Applying a Multi-Criteria Decision Making Framework to Facilitate Adoption of Next Generation Land-Use Systems in New Zealand

Alan Renwick (Lincoln University), Jemma Penelope (Lincoln University), Robyn Dynes (AgResearch),

Warren King (AgResearch), Paul Johnstone (Plant and Food Research) and Lania Holt (Scion)

LINCOLN
UNIVERSITY
TE WHARE WĀNAKA O AORAKI

Section 1
Background

1

Why Next Generation Systems?

Pushing Against our Boundaries?

New Zealand has had a successful growth model based on traditional farm enterprises

However, according to the OECD (2017), the country is experiencing:

- unprecedented levels of water scarcity and quality issues,
- very high per capita greenhouse gas (GHG) emissions,
- threats to biodiversity, and
- significant erosion.

Transformational Change

NZ is facing both external and internal challenges to its current model of primary production and it has been argued that business as usual or even incremental change is not sufficient to enable these challenges to be addressed

For example a lot of good work is being done around adoption of Good (Best) Management Practices. However, may be viewed as incremental change

Cutting edge technology key to meeting GMP

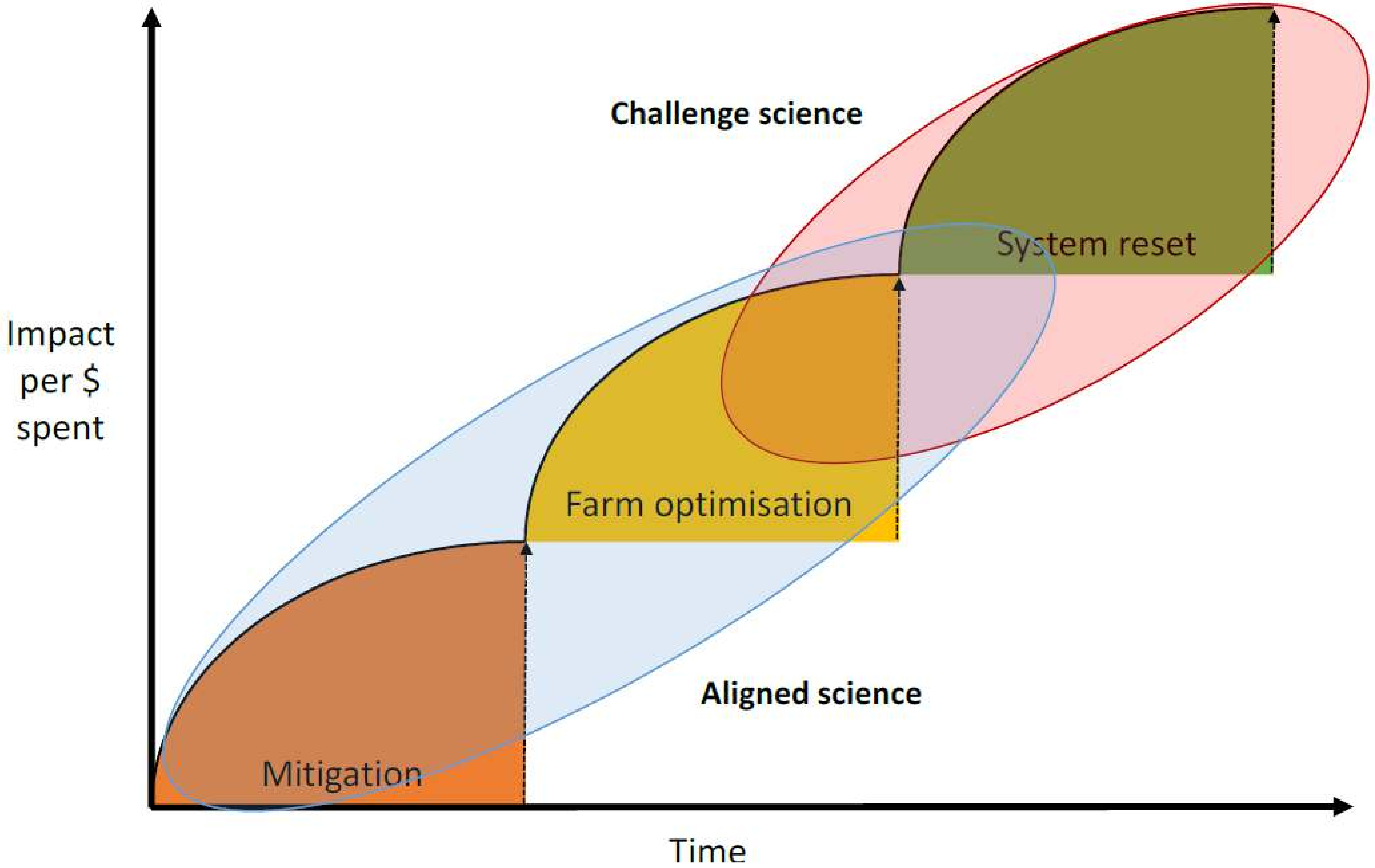
← News archives

Transformational Change

Whilst incremental change will be valuable, solutions to the complex challenges facing the land-based sectors must provide opportunities beyond systems optimisation to transformational change

This is the area where the Our Land and Water National Science Challenge sits

Within the broader context of the OLW Challenge, the project is concerned with identifying NGS and engaging with land-use managers to support the process of transformation



Source Richard McDowell, OLW

What do we mean by Next Generation Systems?

Next-generation systems will include redevelopment or redesign of existing enterprises and production systems, wholly new or novel enterprises, and new technologies that add options across temporal and spatial scales.

Systems may cover a broad range of pastoral, arable, horticultural and forestry industries.

Pick a Winner?

Manuka Honey
Dairy Goats
Dairy Sheep
Cherries
Kiwifruit
Truffles
Mixed use forestry and nuts
Hemp …

Pick a Winner?

