussion (and thus the table) started with dollar-value metrics. Several money metrics were proposed, as shown. They include summary metrics at the farm or enterprise level, such as EBIT. They also include metrics that contain information about efficiency, such as dollars per unit of production or per hectare. Dollar-value metrics met all six criteria for good indicators. However, participants did note that they do not present a full picture of farm performance or of wider impacts such as environmental effects or preparedness for the future.

- The next set of indicators focused on how businesses connect in the economy and society. A number of indicators were proposed, mainly focusing on ways to capture connectedness or the extent to which businesses are networked with each other and with the communities in which they operate. One proposed metric combined dollar-value and connectedness, focusing on the value of indirect and induced economic activity. Another proposed tool was Social Network Analysis. One aspect of network analysis not explored was the fact that there are well-developed metrics of networks, such as measures of betweenness and clustering. While the indicators for connections did meet some criteria, they were not seen as well defined or widely accepted.

- The third set of indicators concerned water quality. Three indicators of water health or quality were raised: macroinvertebrate community structure (which has the associated metric macroinvertebrate community index – MCI), swimmability and contaminants (nitrogen (N), phosphorus (P), sediment and *Escherichia coli*). These indicators are commonly included in discussions about water quality, including policy discussions. Workshop participants judged that the indicators generally meet the six evaluation criteria. However, they raised concerns about swimmability as an indicator. They suggested that it had issues with its validity and acceptance, and that it was a human-centred assessment of water quality. For the other two indicators, the main concern was accessibility because data are not readily available.

This discussion was the end-point of the workshop. The workshop aim was to describe the farming systems being studied, identify the key aspects of those systems and then suggest indicators for those aspects. The workshop activities were successful in that participants were able to determine and evaluate indicators that would be meaningful for their research and to entrepreneurs. However, the results in Table 2 also show that there are issues with the indicators suggested. None of the indicators fully met all the criteria for good indicators. In fact, the participants identified deficiencies across the criteria. Indicators might be mostly valid, or only somewhat accessible, or not be widely accepted. The criterion with the least difficulty was communication: all of the indicators were judged to be easily communicated. These deficiencies, readily identified by the researchers, suggest that it may not be possible to have perfect indicators for these farming systems. Instead, there may be a set of 'good-enough' indicators that provide information to researchers and the primary sector, and are acceptable despite known weaknesses.

This list of indicators is also not unusual. The Indicators Working Group has been brokering conversations with people in research, government and industry. The dollar-value and water-quality indicators are well known and already used by these three stakeholder groups. The fact that researchers from a commercially-focused programme identified a set of largely known indicators provides important information. It provides some suggestion about the kind of work needed to develop indicators with impact. First, researchers noted that one weakness in the indicators was their accessibility, which requires cost-effective collection of data,

across useful spatial and temporal scales, and wide dissemination. The challenge is likely to be in obtaining the resources to collect the necessary data. Second, researchers also raised concerns about these common indicators. Most of the indicators were not considered entirely valid, and they also suffered problems with acceptability. It was not clear that the validity issues could be resolved: researchers noted that they were accurate but incomplete. Future work may need to focus on improving the acceptability of imperfect indicators and understanding the ramifications of their flaws, rather than attempting to create fully valid indicators. That is, it may be better to focus on their acceptability rather than their validity. This acceptance could be particularly important when considering how different actors view the primary sector differently, and so link indicators to wellbeing or success in different ways.

Table 2 Selected indicators and their evaluation

Indicator	Is it valid?	Is it accessible?	Is it performance-based?	Is it easily communicated?	Is it well defined?	Is it widely accepted?
Dollars – Profit Dollars – EBIT Dollars – per ha Dollars – per unit Dollars – variability/volatility	Yes – partly valid, along with diversity and social impacts	Yes	Yes – but is only one aspect	Yes	Yes – it is the indicator of choice for some industries. Question of cash flow vs returns	Yes
Business connections Business networks Social Network Analysis Local money flows Indirect and induced impacts	Diversity of portfolio of business	Yes, or may be – but not necessarily publicly available	They could be performance-based, such as a requirement that 50% of connections are women	Yes	Not clear on what is good or bad	Not for some stakeholders
Water – macroinvertebrate community structure	Yes – with some discussion on swimmability	MICS is not often measured	All three measure outcomes, especially MICS	Yes	Yes	Gold standard
Water – swimmability		Maybe – by looking at notices	Human-centred	Yes	Rubbery	Yes-ish, but not enough
Water – contaminants		–	Not the whole story	Yes	Level are unclear	Widely

