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Agricultural Innovation for Climate Change Mitigation and Adaptation: A Comparison of New Zealand and California Farmers and Policies

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AGRICULTURAL INNOVATION FOR CLIMATE CHANGE MITIGATION AND ADAPTATION: A COMPARISON OF NEW ZEALAND AND CALIFORNIA FARMERS AND POLICIES

By
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Dedication

I want to dedicate this work to my godchildren Franklin and Penny and my other young cousins Janey, Charlotte, Colby, Caroline, Nate and Alex, in the hopes that my work can help make the world they live in better than the one I have lived in.

Table of Contents

Abstract and Introduction

Globally agriculture accounts for 14% of global greenhouse gas emissions and is slated to be affected by a diversity of climate change impacts varying across agroecosystems (Smith et al., 2007b; Smith et al., 2008). As a result, farmers are an important component of strategies to reduce global emissions and implement adaptation strategies for continued food production. There are a suite of existing practices to reduce agricultural greenhouse gas emissions including energy and fuel efficiency, reducing the use or increasing the efficiency of nitrogen inputs, soil management strategies, conservation tillage, organic agriculture, increased animal efficiency, and afforestation to name a few (Johnson et al., 2007). As well, strategies to assist agricultural communities in adapting to climate change impacts will vary greatly across agroecosystems and regions, which may face different potential impacts and options for adaptation. While a number of studies have considered the adoption of agricultural climate change practices, particularly in the developing world (see for example: (Bryan et al., 2009; Gbetibouo et al., 2010; Mertz et al., 2009; Seo and Mendelsohn, 2008a, b; Thomas et al., 2007)), research has only recently examined implementation across developed countries (see for example: (Arbuckle et al., 2013a; Arbuckle et al., 2013b; Barnes and Toma, 2012; Wheeler et al., 2013)), which often have different farm production systems, social norms, and policies.

This work applies the psychological distance theory (Liberman and Forster, 2009; Liberman and Trope, 2008) to empirical data from surveys and interviews conducted with Yolo County, California and Hawke's Bay and Marlborough, New Zealand farmers to understand what drives the adoption of climate change practices across differing agroecosystems and regional climate change policies. The psychological distance theory suggests that events that are "closer" to

individuals (temporally, socially, geographically, and in certainty) are most likely to influence their behavior. In the context of climate change, the psychological distance theory aims to understand how distant versus proximate climate change concerns and experiences influence an individual's potential to implement mitigating and adaptive behaviors (Spence et al., 2011; Spence et al., 2012). This is the first body of work to which the psychological distance theory has been applied to understand farmer adoption of climate change practices. In particular this work considers how climate change experiences, climate change belief and risk perceptions, local concerns for climate change impacts, environmental policy experiences and perceptions, cost barriers, and perceived capacity to reduce emissions affect the adoption of climate change adaptation and mitigation practices and climate change policy support and participation.

Each region faces different climate change policies, which frame the historical and future context in which farmers across both regions consider climate change and potential mitigating and adaptive behaviors. California currently has a cap and trade program to reduce greenhouse gas emissions, which indirectly affects farmers through increased costs (California Air Resources Board, 2008). Conversely, New Zealand was proposing to be the first country in the world to require agriculture to participate in its Emissions Trading Scheme (ETS). Agricultural processors are required to report greenhouse gas emissions and farmers and the agricultural industry have been affected by increased costs associated with fuel and transport's inclusion in the scheme (Ministry for the Environment, 2013b; Moyes, 2008; New Zealand Government, 2011). These various policies are considered both for the extent to which farmers across the regions support the varying policies and what influences this support as well as how the development and implementation of such policies have potentially influenced farmer perceptions of climate change and their responses.

In the fall and winter of 2010 interviews were conducted with 11 farmers and agricultural extension agents in Yolo County, California to assess their climate change beliefs, risk perceptions, potential adoption of adaptation and mitigation practices, and concerns about future climate related impacts and policies. Interviews were transcribed and coded and used to develop a mail survey, which was distributed in winter 2011. A total of 162 farmer responses were obtained and analyzed from the survey using factor analyses, scale creation, multiple mediation models, and structural equation models (Jackson et al., 2012b).

A pilot study was conducted in New Zealand in 2010, including 17 interviews with agricultural processors, industry professionals and regional policymakers about the ETS and climate change. In 2012, an additional 20 interviews were conducted with farmers, agricultural industry professionals and regional policymakers related to climate change belief, risk perceptions, the ETS, and the adoption of mitigation and adaptation practices. All interviews were transcribed, coded, and, along with expert feedback, were used to revise the California survey instrument. The survey was adapted for local context and language as well as relevant practices for the region's given agroecosystems. The survey was implemented via telephone in August-October 2012, first piloted with 10 farmers outside the two regions. A total of 490 farmers responded to the survey. Factor analyses, scale creation, multiple mediation models and structural equation models were utilized to analyze data.

Four total chapters encompass this dissertation. Chapters 1 and 3, based on data from California and New Zealand respectively, use the same multiple mediation model methods to analyze how climate change experiences influence local and global climate change concerns and the adoption of climate change practices. Chapters 2 and 4, based on data from California and New Zealand respectively, utilize structural equation models to consider how climate change experiences, belief and risk perceptions and other factors influence the support for climate change policies within each region.

Chapter 1 details how local versus global climate change concerns influence the adoption of mitigation versus adaptation behaviors differently. I predict that local level concerns for climate change will influence the adoption of adaptation behaviors, since these behaviors are largely for private benefits and will impact farmers more "closely". Conversely, I suggest that global climate change concerns, which are more distant, will influence mitigation behaviors, which are largely for a global benefit and are not as closely observed. In applying the psychological distance theory, I find that climate change experiences (perceived change in water availability) influence both local and global climate change concerns and impacts. I confirm that local concerns for climate change impacts influence the adoption of adaptation behaviors while global climate change concerns affect the adoption of mitigation behaviors. These results are consistent with the psychological distance theory and construal level theory, which suggests that mitigation is largely motivated by psychologically distant concerns and beliefs about climate change, while adaptation is driven by psychologically proximate concerns for local impacts. As such, outreach, education and communication efforts to encourage mitigation or adaptation behaviors may benefit by framing climate impacts and behavioral goals concordantly; either in a global context for mitigation or a local context for adaptation.

In Chapter 2, I apply the psychological distance theory to assess how farmer's past experiences with climate change and environmental policies influence farmer's climate change belief and risk perceptions and in turn, their support or concern for climate change policies and programs ("climate policy risks"). Given that California farmers have historically been exposed to significant environmental regulation, I hypothesize that past environmental policy experiences would have a larger influence on a farmer's climate change belief, risk perceptions and policy support because these regulations were "closer" to a farmer than actual climate change experiences. I tested three hypotheses regarding climate policy risk: 1) That perceived climate change risks will have a direct impact on farmer's responses to climate policy risks, 2) That previous climate change experiences will influence farmer's climate change perceptions and climate policy risk responses, and 3) That past experiences with environmental policies will more strongly affect a farmer's climate change beliefs, risks, and climate policy risk responses. Using a structural equation model I found support for all three hypotheses and furthermore show that farmers' negative past policy experiences do not make them less likely to respond to climate policy risks through participation in a government incentive program. This work suggests that incentive programs are a potential opportunity for policymakers to encourage farmer adoption of climate change practices, even if these farmers have had less than favorable perceptions of previous environmental policies. The work also discusses and highlights the importance of policy engagement with farmers and agricultural communities in light of the lag effect that environmental policies (some more than 30 years since implementation) can have on a farmer's perception of future environmental issues.

In Chapter 3, I shift to New Zealand and build off of the California research to examine how the psychological distance theory can be applied to understand farmer behavior related to climate change. I posit that farmers are likely to respond to climate change threats deemed to be "closest" to them as the psychological distance theory suggests. I suggest that those "close" threats are likely those that farmers have had to historically contend with, and that are likely the most "limiting factor" within their farm system. I combine the psychological distance theory with Liebig's Law of the Minimum, a seminal agricultural science and ecological principle that states an organism is limited in its growth by its most limiting resource. I examine water and temperature related climate impacts as two types of limiting factors, and suggest that these limiting factors will be the mediating factors between a farmer's climate change experiences and their adoption of climate change adaptation practices. I hypothesize that water will be a limiting factor among sheep and beef farmers in Hawke's Bay given their historical exposure to drought, future potential for drought, vulnerability of rain-fed sheep and beef systems to drought, and the lack of irrigation infrastructure in the region. Conversely, I suggest that temperature will be the limiting factor driving the adoption of adaptation behaviors in Marlborough among wine grape growers given the prevalence historically of frosts and temperature extremes, the sensitivity of the region's sauvignon blanc wine variety to temperature change, and the existing water infrastructure. Through multiple mediation models like those utilized in Chapter 1, I find support that water is the limiting factor in Hawke's Bay, but find that both water and temperature are limiting factors in Marlborough. I also demonstrate that a diversity of climate change experiences (perceptions of changes in summer temperature, winter temperature, water availability, annual rainfall, drought, floods, wind and slips) all influence limiting factor concerns for farmers and in turn affect their potential to adopt adaptation practices. This suggests that farmers perceive and respond to climate change in part due to their personal experiences with climate change and the limiting factors within their system. This paper is among the first to theoretically link two interdisciplinary theories to develop a theoretical approach to connect agroecosystem and climatic diversity with farmer decision-making in the context of agricultural adaptation to climate change.

In Chapter 4 I apply the psychological distance theory to understand New Zealand farmer support for the ETS. I assess how climate change experiences influence climate change belief and risk perceptions and subsequently support (or lack thereof) for the New Zealand ETS. In addition, I test whether perceived capacity to reduce emissions (often referred to as a sense of powerlessness in the climate change behavior literature) and cost perceptions are barriers to support for the ETS. Given that New Zealand farmers have no farm subsidies and are a heavily export driven economy, I hypothesize that cost will be a major barrier to support for the ETS. Simultaneously, given the dominance of livestock in the New Zealand economy, in my survey sample, and the large portion of New Zealand's total emissions from livestock, I suggest that perceived capacity to actually reduce emissions is another barrier for policy support. Through a structural equation model I confirm my hypotheses and demonstrate that the psychological distance theory can be applied to understand farmer support or rejection of climate change policies (specifically an ETS in this context). Climate change experiences influenced climate change belief/risk perceptions, which influenced cost perceptions, perceived capacity and ETS support. Cost perceptions and perceived capacity also acted as a mediating factor between climate change belief and ETS support. Overall, the largest influence on ETS support was the perceived costs of implementing the policy. I discuss the need for continued research to provide farmers with cost-effective agricultural mitigation options that can increase a farmer's perceived capacity to reduce emissions, and thus potentially increased their support for policies like the ETS.