Tamarillos

Passion fruit

Raspberries

Plums

Apricots

Pears

Blackcurrants

Strawberries

Boysenberries

Feijoas

Peaches/Nectarines

Table Grapes

Honey & Manuka

Cherries

Avocado

Persimmon

Blueberries

Kiwifruit

Apples

Wine

Chestnuts

Hazelnuts

Beetroot

Truffles

Peas

Walnuts

Potatoes

Tomato

Carrots

Onion

Lime

Lemon

Squash & Pumpkin

Sweetcorn

Tangelos

Navel Oranges

Cucumber

Beans

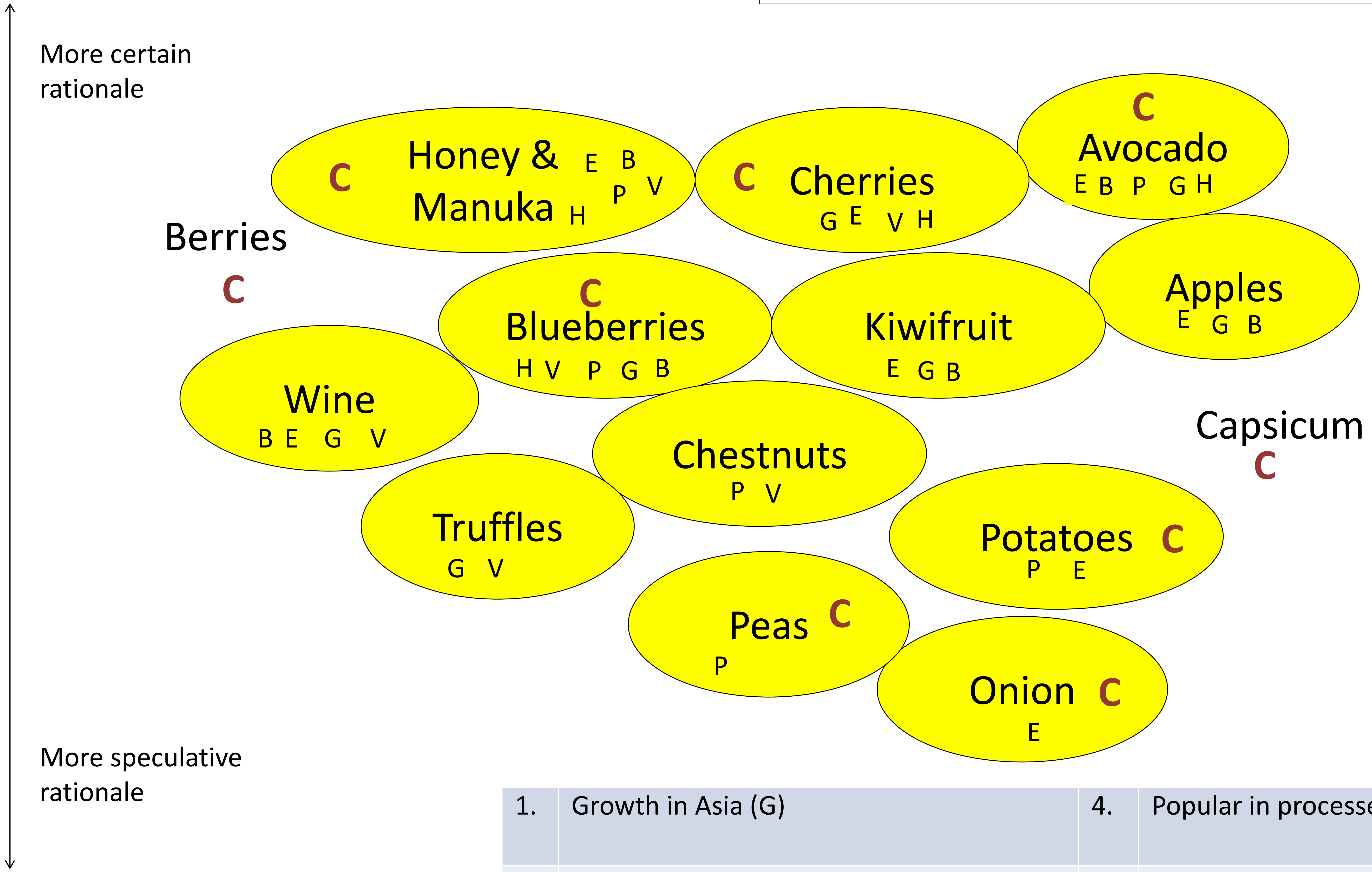
Capsicum/Chillies

Satsuma Mandarins

Source SLMACC: Evaluation of profitability and future potential for low-emission productive uses of land that is currently used for livestock

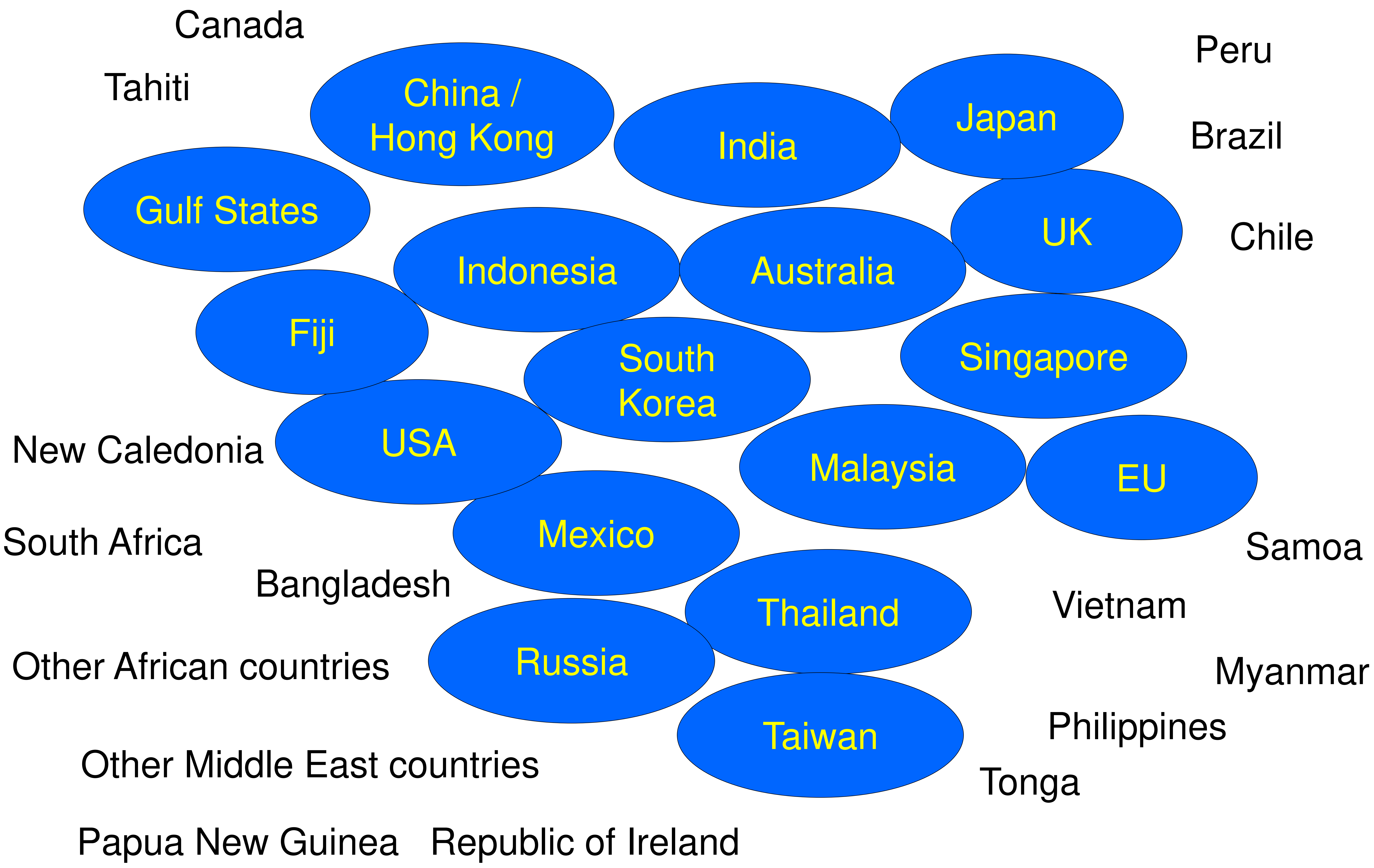
Key:

- Letters indicate rationale from our selection criteria table
- Red “C” indicates product selected in Coriollis Research
- Circled products indicate those in our product selection basket