System change through NGS

NGS supports system transformation in the primary sector

NGS focuses on exploring new land use options and new enterprise options for farmers and land managers. From a factsheet on NGS (Our Land and Water, n.d.):

> *Primary production industries are constantly changing in response to external factors like new market opportunities, consumer demands, changing community expectations of the social and environmental outcomes associated with the primary sector and technological innovation. These external forces for change will likely intensify over the next 10 years. Next generation land-based primary production systems will be critical to enable primary producers to double the value of New Zealand export returns while improving environmental performance. These systems may consist of one or more different land uses within a business enterprise or catchment. Land managers will need new land use options and new ways to select and configure their enterprise mix to simultaneously meet their business goals, those of the catchment and international markets.*

The focus of NGS is on the combination of adding value to exports plus improving environmental outcomes (Dynes, et al., 2017). Research suggests that this combination is feasible: evidence from modelling suggests that environmental outcomes such as nitrogen leaching are only weakly tied to economic performance (Smeaton, Cox, Kerr, & Dynes, 2011). NGS is targeting this combined goal by investigating the systems in which farms operate: the regions, the catchments, the value chains, and more (Dynes, et al., 2017). Researchers are considering dozens of criteria under six different domains: financial, market factors, social well-being, environment, regulation and the knowledge base (Dynes, et al., 2017; Renwick, et al., 2017), as shown in Figure 3. The aim is to have a 'system reset' – not just optimising existing farming system but transforming land use (Renwick, et al., 2017).

The NGS programme includes several projects. An initial project investigated the use of multi-criteria decision-making (MCDM) for prioritising land use in complex systems. The MCDM uses the domains and criteria mentioned above to evaluate land uses and inform decision-making. NGS is also working with businesses in land-based sectors to identify areas where transformation is needed, and then working with them to plan and implement those transformations. Along the way, researchers are testing the tools they develop and seeking to find and fill knowledge gaps.

A review of the publications from NGS shows that the researchers are working with both systems and indicators. They are taking a systems perspective with the farms and businesses in the programme. At the same time, they are using specific criteria to evaluate potential alternative land uses and prioritise them for land managers.

Figure 3 NGS domains and criteria for MCDM

Sources: (Renwick, et al., 2017; Dynes, et al., 2017; Dynes, 2017).

