

Article

Challenges and Opportunities for Land Use Transformation: Insights from the Central Plains Water Scheme in New Zealand

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Abstract: Agricultural systems in New Zealand, as elsewhere in the world, are subject to increasing environmental (and associated social) pressures, for example, around water quality and greenhouse gas emissions. Whilst novel, knowledge-based, alternative land use systems, exist that could relieve these pressures, the challenge facing New Zealand is how to achieve a timely transition to these systems at any meaningful scale. This paper considers the factors that are important to land managers in determining whether or not to change their land use system when the development of an irrigation scheme provides an opportunity for transformative change. A multicriteria decision-making framework using the analytical hierarchy process is used to assess the factors influencing decision makers who are shareholders in the Central Plains Water Scheme in the South Island of New Zealand. As expected, financial factors generally were weighted above other factors in terms of importance. Social, environmental and market factors were rated similarly, whilst regulatory and knowledge factors appeared generally less important. In addition to profitability, the study identified the desire of land managers to simplify complex agricultural systems, their need for scale, their concerns over knowledge competition, their willingness to collaborate and the challenge brought about by ‘cultural path dependency’ as being important. This suggests that 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 a greater chance of engendering a land use transition.

Keywords: land use change; multi-criteria decision making; irrigation schemes; farmer decision making

1. Introduction and Background

Land use and agricultural system change has been a feature of New Zealand’s economy for many decades, although change has generally occurred relatively slowly and, since the economic reforms of the 1980s, it has been driven almost entirely by market forces [1]. However, due to increasing environmental (and associated social) pressures, for example around water quality and greenhouse gas emissions, New Zealand urgently needs to transform the land uses that dominate its economy and landscape [2,3]. Whilst novel, knowledge-based, alternative land use systems, referred to hereafter as NGS exist that could relieve these environmental and social pressures, the challenge facing New Zealand is how to achieve a timely transition to these systems at any meaningful scale. Unlike the EU and US, New Zealand is known for the low level of intervention in the agricultural and wider land use sectors. So whereas the EU can, for example, use its agricultural and rural development

(Pillar 1 and Pillar 2) funding to influence land use decision making, this is currently not the case in New Zealand. The slow-paced relationship between export prices and land use change suggests that relying on commodity prices alone is not likely to drive rapid land use change, let alone towards more sustainable land uses. As a first step in the process of engendering change, there is a need to improve our understanding of how land managers are making decisions concerning land use transition. Such understanding of land use decision making can provide insights into the potential barriers to land use change which can help formulate policy that may influence the behavior of landowners to support land use transformation at a national or regional level [4,5].

A possible way to gain insights into the decision-making process is to consider how land managers have reacted when an opportunity for transformative change occurs, albeit in the context of existing agricultural systems. In New Zealand, such opportunities have arisen through the development of large scale share-based irrigation schemes [6]. In recent decades, irrigation has been identified as a significant and sometimes controversial enabler of agriculture and land use change in New Zealand [7,8]. Increased water availability through irrigation has driven expansion of both dairying and horticulture, whilst at the same time expansion of these sectors has increased demand for irrigation [9]. McClintock, Taylor and McCrostie Little [7] note that rather than acting exclusively as a support to existing land uses and agricultural systems, irrigation schemes have been agents of social change bringing about changes in farm ownership and also in land use, particularly from dry-land sheep and beef grazing towards dairying and/or cropping. In fact, evidence from studies of a number of irrigation schemes across New Zealand highlights that facilitating land use change (and subsequently creating employment and wider economic benefits) is often the most fundamental justification for the schemes [6].

However, evaluations of previous irrigation schemes in the Northland of New Zealand, for example the Maungatapere and Kerikeri Irrigation schemes, have shown mixed results in terms of their impact on land use change. Often, at the outset, major economic benefits were forecast, but for a variety of reasons these have not always fully materialized [6,9]. In contrast, the 2017 survey of rural decision makers in New Zealand appears to highlight that at the farm level there have been significant benefits from adopting irrigation [10]. The majority of respondents stated that their prior expectations of the benefits from irrigation had actually been exceeded in terms of profit, environmental impacts, farm performance, and climate change impacts.

These mixed findings suggest that the influence of irrigation on land use is determined by its interaction with other internal and external factors that influence land use choice. Journeaux et al. [8], whilst noting the important role of irrigation in enabling land use change, also identify that together biophysical, economic, technological, regulations (around animal welfare, food safety, human welfare, and environmental impacts), and personal characteristics of the land use decision maker all are involved in the process of land use change. Of these, economic costs, including opportunity costs, are identified as significant factors in land use change decision making in New Zealand, as illustrated by the large variation in returns between pastoral versus horticultural land uses.

Olssen and Kerr [1] also recognize the importance of economic factors and argue that land use change is being exogenously driven by export prices, not surprising given the high proportion of New Zealand agricultural products that are exported. This has been a significant driver of the transition away from sheep and beef, which has been an important feature of New Zealand agricultural land change, particularly on the Canterbury Plains, one of the country's most intensively farmed regions. Beyond economic factors, there is an increasing volume of research within New Zealand and internationally focusing on rural decision making and adoption of new systems or practices that focuses on the influence and role for non-price factors, and in particular behavioral and psychological factors [11–16]. Approaches to considering the decision-making process need to be able to take into account the influence of these multiple factors.

One way to account for these multiple factors is within a Multicriteria Decision-Making (MCDM) Framework. MCDM has been widely applied in investigating sustainability both generally and in relation to land use [17,18]. A key advantage of an MCDM approach is that it allows the range of

selected criteria to be weighted depending upon the individual's situation, while integrating the sometimes competing aspects of sustainability [19,20]. MCDM also offers the advantages of being able to address different conflicting interests, evaluate alternatives and enable comparative analysis [21].

In New Zealand, Dooley et al. (2009) [22] used MCDM with participants across three different agricultural land use contexts: agribusiness carcass management, beef farming and farming within a lake catchment. They state that 'If policy people and researchers want to facilitate change in farming practices then it is essential that they understand what is important to those who have to make the change. MCDA [M] could contribute to this' ([22] p. 51). They considered MCDM well suited to New Zealand agricultural decision making because of the method's ability to consider trade-offs.