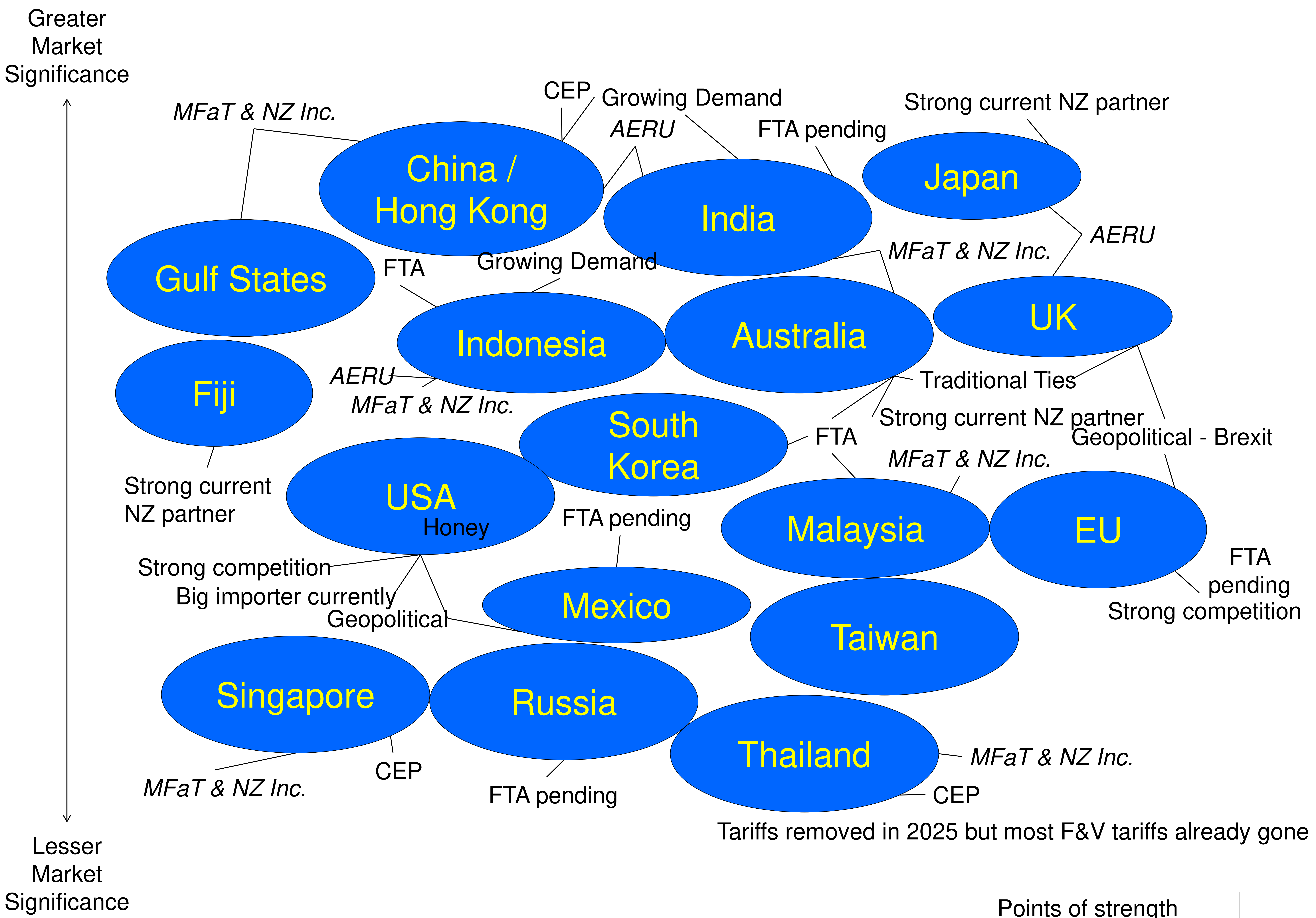


1.	Growth in Asia (G)	4.	Popular in processed foods (P)
2.	Premium/High value product (V)	5.	NZ Band recognition/position (B)
3.	NZ export growth or volume (E)	6.	Unique health benefits (H)

Source SLMACC: Evaluation of profitability and future potential for low-emission productive uses of land that is currently used for livestock



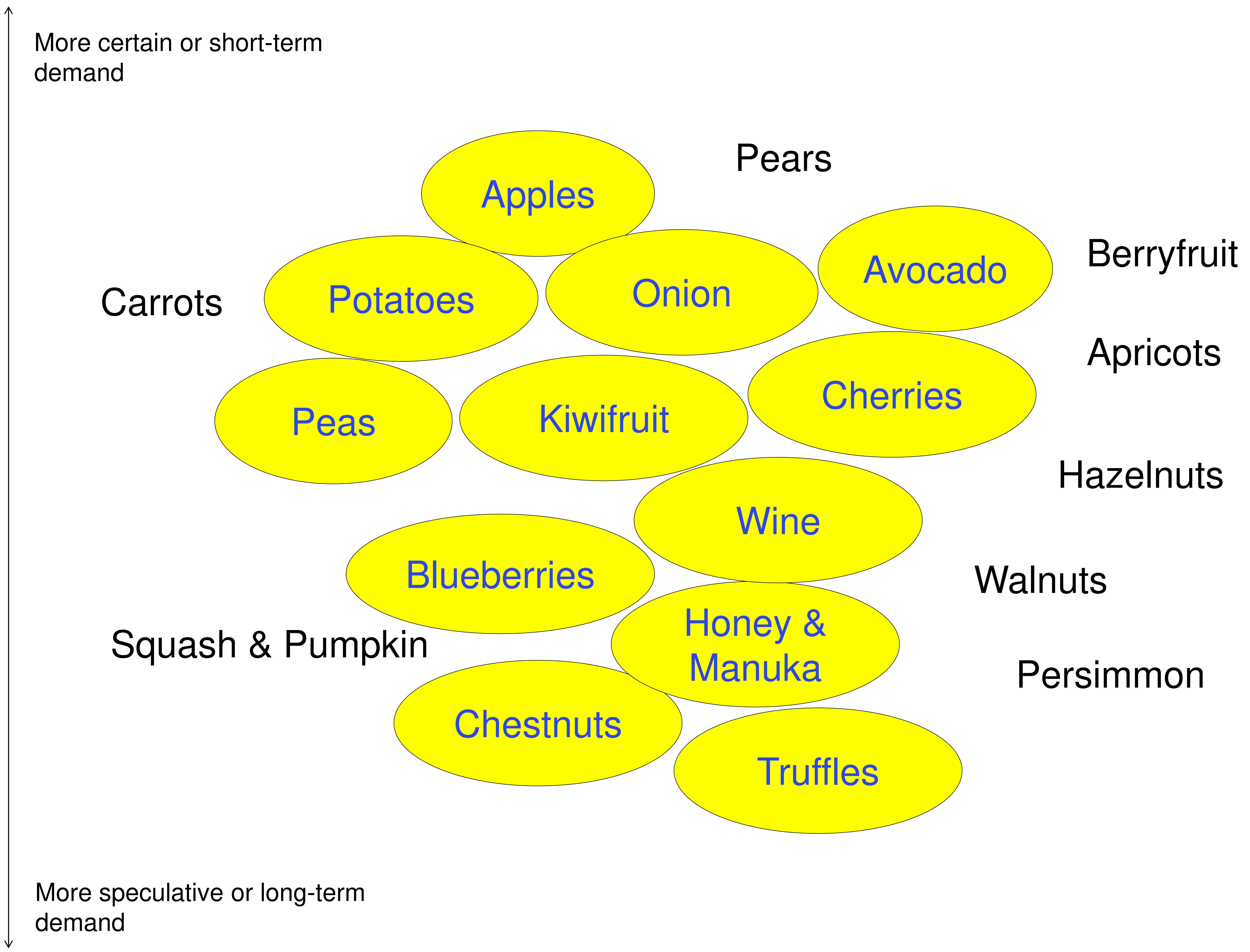
Source SLMACC: Evaluation of profitability and future potential for low-emission productive uses of land that is currently used for livestock



Key: Points of strength

Identified in research by

Source SLMACC: Evaluation of profitability and future potential for low-emission productive uses of land that is currently used for livestock



Source SLMACC: Evaluation of profitability and future potential for low-emission productive uses of land that is currently used for livestock

Land-use Context Specific: Opportunities and Challenges Across New Zealand

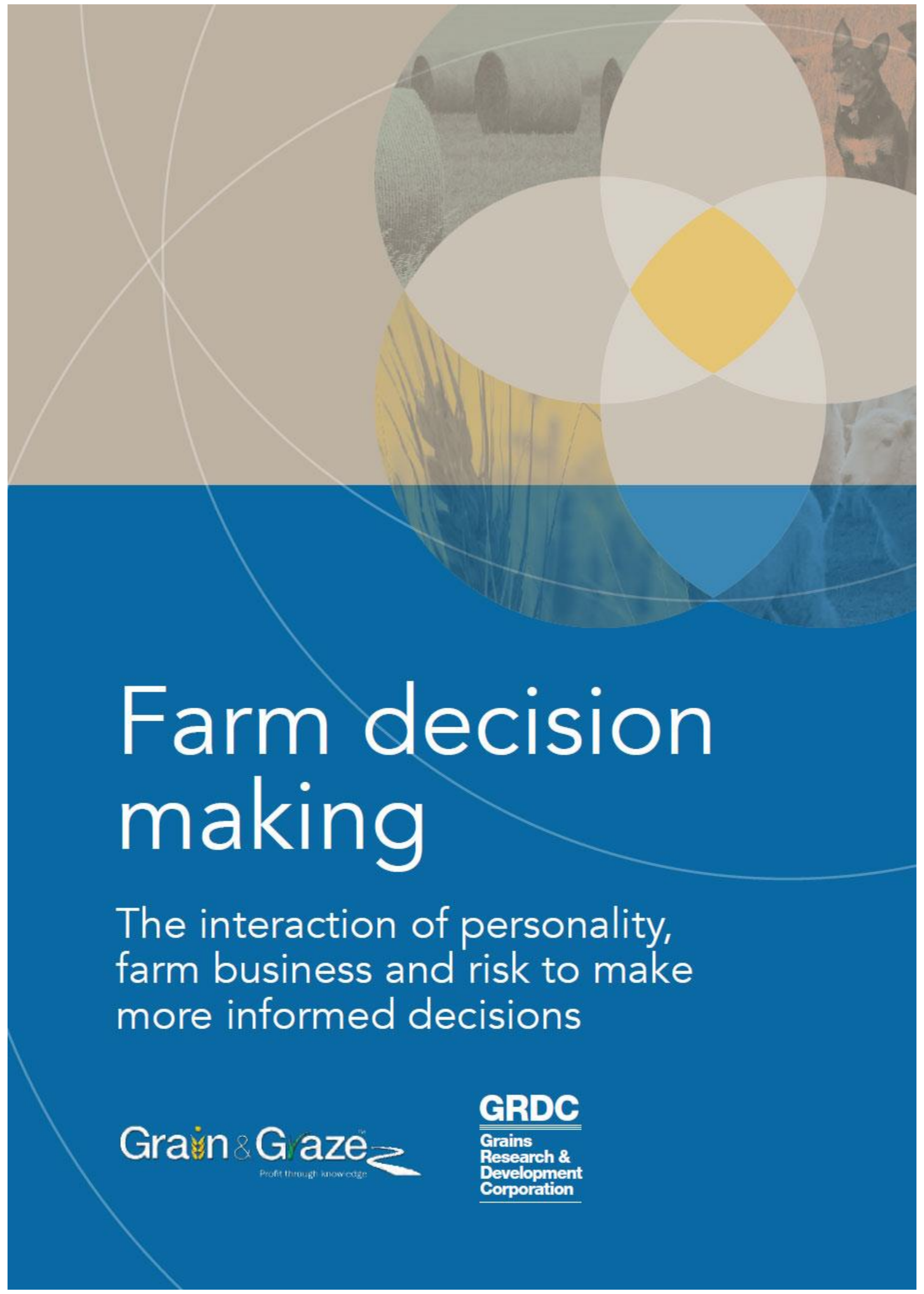
Irrigation Schemes
Environmental Regulation
Maori Agribusiness
…
…

System change is determined by those managing the land

Any system change has to match the needs of the land manager.