Researchers described the systems they are investigating

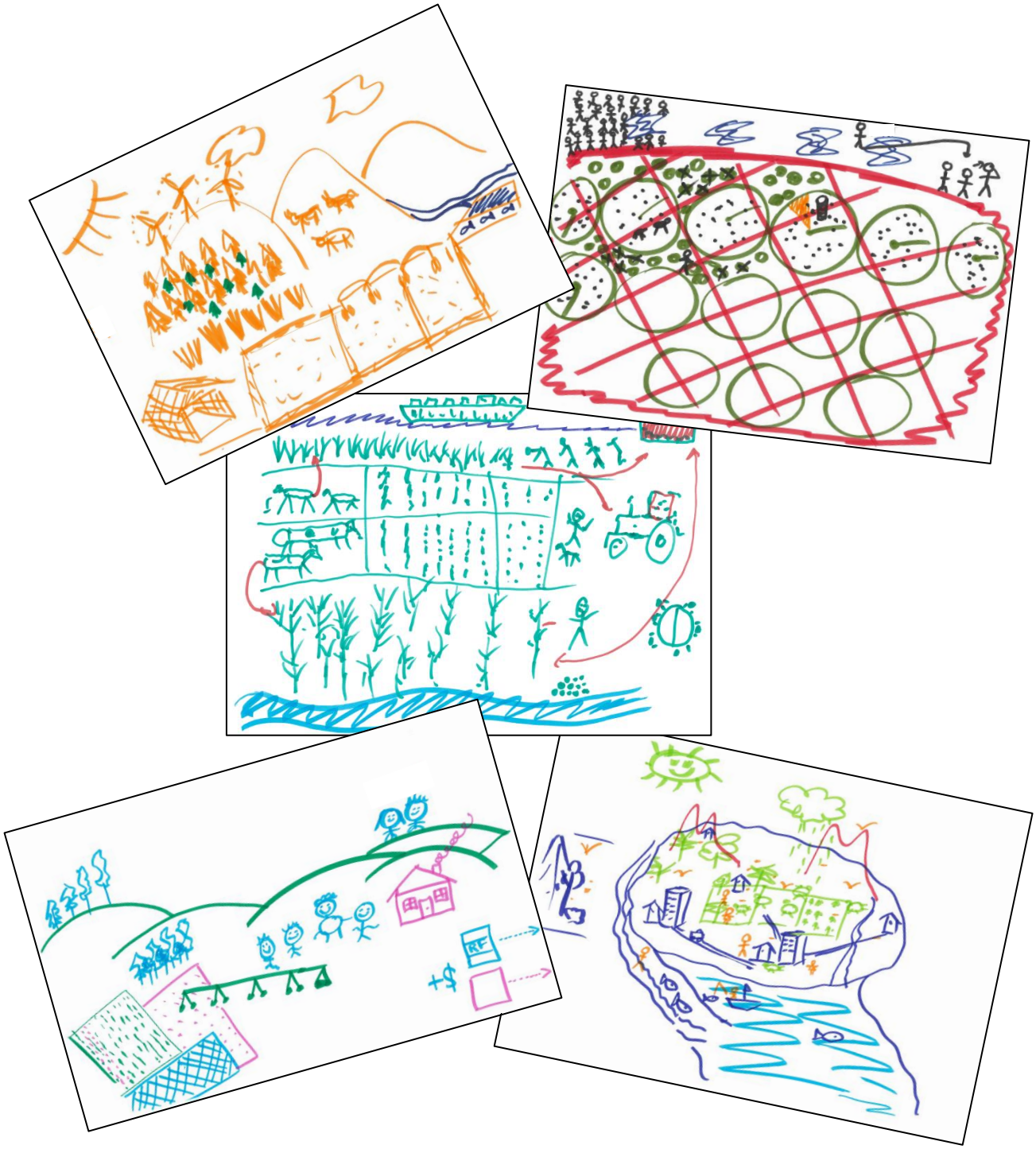
Pictures of systems

Participants were given two opportunities to describe a system on which they are working. First, they were asked to draw a picture of their farmer or project (Figure 4). All of the drawings were landscape-level pictures of farms or wider areas and included many different elements. Four drawings focused on a specific farm or place while one was of a theoretical farm system. Some drawings considered the system as it exists, while others considered the farm system as it could exist and presented a goal or target system. The drawings were completed individually on a large table in a meeting room, and they included a number of elements in common:

- **People** – four of the five drawings included people, including farmers, the farm family, farm workers, whānau and iwi, and community members. At least two drawings included non-farming people
- **Ecosystem** – the drawings included different elements of the landscape, including lowland paddocks, hills, and various waterways, as well as sun and rain
- **Crops** – crops were part of all the systems depicted
- **Trees** – trees were included in all the drawings, sometimes as integrated in the farm system and sometimes as part of the wider landscape
- **Animals** – four of the five systems included livestock and two included fish
- **Built infrastructure** – farm infrastructure was included in the systems, including irrigation, a shed, a farm house and a tractor. Wider infrastructure was also included: wind turbines, roads, town buildings, as well as boats, a factory and an airplane.
- **Movement** – all the drawings also had elements indicating motion: arrows to show flow of resources, or lines showing movement or falling rain.

There are two reasons to catalogue the elements contained in the drawings. The first is to underscore the complexity of the systems being researched in NGS. The participants were attuned to the current and the targeted complexity, and included many different elements in their drawings. For example, animals were part of most of the systems, but none of the systems was based exclusively on animal products: they also included crops and trees. The drawings were therefore more indicative of integrated systems than monoculture farms. The second reason to catalogue the elements is show the different boundaries being drawn around the systems. One or two drawings focused on the farmland owned and managed by the farmers, while others included depictions of the wider society or economy, such as a container ship or a four-storey building.