Against this background, the research presented here applies a MCDM framework to investigate how land users, who are potentially interested in adopting new farm systems, make decisions when faced with the opportunity for significant land use change. This is undertaken via a case-study of the Central Plains Water (CPW) scheme, which brought user-pays irrigation to the previously dry-land or well-irrigated Canterbury Plains in the South Island of New Zealand.

The paper proceeds with a brief description of the key features of the Central Plain Water scheme before the methodology is outlined. The results are then presented following a discussion concerning the insights gained into the land use change process. Finally, conclusions are drawn as to the implications for land use transition in New Zealand.

2. The Central Plains Water Scheme

The Central Plains Water (CPW) scheme commenced operations in 2015 after a long and complicated gestation period, lasting nearly two decades. The scheme is based in the South Island of New Zealand and lies between the Southern Alps to the west, State Highway 1 to the East and is bounded by the Waimakariri and Rakaia Rivers to the North and South, respectively. The CPW scheme was developed with the intention of delivering market-based, user-pays irrigation to dryland and bore-well irrigated farmland and presents an opportunity for scheme participants to significantly change land use. The scheme in total provides 47,000 hectares of irrigation, although its development was split into three stages, according to the construction of water distribution network infrastructure (pipework and water races). The scheme utilizes river water from both the Rakaia and Waimakariri Rivers. The rivers are linked by a 56 km headrace canal running around the foothills and channels water via around 500 km of piped reticulation. Irrigable land above the canal can be watered via pumped systems. At the landscape level, the scheme was designed to alter water use away from groundwater and towards river water with surface water storage. This was intended to increase reliability of water availability to farmers, and address ground water quality and river low-flow issues in the region.

The Central Plains Water scheme was constructed and is operated by the Central Plains Water Limited Company, a farmer shareholder company under an overarching District and City Council governance structure. The ownership and governance structure behind the scheme was designed to ensure that the ownership of the consents will never pass to international or commercial or corporate interests. As such, the scheme has distinct economic, social and environmental drivers [23,24].

Prior to the scheme commencing, prospective scheme participants and regional land managers anticipated that irrigation that would increase crop yield (both through increasing growing season length increases, and per hectare yield) and decrease variability, and allow previously non-viable land uses, such as specialist seeds, to be grown. The impact upon, and potential expansion of, the then-highly lucrative dairying industry was also a point of interest at the scheme's inception. In terms of general land use types, it is noted that CPW undertook a study of 40 farms across the scheme area in 2014. Of these, 20 farms were existing dryland and 20 were irrigated via groundwater. At this time, there were predominantly two farm systems within the Scheme area: dairy, and a mixed system of livestock and cropping, incorporating a range of land use types.

Dairying activities on the Canterbury Plains are of particular interest as the role of dairy farming in New Zealand land use is a prominent topic of discussion nationally and in the region in particular. Concerns have been raised regarding a range of issues with the sector including the future economic viability of the dairy industry, international competitiveness of an economy dominated by the dairy industry, GHG emissions, and water quality impacts [25].

In the context of the environmental and social pressures associated with land use in New Zealand, it is important to note that the CPW scheme was implemented with extensive attention given to nitrogen regulation and management, with additional regulatory requirements including: “Introduction of a fixed allocation or “cap” on nitrogen losses in the catchment (including the CPW scheme). Progressive reductions in cumulative nitrogen losses are required over time [and] a requirement for all farming properties to prepare a farm environment plan (FEP) and implement a range of good management practices” [23]. In addition to environmental benefit, wider social benefits have been associated with the scheme. These include: the creation of up to 1900 direct and indirect jobs through the scheme’s infrastructure construction; improved water supplies for local residential communities, stock, and firefighting operations and; reduction in electricity use from reduced use of electrically-powered bore well pumping of groundwater [26].

These multiple elements of change occurring via the CPW scheme make it an interesting and valuable case-study of the complexity of land use change and adoption of NGS in New Zealand agriculture.

3. Methodology

Following Renwick et al. [27,28], a Multi-Criteria Decision-Making (MCDM) framework was utilized to investigate the CPW case study. In the context of this study, MCDM is well suited to questions concerning sustainability of industries and enterprises, because it provides the ability to simultaneously consider multiple domains (for example, financial, social and environmental) where selection of best alternatives is highly complex [20,29–31]. For these reasons, MCDM has been widely applied in investigating sustainability both generally and in relation to land use [17,18]. In this study, we use MCDM to weight and rank the factors that are important to the decision making of land use managers rather than to develop a predictive model of the land use choices that they make.

MCDM is itself a general framework and there are a range of methodologies that have been developed for undertaking MCDM analysis [18,21,32]. Evaluation of the different approaches highlights that each has particular strengths and weaknesses that pertain to theoretical backgrounds, questions asked and results obtained [21,33]. Given the multitude of applications for MCDM, no one of the many approaches can be seen as definitively better than others [18,33,34].

The Analytical Hierarchy Process (AHP) [35] is adopted for this study as outlined in Renwick et al. [27,28]. AHP is one of the most widely adopted methods used for MCDM analysis [21,31–33]. It assists decision makers to construct their preferences via criteria weighting and scoring.

As outlined by Saaty [35], AHP appears well suited to the requirements of this study which involves understanding land manager’s decision making when considering alternative land uses and has been used in broadly similar contexts (see for example, [30,36–38]).

AHP involves a process of pairwise comparisons of selected criteria to demonstrate the relative importance of the criteria against one-another [29,31,33,39,40]. Simply put, through the pairwise comparison process, the AHP generates weights across the criteria that sum to 1 (or 100 percent) which reflects the overall decision-making process. So, for example a weight of 0.2 (or 20 percent) would indicate that the given criteria (say financial or social etc.) has a 20 per cent influence on the decision-making process. If the process generates a weight for a second criteria of say 15 per cent, we are also able to conclude that it is less important in the decision-making process than the first criteria. It therefore allows us to quantify the overall importance of the criteria as well as their relative importance.