Therefore we need to understand these needs

Considerable work undertaken on understanding decision making, barriers to adoption, sustainable land use etc.



Section 2

The Framework

Multi-criteria Decision Making (MCDM)

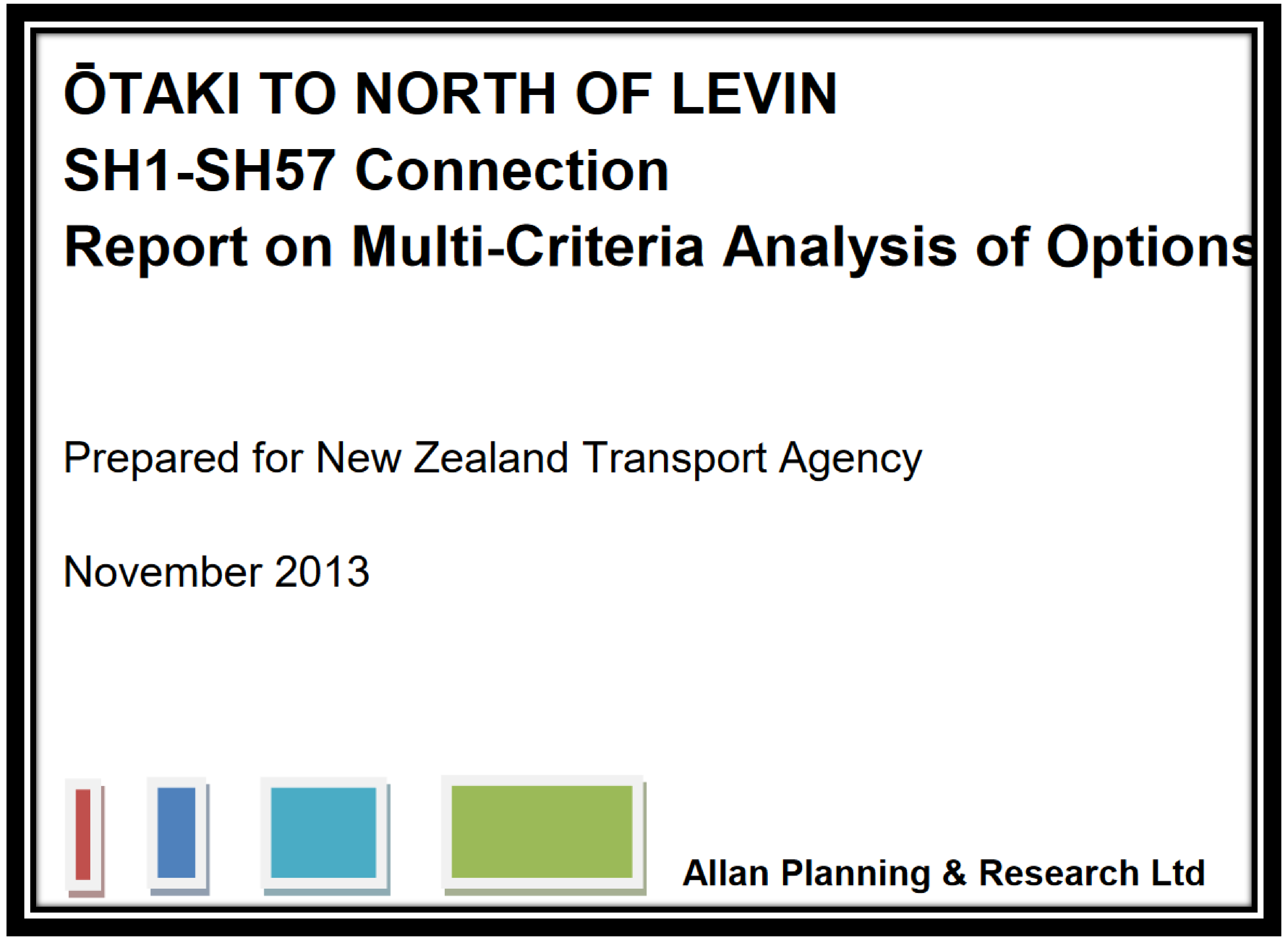
2

Multi-Criteria Decision Making (MCDM/A)

‘Multiple criteria decision analysis (MCDA) is an advanced field of operations research and management science, devoted to the development of decision support tools methodologies to address complex decision problems involving multiple criteria goals or objectives of conflicting nature.’ Financial Times

Change of system or land-use is obviously a complex decision making process involving trade-offs across a number of dimensions – social, environmental, economic etc. MCDM/A is well suited to capturing these trade-offs and has been widely used including in projects considering sustainable land-use

We chose the Analytical Hierachy Process - form of MCDM developed by Saaty (1980). Involves pairwise comparisons



ŌTAKI TO NORTH OF LEVIN
SH1-SH57 Connection
Report on Multi-Criteria Analysis of Options

