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Moving beyond description to explore the empirics of adaptation constraints

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ABSTRACT

The concept of adaptation constraints has become well known in the climate change literature. It describes impediments to the process of adaptation that could in principle be overcome but often are not. Many adaptation constraints have been identified and described in the literature across a wide range of contexts, and the importance of their influence on climate change adaptation is clear. However most studies have focussed on *describing* constraints rather than exploring their origins, processes, and possible impacts. As a consequence, it has been difficult to operationalise the concept to provide information meaningful to decision makers.

This study demonstrates an approach to estimating empirically the processes and the impacts of adaptation constraints, based on a case-study of farmers in New Zealand. It combines established social scientific methods to explore the processes underlying a range of adaptation constraints and estimate the impacts that these constraints may have. The approach can be used to explore further the social and economic impacts of adaptation constraints. This information can then be used to consider sub-optimal adaptation to climate change more fully, and paves the way for policy responses that are more conscious of the human elements of climate change adaptation.

1. Introduction

As limits to our ability to mitigate medium-term climate change and shortfalls in our actions to avoid long-term climate change become clearer (Rogelj et al., 2015, 2016), there has been a growing recognition of the importance of adaptation. Meinke et al. (2009, p.74) state that "Adaptation is rapidly emerging as one of the biggest global agenda items for this decade, and possibly the century". While our understanding of the physical science of climate change has improved, and indicates a significant chance that warming will exceed 4 °C, Adger et al. (2009a, p. 20) point out that "… in effect, there is no science on how we are going to adapt to 4 °C warming".

A small body of literature has identified considerable *potential* for human systems to adapt to climate change (Elliott et al., 2014; IPCC, 2014; Nelson et al., 2013). Some studies suggest that this potential may exceed the expected negative impacts of climate change, even in highly vulnerable communities (Gawith et al., 2015; Iglesias and Garrote, 2015; Nordhagen and Pascual, 2013).

As Adger and Barnett (2009) point out however, adaptive potential does not necessarily translate into adaptation. Despite increases in research and awareness, many studies report a lack of adaptive *action* (Mills et al., 2016; Berrang-Ford et al., 2011; Davidson, 2016; Lesnikowski et al., 2015; Burke and Emerick, 2016). Repetto (2009, p.20) points out that "to say that [we] *can* adapt to climate change does not imply that [we] *will* adapt" (emphasis in original). The difference between these two notions is fundamentally important, because underestimating the difficulties of adaptation risks forming unreasonably optimistic expectations about the costs of climate change.

Observations of the gap between adaptive potential and adaptive action demonstrate the existence of an 'adaptation deficit'. The adaptation deficit is the gap between current and optimal levels of adaptation when optimal adaptation is considered to be that which delivers the "gross (or theoretically maximum) benefit of adaptation and risk management" (IPCC, 2012, p.265; Burton and May, 2004). In this sense, the adaptation deficit can be understood as inadequate adaptation to current climatic conditions (Burton, 2004; Burton and May, 2004), and the term can be closely linked to a broader 'development deficit' (World Bank, 2010; Hallegatte et al., 2016). Efforts to understand the adaptation deficit have focused on adaptation constraints – a term which has been used interchangeably with the terms 'adaptation barrier' and 'adaptation obstacle' in the literature (Fankhauser, 2017; Simões et al., 2017). This study adopts the definition of Eisenack et al. (2014, p. 868) who state that:

"[An adaptation constraint] is (1) an impediment (2) to specified

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adaptations (3) for specified actors in their given context that (4) arise from a condition or set of conditions. A [constraint] can be (5) valued differently by different actors, and (6) can, in principle, be reduced or overcome."

Adaptation constraints stem from the actors involved, their governance systems, and their environments and relate to behavioural, social, economic, and environmental characteristics (Biesbroek et al., 2013; Masud et al., 2017; Simões et al., 2017). Adger et al. (2009a, p.3) suggest that analyses that overlook factors such as adaptation constraints "may present a dangerously misleading understanding of the consequences of climate change". Despite this, adaptation constraints are often ignored in studies seeking to assess the economic impacts of climate change (Nolan et al., 2009; Gifford et al., 2011; Mendelsohn and Dinar, 2009).

While a large number of adaptation constraints have been identified in recent years, there remains what de Bruin and Dellink (2011, p.34) describe as "a significant gap in the literature regarding the effects of restrictions on adaptation". In their review of the adaptation constraints literature, Biesbroek et al. (2013, p.1119) found that a vast number of distinct constraints have been identified, but concluded that there is a need to move beyond the *identification* of constraints to assess their origins, processes, and possible impacts. While recent work by Herrmann and Guenther (2017), Burnham and Ma (2017), and Masud et al. (2017) has added empirical rigour to the identification of adaptation constraints, their methods stop short of estimating the impacts that these constraints may have.