A crucial component of applying MCDM and the AHP is identification of the criteria to be used to evaluate alternative systems [20,30]. A practical challenge with developing indicators within an AHP framework is to have a sufficient number to be comprehensive (i.e., able to capture the key elements of the decision-making process) but also few enough to make the process manageable in an applied situation. This challenge emerges because the need to undertake pairwise comparisons means that as the number of criteria increases so the number of comparisons that the land manager has to make also increases. In earlier work [26], the criteria were identified (and refined) through a process involving review of the literature (including [30,40,41]), scientific opinion and verification with those involved in land management. From this process, a number of criteria emerged which were classified into six key domains: financial; market; environment; social well-being; regulation and; knowledge base (Figure 1).

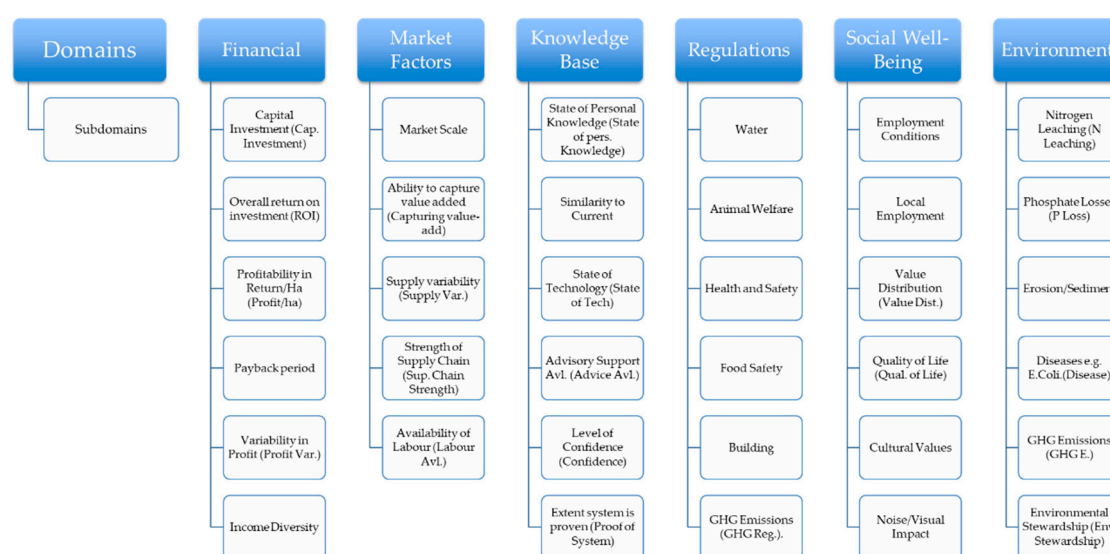


Figure 1. MCDM framework domains and subdomains (subdomain names in brackets are abbreviations used in Figure 3, below).

In practice, the analysis is conducted in three stages. First, the AHP is applied with participants at the domain level and weights generated as to the overall importance of each of the six domains. Second, it is then applied within each of the domains across the subdomain criteria generating weights for each of the criteria. Finally, the weights for each of the criteria at the subdomain level are multiplied by those generated for the overall domain to arrive at an overall value for individual criteria. So for example, if the weight for the financial domain overall was 0.5 and that for return on investment within that domain was also 0.5, this would mean that the overall weight for return on investment in the final decision-making process would be 0.25 (0.5×0.5).

Data Collection

The MCDM framework and AHP analysis were used to conduct in-person interviews with ten landowners and land holders within the CPW scheme area (summarized in Table 1). Interviewees were invited to participate in the study after attending a workshop on NGS, under the New Zealand Government's Our Land and Water programme. They were chosen, not to be representative of the farming community as a whole, but because they were actively considering land use change (or had recently changed land use). The interviews were framed in the context of what factors are important to them as land managers when considering system change. Interviews were recorded in situ during the first half of 2019 and generally lasted between one and two hours.

Table 1. Outline and summary of interview participants.

Code	Land Characteristics	Agricultural System
INT001	Flatland	Recently converted from intensive arable with some grazing to dairy with minor crops and sheep finishing
INT002	Flatland	Dryland sheep and crop
INT003	Flatland. Dryland and Irrigated	Grass crops, sheep finishing
INT004	Flatland	Recently converted from sheep and beef and mixed arable to dairy
INT005	Flatland bore well and surface irrigation	Dairy and beef grazing, minor cropping
INT006	Flatland. bore well and surface irrigation	Mixed arable and dairy grazing
INT007	Flatland; irrigation	Dryland sheep and beef
INT008	Flatland; bore well irrigation	Organic vegetables and sheep
INT009	Flatland; Dryland, bore wells, surface irrigation	Arable crops and livestock and dairy grazing
INT010	Flatland: dryland, spring irrigation, surface irrigation.	Cereal cropping, winter grazing.

4. Results

We begin the presentation of the results by considering the weights generated across the six high level domains (Financial, Market, Social, Environmental, Knowledge, Regulation). We then drill down to consider how this is reflected in the weighting of the individual sub-criteria which sit within the domains. As well as considering the results when the individual subcriteria reflect the weighting given to their overall domain (i.e., through the three stage process highlighted above), we also draw insights from the weights obtained within the individual domains. As noted earlier, one of the strengths of the MCDM process is that it facilitates discussion of the decision-making process which can provide insights to support the quantitative results. We therefore support the analysis by providing contextual statements from the participants that emerged during the application of the MCDM framework. To ensure succinctness in the presentation of the results, only one or two statements for each aspect are given, but they have been selected to represent more general opinions that were expressed.

4.1. Domain Level

Table 2 provides summary statistics for each of the domains, whilst Figure 2a presents the derived weightings for each of the six domains for the individual respondents and Figure 2b presents the average across all the respondents.

Table 2. Summary statistics from the Analytical Hierarchy Process (AHP).