Chapter 1:
Haden, V.R.*, **M.T. Niles***, M. Lubell, J. Perlman, L.E. Jackson. Global and Local Concerns: What Attitudes and Beliefs Motivate Farmers to Mitigate and Adapt to Climate Change? PLoS ONE: 7 (12). * Both authors contributed equally to this manuscript

GLOBAL AND LOCAL CONCERNS: WHAT ATTITUDES AND BELIEFS MOTIVATE FARMERS TO MITIGATE AND ADAPT TO CLIMATE CHANGE?

Abstract

In response to agriculture's vulnerability and contribution to climate change, many governments are developing initiatives that promote the adoption of mitigation and adaptation practices among farmers. Since most climate policies affecting agriculture rely on voluntary efforts by individual farmers, success requires a sound understanding of the factors that motivate farmers to change practices. Recent evidence suggests that past experience with the effects of climate change and the psychological distance associated with people's concern for global and local impacts can influence environmental behavior. Here we surveyed farmers in a representative rural county in California's Central Valley to examine how their intention to adopt mitigation and adaptation practices is influenced by previous climate experiences and their global and local concerns about climate change. Perceived changes in water availability had significant effects on farmers' intention to adopt mitigation and adaptation strategies, which were mediated through global and local concerns respectively. This suggests that mitigation is largely motivated by psychologically distant concerns and beliefs about climate change, while adaptation is driven by psychologically proximate concerns for local impacts. This match between attitudes and behaviors according to the psychological distance at which they are cognitively construed indicates that policy and outreach initiatives may benefit by framing climate impacts and behavioral goals concordantly; either in a global context for mitigation or a local context for adaptation.

Introduction

Even if the most optimistic emissions mitigation targets set by the Intergovernmental Panel on Climate Change are achieved, climate change will continue to progress for many decades to come (Intergovernmental Panel on Climate Change, 2007; Matthews and Caldeira, 2008). Given agriculture's reliance on natural resources and weather, it is inherently vulnerable to climate change impacts (Bryan et al., 2009; Leary, 2006). Agriculture is also an important source of greenhouse gas emissions, accounting for 10-12% of total anthropogenic emissions annually (Smith et al., 2007a). These facts highlight the need to balance effective mitigation efforts that reduce greenhouse gas emissions with robust adaptation initiatives that enable farmers to cope with the effects of climate change and thus safeguard the resilience of social-ecological systems like agriculture (Niles and Lubell, 2012; Ostrom and Cox, 2010; Reganold et al., 2011). In the United States, California has been one of the first states to provide a policy framework for climate change mitigation and adaptation initiatives, many of which have implications for the agricultural sector (California Air Resources Board, 2008; Victor et al., 2005). Under California's Global Warming Solutions Act (AB-32), which aims to reduce greenhouse gas emissions to 1990 levels by 2020, the state is developing policies to encourage voluntary mitigation and adaptation among farmers through the adoption of water and crop management practices, renewable energy technologies, and possible participation in carbon markets (California Air Resources Board, 2008; Niemeier and Rowan, 2009). While a few countries now regulate emissions from agriculture through mandatory reporting, emission caps, or taxes on inputs, most countries employ a voluntary approach (Kerr and Sweet, 2008; Niemeier and Rowan, 2009). Since these climate policies rely on bottom up voluntary efforts by rural communities and individual farmers, their success will require a sound understanding of what motivates farmers to adopt practices that facilitate mitigation and adaptation (Krosnick et al., 2006; Leiserowitz, 2006; Smith et al., 2007b). This study examines how past climate perceptions and local and global climate change beliefs and concerns influence the adoption of both mitigation and adaptation practices among farmers.

One of the primary challenges of climate change is that the risks are often perceived as being rather distant and diffused over space and time. This "psychological distance" associated with climate change is comprised of geographic, temporal, and social dimensions as well as the perceivers' feelings of uncertainty (Spence et al., 2011; Spence et al., 2012). Emerging research on psychological distance and its associated Construal Level Theory (CLT) suggests that individuals experience cognitive perceptions of climate change that can be either close or distant (Liberman and Trope, 2008; Spence et al., 2012). For instance, climate impacts that are psychologically close (e.g. geographically or temporally proximate) are construed as concrete, tangible events relevant to the perceiver's specific local or personal context (i.e. low level construal). In contrast, climate impacts that may occur further away or well into the future are perceived as being psychologically distant, and thus require higher levels of cognitive abstraction (i.e. high level construal).

As a result, some hypothesize that framing climate change in terms of local consequences may motivate action because the personal risks are psychologically close (Spence and Pidgeon, 2010; Spence et al., 2012). Several studies have found that first-hand experience with local climate-related events can increase concern for local climate impacts, thereby increasing an individual's response to mitigate climate change (Spence et al., 2011; Whitmarsh, 2008). For example, Spence et al. found that experience with flooding increased people's concern for climate change and their willingness conserve energy (Spence et al., 2011). Whitmarsh found a similar effect of past experience on risk perceptions and climate change response among air pollution victims, but not among flood victims (Whitmarsh, 2008). Conversely, Spence et al. also found that framing climate change in terms of distant impacts can influence mitigation behavior presumably by tapping into people's core values and beliefs, which also require high level abstract construal (Liberman and Trope, 2008; Spence and Pidgeon, 2010). This view is consistent with other studies which indicate that high level construal leads people to act in cooperative (rather than competitive) ways when addressing environmental issues and other collective action dilemmas (Sanna et al., 2009; Sanna et al., 2010). Notably, most of the studies involving psychological distance and climate change have focused on the attitudes that influence mitigation behavior, while little is known about how construal level affects adaptation behavior. Moreover, CLT has not yet been applied to agricultural decision-making and farmers' adoption of mitigation and adaptation practices in response to climate change.

Our main hypothesis is that global beliefs and concerns about climate change will have a strong influence on farmers' mitigation behavior, while psychologically proximate concerns for local climate impacts will motivate farmers' adaptation behavior. This premise is derived from recent studies which suggest that the association between attitudes and behaviors is stronger when there is a *match in construal level (Sanna et al., 2009; Sanna et al., 2010)*. While the difference in construal level between distant global concerns and proximate local concerns is self-evident, an understanding of how mitigation and adaptation behaviors are cognitively construed requires a closer examination. Greenhouse gas mitigation is a collective action problem requiring global cooperation to address the causes of climate change, while adaptation appeals to a farmer's self-interest by helping them cope with specific local consequences (Lubell et al., 2007; Weber, 2006).

This distinction is important because the outcomes of a farmer's efforts to mitigate emissions are diffused globally, whereas his/her efforts to adapt to local impacts yield results that are easier to observe firsthand. Thus we contend that mitigation behaviors have a higher level of construal than adaptation behaviors and predict that the construal level of their climate change concerns will match and influence the respective behaviors.

Results and Discussion

To test this hypothesis we used a survey to measure farmers' past climate perceptions, local and global climate change concerns, and willingness to adopt mitigation and adaptation practices (see methods below and online supplementary material). Questions in the survey were used to develop scales which served as variables in a series of multiple-mediation models predicting farmers' intention to adopt various mitigation and adaptation practices (Table 1). Multiple mediation models assess whether the effects of an independent variable on a dependent variable are "mediated" by one or more additional variables (Hayes, 2009; Zhao et al., 2010). The main value of multiple mediation analysis in social psychology research is that it allows one to examine mechanisms and test theories about how information, experiences, and attitudes influence behavioral intentions (Preacher and Hayes, 2008; Rucker et al., 2011). Here, the independent variables were farmers' perceptions of past change in local water availability and summer temperature (Table 1). We considered a total of six agricultural practices for both mitigation and adaptation which are relevant to intensive agricultural systems in the dry summer climate of California's Central Valley (Figure 1). Factor analysis yielded two sets of dependent variables for mitigation behaviors (e.g. "energy and nitrogen (N) efficiency practices" and "renewable energy technologies") and adaptation behaviors (e.g. "new irrigation practices" and "new cropping practices") (Table 1). Mediating variables included local concern for water availability and temperature change, and global climate change belief and concern. Key farmer demographics (age, education, local origin, and full-time farmer) and farm characteristics (acres managed and organic status) were also included as covariates. Respondents who are more concerned about climate change may also report changes in past local climate more frequently. We controlled for this by allowing independent, mediator, and demographic variables to co-vary in the multiple-mediation models. Thus, the effect of any significant mediation pathway may be viewed as over and above the effects of these other factors.

On average, farmers in this region of California perceived a decrease in both local water availability and summer temperature over the course of their career (Table 1). When asked to consider future local climate impacts, a majority of farmers were either concerned or very concerned about less reliable ground water (57%) and surface water (56%), while 36% were concerned about more severe drought. A minority of respondents expressed concern for more frequent heat waves (27%), warmer summer temperatures (26%), or fewer winter chill hours (26%). Overall, farmers tended to show greater concern for future changes in local water availability relative to local temperature. While a majority of farmers agreed to some extent that the global climate is changing (54.4%) and poses risks to agriculture globally (53.4%), they were more divided in their views regarding whether global temperatures are increasing (37.5% agreed, 31.0 % disagreed, 24.8% neutral, 5.6% uncertain) and whether human activities play a role in causing climate change (35.2% agreed, 34.5% disagreed, 26.0% neutral, 4.3% uncertain).