Indeed, because of the lack of empirical depth, Biesbroek et al. (2015) have questioned the value of the concept of adaptation constraints. They argue that the linear, functionalist, and generally descriptive treatment of constraints has provided little insight useful for policy. De Bruin and Dellink (2011, p.42) acknowledge that "Understanding what adaptation restrictions are actually being faced or are likely to arise is an important issue that direly needs more attention."

This study aims to demonstrate a generalizable method for exploring the empirics of adaptation constraints. It uses qualitative and quantitative data from a case study of farm decision-makers in New Zealand to evaluate which constraints are likely to be important, how they manifest, and how large their impacts might be. The results of this work are presented in a way that could be used meaningfully in policy and model-based analysis of climate change adaptation.

2. Empirical methods

2.1. Focus

This study focusses on the constraints on adaptation in agriculture because of the vulnerability of the sector to climate change. While climate change is a global problem, its impacts vary at local scales and require local adaptive solutions. Therefore, this study focuses on adaptive responses in a single agricultural case study catchment in New Zealand called the Hikurangi catchment, shown in Fig. 1. The Hikurangi catchment is located in the Northland region and covers an area of approximately 84,000 ha. Of that total area, 41% is currently used for drystock farming, 38% for dairy farming, 9% for plantation forestry, and 1% for horticulture.

Approximately half of all farms in New Zealand are owner operated or owned in a single family trust (Nuthall, 2006; Brown et al., 2013). Owner operators were therefore the primary actors of concern in this study. Landlords, banks, private-sector extension services, and local authorities were also likely to be important actors in adaptation decision making, so their influence was also considered.

2.2. Empirical approach

The empirical assessment of adaptation constraints was designed to assess the relative impacts of adaptation constraints and to develop numerical preference functions to represent them in modelling and policy analysis. Given that the dominant models that explore the economic impacts of climate change use various forms of economic optimization (Mendelsohn and Dinar, 2009; Nolan et al., 2009), these preference functions were defined as quantitative deviations from a profit-maximising scenario. For example, a number of constraints are put forward as reductions in the likelihood that farmers will make a profit-maximising adjustment. Others are put forward as adjustments to the profit-maximising calculus whereby adjustment costs or time delays affect farmers' decisions.

Constraints were explored first in a review of existing literature about the constraints on agricultural adaptation to climate change. This informed the design of a mixed methodological approach to empirically assessing adaptation constraints. Semi-structured interviews were used to gain an understanding of farmers' attitudes, perceptions of risk, and how and why their adaptive behaviours might depart from profit maximisation. An extensive socioeconomic survey was used to assess whether the hypothesised constraints correlate with farmers' expressed adaptive propensities, and if so, how strong these correlations were. The qualitative findings were used to inform the construction of preference functions, a number of which were quantified using the results of the quantitative assessment. This structure is shown diagrammatically in the graphical abstract.

2.3. Survey approach

Surveys were used to understand the characteristics and variance of important farmer attributes, as well as to test the significance and strength of a range of adaptation constraints. In order to maximise the potential reach of survey questions, this study contributed to the design of, and took data from, an existing large-scale national longitudinal survey programme called the Survey of Rural Decision Makers (SRDM) (Brown et al., 2013; Brown, 2015). The 2015 SRDM collected data on a wide range of conditions and opinions relevant to rural land use and management (Brown, 2015; Brown and Roper, 2017). A suite of questions relating to expected changes in climate, challenges in accessing climate change information, expected changes in future land use and management practices, the perceived importance of profit, lifestyle, and environmental performance, past experiences of climate related stress, and the efficacy of institutions was developed and included specifically for this study.

The survey was designed and administered online. It was sent to 65,000 email addresses of farmers listed in the National Animal Identification and Tracing database (1831 responses), 1897 individuals who had previously responded to the 2013 SRDM (636 responses), and was advertised by a number of industry groups including Beef + Lamb New Zealand, the Farm Forestry Association, Federated Farmers, Horticulture New Zealand, the QEII Charitable Trust, and Rural Women (Brown et al., 2016). This garnered 2832 responses from commercial farm owners and farm managers. Due to space constraints in the survey, a randomly selected 25% (708) of the 2832 commercial respondents were asked questions about climate change relevant to this study.

Given the mixture of distribution techniques, it was not possible to determine an overall response rate. These techniques may be expected to bias the dataset towards farmers who use computers and email on a regular basis. Furthermore, given the major source of responses was a livestock database, the techniques also risked under representing non-pastoral agriculture. Despite these potential biases, the overall dataset was found to closely match population data from the 2012 census in terms of farmer age and industry (Brown and Roper, 2017).

2.4. Interview approach

Semi-structured interviews were used to explore the salience, origins, and processes of adaptation constraints. Interviews were designed