Statistic	Mean	Standard Deviation	Range	Minimum	Maximum
Financial performance	0.25	0.12	0.35	0.10	0.45
Market factors	0.17	0.07	0.21	0.05	0.26
Social well-being	0.18	0.08	0.23	0.06	0.29
Environment	0.17	0.07	0.19	0.11	0.29
Knowledge base	0.13	0.06	0.16	0.06	0.22
Regulation	0.10	0.06	0.2	0.03	0.23

Despite the fact that the interviewees are located in one geographic area and therefore generally subject to similar external drivers (such as market forces, access to the CPW scheme, environmental regulations, etc.), the importance (weights) that they place on the different domains varies considerably (Figure 2a). In addition, for individual respondents, no one aspect completely dominates decision making. Whilst two respondents do give a markedly higher weight to financial factors, even in their

case other domains (in particular market and environmental) are still considered important. This is reflected when participants' responses are aggregated and an average taken (Figure 2b).

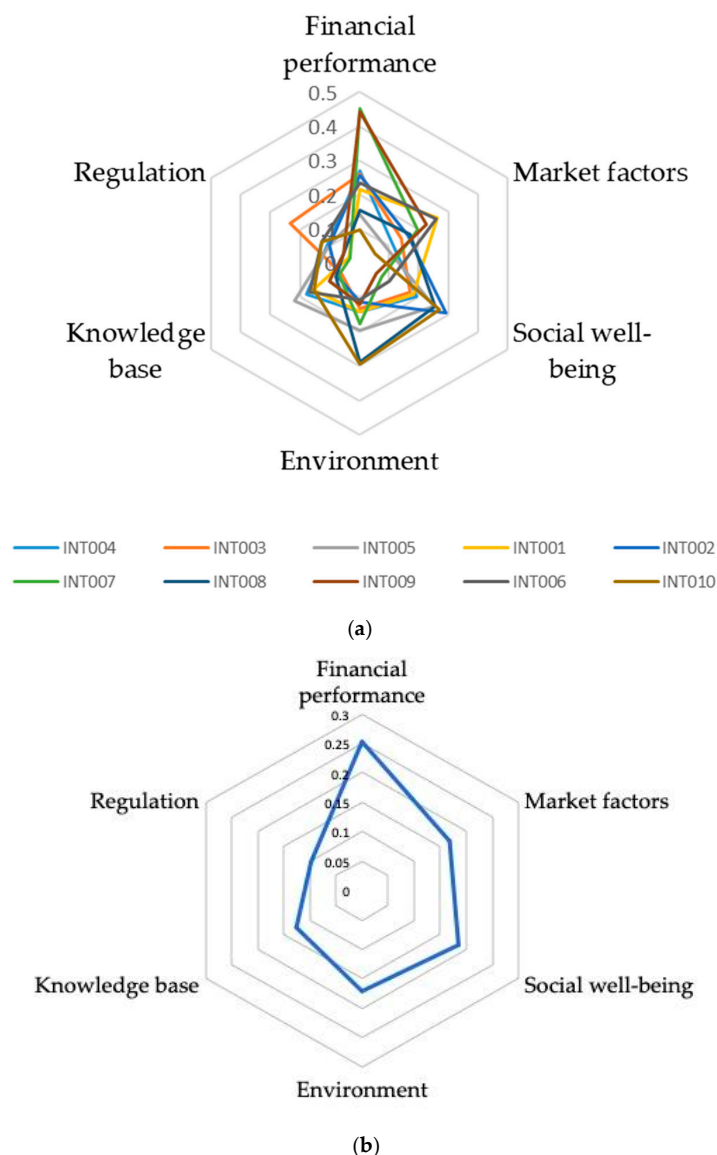


Figure 2. Spider graph of all participants' results (a) individually at the Domain Level, and (b) the average of participants' results at the Domain Level.

This said, the financial domain was generally rated as one of the more important factors (reflected in its higher average weighting shown in Table 2), and while other domains were often ranked of similar importance, rarely did any other domain outweigh the financial. The importance of financial factors highlighted in the weightings closely reflected the views expressed by the respondents.

INT006—"If it doesn't hit this hurdle here [financial], it's unlikely to go any further. Notwithstanding the want to know about all the other things here [remaining domains] ... Financial is going to be your first decision, but part of that decision is your market. It won't work if you don't have a market to sell your product to ... you'd start off with financial but then you'd come back and look at your market."

Market, environment and social factors appear to be, on average, similarly important in influencing the decision-making process. For example, participants were keenly aware of the importance of market factors, with a number (INT002, INT003, INT006, INT005) particularly highlighting them as an important

element of decision making. Whilst the importance of the environment in influencing decision making was stressed by the respondents, this was often tempered by the need to be financially viable.

INT005—“We like to think we’re more on the environmental side, but if it can’t do a return, we can’t actually do it, because there’s no point going broke over it”.

However, some participants offered examples where they had indeed prioritized environmentally positive land use decisions or had forgone a financially lucrative land use option due to environmental concerns or factors (for example not overwintering dairy cows). Others had taken a proactive approach and had changed their systems for example adopting Integrated Pest Management techniques.

INT003—“Environmental Stewardship is very important I think, [such as] riparian planting and integrated pest management ... [on the brassica crops and wheat] ... Trying to reduce our inputs. As soon as you’re spraying something you’re killing beneficials as well”.

There was also a recognition of the growing importance of the environment in affecting their future decisions.

INT007—“[The Environmental Domain] It has become more important. And it’s something we have to be pretty aware of. Particularly here ... N leaching. I try not to think about GHG, because they’re coming”.

As Table 1 highlights, the social domain was, on average, second only (albeit by a small margin) to financial factors in terms of the implied weight given to it. This was supported by a range of comments made during the discussions.

INT003—“Social Wellbeing ... that’s actually quite important [when compared to the Financial Domain] ... If it was all financial, I’d be dairy farming. And I don’t want to be dairy farming!”

The MCDM results may suggest that knowledge and regulation are not generally major factors in the land use decision making of the participants with average weights of 12 and 9 percent, respectively. For regulation, however, two main opinions emerged in the discussion. The first was that regulations were a significant element of their decision making to the point that it presented a real challenge to their operations now, suggesting that it would be important in future land use decisions.

INT006—“If you don’t have it [regulatory compliance] you’re dead and buried. If you’re not compliant and you get your licence to operate pulled off you. You’re out of business”.

The other perspective was that regulations were an unavoidable factor of land use and agriculture and compliance was an automatic and assumed component of any land use or potential NGS, and that familiarity with what is needed for compliance with regulations would enable them to absorb any other requirements without significant disruption (INT005).