The multiple-mediation models also indicate that a perceived decrease in past water availability increased farmers' concern for local water availability in the future, and to a lesser extent, their concern for and belief in global climate change (Fig. 2, 3). In contrast, perceived changes in summer temperature had no effect on concerns for local temperature-related impacts or their belief in global climate change in any of the models (Fig. 2, 3). This lack of concern for changes in temperature is likely due to the perception among most farmers (61.9%) that no change in summer temperatures had occurred over the course of their career. Of those who did observe a change, most felt that summer temperatures had decreased (21.3%) rather than an increased (5.6%). These differences in perception may be specific to the local context since declining water availability is a persistent issue of personal and political apprehension among California farmers, while local temperatures during the summer growing season are perceived to have changed little in this region. In regions where temperature increases during the main growing season are more prominent temperature-related impacts are likely to be a more important source of concern, as has been demonstrated among African and Andean farmers (Bryan et al., 2009; Valdivia et al., 2010).

Consistent with our main hypothesis, the multiple-mediation analysis indicated that perceived change in past water availability had a significant indirect effect on both sets of mitigation practices, which were mediated only through farmers' global climate change beliefs and concerns. A significant direct effect of global climate change belief and concern on farmers' willingness to adopt mitigation practices was observed in all models (Fig. 2). This contrasts with adaptation practices that show a different pattern, whereby local concern for future water availability was the only significant mediator between the independent and dependent variables (Fig. 3). Among the two types of adaptation practices, only new irrigation practices were significantly affected by local water concerns, which mediated the effect of perceived change in past water availability. Adopting new cropping practices such as using a drought tolerant variety of a farmers' current crop or shifting to a less water intensive crop had a lesser likelihood of adoption among farmers (Fig. 1), which explains why these practices were not influenced by local and global concerns in our models.

These findings provide evidence that the attitudes motivating mitigation versus adaptation behavior tend to be cognitively represented at different construal levels. These results are consistent with psychological experiments conducted by Sanna et al. showing that high level construal leads to cooperative environmental behavior (e.g. mitigation practices), while lower level construal generally encourages action to safeguard one's self-interest (e.g. adaptation) (Sanna et al., 2010). The fact that psychologically distant concerns were a key determinant of mitigation behavior is likely a function of the abstract processing required for one to develop cogent beliefs (or skepticism) regarding the veracity, cause, and solution for global climate change. This suggests that adoption of mitigation practices is motivated more by a farmer's belief in and concern for long-term risks to society at large as opposed to the near-term personal risks, which, by contrast, are one of the goals of adaptation. Thus, framing climate change in terms of global impacts and the societal "gains" that might be achieved through mitigation can appeal to an individual's desire to contribute to the public good and may yield greater adoption than messages intended to provoke fear of local and/or personal consequences (Spence and Pidgeon, 2010).

By contrast, adaptation among these farmers is primarily motivated by their concern for local climate impacts, which have low level construal and are by definition psychologically close (Table

1). Individuals who are operating in a psychologically proximate mindset - be they farmers or otherwise - will tend to pursue specific goals that they perceive as being both feasible and effective for dealing with problems near at hand (Rabinovitch et al., 2009). Past studies also indicate that the adoption of agricultural practices to cope with climate change is strongly influenced by affect and emotion, presumably because affect-driven concerns tend to be construed as psychologically closer to one's personal circumstances (Weber, 2006; Weber, 1997). For example, when people know from past experience that certain circumstances pose a threat to them, feelings of concern and worry motivate them to take specific self-protective measures (Loewenstein et al., 2001). This combination of context-specific goal-setting and elevated emotional engagement, which are characteristics of a low level construal, suggest that adaptation initiatives should seek to draw farmers' attention to highly specific local impacts and perhaps more importantly to the private benefits that may be secured if they take action to cope with the consequences of climate change.

Despite these findings, the temporal dimension of psychological distance remains an important barrier to both mitigation and adaptation. This is due to the strong tendency of people to discount the long-term benefits of taking immediate action on climate change as compared to the more tangible near-term costs (Loewenstein and Elster, 1992; Weber, 2006). Thus, when faced with a choice among mitigation and adaptation practices farmers may generally opt for practices that offer greater private benefits attainable in the immediate future. Here, farmers indicated that they were more likely to adopt measures to reduce fuel and electricity consumption and/or improve nitrogen use efficiency, which might allow them to save money on energy and inputs in addition to reducing their greenhouse gas emissions (Fig. 1). Likewise, adaptation practices such as drip irrigation and increased use of ground water, which are relatively easy to adopt and offer clear economic incentives, were preferred over other risk reduction measures (Fig. 1). Farmers were also less inclined to implement adaptation and mitigation practices with relatively large up-front costs (e.g. drilling new wells or installing renewable energy technologies). This indicates that there are opportunities for expanding the adoption of mitigation and adaptation practices among farmers with a shorter term planning horizon by highlighting the immediate and personal benefits that might be reaped in addition to the broader societal benefits.

Conclusion

One conclusion that may be drawn from our work is that efforts to encourage farmers to participate in voluntary climate initiatives, ought to consider framing climate impacts and behavioral goals concordantly; either in an abstract global context for mitigation or a specific local context in the case of adaptation. The strength of this approach is that people tend to pay closer attention to persuasive messages that are able to match attitudes and desired behavior according to their levels of construal (Fujita et al., 2008). But while it seems intuitive to keep mitigation and adaptation messages focused on their respective global and local spheres, emerging evidence suggests that a combination of global and local framing may prove even more effective in stimulating the adoption of sustainable behaviors (Rabinovitch et al., 2009; Spence and Pidgeon, 2010; Spence et al., 2012). Many agricultural practices have ramifications for both mitigation and adaptation that involve a complex mix of benefits and tradeoffs that require farmers to balance multiple economic and environmental objectives (Antle and Capalbo, 2010; Haden et al., 2013; Smith et al., 2007b). In some cases, a new agricultural practice may reduce GHG emissions while also minimizing economic and/or climate related risks. For other management strategies important economic and practical drawbacks will no doubt influence agricultural decision making more than climate-related concerns. For instance, in our study practices that improve energy or N use efficiency can often reduce production costs, and as a consequence may be seen by farmers as a way to simultaneously mitigate and adapt to climate change. Within the context of CLT, practices with clear co-benefits to one's self and society are likely to engage both psychologically proximate and distant mindsets. As such, outreach programs that allow farmers to examine the pros and cons of individual agricultural practices by framing each in both a global and local context may help facilitate agricultural decisions that are well-aligned with farmers' economic goals, their past experience, and their beliefs and concerns regarding climate change. Thus, having farmers consider on how certain agricultural practices address both global and local concerns may even help them span the gap between good intentions and successful implementation.

Methods

Ethics Statement

The University of California Institutional Review Board approved the interview protocol used in the study (approval no. 201018309-1), and documented that written informed consent was ethically obtained and that the anonymity of participants' responses was maintained. A separate ethics approval was obtained from the University of California's Institutional Review Board for the mail survey protocol (approval no. 208213-1), which was returned by participants on a voluntary and anonymous basis.

Survey Instrument and Study Area

The survey instrument used in this study was developed with input from semi-structured interviews with a cross-section of farmers in the study area and a panel of academic researchers, agricultural officials, agricultural policy organizations (i.e. local Farm Bureau), and agricultural extension advisors. In the winter and spring of 2011, the survey was distributed by mail to 572 farmers in Yolo County, California using the tailored design method (Dillman, 2007). A total 162 surveys were returned with sufficiently complete answers to be used in the study (Table S2). This amounted to a raw response rate of 28.3% as a proportion of the total surveys mailed out, and a final response rate of 33.2% as a proportion of the estimated number of surveys sent to eligible farmers excluding those that were returned undeliverable (American Association for Public Opinion Research, 2011). The online supplementary materials provide a comprehensive description of the interview and survey methods. This county was chosen for its representative mix of grain, vegetable, orchard, and livestock systems used throughout California's Central Valley (Table S1). A detailed case study of the research site, which examines innovative local strategies for climate change adaptation and mitigation, is also available in the recent peer-reviewed literature (Jackson et al., 2011).

Statistical Analysis

The statistical analysis used a series multiple-mediation models to test for direct and indirect relationships between the independent, dependent, and mediating variables detailed in Table 1. The mediating and dependent variables represent socio-cognitive constructs developed using factor analysis to group highly correlated questions into a single scale with a Cronbach's α reliability coefficient ≥ 0.70 (Table 1). Details regarding scale development and factor analysis can be found in the online supplementary materials (Table S3). The multiple-mediation analysis was conducted according to a product-of-coefficients approach using seemingly unrelated regression (Preacher and Hayes, 2008). A bootstrapping method was used to reconstruct the distribution for the indirect effects (e.g. data were resampled 1000 times), and thus avoid violating the assumption of normality (Hayes, 2009). A summary of the models' direct and indirect effects and their confidence intervals can also be found in the online supplementary materials (Table S4).

Table 1.1 Survey questions, scales, mean values, standard errors and reliability coefficients (Cronbach's α) for variables used in the multiple-mediation models. Independent variables for perceived change in local climate (i.e. water availability and summer temperature) are based on individual questions, while scales for the mediator and dependent variables are comprised of multiple questions that have a high reliability coefficient (Cronbach's $\alpha \geq 0.70$).