Prepared for New Zealand Transport Agency

November 2013

Allan Planning & Research Ltd

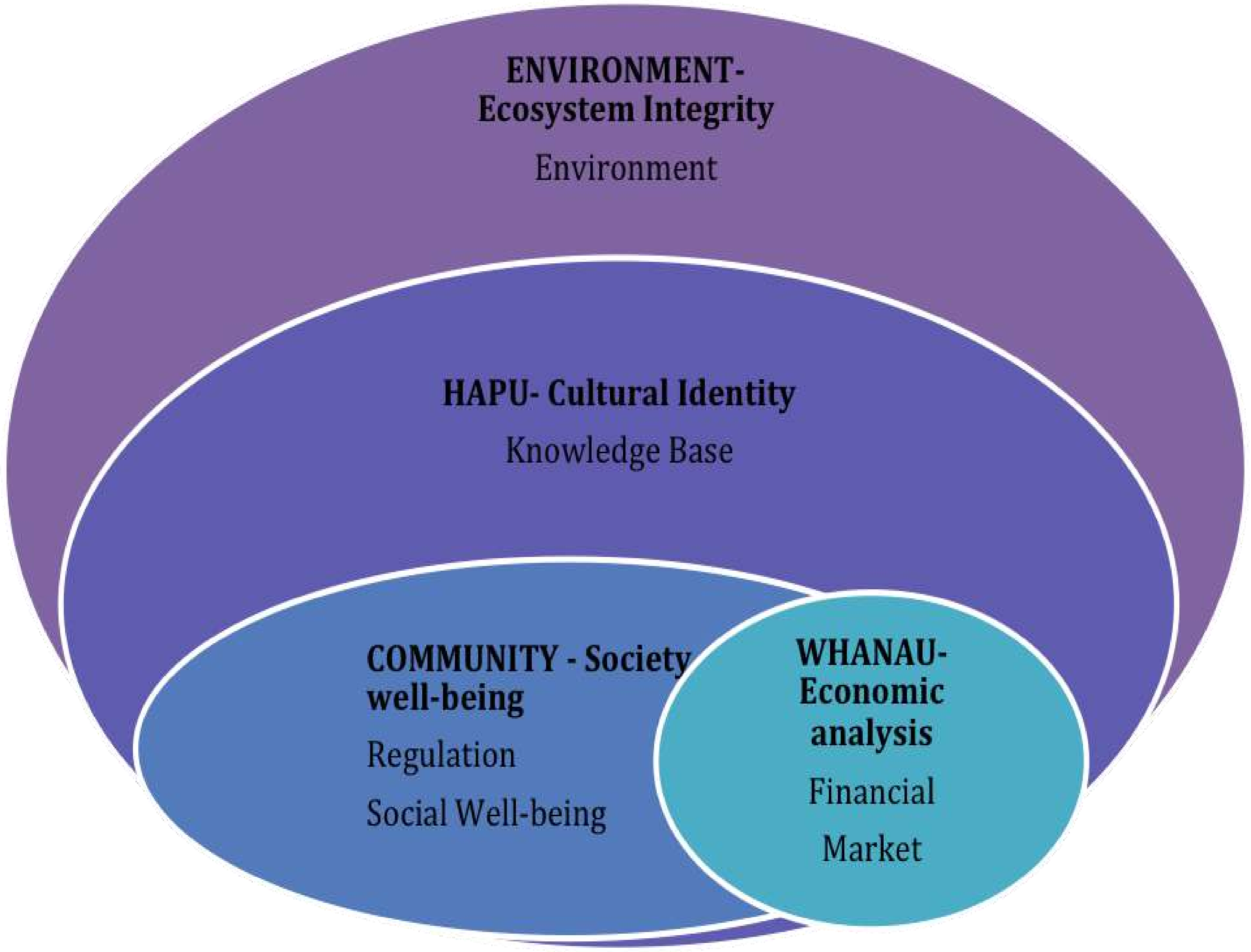
Selection of Criteria: Domains

Criteria selected through a review of the literature, scientific opinion and verification with those involved in land management.

Considerable work in New Zealand
- Sustainability Dashboard
- The Mauri Model

We identified 6 domains

Within each domain 5/6 criteria were chosen

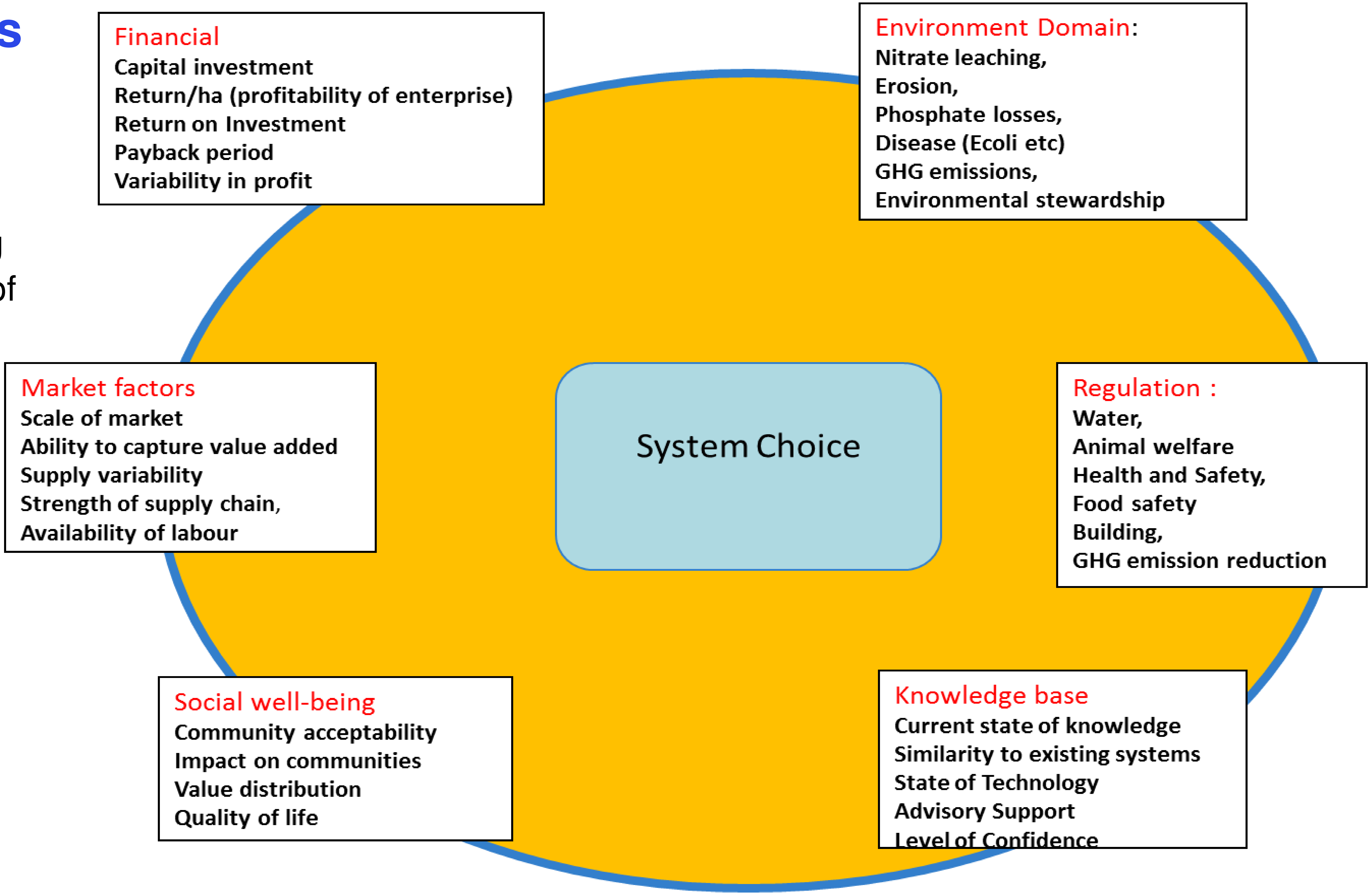


Integration of The Mauri Model hierarchy of domains from Morgan (2014) and the six domains employed in our study. This illustration represents the complementary nature of the six domains adopted in this study, with other New Zealand frameworks.

Sub-domains

Challenge is to be comprehensive but recognising the trade-off between number of criteria and number of pairwise comparisons the land manager will have to make.

With this number there are 100 comparisons that need to be made



How it works

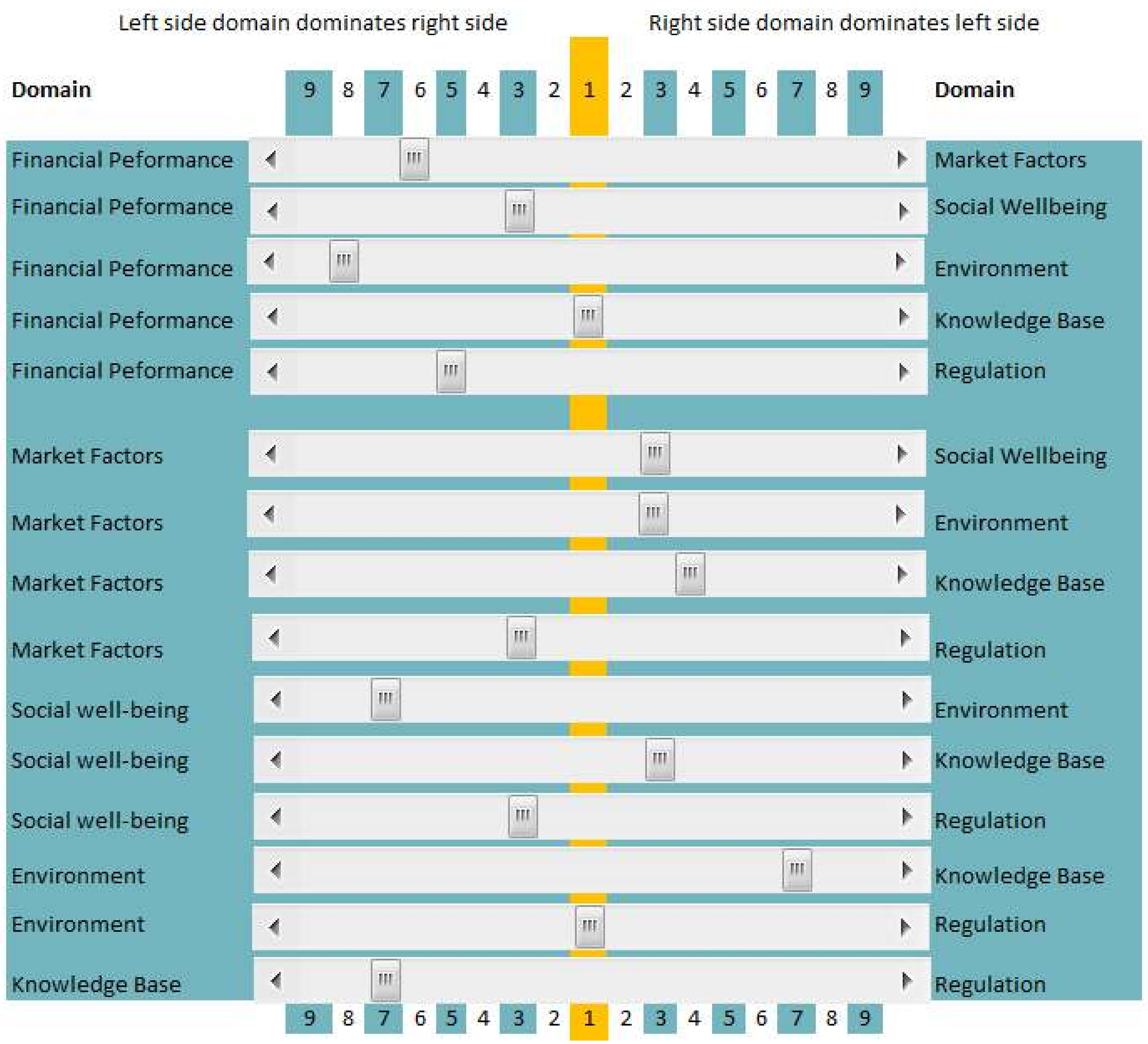
Score	Definition	Explanation
1	Equal importance	The two domains contribute equally to the decision process
3	Moderate importance	One domain is slightly more important than the other
5	Strong Importance	One domain strongly dominates the other
7	Very strong importance	One domain very strongly dominates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