Similarly, a range of views emerged as to the importance of knowledge. On the one hand, farmers clearly valued knowledge, which may seem to contradict the weights generated through the MCDM process.

INT005—“The better the knowledge, the better decision I can make ... It’s better to get outside your business and [be] looking in, than being inside your business looking out”.

However, it was clear that whilst they felt knowledge was important they did not see it as a hurdle to land use change as they were comfortable and confident in their ability to easily acquire the knowledge a new land use would require.

4.2. Subdomain Results

The diversity in the weights generated at the domain level is also reflected at the individual subdomain level (Figure 3). Whilst for some respondents there is a clear criterion that dominates (such as environmental stewardship for INT007 and ROI for INT005) the weights are still relatively low at 0.15 (15 percent) or less. The subdomain results provide finer detail of the decision-making process and highlight that even if through the pairwise comparison at the domain level landowners may have given similar weights to a particular domain, they can differ considerably in terms of the importance they place on particular criteria within that domain.

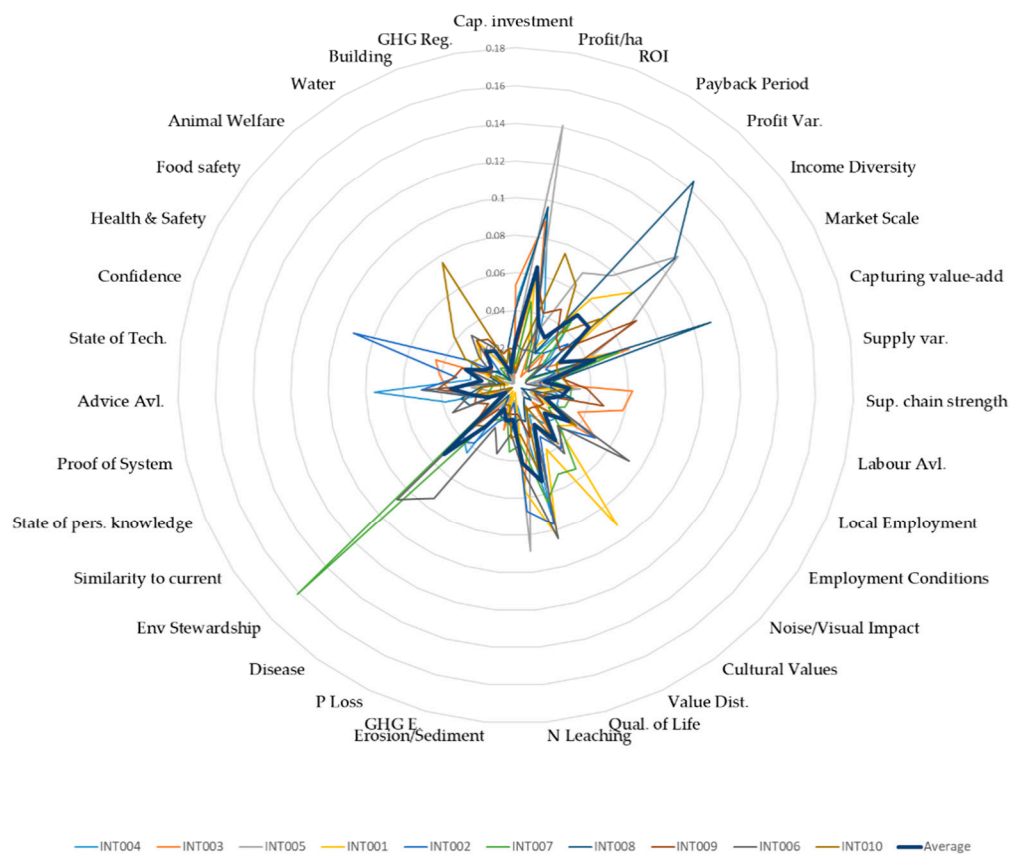


Figure 3. Weightings across all subdomains for all participants.

As noted, differences in the weights of the criteria in the subdomains shown in Figure 3 are in part driven by the weights given to the overall domain. Figure 4, however, presents the weights generated for the individual criteria within the subdomains in their own right and shows a different perspective as to how the criteria are viewed by land managers. For example, within the financial domain (Figure 4a), either profit per hectare or return on investment were usually highly weighted, whilst the capital investment required or the length of the pay-back period were less important. In the other domains, other key criteria emerge, for example: the ability to capture value and scale of the market (Figure 4b); water quality and animal welfare (Figure 4c); nitrate leaching and environmental stewardship (Figure 4d); quality of life, cultural values and conditions of employment (Figure 4e) and; availability of advisory support (Figure 4f).

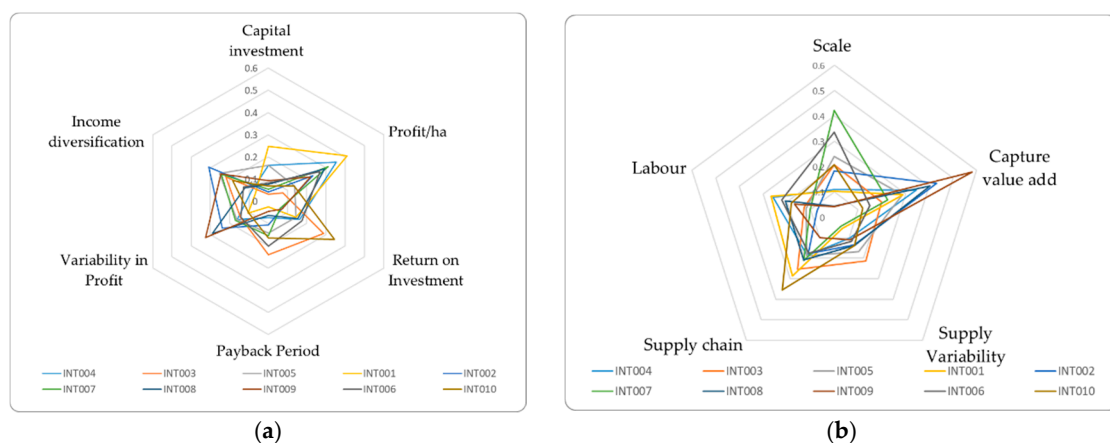


Figure 4. Cont.

