National
SCIENCE
Challenges

**OUR LAND
AND WATER**

Toitū te Whenua,
Toiora te Wai

Supporting complex decisions on land-use changes

WHO IS THIS RESEARCH BRIEF FOR?

Farmers and growers

Farm consultants

Rural professionals

Policy makers

RESEARCH CONTACTS

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AgResearch

RESEARCH TIMELINE

July 2016 – December 2019

Key points

This research plays a part in understanding, supporting and encouraging land-use change, specifically to 'next generation systems'. Next generation farm systems (such as redesigned or redeveloped systems and enterprises, new or novel enterprises, and new technologies) aim to reduce food production's environmental footprint and maintain or increase profit.

Deciding on land-use changes is a complex process that differs for every individual or group.

Phase 1 of the Next Generation Systems programme developed, tested and applied a multi-criteria decision-making (MCDM) framework for supporting decision making about land-use change. The MCDM framework provides the ability to simultaneously consider multiple assessment criteria.

Researchers worked with different types of land managers who were considering land-use changes.

How can this research be used?

Support decision making and identification of potential land uses

The MCDM framework can be used to engage and support land managers (individuals or groups) undergoing complex land-use change decision-making processes. It can also support decision making at other levels, for example by regional councils.

The framework can support decision-making processes from the outset, or those that are underway. It can also be applied to decisions that have been made. For example, by highlighting how well a current system fits the land managers' needs, the MCDM framework can indicate the extent of pressure for change

Working through the MCDM process enables land managers to quantify criteria, and to visualise the relative importance they place on each criteria. They can then examine their priorities against the relative attributes of different land-use options.

Direct efforts to encourage land use change

By providing a better understanding of land manager motivations and perceptions behind land-use change decisions, the MCDM framework can help direct efforts to encourage land-use change.

The framework facilitates discussion of the decision-making process, which can provide insights, such as factors that may be barriers or facilitators for land-use change, to support the quantitative results. This can help to formulate regional or national policies that may influence the behaviour of land managers to support land-use change.

By identifying land managers' needs and concerns in relation to land-use change, systems can be developed that better meet these needs and concerns. This could result in a greater chance of engendering land-use change.

Assess new technologies

For a particular system, the MCDM framework can be used to assess the extent to which new technologies can enable a positive shift in criteria valuable to the land manager, for example, reducing its environmental footprint. This can result in the system better fitting their requirements, and increase the likelihood of adoption.

Agricultural development in sub-Saharan Africa

The International Institute for Environment and Development's SENTINEL (Social and Environmental Trade-offs in African Agriculture) project is using the MCDM framework to inform agricultural development strategies in sub-Saharan Africa.

The project's vision is for public and private sector decision makers to take environmental and social impacts of agricultural development more into account.

The project will engage key stakeholders to build scenarios that simulate the complex factors such as climate change and population growth that affect agriculture and land use change.

Ultimately the project will support stakeholders to understand and refine scenarios to inform policies, investments and advocacy at sub-national and national level. Poor rural and urban households, which make up a large proportion of the population, will benefit from more coherent policies that support sustainable, resilient farming systems and key ecosystem services.

More information:
www.iied.org/social-environmental-trade-offs-african-agriculture

Why is this research needed?

Environmental, regulatory and associated social pressures are prompting discussion on land-use change in New Zealand. However, such change is a complex business decision which needs to meet the expectations of the land manager as well as wider society.

Some land uses, such as horticulture, have the potential for expansion due to market opportunities. They may have lower environmental footprints and provide a viable or even greater return, compared to current land uses. However, little progress has been made in transitioning to such land uses on the scale required to reduce food production's environmental footprint.

Deciding on land-use change is complex for land managers, with many land uses and a multitude of factors to consider. It is also a highly individualised process, with individuals' land and motivations for change coming into play. The chosen land use must best suit the individual context.

Ultimately it is the land manager who decides on land-use change, and to encourage transition, their decision-making process needs to be better understood and supported.

Identifying crops for hill country farm systems

The Integrating Horticultural and Arable Land Use Options into Hill Country Farm Systems project used an MCDM framework, developed by Perrin Ag's Liz Dooley, to help Taihape sheep and beef farmers identify crops to integrate into their systems.

At a workshop, crop alternatives suited to local farming areas along with some previously identified potentially important criteria were provided to farmers, who selected the crops and criteria of interest to them, and added any other crops or criteria of interest.

All farmers were interested or possibly interested in horticultural or arable enterprises. Higher-returning niche crops suited to smaller areas of flat land such as medicinal crops, and fruit trees, fruit bushes and nut trees were of greatest interest.