Left side domain dominates right side

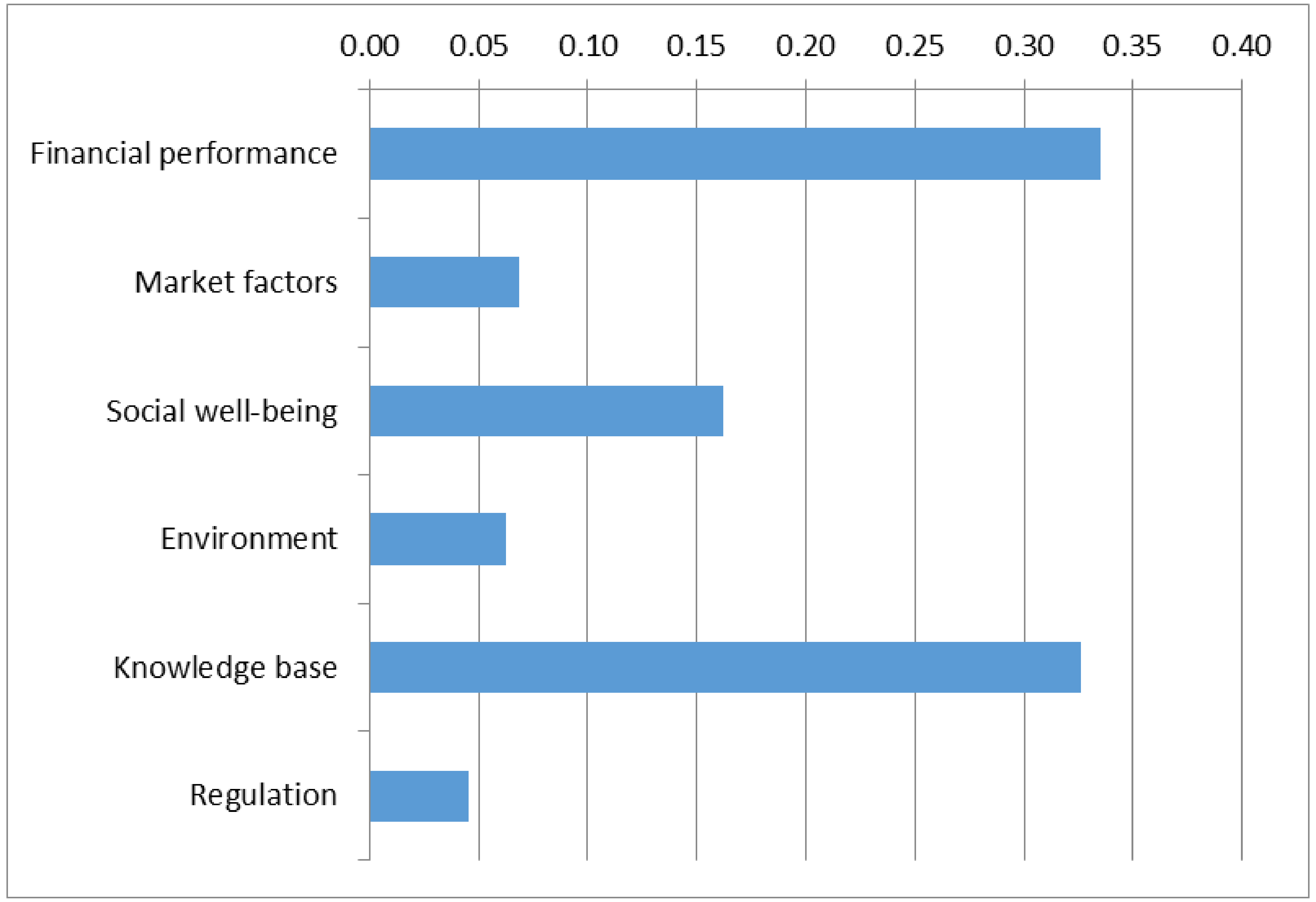
Right side domain dominates left side

Domain	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Domain
Financial Peformance																		Market Factors
Financial Peformance																		Social Wellbeing
Financial Peformance																		Environment
Financial Peformance																		Knowledge Base
Financial Peformance																		Regulation
Market Factors																		Social Wellbeing
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

An Example



Weights Generated



Case Studies

Land Manager type	Location	Driver for Change	Considering
Small Family Farmer SFF1		Generate income from relatively small area	Sheep dairy
Small Family Farmer SFF2		Needs value added from area constrained by strong regulatory control in terms of nitrate limits	Value added beef
Large Family Farmer LFF		Succession planning key. Return from arable seen as too low.	Switch to horticulture (apples, kiwifruit)
Smallholding SH		Needs high value added, concerned about regulatory impact	Multiple cropping linked with forestry (nuts etc)
Maori Trustees MT		Harvested forestry land and now looking for alternatives	Hazelnuts, mixed tree crops, tourism, horticulture
Maori Corporate MC		Looking for returns from land coming out of forestry and diversification from dairy investment	Sheep dairy, horticulture


MT
MC
SH
SFF1
SFF2
LFF
Financial performance
Market factors
Social well-being
Environment
Knowledge base
Regulation
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

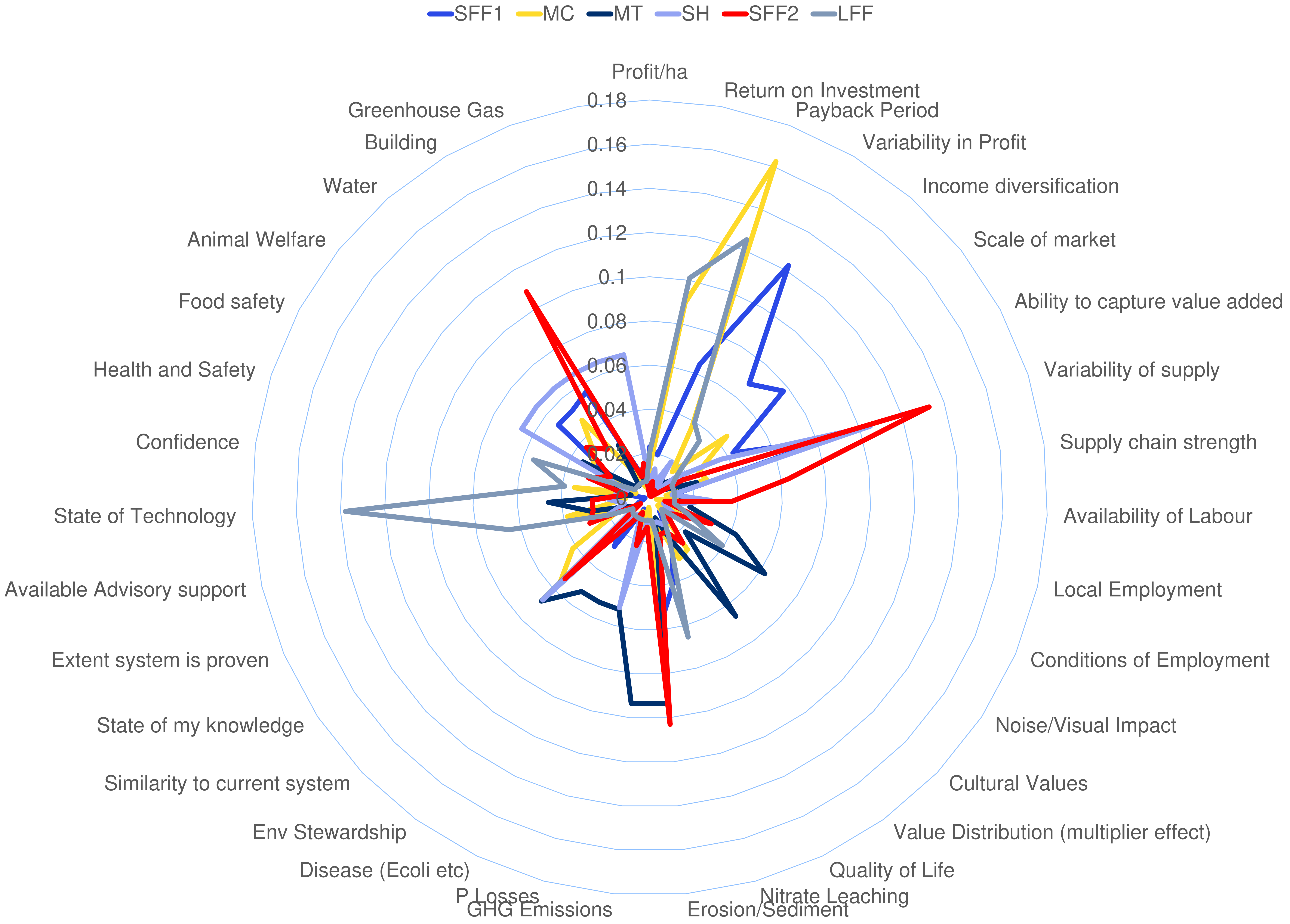
Allows us to check the consistency of the pairwise comparisons