Figure 4 Illustrations of farming systems



System narratives

The second approach to describing farm systems used in the workshop was based on narrative. Participants were asked to outline a play based on their project. This approach sought to elicit information about stakeholders (the characters in the play) and the issues that they face (the dramatic conflict in the narrative).

Participants were asked to identify stakeholders belonging to two groups. They noted the following:

- **Main stakeholders** ('Main characters') – farm owner/manager; community representative, such as a mayor; iwi and iwi organisations; the farm family's children; whānau and hapū incorporation; CEO, Chair and Trustees of incorporation; shareholders of incorporation; land managers
- **Other stakeholders** ('Supporting characters') – farmer's family; random members of the public; farm managers and staff; iwi; extended family; industry groups; research teams and organisations; consultants and bankers; salespeople; regional and local communities; central government; local government; other iwi/hapū; neighbours; investors and financial institutions; forest managers; public; environment ('Who shall talk for the trees?'); value chain; workers.

These two lists provide some interesting material. First, the list of main stakeholders is shorter; the list of other stakeholders who might want to be consulted or have a say in the farming system is quite long. Second, there is overlap between the two lists. The farmer's family and children appear in both lists, as do farm managers, iwi and iwi organisations. Third, iwi, hapū and related organisations are considered main stakeholders in a Māori context, which suggests that decision-making and balancing of priorities could be complex for those farming systems.

The activity asked participants to describe the issues or problems that they see in their farming systems. The activity was organised as a fiction exercise, so participants may have taken some licence in dramatizing the issues. Nevertheless, the underlying issues are still pertinent.

Most of the farming systems were considered successful currently. They are productive and generating income for their stakeholders. Participants described successful farms, industries and Māori organisations.

The issues arose because the current situation was not see as sustainable. The issues could be grouped into three categories:

- **Commercial pressures** – Farming and forestry are under pressure to continue performing. However, they are contending with a number of difficulties. At the farm level, long hours and falling returns are putting more pressure on the farmer and the farm family. At the industry level, the concentration of the primary industry in dairy production is seen as a problem. For a Māori organisation about to harvest its forest, using that income to create some commercial opportunities and momentum is important. They are looking for ways to translate those resources into employment and connections to whānau/hapū businesses. At whatever scale, the commodity cycle was identified as a problem: the boom and bust puts pressure on farming businesses.
- **Environmental issues** – There is increasing pressure to reduce the environmental impacts of farming. This pressure is being felt at the farm level and the industry level, with signals coming from local communities and overseas governments and markets. For iwi, meeting the desires of whānau/hapū for healthy ecosystems is important. Specific environmental issues highlighted were water quality and greenhouse gases or carbon emissions.
- **Risk concerns** – Farmers and land managers are looking for ways to de-risk their enterprises. The risk seems to arise from having farms and industries that are concentrated in one activity, and from having long-term investments tied up in one industry, such as forestry.

These issues were connected to each other. Participants noted the tension between commercial drivers and environmental concerns, at the farm and industry level and for iwi. This was presented not just as a tension between competing priorities, but also as a conflict between the farmer and the surrounding community. They also noted the compounding effect of risk, which makes it more difficult to make changes to farming practices because of the constant commercial pressures.

The solutions revolved around three potential changes. The first change was towards new, mixed systems that were still profitable. This view of diversity as a tool for change came across in several ways. For one participant, the farmer would undertake a portfolio of activities on farm. For another participant, physical farms could become the site of multiple diverse activities undertaken by different people. For a participant focused on a Māori incorporation, creating a portfolio of diverse activities was the solution, and it could

include new investments as well as new activities. At the industry level, the solution was to diversify land uses.

The solutions also considered changes in governance. For one farm-based narrative, the solution was that the community would take a stake in the farm and de-risk the enterprise for the farmer. The farmer would be under less commercial pressure and could diversity on-farm enterprises, thereby creating opportunities for new on-farm employment. Solutions also emphasised the importance of having all staff involved. Outside the farmgate, these changes in governance were presented as new models for the industry, and as focusing on connecting to the land, the culture and networks of whānau/hapū businesses.