Variable	Question / Statement	Scale	Mean	Standard Error	Cronbach α
Perceived Change in Local Climate (Independent)	*Local water availability has ________ over the course of your farming career.*	Three Point Scale 1 = Increased, 2 =Stayed the same, 3 = Decreased	2.457	0.044	---
	Local summer temperature has ________ over the course of your farming career.		2.194	0.045	
Future Local Water Availability Concerns (Mediator)	*How concerned are you about the following climate related risks and the future impact they may have on your farming operations during your career?*	Four Point Scale 1 = Not Concerned 4 = Very Concerned			
	• Less reliable surface water supply		2.535	0.113	0.77
	• Less reliable ground water supply		2.547	0.100	
	• More severe droughts		2.340	0.096	
Future Local Temperature Concerns (Mediator)	*How concerned are you about the following climate related risks and the future impact they may have on your farming operations during your career?*	Four Point Scale 1 = Not Concerned 4 = Very Concerned			
	• Fewer winter chill hours		1.659	0.090	0.86
	• Warmer summer temperatures		1.868	0.084	
	• More frequent heat waves		1.907	0.083	
Global Climate Change Belief and Concerns (Mediator)	*Indicate your level of agreement with the following statements*	Five Point Scale 1 = Strongly Disagree 5= Strongly Agree			
	• The global climate is changing		3.414	0.113	0.93
	• Average global temperatures are increasing		3.068	0.116	
	• Human activities such as fossil fuel combustion are an important cause of climate change		3.000	0.114	
	• Climate change poses risks to agriculture globally		3.470	0.115	
	• Climate change presents more risks than benefits to agriculture globally		3.256	0.102	
Adaptation 1 New Irrigation Practices (Dependent)	*What is the likelihood that you would use the following management strategies, above and beyond what you currently use in a normal rainfall year?*	Five Point Scale 1 = Very Unlikely 5 = Very Likely			

Variable	Question / Statement	Scale	Mean	Standard Error	Cronbach α
	• Pump more ground water		3.810	0.126	0.74
	• Adopt drip or micro-sprinkler irrigation		3.684	0.137	
	• Drill more wells or seek alternative water sources		3.266	0.137	
Adaptation 2 **New Cropping Practices** (Dependent)	*What is the likelihood that you would use the following management strategies, above and beyond what you currently use in a normal rainfall year?*	Five Point Scale 1 = Very Unlikely 5 = Very Likely			
	• Concentrate surface water allocation on a smaller percentage of acreage		3.570	0.127	0.70
	• Use drought tolerant varieties of the crops already grown		3.367	0.131	
	• Change to a less water intensive crop		3.038	0.134	
Mitigation 1 **Energy and N Efficiency Practices** (Dependent)	*Which of the following practices would you be likely to adopt voluntarily to reduce your energy use and/or greenhouse gas emissions?*	Five Point Scale 1 = Very Unlikely 5 = Very Likely			
	• Invest in more fuel efficient farm equipment		3.872	0.099	0.74
	• Take measures to reduce electricity usage in farm operations or buildings		3.735	0.100	
	• Improve N use efficiency through precision placement or timing		3.735	0.072	
	• Use conservation tillage		3.701	0.092	
Mitigation 2 **Renewable Energy Technologies** (Dependent)	*Which of the following practices would you be likely to adopt voluntarily to reduce your energy use and/or greenhouse gas emissions?*	Five Point Scale 1 = Very Unlikely 5 = Very Likely			
	• Install solar panels or wind turbines for on-farm energy needs		3.444	0.117	0.71
	• Use biomass or biofuels for on-farm energy needs		2.830	0.104	

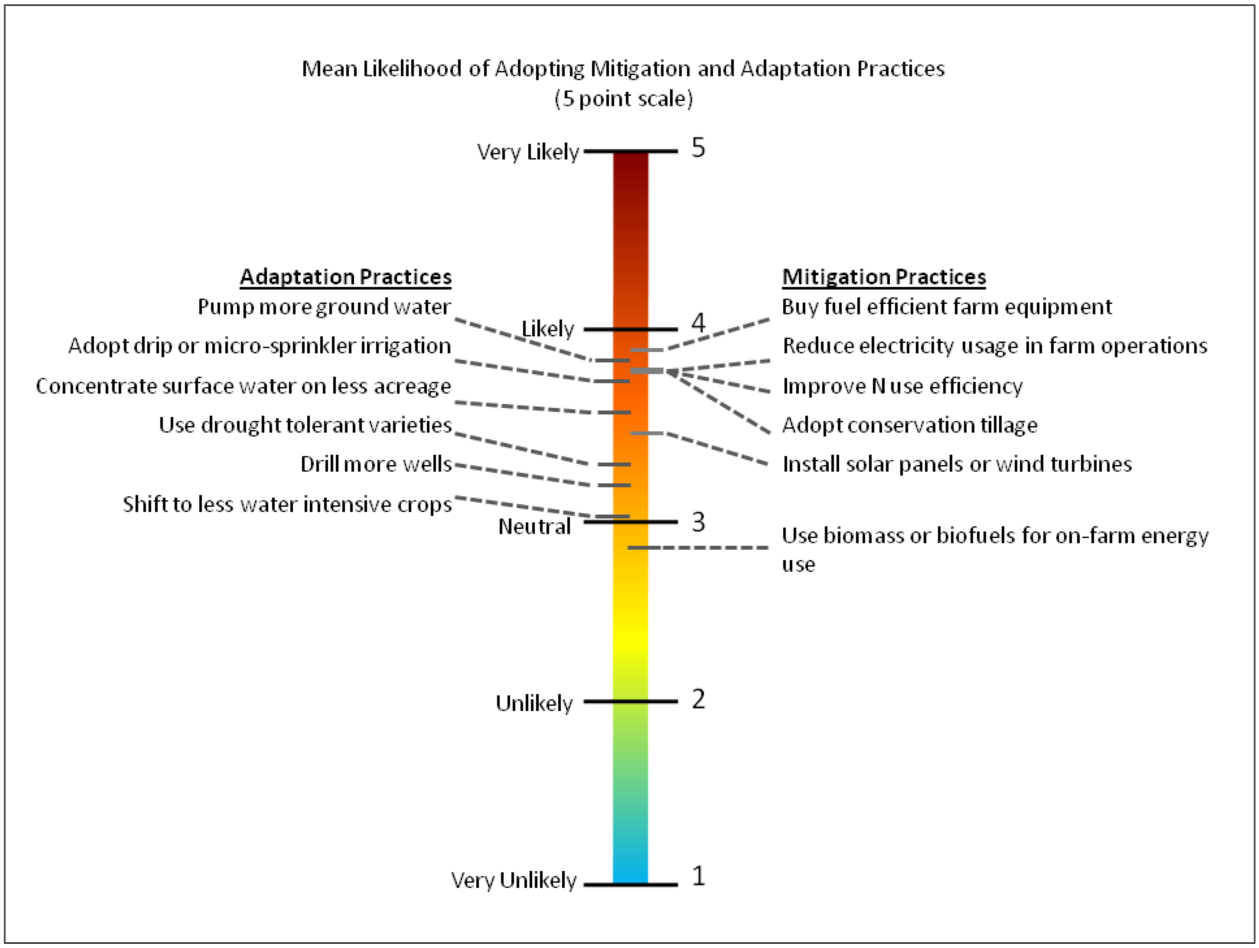


Figure 1.1 Mean likelihood of farmers adopting various mitigation and adaptation practices as measured on a 5 point scale.

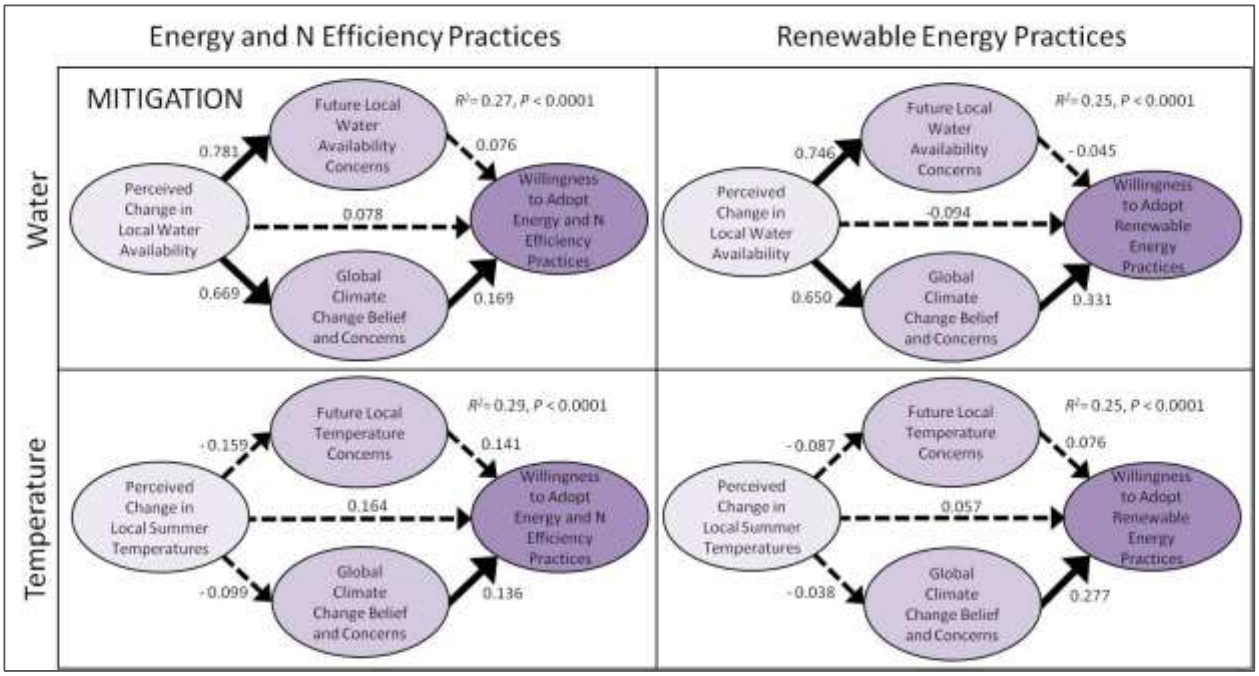


Figure 1.2 Effects of perceived change in local water availability and summer temperature on farmers' willingness to adopt mitigation practices such as energy and nitrogen (N) efficiency practices and renewable energy technologies, as mediated by future local water availability and temperature concerns and global climate beliefs and concerns. Values provided are unstandardized *b* coefficients indicating the strength of the relationship between variables. Solid arrows represent a significant effect between variables in the pathway ($P \leq 0.05$), while broken arrows indicate no significant effect. Overall R^2 and P values associated with prediction of dependent variables are listed for each model.