Land Manager type	Consistency Ratio
Small Family Farmer SFF1	0.08
Small Family Farmer SFF2	**0.97**
Large Family Farmer LFF	0.10
Smallholding SH	0.19
Maori Trustees MT	0.12
Maori Corporate MC	0.19

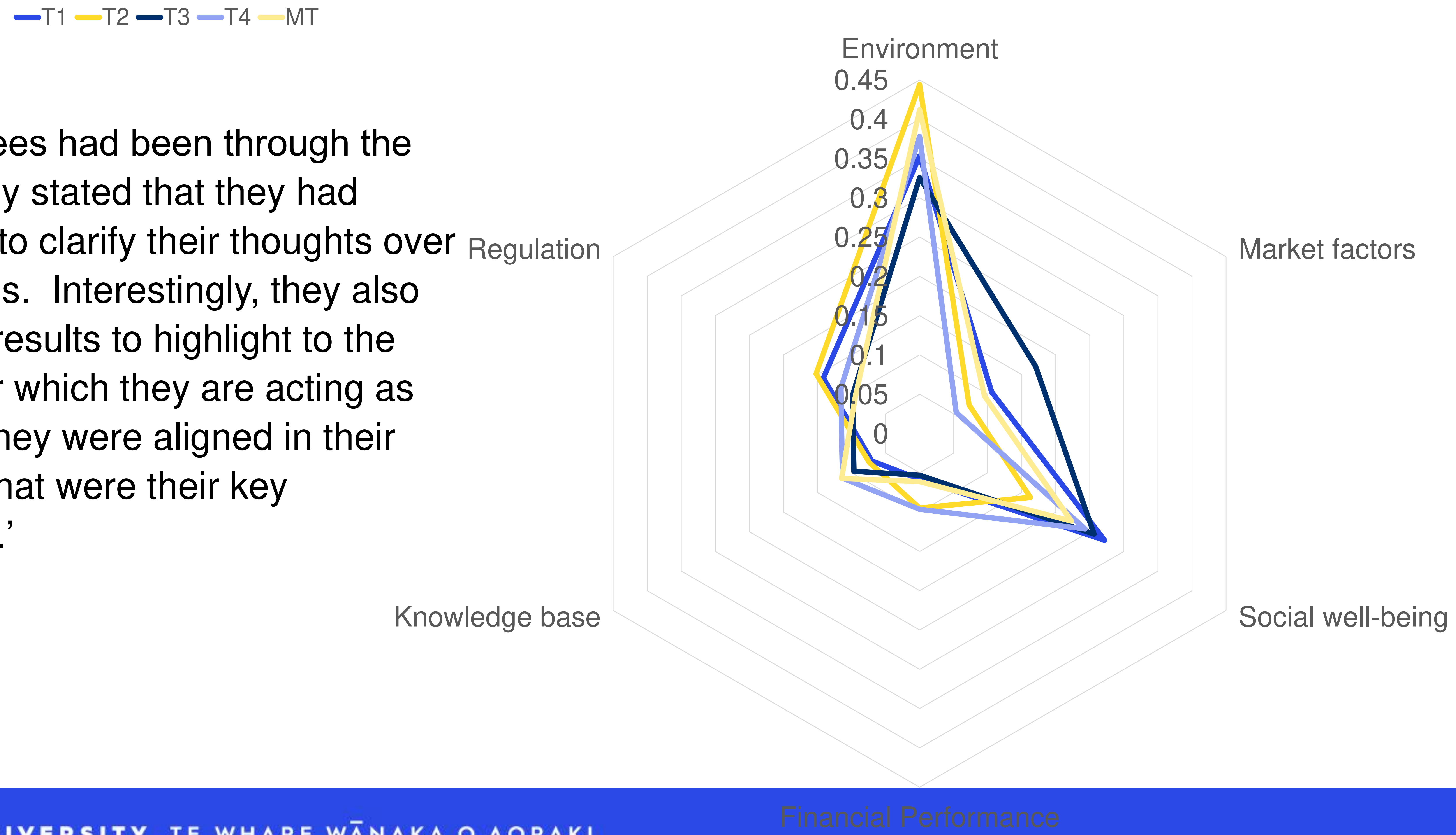
Saaty suggests that a score of under 10 per cent (0.10) highlights consistency