The third change was better information and knowledge. Change requires knowledge, experience, insight and resources, to scope the alternatives and pick possible options to try next. There was also a focus on getting clarity about trade-offs that are at stake. The work would include measuring performance and then managing it.

NGS researchers have a systems perspective

Through the workshop activities, the NGS researchers demonstrated their systems perspectives on the farming systems they are researching. They expressed in pictures and narratives the many different parts of the systems and the ways they interact. They also demonstrated a dynamic view of the systems: their current state but also the pressures they face. The researchers could articulate the potential for better farming systems in the future, with less risk, more diversity and better outcomes for the environment and stakeholders.

One question is whether there are gaps in the understanding of these complex systems. To look for gaps, holistic frameworks could be useful. Across NGS and the IWG, several frameworks have been used. The NGS MCDM framework, the AgResearch Resilience Framework and the criteria for good indicators are all tools for ensuring that broad perspectives and systems thinking are included in the research. These frameworks, however, are only as good as their application. Research needs to refer back to them and measure itself against them, to determine which areas or topics are well covered and where there is work to be done. The exercise reported here did not specifically look to assess gaps or weaknesses. Undertaking an assessment – and seeking to identify things that have not been previously considered – could be a useful next step. Land use change involves complexity across time and locations and people. Representing this complexity in a tractable way is likely to require the kinds of thinking support tools described in this report.

Appendix A References

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Appendix B Method

Purpose

PwC is running the Indicators Working Group for the Our Land and Water National Science Challenge. The group's focus is on fostering discussions among people in government, industry and research about the indicators required for their different priorities. It was tasked with working with the Challenge-funded New Generation Solutions/Systems programme to test the utility of indicators across different regions for high-performing farms as determined by rural entrepreneurs.

The IWG ran a workshop with lead researchers in NGS in order to elicit descriptions of the system changes they are working to support and to identify indicators that researchers and rural entrepreneurs could use to describe change and success.

Workshop description

PwC hosted the workshop on 12 November 2018 at the PwC Centre in Wellington. The participants were Robyn Dynes (AgResearch), Alan Renwick (Lincoln University), Lania Holt (Scion), Paul Johnstone (Plant and Food Research) and Warren King (AgResearch), as well as the PwC facilitator, Bill Kaye-Blake. The workshop was organised around four activities and a presentation:

- **Activity 1. This is my picture.** Participants were asked to draw a picture of a farm or project that was part of their research, and then describe it to the group. The aim of the activity was to start the discussion at the system level and to encourage participants to provide their own perspectives on which elements of a system are important.
- **Activity 2. Author, Author!** Participants completed a worksheet in which they wrote about their project from Activity 1 as if it were a play. They were asked to name the characters, set the scene (Act 1), describe the conflict (Act 2) and resolve the issues (Act 3). The aim of this activity was to develop the narrative around each project, and in particular identify the people involved and describe the elements of the system that need to change or could be changed.
- **Presentation. Criteria for good indicators.** PwC gave a short presentation about its work on indicators. The focus was on the criteria for good indicators or fit-for-purpose indicators. The presentation built on prior work by the IWG and served two purposes. One was to continue to tie together the different sub-projects within the IWG programme. The other was to provide information to the participants about the criteria for good indicators, as an input into the discussion.
- **Activity 3. Boxes, little boxes.** This activity presented the AgResearch Resilience Framework (Fielke, Kaye-Blake, & Vibart, 2017; Fielke, et al., 2018) to participants and asked them to fill in the boxes in the resilience matrix for the projects from Activities 1 and 2. The framework, developed by AgResearch and PwC over a couple of years, provides a way to describe different aspects of resilience. It includes six dimensions – economic, environmental, social, cultural, institutional and external. It also includes three scales – farm/household, regional/intermediate, and national. The dimensions and scale together form a matrix that is useful for focusing on one topic at a time as a step towards building a complete picture of resilience. The aim of the activity was to shift the perspective from a systems view to an analytical approach.
- **Activity 4. Making a list, checking it twice.** This activity was a group exercise in which participants listed indicators from Activity 3 on a large piece of brown paper and assessed them against the criteria in the PwC presentation on good indicators. The aim was to identify some indicators and encourage discussion about them.