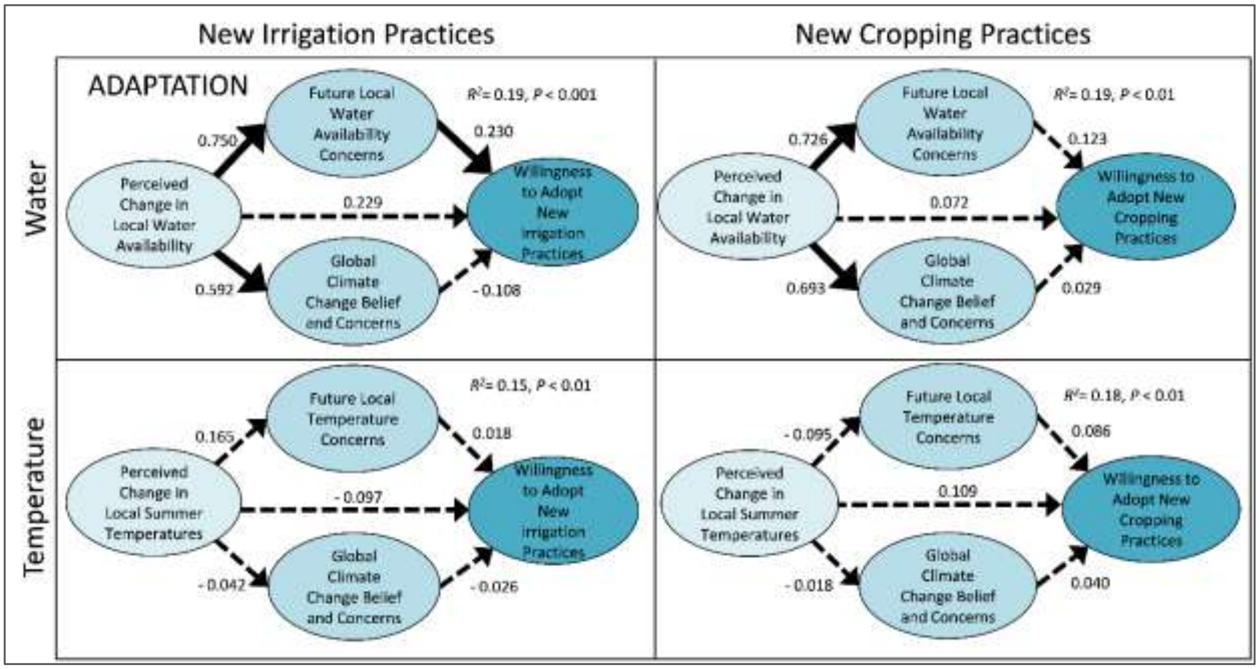


Figure 1.3 Effects of perceived change in local water availability and summer temperature on farmers' willingness to adopt adaptation practices such as new irrigation and cropping practices, as mediated by future local water availability and temperature concerns and global climate beliefs and concerns. Values provided are unstandardized *b* coefficients indicating the strength of the relationship between variables. Solid arrows represent a significant effect between variables in the pathway ($P < 0.05$), while broken arrows indicate no significant effect. Overall R^2 and P values associated with prediction of dependent variables are listed for each model.

Supplementary Materials for
Global and local concerns: What attitudes and beliefs motivate farmers to mitigate and adapt to climate change?

Study Area

The study was conducted in Yolo County, California from 2010-2011. We focus on Yolo County for several reasons. First, Yolo County is among the first rural counties in California to specifically address climate change mitigation and adaptation in their recently passed climate action plan (Yolo County Government, 2011). Consequently, concerns about the impact of climate change as well as new state and local environmental policies have brought a diverse range of stakeholders into the discussion about climate change mitigation and adaptation. A detailed case study of the research site examines context-specific strategies for mitigation and adaptation (Jackson et al., 2011).

Yolo County was also chosen because it has many attributes typical of the Central Valley: small towns and cities with a changing mixture of urban, suburban, and farming-based livelihoods. Yolo County has nearly 540,000 acres of agricultural land comprising 81% of the total county land area (California Department of Conservation, 2008). The average farm size in Yolo County is 488 acres, though nearly half of all farms are less than 50 acres. The average market value of agricultural products sold per farm is approximately $390,000 a year, with an average net cash income just below $100,000 annually (United States Department of Agriculture, 2007).

The agricultural landscape in Yolo County includes a mix of irrigated row crops and orchards grown on alluvial plains, rice cultivated on poorly drained soils along the western bank of the Sacramento River, and grazed rangelands on the eastern slope of California's Coastal Range. The most significant crops in the area include tomatoes, alfalfa, wine grapes, almonds and walnuts

(Yolo County Government, 2011). Livestock grazed on rangeland occupy 24% of county land area (California Department of Conservation, 2008). Beef cattle and sheep are the main livestock types, while dairy and poultry are relatively minor components of the local livestock industry (Yolo County Government, 2011). In recent years there has been a local trend towards larger farm sizes with less crop diversification (Jackson et al., 2011). Organic farms make up less than 5% of total irrigated cropland, but organic acreage has expanded considerably over the past 20 years (Yolo County Government, 2011). Agricultural production in the county is largely reliant on intensive inputs including fossil fuels and synthetic fertilizers. The mitigation and adaptation strategies examined in this study were chosen due to their local relevance, and thus may not always reflect practices suitable for other regions.

Semi-structured Interviews

Separate Institutional Review Board approvals were obtained for the interview and mail survey components of this study. To develop a sound ethnographic understanding of local farmers' livelihoods, their perceptions of climate change, and their views regarding climate risks, we conducted semi-structured interviews with eleven farmers and two agricultural extension agents in the fall of 2010. A purposive sampling strategy was used to recruit local respondents from a cross section of farm sizes, cropping systems, management practices, and market orientations (Kemper et al., 2003; Pearce et al., 2010). Interviewers followed a set of open ended questions to minimize prompting and interviewer bias, but allow respondents to share personal experiences from their career in agriculture. Interviewees were asked questions related to their perceptions of climate change, climate change mitigation and adaptation practices, regulations, marketing, and perceived changes in climate in the region over time. The interviews were voluntary and respondents were given the opportunity to remain anonymous. Interviews were transcribed and analyzed using axial coding methods in N-Vivo version 9.0 (QSR International, Victoria, AUS) (Corbin and Strauss, 1990).

Survey Design

The results of the semi-structured interviews were used to design a mail survey carried out in the winter and spring of 2011. The survey instrument was developed with input from a cross-section of farmers in the study area and a panel of academic researchers, agricultural officials, agricultural policy organizations, agricultural and food industry representatives, and agricultural extension workers. A copy of the final survey is available upon request to the corresponding authors. The survey sample was drawn from a mail and phone list of 572 individuals in Yolo County who have submitted pesticide use permits to the Yolo County Agriculture Commissioner's office. The State of California requires all farms and businesses that apply federally restricted use pesticide or state restricted material (including organic pesticides) must hold an applicator certificate and register the use of the pesticide through the local agricultural commissioner (Yolo County Government, 2008). The local agricultural commissioner then maintains this database as a part of the public record. Since this database includes the vast majority of farmers in Yolo County it provides a viable list of farmers to use in this study. The mail survey was conducted using the tailored design method in order to maximize survey response rate (Dillman et al., 2009). An alert postcard was mailed in mid-February and followed a week later by a survey packet containing a cover letter, survey booklet, and return envelope. A second round of postcards and survey packets were mailed two weeks later. A final round of follow-up postcards was mailed and phone calls were made to those on the mail list that did not respond. Additional surveys were sent when requested by farmers.

Response rate was calculated using methods published by the American Association for Public Opinion Research (Table S2) (American Association for Public Opinion Research, 2011). The follow-up phone calls indicated that approximately 28 people were outside the intended scope of our survey (e.g. managers of golf courses, grain storage facilities, university research stations). Of the 572 surveys mailed out, 162 were returned with sufficiently complete answers to be used in the study. This amounts to a raw response rate of 28.3% as a percentage of the total surveys mailed out, and a final response rate of 33.2% (Eq. 1) as a percentage of the estimated number of surveys sent to eligible farmers excluding those that were returned undeliverable[8].

Eq. 1 $$\text{Final Response Rate} = \frac{\text{Total Returned Surveys}}{(\text{Total Returned Surveys}) + \text{E}*(\text{Total Unreturned Surveys})}$$

Variable Measurement and Multiple Mediation Analysis

Multiple mediation models assess whether or not the effects of an independent variable on a dependent variable are mediated by one or more additional "mediating" variables (Hayes, 2009). Likewise, we hypothesized that past perceptions of water availability and temperature change may affect farmers' mitigation and adaptation behavior through their concern for local and global climate impacts, which act as mediating variables. In this study, the independent variables for perceived change in local water availability and summer temperature were based on individual questions in the survey (Table S3). The four dependent variables that characterize mitigation and adaptation behavior, and the three mediator variables that describe local and global concerns, are composite scales made up of related questions that reflect latent socio-cognitive constructs (Table S3). Factor analysis with a varimax rotation was applied to each set of questions germane to a particular latent construct in order to determine composite scales (Table S3). Only variables with factor loadings $\geq$ 0.40 on at least one factor were retained for further analysis (Costello and

Osborne, 2005). Since a single factor solution was obtained for each factor analysis, the data justifies treating the retained questions in each construct as single composite scale. Scales were created by averaging responses across the retained questions for a given construct. Cronbach's α reliability coefficient was also used to measure the internal consistency of each scale. Table S3 shows that each of the scales had an $\alpha \geq 0.70$ and thus are valid for use (Nunnally, 1978). Important farmer demographics (age, education, local origin, and full-time farmer) and farm characteristic (acres managed and organic status) were also measured.

The multiple-mediation analysis was conducted according to a product-of-coefficients approach using seemingly unrelated regression in STATA version 11.0 (StataCorp LP, College Station, TX, USA). To conduct the multiple mediation analysis we ran seemingly unrelated regression models with bootstrapped standard error calculations (n= 1,000), which did not require assuming that indirect effects be normally distributed (Costello and Osborne, 2005). Farmer demographics and farm characteristics were included as covariates during each step of the regression analysis. To avoid overestimating the indirect effects, the models also allowed the mediator variables to co-vary. A total of eight multiple mediation models were produced, four for mitigation and four for adaptation (Fig. 1, Fig. 2). In three of our eight models we observed "indirect-only mediation", a term used by Zhao et al. (Zhao et al., 2010) to describe mediation pathways where the indirect effects are significant and the direct effects are not ($P \leq .10$) (Table S4). Early work on mediation analysis assumed that a significant direct relationship between an independent and dependent variable must be established before possible indirect effects (i.e. mediation) can be tested for (Baron and Kenny, 1986). However, recent studies by Hayes (Hayes, 2009) and Zhao et al. (2010) provide empirical evidence that this assumption is flawed, and contend that a failure to test for indirect effects when no direct effect is present can often lead researchers to overlook or discard likely causal mechanisms. Thus, in light of this recent shift in mediation analysis theory, our study should be viewed as both statistically sound, and an important case in point, which suggests that future efforts to understand the effects of climate change attitudes on behavior should go beyond examining mere direct effects.