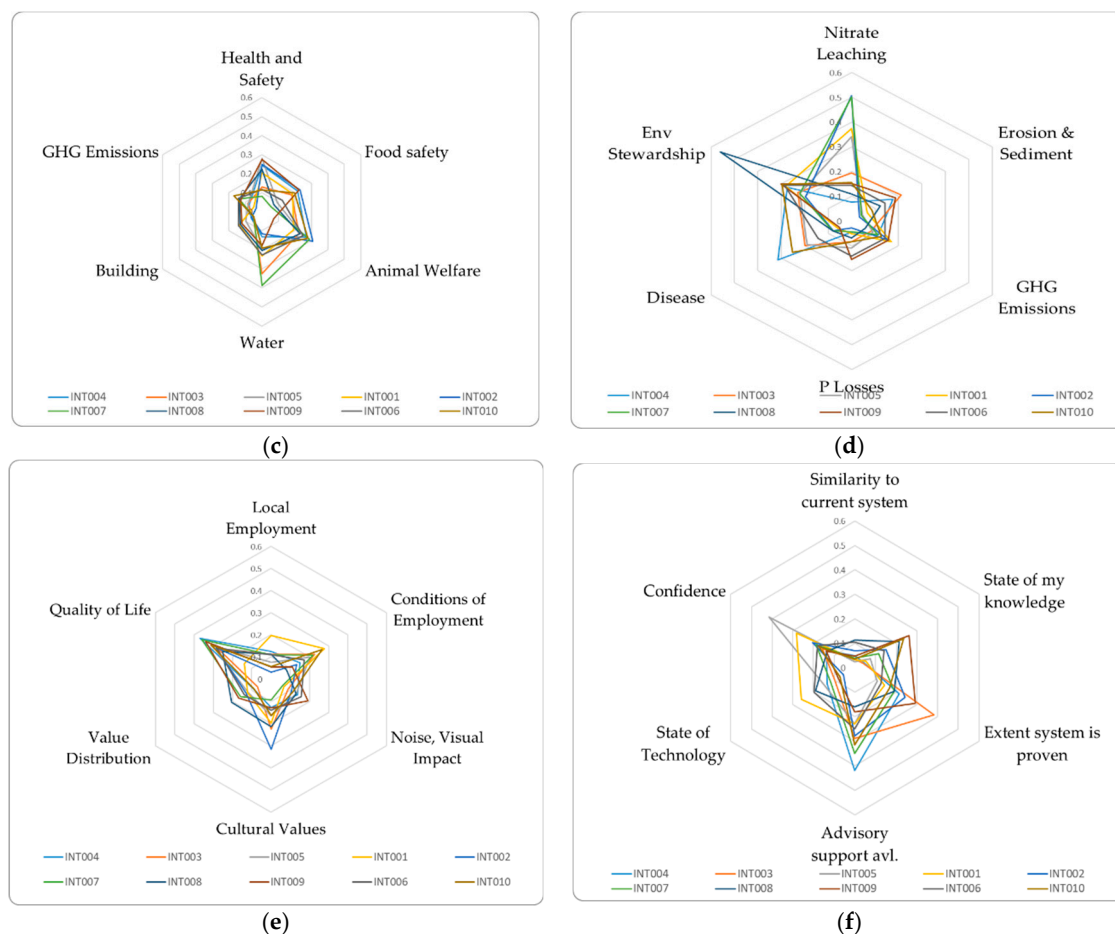


Figure 4. Spider diagrams of individual subdomain weightings by participants. (a) Financial Performance (b) Market (c) Regulation (d) Environment (e) Social Wellbeing (f) Knowledge Base.

4.2.1. Financial and Market Subdomains

Within the financial domain, participants were more focused on making decisions based on long-term financial prospects, with the primary short-term outcome being the reliability of cash flow, often via income diversification for risk management.

INT001—“We haven’t thought about payback period . . . We’ve thought about a secure capital asset in the long run. We’re farmers and that’s what we know how to do. Don’t want to get involved in the share market . . . so have ploughed the money into an asset we think will be secure in the long run.”

Within the market domain, participants seemed more concerned with the ability to capture value, or to access that value through the supply chain and often this was an area where they faced the greatest challenge (INT006, INT003, INT005). The ability to capture value added was seen as an important distinguisher between different land use options, and an important requirement when considering another land use, whether or not this involved adopting an NGS.

In the context of scale, niche industries were discussed by participants. They noted that, in order to protect the increased revenue from farming niche products, it was necessary that supply was limited, as additional supply would depress the prices farmers received. Hence, there was not only limited scale in these land uses, but also the supply side of the market became highly competitive and unattractive from a social perspective. The nature of niche products therefore made them difficult to adopt (INT004; INT003).

Many participants compared possible alternative enterprises with the dairy sector and referred to the size of the dairy market overseas, particularly in China. This scale they felt was hard to replicate in

other sectors. In addition, it was not just the scale but also the ease by which farmers could access the value-added market through the operations of the main dairy processors.

Labour was one criterion where there seemed to be some anomaly between how it was weighted through the MCDM process and the sentiments expressed during the discussion. For example, as Figure 4b highlights it appeared generally not to be an important factor in the decision-making process, but in discussion opinions were expressed that would indicate a contrary view.

INT004—“It’s getting very hard to find skilled labour, or people wanting to upskill, more than anything.”

4.2.2. Social and Knowledge Subdomains

As suggested by Figure 4e, the Social Domain was the area within which the greatest agreement between participants was observed. Three factors (conditions of employment, quality of life and cultural values) were consistently highlighted as being important in the decision-making process.

Discussion of cultural values in particular provided insights into the motivations of the participants as a strong view emerged that land should be productive and that productivity was intrinsically linked to being a farmer.

INT001—“I’ve always believed that land should be productive and we have a responsibility to make it productive”.

Within the knowledge domain, Figure 4g highlights that farmers are willing to consider systems that are outside of their current sphere of knowledge. This is highlighted by the low weights generated for the importance of the system being similar to their current system and also their own level of knowledge about the new system. In contrast, the availability of advisory support was highlighted as being important by a number of participants, although they felt that this would be generally be available if they needed it.