The important crop selection criteria for the farmers related to value chain success, crop production, enterprise fit, and environmental and biodiversity impacts. Criteria were weighted according to their preference.

Farmers then used the MCDM framework to assess and score the performance of the crops against their selected decision-making criteria.

Most of the farmers found the MCDM process relatively easy and rated it positively. The workshop also raised awareness of the range and variety of crops suited to the area, and people commented that they had gained new insights from using the MCDM process.

This project involved Massey University, Perrin Ag Consultants Ltd and Thought Strategy, with funding from the Our Land and Water Rural Professionals Fund.

More information:

Integrating horticultural and arable land use options into hill country farm systems: The Multi-Criteria Decision-Making Process. Report for Our Land and Water National Science Challenge, August 2021 (ourlandandwater.nz/RPF2020)

What did we do?

We considered the decision-making process land managers undergo when thinking about land-use change, and developed, tested and used a software-based MCDM framework that has the flexibility to effectively support this process.

Developing and testing the MCDM framework

A literature review, expert opinion and consultation with people involved in land management were used to identify and refine the key criteria individuals consider in land-use change decision-making processes. The criteria were then classified into six domains (see Figure 1).
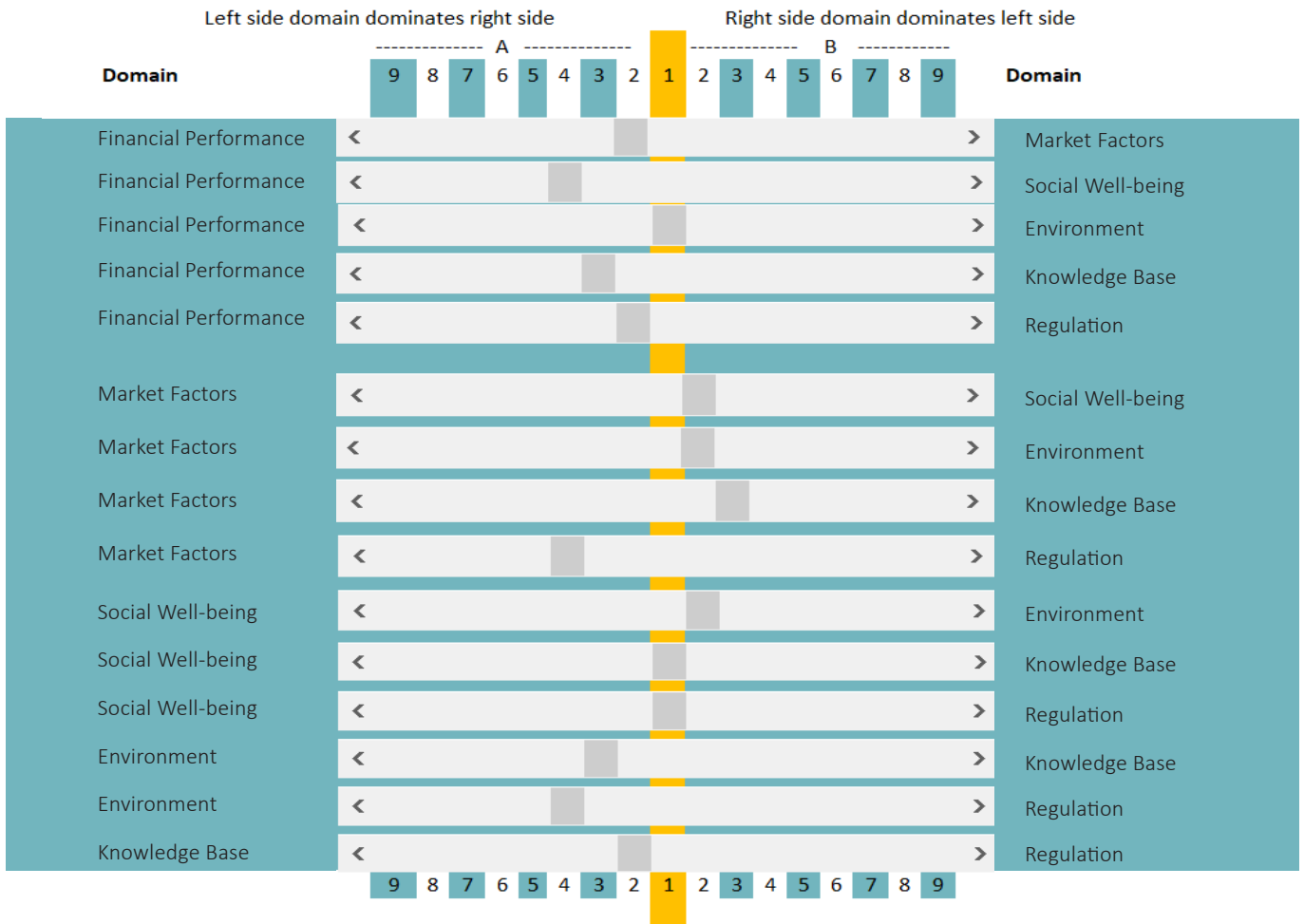
- financial
- market factors
- environment
- social wellbeing
- regulation
- knowledge base