Workshop materials

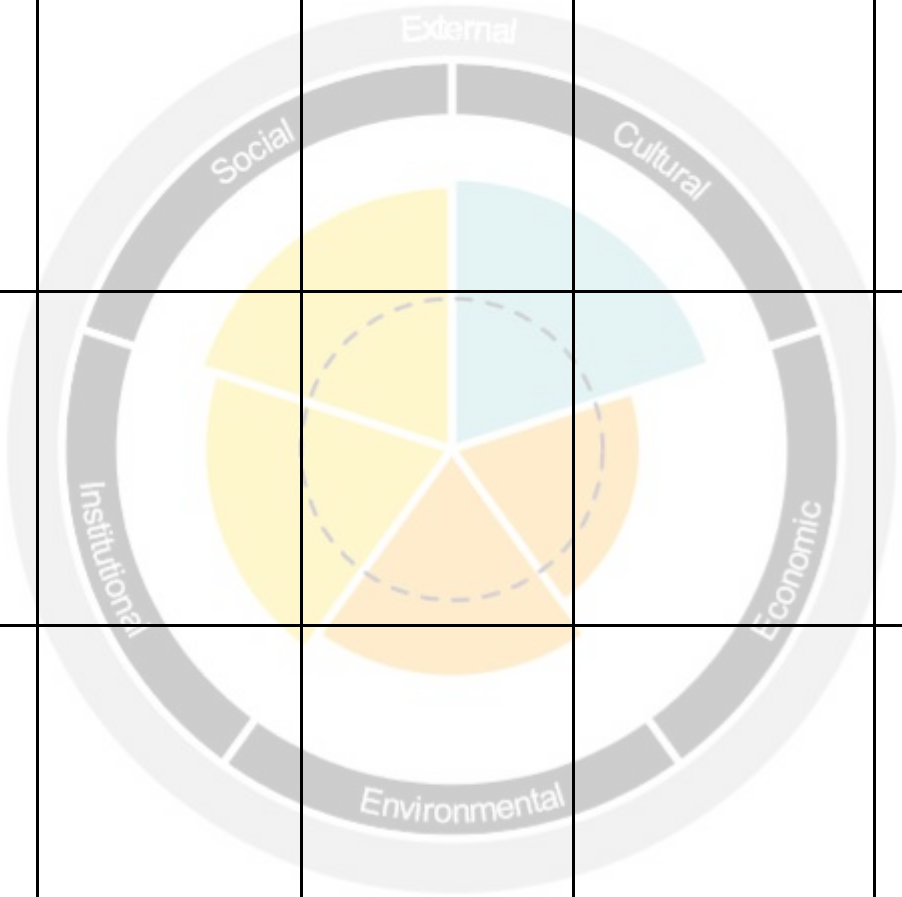
Author, Author!

Narrative plan for a play based on your research project

Cast	Main characters Supporting characters
Act 1 Set the scene – give us the background	
Act 2 Describe the conflict – what are the issues or problems?	
Act 3 Resolve the issues – how are the issues fixed?	

Resilience Matrix

Scale	Social	Cultural	Economic	Environmental	Institutional	External
National						
Community/Region						
Farm household						



Appendix C Restrictions

This report has been prepared solely for the purposes stated herein and should not be relied upon for any other purpose. We accept no liability to any party should it be used for any purpose other than that for which it was prepared.

To the fullest extent permitted by law, PwC accepts no duty of care to any third party in connection with the provision of this report and/or any related information or explanation (together, the "Information"). Accordingly, regardless of the form of action, whether in contract, tort (including without limitation, negligence) or otherwise, and to the extent permitted by applicable law, PwC accepts no liability of any kind to any third party and disclaims all responsibility for the consequences of any third party acting or refraining to act in reliance on the Information.