INT006—“We’re pretty confident we’d be able to engage advisory support . . . if you don’t have it, you can generally buy it in”.

In addition, many participants described their own knowledge-gathering activities, and small trials they had conducted, were conducting or would like to conduct on their properties, to build the knowledge they needed (INT002, INT005, INT001, INT006).

Whilst not reflected in the MCDM results, the discussions gave insights into what can be described as a challenge with ‘knowledge competition’. For example, INT004 noted that when part of the arable agriculture sector they experienced an attitude of “it’s for me to know and you to find out” in terms of others not wanting to share knowledge with other farmers in case that increases competition and lowers the overall price. This was reflected by INT001 who felt they experienced less sense of competition and secrecy of knowledge in dairying compared to their time as arable farmers. They noted that competition was especially prevalent when the crop is a small crop; in this situation, farmers did not like to share information for fear of losing their competitive advantage.

4.2.3. Environmental and Regulatory Subdomains

The importance of water quality in the regulation domain (Figure 4c) and nitrate leaching in the environmental domain (Figure 4d) reflect clearly environmental (and subsequent regulatory) issues in the Canterbury Plains, which were a key issue in the development of the CPW scheme. In contrast, despite the rhetoric around GHG in New Zealand, it generated low weights in both the environmental and regulatory domains.

Given the importance of the environment to future land use, it is interesting to note the range of perspectives that emerged during discussion of the environmental domain. As a group, there was no uniform consensus as to which land uses and systems had the largest impacts. Some participants saw dairy as having a higher impact than cropping and arable systems, however some felt that their conversion (or conversion observed by others) to dairy from other systems had actually reduced the environmental impact. Irrespective of the land use changes made or being considered, participants

generally perceived that they were making decisions, or likely to make decisions, in line with improving environmental outcomes.

A final recurring theme in the discussion emerging through the process is that participants were either observing changes in their decision-making factor weightings over recent years, and/or expect changes to occur in the future.

INT006—“The weight of it [regulation] is really coming to the fore . . . If you’re not starting now [complying with regulations and seeking reduction targets], you’re already behind . . . if we did this [assessment of the weighting of regulations] in, even two years time, it would be quite different.”

In particular, recent dairy converts noted that increased regulation over the past five to ten years had reduced the attractiveness of dairy. Some suggested that if they were now making the decision to convert to dairy, regulation would play a much more important role in the decision-making process (INT001, INT002, INT006).

5. Discussion

Overall, the results support the extensive literature (for example, summarized by Liu et al. (2018) [42] in terms of adoption of conservation agriculture) highlighting that multiple factors are influencing land use decision making. They also reflect how an important driver in New Zealand, such as irrigation, can have very different impacts on land use change through the way it interacts with these multiple factors that influence the decision-making process. This appears to support the earlier work of Journeaux et al. [8].

In terms of insights into how land use change towards NGS may be influenced, first and foremost NGS have to offer a financial advantage, or at least not a disadvantage if it can provide other benefits. This again supports previous work, for example that of Brown et al. (2018) [11] who note the importance of economic stimulus to ensure profitability among landowners who were adopting Conservation Agriculture. The overall profitability of the NGS is key, but it is also clear that cash flow is an important consideration. Those that had transitioned to dairy for example, highlighted the advantages of a monthly milk cheque compared to arable where there is a significant period between crop outlays and returns and also where everything rests on one harvest a year.

Although only one respondent mentioned it specifically, when highlighting that they felt it was easier to gain access to funds to transition to dairy than it would have been to develop their arable business, it does highlight the role financial institutions will have in supporting any transition in land use. This reflects the finding of Renwick et al. (2014) [43] on the role of financial institutions in the innovation process. As noted by one respondent in that study “Banks are not in the innovation game. [They’re in the] lending money game and getting that money back game.” ([43] p. 21)

Throughout the interviews, a key challenge was the problem of complexity of their current systems and the desire to have alternatives that could be implemented at scale which could help simplify their businesses. Those who were trying to develop new enterprises to raise the overall profitability of their business (in part to pay for the cost of the CPW) were generally adding additional smaller enterprises onto their farms. For example, high value seeds which can generate significant revenue per hectare, but generally only over a few hectares. The general difficulty is whilst niche products can add value, they tend to be only on a small area of the farm and therefore are an addition to rather than an alternative to existing enterprises. This means they can often add complexity in terms of how they are programmed into the farm system (such as their place in rotations). Comparison was often made by those with these complex cropping and livestock systems with dairy farming, which they viewed as a simpler farm system to operate. For example, some of the respondents had as many as 10 different crop and livestock enterprises that they were trying to manage over their farm area. Whilst overall scale of the market is important, it is also clear that for individual farmers, it is often how much of the market that can be easily accessed, rather than the overall size of the market that determines whether it is an attractive proposition.

Linked to this, developing markets was a key issue for many of the producers who were trialling alternative enterprises on their holdings. The difficulty with these alternative enterprises in general was that not only did farmers have to get to grips with the technicalities of production, but in many cases they had to find and develop the market for these niches themselves. This meant that much of their time was taken up on what were relatively small elements of their overall business. In addition, despite this time commitment, even when they could see potential for growth in the alternative enterprises it was clear that they struggled for the necessary resources and time to develop the enterprise successfully. Similar findings were highlighted by Bowie (2016) [44] in her examination of niche marketing in New Zealand. As noted earlier, the competition in the markets was also problematic for producers with a feeling that they were in competition with each other. Again this was often contrasted with the situation in the dairy sector. Overall, the challenges facing the farmers within this study who are trying to develop new or niche enterprises reflect closely those identified by Hammervol and Toften (2012) [45].