Table S1.1 Yolo County agricultural statistics and top 10 commodities by market value.

Yolo County Agriculture Statistics	
Percent of County Land in Agriculture[1]	81%
Percent of County Land in Cropland	57%
Percent of County Land in Rangeland	24%
Average Farm Size[2]	488 acres

Top 10 Commodities by Market Value[3]	
1.Processing Tomatoes	6.Almonds
2.Wine Grapes	7.Organic Production
3.Rice	8.Walnuts
4.Seed Crops	9.Cattle and Calves
5.Alfalfa Hay	10.Wheat

[1] (California Department of Conservation, 2008)
[2] (United States Department of Agriculture, 2007)
[3] (Yolo County Government, 2011)

Table S1.2 Survey response rate calculations according to AAPOR methods[1]

Formula component	Frequencies
Total Returned Surveys = I + P	**162**
Complete interview (I) - Returned completed survey	158
Partial interview (P) - Returned partially completed survey with sufficient information for inclusion	4
Total Unreturned Surveys = NR + RU	**382**
Mail Survey Not Returned (NR)	365
Mail Survey Returned Undelivered (RU)	17
Not eligible (NE) - Screened out of sample population	28
	Proportion
Estimated proportion of cases of unknown eligibility that are eligible (E) = I+P/(I+P)+NE	0.853
Raw Response Rate	**0.283**
Final Response Rate	**0.332**

[1]AAPOR 2011

Table S1.3 Survey questions, scales, eigenvalues, factor loadings and reliability coefficients (Cronbach's α) for variables used in the multiple-mediation models. Independent variables for perceived change in local climate (i.e. water availability and summer temperature) are based on individual questions, while scales for the mediator and dependent variables are comprised of multiple questions that load on a single factor.

Variable	Statement/Question	Scale	Eigenvalue	Factor Loading	Cronbach α
Perceived Change in Local Climate (Independent)	*Local water availability has _______*	Three Point Scale 1 = increased, 2 =stayed the same, 3 = decreased	---	---	---
	Local summer temperature has _______ over the course of your farming career.				
Future Local Water Availability Concerns (Mediator)	*How concerned are you about the following climate related risks and the future impact they may have on your farming operations during your career?*	Four Point Scale 1 = Not Concerned 4 = Very Concerned	1.52		0.77
	Less reliable surface water supply			0.64	
	Less reliable ground water supply			0.74	
	More severe droughts			0.75	
Future Local Temperature Concerns (Mediator)	*How concerned are you about the following climate related risks and the future impact they may have on your farming operations during your career?*	Four Point Scale 1 = Not Concerned 4 = Very Concerned	2.07		0.86
	Fewer winter chill hours			0.58	
	Warmer summer temperatures			0.93	
	More frequent heat waves			0.91	
Global Climate Change Belief and Concerns (Mediator)	*Indicate your level of agreement with the following statements*	Five Point Scale 1 = Strongly Disagree 5= Strongly Agree	3.68		0.93
	The global climate is changing			0.68	
	Average global temperatures are increasing			0.77	
	Human activities such as fossil fuel combustion are an important cause of climate change			0.63	
	Climate change poses risks to agriculture globally			0.54	
	Climate change presents more risks than benefits to agriculture globally			0.41	
Adaptation 1 New Irrigation Practices (Dependent)	*What is the likelihood that you would use the following management strategies, above and beyond what you currently use in a normal rainfall year?*	Five Point Scale 1 = Very Unlikely 5 = Very Likely	1.41		0.74

Variable	Statement/Question	Scale	Eigenvalue	Factor Loading	Cronbach α
Adaptation 2 New Cropping Practices (Dependent)	*What is the likelihood that you would use the following management strategies, above and beyond what you currently use in a normal rainfall year?*	Five Point Scale 1 = Very Unlikely 5 = Very Likely	1.27		0.70
	Use drought tolerant varieties of the crops already grown			0.72	
	Change to a less water intensive crop			0.70	
	Concentrate surface water allocation on a smaller percentage of acreage			0.52	
Mitigation 1 Energy and N Efficiency Practices (Dependent)	*Which of the following practices would you be likely to adopt voluntarily to reduce your energy use and/or greenhouse gas emissions?*	Five Point Scale 1 = Very Unlikely 5 = Very Likely	1.66		0.74
	Take measures to reduce electricity usage in farm operations or buildings			0.59	
	Invest in more fuel efficient farm equipment			0.68	
	Use conservation tillage			0.72	
	Improve N use efficiency through precision placement or timing			0.59	
Mitigation 2 Renewable Energy Technologies (Dependent)	*Which of the following practices would you be likely to adopt voluntarily to reduce your energy use and/or greenhouse gas*	Five Point Scale 1 = Very Unlikely 5 = Very Likely	0.84		0.71
	Install solar panels or wind turbines for on-farm energy needs			0.65	
	Use biomass or biofuels for on-farm energy needs			0.65	

Table S1.4 Indirect and direct effect estimations for the multiple-mediation models. Mediation type calculated based on P ≤ 0.10.

		Indirect Effects									Direct Effects		
Independent Variables	Dependent Variables	Local Concerns Effect	P Value	Bias Corrected 95% CI	Global Concern Effect	P Value	Bias Corrected 95% CI	Total Indirect Effect	P Value	Bias Corrected 95% CI	Beta	P Value	Type of Mediation
Water Availability	Efficiency Mitigation Practices	0.060	0.42	-0.076, 0.213	0.113	0.06	0.022, 0.250	0.172	0.05	0.017, 0.373	0.078	0.58	Indirect-only Mediation
Water Availability	Renewable Energy Mitigation Practices	-0.034	0.76	-0.283, 0.159	0.215	0.02	0.039, 0.406	0.182	0.17	-0.070, 0.461	-0.094	0.64	Indirect-only Mediation
Summer Temperature	Efficiency Mitigation Practices	-0.022	0.51	-0.133, 0.015	-0.013	0.64	-0.114, 0.021	-0.036	0.45	-0.160, 0.041	0.164	0.18	Non-Mediation
Summer Temperature	Renewable Energy Mitigation Practices	-0.007	0.83	-0.125, 0.030	-0.010	0.86	-0.134, 0.120	-0.017	0.81	-0.165, 0.120	0.057	0.76	Non-Mediation
Water Availability	Irrigation Adaptation Practices	0.173	0.06	0.017, 0.378	-0.064	0.28	-0.197, 0.038	0.109	0.25	-0.069, 0.307	0.229	0.17	Indirect-only Mediation
Water Availability	Crop Adaptation Practices	0.089	0.30	-0.073, 0.270	0.020	0.80	-0.145, 0.175	0.109	0.35	-0.114, 0.346	0.072	0.72	Non-Mediation
Summer Temperature	Irrigation Adaptation Practices	-0.004	0.91	-0.103, 0.040	0.001	0.95	-0.029, 0.054	-0.002	0.94	-0.086, 0.055	-0.097	0.53	Non-Mediation
Summer Temperature	Crop Adaptation Practices	-0.008	0.77	-0.125, 0.019	-0.001	0.97	-0.061, 0.031	-0.009	0.80	-0.116, 0.040	0.109	0.55	Non-Mediation

Chapter 2:
Niles, M.T., M. Lubell, V.R. Haden. 2013. Perceptions and Responses to Climate Policy Risks Among California Farmers. Global Environmental Change. 23: 1752-1760.

PERCEPTIONS AND RESPONSES TO CLIMATE POLICY RISKS AMONG CALIFORNIA FARMERS

Abstract

This paper considers how farmers perceive and respond to climate change policy risks, and suggests that understanding these risk responses is as important as understanding responses to biophysical climate change impacts. Based on a survey of 162 farmers in California, we test three hypotheses regarding climate policy risk: 1) That perceived climate change risks will have a direct impact on farmer's responses to climate policy risks, 2) That previous climate change experiences will influence farmer's climate change perceptions and climate policy risk responses, and 3) That past experiences with environmental policies will more strongly affect a farmer's climate change beliefs, risks, and climate policy risk responses. Using a structural equation model we find support for all three hypotheses and furthermore show that farmers' negative past policy experiences do not make them less likely to respond to climate policy risks through participation in a government incentive program. We discuss how future research and climate policies can be structured to garner greater agricultural participation. This work highlights that understanding climate policy risk responses and other social, economic and policy perspectives is a vital component of understanding climate change beliefs, risks and behaviors and should be more thoroughly considered in future work.

Keywords: climate change adaptation, psychological distance, climate policy risk, agriculture, farmers, risk

Introduction

Global climate change will require socio-ecological systems to adapt across multiple geographic, time, and ecological scales (Adger et al., 2005). Research on agricultural systems has focused heavily on weather patterns, the frequency and intensity of extreme events (Rosenzweig et al., 2001), and time horizons that require a new set of adaptive behaviors (Jackson et al., 2011). Additional research has examined the potential economic impacts of climate change (Fischer et al., 2005; Tol, 2002) and the policy structures that may be needed to assist the agricultural community in adaptation (Howden et al., 2007; Smit and Skinner, 2002) and mitigation (Smith et al., 2007b). This paper proposes that existing research has underemphasized a key feature of adaptation: how farmers perceive and respond to *climate policy risk*. The concept of policy risk is defined as a regulation or policy that may present economic, environmental or social risks to an individual or enterprise. In the context of agriculture, climate policy risk is the potential threat posed by climate change regulations or policies to mitigate or adapt to climate change.

We study climate policy risk in the local context of farmer attitudes and decision-making in Yolo County, California. Our global capacity for responding to climate change requires understanding how policies across multiple scales affect the local daily activities and perceptions of individuals (Ostrom, 2010) and how those local activities scale up to influence global outcomes (Wilbanks and Kates, 1999). In California, farmers are contending with the local development of county climate action plans (Haden et al., In Press) in conjunction with the state-wide cap and trade program AB-32 (California Air Resources Board, 2008), which though it doesn't include agriculture, does allow for a carbon offset market that may provide financial incentives for agricultural mitigation (California Air Resources Board, 2011; De Gryze et al., 2009). Nationally, policies require some large farms to report their greenhouse gas emissions (United

States Environmental Protection Agency, 2009). California is not anomalous- farmers across the globe deal with multiple policy risks that influence their decisions and collectively scale up to affect the global food supply, environment, and agricultural markets in an increasingly global world (e.g. (Cassells and Meister, 2001; Mihyo, 2003; van Meijl et al., 2006).