To test the framework's viability, it was used with a variety of land managers who differed in their drivers for change, location, and business type. These included:

- a small family farm considering dairy sheep to generate income from a relatively small area
- a Māori corporate farm considering dairy sheep and horticulture as a way of generating returns from land coming out of forestry and to diversify from dairy
- a regenerative farmer considering hazelnuts to achieve sustainable land use at scale

Figure 1: Domains and criteria

Financial	Market factors	Knowledge base	Regulations	Social wellbeing	Environment
Capital investment	Market scale	State of personal knowledge	Water	Employment conditions	Nitrogen leaching
Overall return on investment	Ability to capture value added	Similarity to current	Animal welfare	Local employment	Phosphate losses
Profitability in return/ha	Supply variability	State of technology	Health and safety	Value distribution	Erosion/sediment
Payback period	Strength of supply chain	Advisory support availability	Food safety	Quality of life	Diseases e.g. *E. coli*
Variability in profit	Availability of labour	Level of confidence	Building	Cultural values	GHG emissions
Income diversity		Extent system is proven	GHG emissions	Noise/visual impact	Environmental stewardship

-------------- A --------------   -------------- B ------------

Domain	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Domain
Financial Performance	‹ ›	Market Factors
Financial Performance	‹ ›	Social Well-being
Financial Performance	‹ ›	Environment
Financial Performance	‹ ›	Knowledge Base
Financial Performance	‹ ›	Regulation
Market Factors	‹ ›	Social Well-being
Market Factors	‹ ›	Environment
Market Factors	‹ ›	Knowledge Base
Market Factors	‹ ›	Regulation
Social Well-being	‹ ›	Environment
Social Well-being	‹ ›	Knowledge Base
Social Well-being	‹ ›	Regulation
Environment	‹ ›	Knowledge Base
Environment	‹ ›	Regulation
Knowledge Base	‹ ›	Regulation

9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9

Using the MCDM framework

As the MCDM framework's strength is its ability to support individuals and groups, engaging decision makers to prioritise each domain, and the criteria within each domain, is key.

This is done using a graphically based analytical hierarchy process. It involves pairwise comparison between the criteria of interest, to determine their relative importance. Weights for each of the criteria are derived from this process, as highlighted in Figure 2, and these sum to one. These weights can be interpreted as indicating how much of the decision-making process as a whole is accounted for by each of the considered criteria.

In a further step, each land use system under consideration can be evaluated against the same criteria and then the two results compared to see how closely they fit the land manager's preferences, enabling identification of the preferred option.

Score	Definition	Explanation
1	Equal importance	The two domains contribute equally to the decision process
3	Moderate importance	One domain is slightly more important than the other
5	Strong importance	One domain strongly dominates the other
7	Very strong importance	One domain very strongly dominates the other
9	Extreme importance	One domain completely dominates the other in the decision process

2,4,6,8 can be used to express intermediate values

Weights

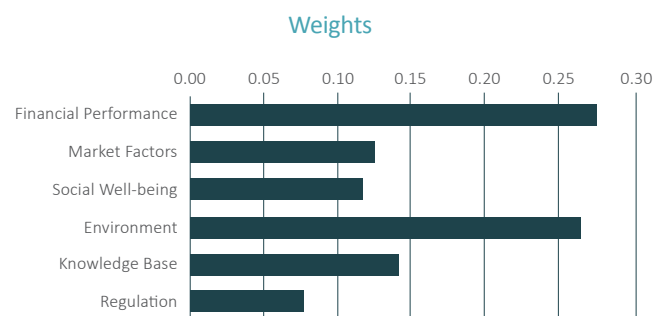|	0.00	0.05	0.10	0.15	0.20	0.25	0.30
Financial Performance							
Market Factors							
Social Well-being							
Environment							
Knowledge Base							
Regulation							