At the higher level we derive the weights for each domain

We then undertake a similar process for the criteria within each domain

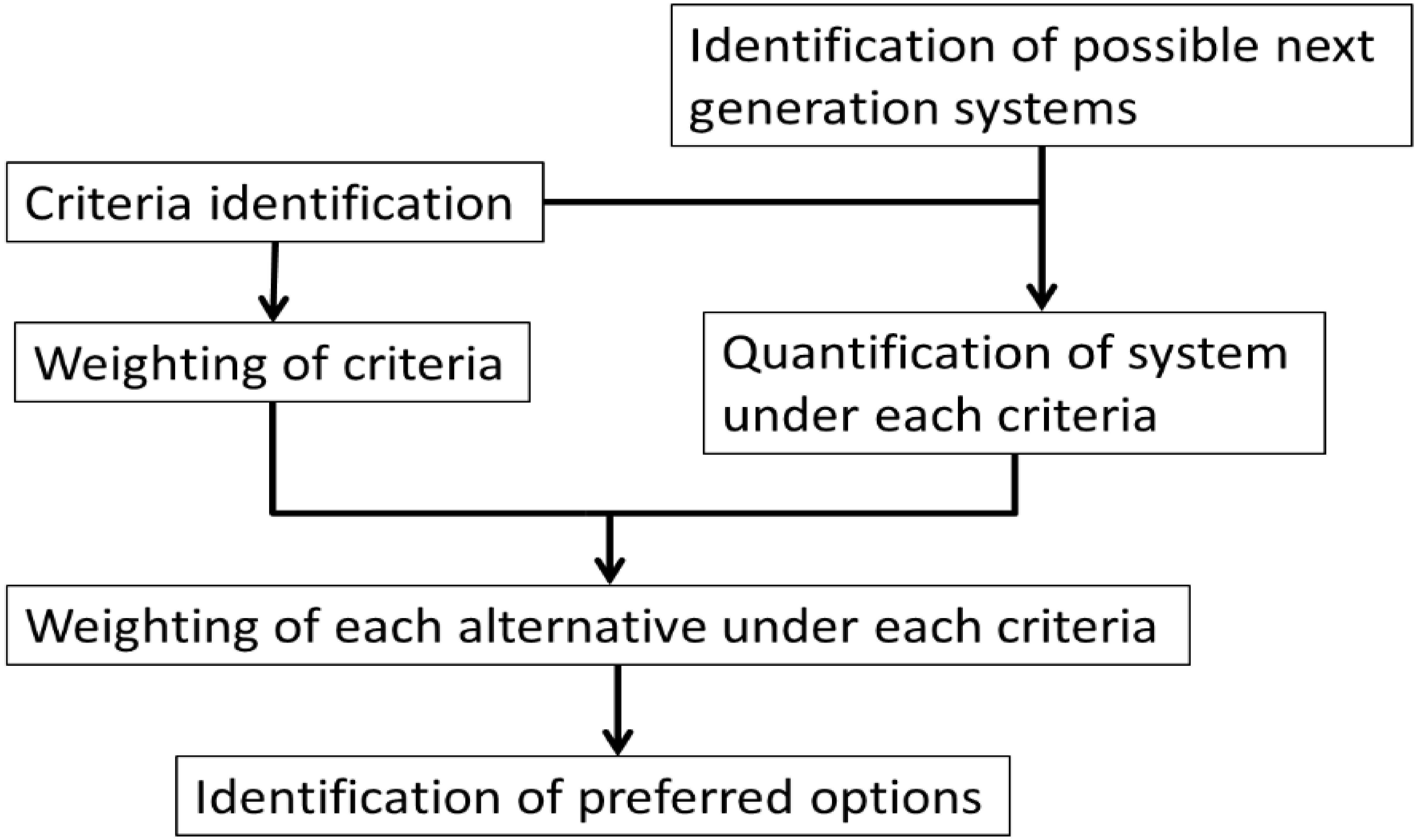


Group decision making



‘After the trustees had been through the framework, they stated that they had found it useful to clarify their thoughts over future land uses. Interestingly, they also later used the results to highlight to the wider group for which they are acting as trustees, that they were aligned in their thinking and what were their key considerations.’

Rating Next Generation Systems



How well does a system fit? An example with two land managers and sheep dairy

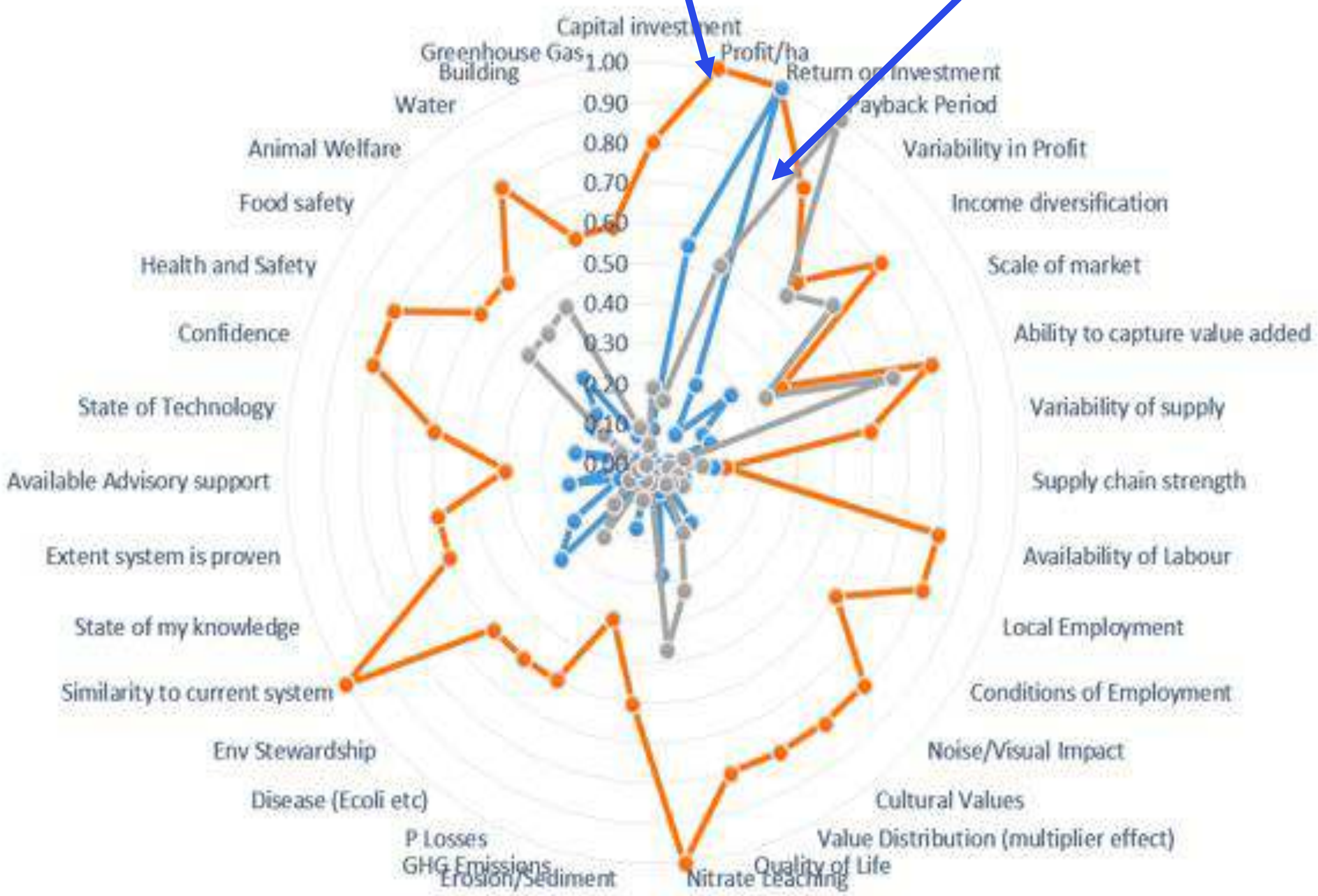
1) Obtain weights for the criteria through framework process
2) Score/rate system(s) according to the criteria (objective or subjective)
3) Multiply the rating score by the weights derived to obtain overall score for system

In this example the sheep dairy was scored out of 5 for each of the criteria (5 meaning it performed well)

Overall scores were 3.69 and 3.79 (out of 5) highlighting it scored pretty well for both land managers

Orange highlights expert scoring of sheep dairy against criteria

Blue and Grey highlight the results from two land managers



Advantages

The interactive approach (using a graphical interface) for selecting the criteria weights allows a detailed discussion with the land-user about the process of system change.

Reflection on and crystallization of what is driving the land manager

Advantages (Uses) of the Framework

- Through identifying the criteria that are important in influencing adoption of new systems, attention is drawn to areas where objective information is required to support decision making.
- Can highlight where there are potential gaps in our knowledge that (transformational) science can be used help fill which in turn can reduce the risks to land managers of adopting new systems.
- The framework can also highlight how well a particular system fits with the land-users' needs and therefore give an indication of the extent of the pressure for change.
- It also can help assess the extent that new technologies etc. can shift systems so that they better meet the criteria set by land managers.
- It may used to consider decision making at different levels, for example regulators (regional councils), land managers and wider stakeholders.

Some challenges with the framework

- Pairwise comparisons – time constraining
- Related to this, the criteria selected were not exhaustive in terms of capturing all possible factors that may influence decision making.
- Some decisions more binary in nature
- Trade-off process
- Throughout the process a challenge was to maintain consistency of interpretation of the criteria within the defined domains
- Interpreting the graphs – presenting the overall picture

"As a process this is challenging" and "I struggle to answer that because my social wellbeing is inextricably linked to my financial performance." SFF2

So What?

The measure of success for the NGS project is engendering change not nice radar diagrams

The next stage of the project will be to support decision making using the framework through partnerships with innovative businesses undertaking investments in partial or full system transformation.

The needs of the individual are site specific, so climate, soils, topography will all play a role in terms of which NGS could be applied. Therefore a follow on step for many of these businesses is to undertake detailed suitability studies.

Therefore, considerations of the land manager will be put together with the characteristics of the NGS which in turn are placed in the context of the suitability of the land to provide a more complete picture which can then form the basis of NGS choice

Suitability

Reproduced by kind permission of
Edmar Teixiera, Plant and Food Research.
Work in progress please do not distribute

Acknowledgements: This research was funded through:

Our Land and Water National Science Challenge
Next Generation Systems

PI Robyn Dynes
AgResearch

SLMACC
Evaluation of profitability and future potential for low-emission productive uses of land that is currently used for livestock

PI Steve Thomas
Plant and Food Research

If you are interested in this then you might also find the following interesting….

NZARES – AARES One Day Forum

29th August 2018,

Wellington, New Zealand

Land-use: The answer seems to be change, now how do we achieve it?

Register at www.nzares.org.nz

SCIENTIA ET·INDUSTRIA·CUM PROBITATE

LINCOLN

UNIVERSITY

TE WHARE WĀNAKA O AORAKI