This concept of climate policy risk builds upon a growing body of work in energy policy and management to assess how investors and firms may respond to climate policy risks. Yang et al. (2008) examine how climate policy risks and uncertainty drives investors behavior in their choice of different energy generation options as a result of price changes. Related work shows how renewable energy investors respond to policy risks related to renewable energy policies, which affect their investment potential in a given region (Lüthi and Wüstenhagen, 2012; Nemet, 2010). Like these decision-makers in other sectors, changes in climate policy directly affect the overall risk portfolio faced by farmers in terms of the costs, benefits, and uncertainty around different decisions.

We extend the existing climate policy risk work into the realm of climate change adaptation and consideration for a farmer's adaptive capacity, vulnerability and resilience. The analysis builds on our previous work, which found that farmer adoption of adaptation and mitigation behaviors is influenced by their climate change attitudes and personal experience with climate change (Haden et al., 2012). Here we explore the relationship of climate change attitudes with policy experiences to expand beyond traditional measures of experience focused on biophysical indicators. Climate policies may affect the adaptive capacity of agricultural systems to respond to climate change if they require resources and costs that exacerbate vulnerabilities. We assess two dimensions of response: their concern for future climate policies and potential participation in a climate adaptation and mitigation incentive program, thereby measuring both a potential threat and opportunity. In the words of one farmer in Yolo County California, "*We can adapt to the environmental aspects of climate change. I'm not sure we can adapt to the legislature*." Failure to consider climate policy risk responses overlooks key drivers of climate change attitudes and an opportunity for policymakers to gain policy support and participation on mitigation and adaptation initiatives (Falconer, 2000). Our results suggest that climate policy risks and non-climatic drivers should be more adequately considered when assessing climate change attitudes and behaviors.

Methods and Place

Data were collected from interviews and a mail survey implemented in Yolo County in the Central Valley of California (Haden et al., 2012; Jackson et al., 2012b). Yolo County is a predominantly agricultural region with more than 80 percent of the land in agriculture (California Department of Conservation, 2008). It was chosen for its diverse mix of cropping and livestock systems typical of the Central Valley, especially the Sacramento River region. The county is comprised of high-input, highly productive crop systems with a small (5 percent of total irrigated cropland) but growing organic sector, as well as grazed, non-irrigated grasslands and oak savannas (Yolo County Government, 2011). A case study describing the agricultural responses to climate change in the region can be found in Jackson et al. (2011). The rural and westernized context of our study site is worth noting as it may affect the overall policy and climate attitudes we found and may limit the generalizability of our results to other agro-ecological contexts. Understanding the diversity of policies and response to climate policy risks across regions is a key future research topic.

Interviews and consultation with a stakeholder advisory committee assisted in the development of a survey sent to 572 farmers (including ranchers) in 2011. Semi-structured qualitative interviews were conducted in 2010 with 11 farmers and two cooperative extension agents. Farmers' addresses were gathered from the County Agricultural Commissioner's Pesticide Use Reporting database, which reports all agricultural pesticide use (conventional and organic) (California Department of Pesticide Regulation, 2000), providing a viable list of most farmers in the county. Using the tailored-design method (Dillman, 2007), postcards were sent to farmers followed by a survey, a follow-up postcard, and an additional survey if necessary. Farmers with no response were contacted through telephone to provide reminders. In total, 162 surveys were analyzed resulting in a response rate of 33.2% when surveys outside the intended scope were withdrawn (American Association for Public Opinion Research, 2009). A copy of the survey is available upon request.

Table 1 reports the complete list of questions, variables, scales, and their descriptive statistics used in this analysis. Two dependent variables were used to measure responses to climate policy risks: *Regulation Concern* (i.e. a farmer's concern for climate change regulations and economic impacts) and *Government Program Participation* (i.e. willingness to participate in a climate change incentive program). Regulation Concern was determined with a factor analysis using principal component factors with varimax rotation, which indicated a single factor solution with factor loadings significantly greater than a cut-off of .40 (Costello and Osborne, 2005). We created a scale to combine questions measuring similar latent concepts to average responses (*Regulation Concern*, α= 0.72) (Clark and Watson, 1995), which had a Cronbach's α coefficient higher than .70, a generally accepted cut-off point for reliability (Nunnally, 1978).

A number of independent variables were considered including *Climate Change Experience, Past Policy Experience*, *Climate Change Belief* and *Climate Change Risk*. *Past Policy Experience* was measured by assessing a farmer's overall perspective on four past environmental policies (Table 2). Farmers were asked to consider four questions for each policy as described in Table 1 (*Regulation Environment*, α= 0.69, *Regulation Time*, α= 0.77, *Regulation Cost*, α=0.74, *Regulation Balance*, α= 0.73). A factor analysis was also conducted as described above, which determined that each of the four questions grouped together across environmental policies. In other words, farmers tended to have the same general opinions about whether environmental policies were effective, expensive, time consuming, or balanced in their approach. Each question formed its own scale (i.e. *Regulation Environment, Regulation Time, Regulation Cost, Regulation Balance*) that together formed the observed variables related to the latent variable *Past Policy Experience*. Other independent variables included *Climate Change Experience* measured using a farmer's perceived change in water availability over time in Yolo County and *Climate Change Belief* and *Climate Change Risk* as latent variables compiled through several questions indicated in Table 2.

We constructed a structural equation model (SEM) using maximum likelihood estimation. The model was continually refined by removing non-significant pathways in a step-wise order. Only significant coefficients and models are reported in this paper. Statistically significant measures for farmer and farm characteristics (education level, full-time farmer status, organic status, local Yolo County origin) were included in the final model, which are shown in detail in the supplementary materials. Our previous work found that farmer experiences with temperature change did not influence their climate change belief or risk perceptions or their willingness to adopt behaviors for climate change adaptation and mitigation. This is likely because of a general perception that Yolo County has not seen significant changes in temperature, providing minimal variance in farmer responses. Based on this we excluded temperature change perceptions from our structural equation model in this analysis. Additional research in other regions where temperature-related impacts may be more apparent or perceived to be more common may find that temperature-related perceptions are an important predictor for climate change belief and risk perceptions, policy attitudes and the adoption of practices for climate change mitigation and adaptation.

The results of our SEM should be considered in the context of our population- a rural region made up of a small group of farmers. While some researchers argue the sample is too small for robust estimation of SEM models (MacCallum and Austin, 2000), others suggest SEM can perform well even with sample sizes less than 100 (Iacobucci, 2010) and small sample sizes are especially acceptable where the population size is limited such as in our case (Schreiber et al., 2006). According to Kim (2005) our sample size fits the minimum required as determined by our degrees of freedom (df=123) and RMSEA (0.056). Given the smaller sample size of our study we report several fit statistics beyond a χ^2 since it may be significantly influenced by sample size (Boomsma, 1982; Fan et al., 1999). For this reason we also report the CFI and

RMSEA, which have been shown to be the least affected by sample size compared to other SEM fit statistics (Fan et al., 1999).

Theoretical and Policy Background

Drawing on the public opinion and climate change literature (e.g. (Bray and Shackley, 2004; Brulle et al., 2012; Dietz et al., 2007; Krosnick et al., 2006; Leiserowitz, 2006)), we focus on three core hypotheses related to responses to climate policy risks. First, we expect that perceptions of climate *change* risk will have a direct influence on responses to climate *policy* risks. Farmers who believe that climate change is risky are more likely to support and participate in policies that aim to address climate change. Several existing social science frameworks support this hypothesis by demonstrating that environmental behaviors (including policy support) are more likely to occur when an individual believes there is a problem and that it presents risks (Grothmann and Patt, 2005; Krosnick et al., 2006; Lubell et al., 2007; Stern et al., 1999). Individuals that believe in global warming and its associated risks are more likely to support policies and engage in behaviors to ameliorate global warming (Krosnick et al. (2006) and Lubell et al. (2007); Haden et al. (2012)) . Consistent with this concept, we also expect a direct relationship between the two dependent variables, *Government Program Participation* and *Regulation Concern*. Farmer's with higher concern for future regulations are hypothesized to be less likely to participate in a government incentive program for climate change since it may be viewed as risky by some farmers due to unknown returns for adopting new practices.

This hypothesis is also consistent with the existing body of literature developed by Hurwitz and Peffley (1987; 1993; 1985), which used hierarchical models to show that specific policy attitudes are constrained by more general abstract postures. "*Climate Change Risk*" is a set of broad abstract questions largely about global climate risk whereas concern for climate policy risks is measured by "*Regulation Concern*" and a set of questions focused mostly on climate change impacts on individual farming enterprises. As such we anticipate that the broad, abstract-level risks represented in "*Climate Change Risk*" will have an effect on the specific risk-oriented policy attitudes inherent in "*Regulation Concern*".

Second, we build upon emerging literature applying the psychological distance theory to climate change by testing whether previous climate experiences influence a farmer's perception of climate change risks. The psychological distance theory suggests that events that are temporally, socially, or geographically close to a person are more tangible and this experience results in greater likelihood to adopt behaviors to help a person adapt to or mitigate the problem (Liberman et al., 2002b; Spence et al., 2011; Spence et al., 2012). A first hand encounter can help clarify risks often leading to heightened assessments of risk (Whitmarsh, 2008). These personal experiences can also affect climate belief (Myers et al., 2013) and intentions and behaviors to deal with such risks (Baldassare and Katz, 1992; Moser and Dilling, 2004). Our previous work shows that farmers who felt water availability had decreased over time were more likely to believe in climate change is risky and adopt behaviors for adaptation and mitigation (Haden et al., 2012). This paper will test this relationship using responses to climate policy risks to determine whether similar pathways exist.