Figure 2: Screen shot of MCDM software, showing pairwise comparison between domains (below) and the resulting weights assigned (above)
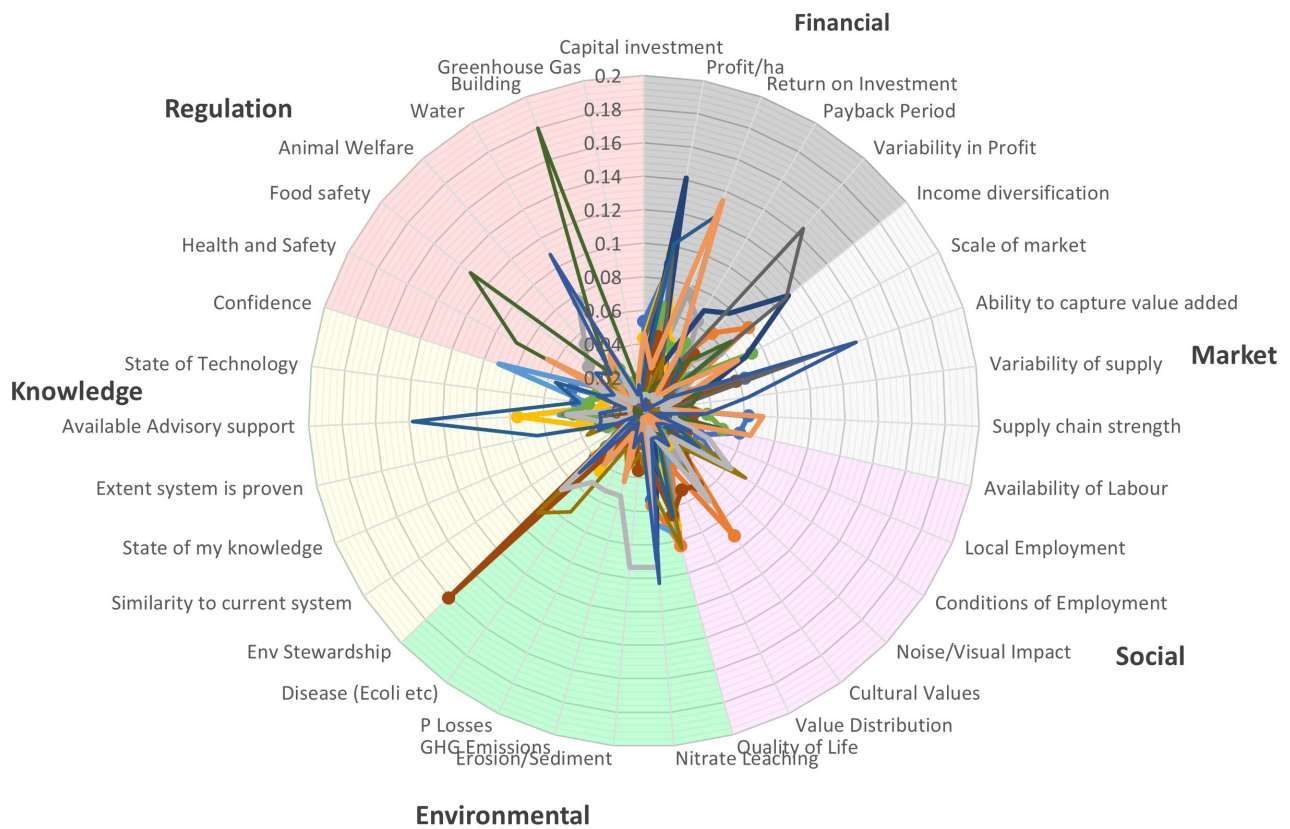
Figure 3: Screen shot of MCDM software, showing individual interviewees' results across the subdomains

Following development and testing, the MCDM framework was used with a variety of land managers with very different characteristics and requirements from system change. It was used to:

- increase the understanding of how to develop edible nut trees into a next generation system in the Rotorua lakes catchments

- assess factors influencing land managers (shareholders in the Central Plains Water Scheme) who were deciding whether to change their land use system when the development of an irrigation scheme provided an opportunity for transformative change

What did we find?

As expected, decision making on land-use change is context specific. The MCDM framework appeared able to capture effectively the individual contexts, suggesting it has the flexibility to be more widely applied.

The framework can also provide useful insights into the requirements of land managers and how research can support and de-risk land-use change decisions.

New irrigation scheme and opportunities for change

The MCDM framework was used to assess the factors influencing participants in Canterbury's Central Plains Water Scheme in deciding whether to change land use, in light of a new irrigation scheme providing a more reliable water source.

