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Advancing primary sector adaptation in Aotearoa New Zealand

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ABSTRACT

Climate change is already being experienced across the primary sector in Aotearoa New Zealand. Adapting to the impacts already being observed, while also anticipating future impacts, requires consideration of different time frames as well as grounding within the farmer or grower's own contexts. Uncertainty regarding longer-term climatic changes can present challenges for decision-making in the present time, but a growing body of analytical and practical processes can support this. Although some farmers are experimenting with different types of adaptation, more generally there is a dearth of action, particularly planning beyond the present and immediate future. Policy for monitoring and evaluating the effectiveness and lifetimes of adaptation actions is required, as well as extension services supporting farmers and growers.

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Introduction

Climate change is already being experienced across Aotearoa New Zealand. The effects are felt across communities, productive sectors and the natural environment. Temperatures have risen by 1.1° since pre-Industrial times, leading to changing seasonality, increasing frequency and intensity of drought, changing rainfall patterns, more extreme fire weather and more extreme rainfall (Lawrence *et al.*, 2022). Drought has caused economic losses attributable to climate change of at least $800M NZD (Frame *et al.*, 2020), and the extreme weather events of 2023 are likely to cause significant economic losses to the horticultural industry. Farmers and growers are facing increased disruption and stress from these changes, in conjunction with the uncertainty regarding the future and the multiple other demands on their businesses.

Adaptation to a changing climate

Many farmers and growers are aware of the need for change, but understanding what this looks like and what it might cost is less certain. Adaptation is very locally specific, and also depends on the diverse goals and aspirations of farmers, growers, industry groups and the wider sector. In some cases, adaptation may focus on preserving the current system, in other cases, and over time, adaptation may mean shifting to a different system. Farmers' and growers' goals will also change over time and as climate impacts intensify (and they face increasing other pressures).

Adaptation is often referred to as being as much a process as an outcome, and the ongoing nature of adaptation is one of the reasons for standard economic techniques for estimating costs and benefits no longer being appropriate. As the climate continues changing, adaptation must continue evolving. We

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are unlikely to reach a state where we are 'adapted' (or 'climate-proofed'); indeed, we are not adapted to the current climate, as illustrated by recent damages associated with flooding and drought.

Farmers and growers are experts in their local context (Griffin, Wreford, & Cradock-henry, 2023). Many have been making gradual adjustments to the timings of their operations (e.g. experimenting with different pasture/feed mixes (Moot & Davison, 2021)). Collecting data to monitor the effectiveness of these different approaches is necessary both to identify trends over time but also to provide evidence to other farmers to support their adaptation.

Short-term adaptation may reach limits or have maladaptive outcomes

Incremental adjustments to current systems will be sufficient for the current climate and in the short-term. However, as warming increases and the impacts intensify, these types of changes may reach the limits of their effectiveness (Adger *et al.*, 2009). Potentially, adopting certain approaches in the short-term could close off other approaches into the future, or lock the farmer/grower into a particular system that is no longer appropriate in the new climate, due to sunk-costs and potentially debt (Cradock-Henry, 2021).

Short-term decision-making also has the potential for maladaptive outcomes. Maladaptation refers to the unintended negative consequences of adaptation (Barnett & O'Neill, 2010). This might be over time, when an adaptation that is successful in the current climate or short-term leads to a negative impact later. Changing to a new type of crop that may be expected to perform better in the changing climate may lead to an increase in fertiliser use, and therefore increase greenhouse gas emissions, or be more vulnerable to pests and diseases and require more pesticide use, or could lead to lower soil quality over time.

Maladaptation also has scale effects, when the impact of one farmer implementing an adaptation may be neutral, but if all farmers in an area implement the same action, leading to negative effects. An example is the widespread adoption of irrigation, which is an effective adaptation for individual farmers, but can lead to a reduction in water quality and ecological implications for rivers, as well as conflicts between wider water users (Lawrence *et al.*, 2022). Similarly, increased drainage may help avoid waterlogged soils on the implementing farm, but may shift the water flows to neighbouring farms and negatively affect biodiversity and wetlands.