These findings provide useful insights into the demand for NGS, in that if they can offer profitability at a reasonable scale (which potentially can also help with the farm system complexity issue) then they are likely to be attractive to land managers. There was a recognition that in order to achieve the necessary scale in NGS, then collaboration across landowners was necessary. A number of those that had developed alternative enterprises noted that they simply did not have the scale (in terms of land availability) to go to the next level, for example supplying supermarkets or export markets despite being aware that there was high demand for the products. This said, all the farmers expressed a willingness to collaborate in terms of developing new markets, for example making land available for specialist producers, etc., which would suggest that there is scope for the development of NGS at scale across the CPW scheme. The findings suggest that there is a role for facilitating what might be described as collective action in market formation [46]. These markets could, for example, relate to capturing value back to producers from the apparent willingness to pay premiums for products with credence attributes [47].

The analysis provides a clear picture of the opportunities and challenges with the provision of water in terms of encouraging a land use transition to NGS. Water was seen as financially attractive to some (worth the CPW investment), because it would increase the certainty of profit and reliability of return of existing crops as well as broadening the opportunities available to land-owners. However, the high cost of water in the scheme (estimated to be around \$800 dollars per hectare per year in the Stage 2 scheme, comprising \$600 for debt and \$200 for operational costs [48]) means that any enterprise has to generate a sufficient return to cover this even before the other costs of production are considered. Traditional sheep and beef enterprises would struggle to produce this sort of return and the main arable crops such as barley also produce a margin which is not much above this. Therefore, there is considerable pressure to change land use to more profitable enterprises. Whilst there are environmental constraints around the CPW scheme, the greater pressure would appear to be financial rather than environmental. INT001 for example stated that he did not think you could afford to be simply arable on CPS water, whilst in a similar vein INT004 was concerned that 'traditional approaches' would not be able to generate enough money to support the CPW costs. More generally, a number of respondents felt that some existing farmers would not be able to sustain their business. This illustrates the fact that matching current levels of profitability will not be enough to ensure NGS adoption, they need to be *more* profitable than current systems to enable farmers to cope with the costs of the irrigation scheme.

The technical and other knowledge requirements associated with new enterprises do not seem to be a barrier to adoption. It is clear from the interviews that farmers are confident in their ability to access knowledge even if they do not have the knowledge themselves. However, this does assume that the knowledge is available and if it is not it will need to be provided and for more novel NGS this may well be a challenge.

The results highlight that NGS are unlikely to be adopted if they are in conflict with the cultural values of the farmer. This corresponds with studies undertaken in Australia, Europe and North America highlighting the importance of cultural values in decision making about land use (for example see, [15,49,50]). For a number of participants, these values equate closely with the view that the land should be productive, which resonates with the research by Hand and Tyndall (2018) and was reflected in their reasons for joining the scheme. This may suggest the idea of some form of cultural path dependency in terms of land use and that there may be a role for extension and education activities to help redefine what it means to be a farmer.

As stated at the beginning of the paper, a key purpose of NGS will be to meet the wider environmental and social challenges facing New Zealand, however what emerges from this study is that whilst farmers are acutely aware of these challenges and their own role in environmental stewardship, currently they are not at the forefront of the land use decision-making process (other than issues around water quality). Whilst there was a clear recognition that wider environmental issues were rising up the policy agenda, for example the need to reduce GHG emissions, this was not currently a key focus of the planning for the future. This suggests that outside of the nitrogen leaching/water quality area (which is already built into the fabric of the CPW scheme) strong environmental performance alone will not be a major facilitator of adoption of NGS. It may be reasoned that the forces pushing away from traditional land uses or pulling towards NGS need to be strengthened, as relying on current market forces will not engender the necessary change. The recent proposals by the NZ Interim Committee on Climate change [51] for a levy on agricultural production is an indication that these push factors may be becoming stronger.

Overall, it is clear that NGS will be evaluated not just in terms of their overall performance across the domains considered in this study, but also how they perform relative to existing systems. There are clearly a number of advantages to dairy in terms of profitability, scale, advisory support, technology, ease of marketing, cash flow that makes it an attractive enterprise [25]. Whilst accepting that regulatory, environmental and social pressures on the dairy sector are increasing, it is currently hard to see alternative land uses (NGS) that can compete across all these dimensions.

Given the liberalization of agriculture in NZ, it may be argued that it is unlikely that subsidies will be widely used to encourage a transition to NGS, however there may be a role for government in helping with the process of forming markets (including strengthening the supply chains) for the products emerging from NGS, which may increase the attractiveness (the pull) of these systems for land managers.

6. Conclusions

This paper applied an MCDM approach to assess the factors influencing decisions around land use by land managers who were part of the CPW scheme in the South Island of New Zealand. The main purpose was to provide insights into the factors that land managers take into account when considering changing land use and to draw inferences as to what this may mean for encouraging a land use transition that relieves the environmental and social pressures that are emerging as a result of current land use. The CPW scheme was chosen as it provided the possibility of investigating the decision-making process in the situation where water has brought a range of new opportunities and challenges to land managers who are actively considering changing land use.

A number of criteria important in land use decision making were identified, classified into six higher level domains (Financial, Market, Social, Environmental, Knowledge and Regulatory) and included in the MCDM process. The results highlighted that no one domain completely dominated decision making, although financial factors were, on average, weighted more heavily than the others. Social, Environmental and Market factors were similarly weighted, whilst knowledge and regulatory domains appeared to have less influence on the decision-making process. The results also highlighted the very context-specific nature of land use change and how the weights generated for the different

factors varied considerably across farms, even within a relatively homogeneous region such as that covered by the CPW.

In addition to profitability, the study identified the desire of land managers to simplify complex agricultural systems, their need for scale, their concerns over ‘knowledge competition’, their willingness to collaborate and the challenge brought about by ‘cultural path dependency’ as being important. This suggests that if NGS can be developed that better meet these needs and concerns, then there may be a greater chance of engendering a land use transition. There would appear to be opportunities for the state and the private sector to support and facilitate the process.

The small sample size of those interviewed means that the ability to generalize beyond these farms that are part of the Central Plains Water scheme is limited. However, the findings do illustrate some of the challenges faced in NZ in terms of engendering a transformation in land use through the adoption of NGS. Without intervention aimed either at increasing the attractiveness of NGS in terms of meeting the needs of land managers (pull factors) or constraining more tightly existing land uses (push factors), or a combination of both, it would appear based on the decision-making processes identified in this study that large-scale land transformation is unlikely to occur.

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