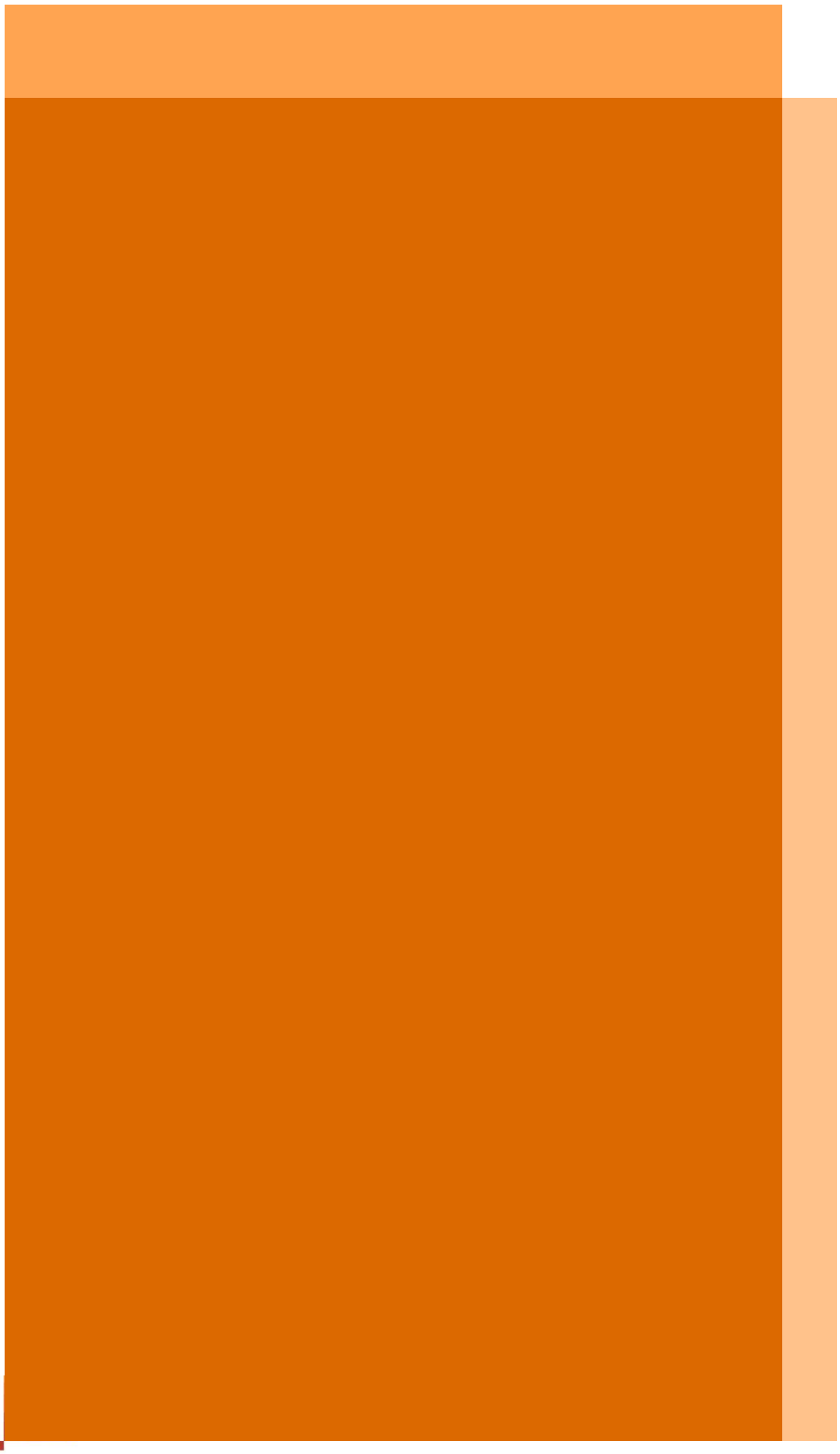
We have not independently verified the accuracy of information provided to us, and have not conducted any form of audit in respect of the organisation for which work is completed. Accordingly, we express no opinion on the reliability, accuracy, or completeness of the information provided to us and upon which we have relied.

The statements and opinions expressed herein have been made in good faith, and on the basis that all information relied upon is true and accurate in all material respects, and not misleading by reason of omission or otherwise.

The statements and opinions expressed in this report are based on information available as at the date of the report.

We reserve the right, but will be under no obligation, to review or amend our report, if any additional information, which was in existence on the date of this report was not brought to our attention, or subsequently comes to light.

This report is issued pursuant to the terms and conditions set out in our contract with the Our Land and Water National Science Challenge (via AgResearch) received 4 July 2017.



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