Decision-making in the longer term

Decisions with implications beyond the short-term encounter questions of uncertainty. Although projections of future climate change are available at regional levels (e.g. for New Zealand, MfE (2018)), these still contain considerable uncertainty. Four greenhouse gas concentration pathways (Representative Concentration Pathways, RCPs) are currently available, and in New Zealand, these are modelled by six General Circulation Models, which are then down-scaled to provide regional projections, which are potentially used to model hydrological, biophysical and economic outcomes. Every layer of additional modelling adds further uncertainty, leading to an 'uncertainty cascade' (Wilby & Dessai, 2010).

This uncertainty means that selecting one climate scenario to base risk assessments or adaptation decisions on is problematic. High-resolution down-scaled projections can generate a false sense of precision for decision-makers, particularly if only one climate scenario is considered. Accommodating the range of potential climate futures will lead to more resilient outcomes. Other uncertainties, such as around socio-economic development, trade and regulation can also be explored through scenarios, and the most recent IPCC cycle generated scenarios that combine socio-economic changes together with greenhouse gas concentration pathways (known as Shared Socio-Economic Pathways, SSPs (IPCC, 2021)).

Uncertainty cannot be a reason for inaction, however. Considerable advances have been made in developing and applying methodologies for decision-making under uncertainty. Some have been

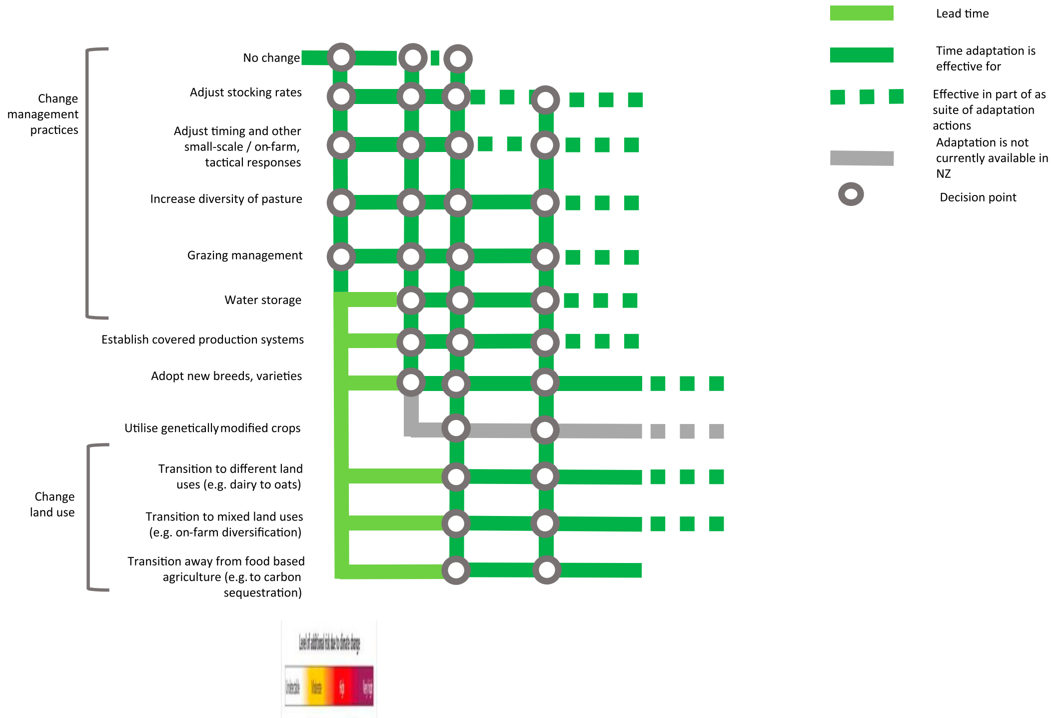

Figure 1. An example of an agricultural dynamic adaptive pathway (adapted from Cradock-Henry *et al.*, 2020).

adopted from other fields, such as Real Options Analysis (ROA) (Wreford, Dittrich, & van der Pol, 2020), which has its roots in financial economics, as does Portfolio Analysis (Fraschini, Hunt, & Zoboli, 2022). Some of these are alternatives to cost–benefit analysis (CBA) (Wreford & Renwick, 2012), where a range of climate futures are taken into account and flexibility is allowed for and explicitly valued (in ROA for example). Others seek to identify options that perform well across a wide range of climate futures (Robust Decision Making). Others have been developed specifically for adaptation decision-making, such as Dynamic Adaptive Pathways Planning (DAPP) (Haasnoot, Kwakkel, Walker, & ter Maat, 2013). Each approach is suitable for specific types of adaptation decisions and all have benefits and drawbacks.