Ten land managers who were considering land use change or who had recently changed land use were interviewed using the MCDM framework. Financial factors were generally most important, with social, environmental and market factors of similar but lesser importance. Regulatory and knowledge factors were even less important.

The interviews also provided valuable insights into potential barriers to land use change (see 'Challenges of land use change in Canterbury').

Edible nuts in Rotorua lakes catchments

This research involved a Māori forest owner, a small block/lifestyle farmer and a sheep/beef/forest farmer who were all interested in integrating edible nut trees into their systems.

The most valued domains for the Māori forest owner and the sheep/beef/forestry farmer were 'environment' followed by 'social wellbeing'. The smallholder valued 'environment', but it was rated below 'regulation' and 'market factors'.

Analysis of the factors and forces that would affect the integration of tree nuts into existing systems revealed that scalability appears to be a key factor, and this could be strengthened through cross-sector collaboration.

Challenges of land use change in Canterbury

When the MCDM framework was used with Central Plains Water Scheme participants, the discussions that occurred illustrated some of the challenges of land-use change.

Many interviewees wanted to simplify their current complex system, so were seeking alternatives that could be implemented at a scale to help achieve this. Adding smaller enterprises could generate significant revenue per hectare, but only on a small scale, so could increase the complexity of their current system.

There was also recognition that collaboration across landowners could achieve the necessary scale to reduce complexity and also to develop new markets. Facilitating such collaboration could help.

Developing markets was also a key issue for many of the producers who were trialling alternative enterprises, with them having to find and develop markets as well as deal with production technicalities, which could take a lot of time for a small part of their overall business.

Some interviewees also mentioned the challenge of 'knowledge competition' as being especially prevalent in smaller scale enterprises when producers were less likely to share information for fear of losing their competitive advantage.

Results also highlighted that it is important for new land uses to be in accordance with the farmer's cultural values, especially for land to be productive.

If novel systems can be developed that better meet these needs and concerns as well as addressing the wider environmental and social challenges, then there may be increased land-use transition.

Next steps

The MCDM framework is now available to those working on land-use change.

There is an opportunity to engender land-use changes by supporting and facilitating the process of developing next generation systems to better meet the needs and concerns of land managers.

Key publications

Challenges and Opportunities for Land Use Transformation: Insights from the Central Plains Water Scheme in New Zealand. Alan Renwick, Robyn Dynes, Paul Johnstone, Warren King, Lania Holt, Jemma Penelope. Sustainability, September 2019. doi.org/10.3390/su11184912

Applying a Multi-Criteria Decision Making Framework to Facilitate Adoption of Next Generation Land-Use Systems in New Zealand. Alan Renwick, Jemma Penelope, Robyn Dynes, Warren King, Paul Johnstone, Lania Holt. NZARES – AARES One day forum, August 2018, Wellington. ourlandandwater.nz/future-landscapes/next-generation-systems/

Next generation systems: a framework for prioritising innovation. Alan Renwick, Anita Wreford, Robyn Dynes, Paul Johnstone, Grant Edwards, Carolyn Hedley, Warren King, Peter Clinton. Science and policy: nutrient management challenges for the next generation, Occasional Report No 30, Fertilizer and Lime Research Centre, 2017 ourlandandwater.nz/future-landscapes/next-generation-systems/

The case for a novel agroforestry system and cross-sector collaboration. Lania Holt, Alan Renwick, Paul Johnstone, Robyn Dynes, Warren King. Nutrient loss mitigations for compliance in agriculture, Fertilizer and Lime Research Centre, Massey University, 2019. ourlandandwater.nz/future-landscapes/next-generation-systems/

Beyond Sustainable Intensification: Transitioning Primary Sectors through Reconfiguring Land-Use. Karen Bayne, Alan Renwick. Sustainability, March 2021. doi.org/10.3390/su13063225

Applying a Multi-Criteria Decision Making Framework to Facilitate Adoption of Next Generation Land-Use Systems under review, not yet published

Balancing the Push and Pull factors of Land-Use Change: A New Zealand Case-Study. Alan Renwick, Robyn Dynes, Paul Johnstone, Warren King, Lania Holt, Jemma Penelope. Regional Environmental Change, February 2022. doi.org/10.1007/s10113-021-01865-0

Our Land and Water (Toitū te Whenua, Toiora te Wai) is working towards an agri-food and fibre system that enhances the vitality of te Taiao with a diverse mosaic of land uses that improve the health of land, water and people.

Our Land and Water is one of 11 National Science Challenges that focus on defined issues of national importance identified by the New Zealand public.

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Please use the following citation

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