Incorporating flexibility in the design and sequencing of adaptation is important in the agricultural sector. DAPP can assist farmers and growers to begin thinking about adaptation in their own contexts. DAPP involves identifying possible options for the future, what would trigger a shift to these options, and putting plans or finance in place so that those options can be implemented when the time comes.

Figure 1 illustrates a conceptual pathway identification process for a pastoral system. It illustrates adjustments to the status quo and best management practices at the top that may be sufficient in the short term. Moving down the figure, the actions become more transformative, including transition to mixed land-uses and away from food production altogether at the bottom. The circles represent decision-points, when the farmer may decide to move from one option to another. The solid darker green line indicates for how long the adaptation may be effective for (against the levels of risk illustrated along the bottom of the figure). The dashed green line indicates adaptations that may retain some effectiveness in conjunction with other adaptations. The solid light green line represents a lead-in time, where farmers will not begin implementing the option, but will need to investigate and put in place actions so they are able to implement it when necessary.

Scale of decision-making responsibility

Figure 1 represents a pathway for an individual farmer; however adaptation in the agricultural sector is wider than individual farms on their own. Industry bodies, regional and national government also have roles to play, which may enable or constrain the options available to farmers. Many of the farm-level adaptations are managerial, which while not necessarily costly, may require greater farm management skills than some farmers currently have. Supporting farmers through extension programmes and knowledge sharing is an important role for industry bodies. Investing in research and technology, so that these are available in the future when climate impacts intensify is also a critical role for industry bodies and perhaps also government. This investment may be in developing more drought-tolerant species or enhancing animal genetics for heat tolerance, for example.

The geography of New Zealand offers some scope for spatial adaptation: shifting production from one region to another as the climate suitability changes. Regional specialisation has evolved based on a combination of climatic as well as biophysical factors, including geology and soil type, so it may be more complex than shifting production southwards. However, there may be potential opportunities to shift production as well as try new crops that have until now not been able to be grown in New Zealand.

Conclusion and recommendations for policy

Globally, and in Aotearoa New Zealand, there is strong evidence of an 'adaptation gap' – where adaptation is necessary and possible but is not occurring. Reasons for this vary by region and context. However, even for countries, groups and individuals with theoretically high adaptive capacity, an adaptation gap can exist. This will be due to the existence of barriers, whether they are financial, behavioural or cognitive, knowledge, structural, or regulatory (Wreford, Ignaciuk, & Gruere, 2017).

The critical roles for policy and industry in supporting agriculture to adapt effectively to climate change focuses around collecting data and monitoring existing adaptations for their performance over time, and providing extension and knowledge sharing to support farm management skills for adaptation. Investment in research and technology for crops and livestock in future climates needs to begin now so they are available when farmers and growers need them. But these investment decisions must be made carefully and using the most robust investment appraisal approaches. Because most of the benefits of on-farm adaptation accrue privately, there is currently little requirement for regulation. However, if the adaptation gap persists while impacts intensify, there may be scope to require adaptation planning, in Farm Environment Plans for example.

Every context will be different, so developing a blueprint for optimal adaptation is impossible. However, the principles of considering different time frames; anticipating and avoiding unintended consequences; and allowing for flexibility in adaptation decisions are the foundations for robust adaptation.

Insufficient evidence currently exists for understanding the lifetime of possible adaptation strategies in New Zealand agriculture, but in general, as the climate changes intensify, more transformative changes will be required. Supporting farmers and growers to make these changes will be essential.

The concept of limits to adaptation serves to emphasise the critical importance and urgency of reducing greenhouse gas emissions. Every 0.1 degree of avoided warming will mean slightly less intense and rapid changes. The difference between keeping warming below 1.5 degrees and going beyond can mean the difference between operating within our current range of experience, and going into unchartered territory. The agricultural sector must also play its part in emissions reductions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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