Third, we hypothesize that past experience with environmental policies will affect climate attitudes policy risk responses more strongly than past experience with biophysical climate change (measured here as the perceived change in water availability over time). While previously unexplored, this is consistent with statements from researchers who have observed that climate change attitudes are heavily affected by broader social, economic, and policy issues (Brulle et al., 2012). Adger (2005) describes climate adaptation as "*an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities*." Adger also acknowledges that "*policies and non-climatic drivers…currently play perhaps an even more important role [than climatic drivers] in influencing adaptive behaviors to climate change*" (Adger et al., 2009). This hypothesis is also consistent with other sociological work demonstrating that policy discourses and processes can affect people's attitudes towards an issue (Bröer, 2008).

In fact, despite anticipated impacts (Jackson et al., 2012b; Southworth et al., 2000), there is a perception among many agricultural producers in the United States that agriculture has not and will not be affected by climate change (Arbuckle et al., 2011; Morello, 2012). Some local agricultural producer groups, grower organizations, and non-profits have encouraged climate adaptation and mitigation. However, there remains national-level resistance to climate change from major farm organizations who assert that producers face the greatest climate change threats from policies (American Farm Bureau, 2012), which may be viewed as burdensome by farmers. This may be particularly true for policies developed without adequate input from the agricultural community. In California farmers have been directly exposed to developing climate change policies as discussed in the introduction. At the same time, farmers have seen an increase in environmental regulations over the past several decades that have shifted management strategies and required new economic investment in infrastructure or equipment (Table 2). We suggest, based on the psychological distance theory, that these local policies are "closer" (temporally, geographically and socially per Liberman and Trope (2002)) and more tangible to farmers than the biophysical impacts of climate change and will have a greater effect on climate change attitudes and responses to climate policy risks.

Descriptive Results

Responses to Climate Policy Risks

Figure 1 reports the average level of concern for various climate-related impacts, and shows that farmers believe government regulations are the greatest climate risk they face in the future. On a scale from 1 (not concerned) to 4 (very concerned) more regulation had the highest level of concern (mean = 3.44) while temperature related impacts like fewer winter chill hours (mean = 1.68) and warmer summer temperatures (mean = 1.86) were of lesser concern. Water related issues were of moderate concern, with less reliable surface and groundwater (mean= 2.54, 2.60, respectively) more concerning than extreme events like more severe drought (mean = 2.35) or flooding (mean= 1.84).

We asked several questions related to farmer's responses to climate policy risk. Concern for government regulation was considered in how it could affect a farmer's adaptive capacity. When asked whether government regulations would make it more difficult for a farmer to adapt to climate change risks, more than 70% (n=109) agreed. As the quote in our introduction eluded, some farmers even perceived that it would be the government, not climate change that would be causing impacts. One farmer stated, "*Theoretically it's more likely the drought will be because* *of a government changing the rules on water rights and shipping some of it down south*." Nevertheless, despite the negative perception of regulations, farmers did express interest in government technical assistance to aid with mitigation and adaptation efforts. More than 48%of farmers agreed that they would participate in a government incentive program for climate change mitigation or adaptation (*Regulation Concern*). One farmer noted, "*I think agriculture is probably one of the most important industries today that has the ability to make the most difference in climate change and greenhouse gases. But you have to incentivize it for the producers and the farmers. You need the carrot and not the stick.*"

Climate and Policy Experience

Farmers have perceived changes in water availability over time in Yolo County (*Climate Change Experience*). A minority (43 percent, n=68) of farmers felt that water availability had decreased over time while approximately 47% (n=74) felt it had stayed the same. Less than 1%of farmers felt that water availability had increased (n=1) and nearly 10% (n=15) were unsure about the status of water availability over time.

When asked to consider specific environmental policies, farmers tended to have more favorable perspectives of policies in existence the longest. For the pesticide use reporting program and the rice straw burning regulations (implemented in 1990 and 1991, respectively) 46% (n=70) and 43% (n=57) of farmers felt these policies were improving the environment. This is contrasted with only 24% (n=36) and 36% (n=51) agreeing with this statement for the water quality conditional waiver programs and stationary diesel engine emission regulations (implemented in 2003 and 2007, respectively). Similar trends were observed for whether the policies required significant practice or equipment changes perceived to be impractical or costly. Only 17 and 20% felt this was true for the older policies (pesticide use reporting and rice straw burning, respectively) compared with 27% (n=40) and 51% (n=65) for water quality conditional waivers and diesel engines. Older policies were also perceived to better balance farmer and public interests as many farmers discussed the most recent issue of diesel engine regulations without mentioning other past policies. One farmer stated,

> "*The California Air Resources Board does not understand agriculture and how you have a dirty engine that serves a purpose on several square miles of farmland for just a few hours a year and you have to get rid of that engine and drop 30 or 40 grand for a brand new engine, which will be obsolete again in a few more years. They don't realize how that can break a farm."*

Yet despite some of the impacts that agriculture in the region has faced, there was a sense of acceptance and appreciation for the role that environmental regulations can play as mentioned by one farmer, "*I think that in 10 years we've made huge steps with regulations*." This demonstrates that policy perceptions over time can become more positive as they become accustomed to the change in practice and farmers and their communities see environmental benefits that may result from regulations.

Climate Change Belief and Risk

As previously discussed (Haden et al., 2012; Jackson et al., 2012b) farmers in Yolo County hold a range of views related to climate change belief and risk (Figure 2). During interviews, one farmer remarked "*What I think is changing is that the weather has been so unpredictable in the last ten years, and sometimes these events we get seem like they're larger, stronger events than we've historically had."* Several farmers expressed that the potential impacts of climate change were likely not occurring on time-scales that are currently influencing their decisions. One farmer expressed uncertainty about climate change: "*I believe it's happening. I think it's gonna be pretty slow and I don't know if I'll see it in my career actually effect my crops. And if I do see it, you won't even really be able to say, 'Yeah that was because of climate change'*". An additional farmer noted, "*For me, to be concerned about it (climate change) at my level and at my point, I don't think it's useful for me. I have other more important things that affect my business or my family that I want to spend time on versus something that could happen ten thousand years from now*."

Perhaps in part because of these perceived long-term time horizons, farmers expressed high confidence when asked about their ability to adapt to the possible risks posed by climate change. Seventy-six percent of farmers stated confidence in their ability to adapt to climate change compared with only 8% of farmers stating pessimism for their adaptive potential. One farmer said, "*I think that with the years of experience in farming that we have, I think we know how to deal with problems. I think farmers in general are fairly adaptable*." Another farmer echoed these sentiments saying, *"I still have to be a farmer just like I've always been and I'll have to react to it [climate change] and adapt to it. But that's been my business. In agriculture you're dealing with the weather, that's what you have to deal with."*

Structural Equation Model

A SEM was used to test hypotheses about the direct and indirect relationships among past climate experience, past policy experience, current climate change risk perceptions, and responses to climate policy risks. Multiple measures were used to build a model based on our hypotheses that climate change risk perceptions would influence policy adaptation and that past policy perceptions would influence climate change belief, risk, and policy concerns more than personal experience with climate change. Significant results of the final model are shown in Figure 3. The model (χ^2/df= 1.509) had a comparative fit index (CFI) of 0.952 and a root mean square error approximation (RMSEA) of 0.056 suggesting an overall excellent fit.

Climate Change Belief/Risk→ Climate Change Risk Responses

Climate Change Belief did not significantly directly influence *Regulation Concern* or *Government Program Participation*; instead it was mediated through *Climate Change Risk*. *Climate Change Belief* had a larger direct effect on *Climate Change Risk* (β= .95, $p \leq .01$) than past climate change and policy experience (Figure 3). Farmers with greater climate change risk concerns were more likely to participate in a government incentive program (β= .72, $p \leq .01$) and be concerned about future climate change regulations (β= .21, $p \leq .05$). Overall, *Climate Change Risk* attitudes were the largest influence on *Government Program Participation*; however, we found no significant relationship between *Regulation Concern* and *Government Program Participation*.

Climate and Policy Experience→ Climate Change Belief/Risk

As hypothesized, *Climate Change Experience* positively influenced both *Climate Change Belief* (β= .20, $p \leq .05$) and *Climate Change Risk* (β= .13, $p \leq .05$) (Figure 3). Farmers who expressed that water availability had decreased over time were more likely to believe in climate change and also more likely to have concerns for climate change risks in the future. To account for recent research suggesting that climate beliefs influence an individual's perception of actual climate experiences (Myers et al., 2013) we tested for reciprocal causality using a three-stage least squares analysis with instrumental variables (Kennedy, 2008; Zellner and Theil, 1962) (detailed in the supplemental materials). We found no indication of reciprocal causality. *Past Policy Experience* also influenced *Climate Change Belief* and *Climate Change Risk* among farmers. Farmers with a positive perception of local environmental policies (i.e. those who felt that regulations were effective at balancing farmer interests, improving the environment, and not too costly or time consuming) were more likely to believe in climate change ($\beta = .62$, $p \leq .01$) but tended to be less concerned about future climate change risks ($\beta = -.16$, $p \leq .10$). As predicted, policy experience had a more significant influence on climate change belief than a farmers' personal experience with climate change impacts.

Climate and Policy Experience → Climate Change Policies

The direct influence of *Climate Change Experience* on *Regulation Concern* and *Government Program Participation* was less straightforward. While farmers who believed that water availability had decreased over time were more concerned about future climate change policies ($\beta = .18$, $p \leq .05$), they tended to be less likely to participate in a government incentive program for climate change mitigation and adaptation ($\beta = -.13$, $p \leq .10$). Though we predicted that *Past Policy Experience* would affect both *Government Program Participation* and future *Regulation Concern*, only the relationship to *Regulation Concern* was significant ($\beta = -.75$, $p \leq .01$). We found that farmers who had a positive perception of local environmental policies were much less likely to be concerned about future climate change policies. There was no significant effect of *Past Policy Experience* on *Government Program Participation*.

Discussion

Climate policy is the highest priority risk perceived by California farmers. As predicted, climate change risk perceptions significantly influenced farmer's responses to climate policy risks. Climate change belief did not directly influence either measure for responses to climate policy risks (*Government Program Participation* or *Regulation Concern*) and was instead mediated through climate change risk perception. This suggests, as others have concluded, that the perceived risks and impacts of climate change are very important for understanding how people may change their behaviors or support policies to address climate change (Grothmann and Patt, 2005; Leiserowitz, 2005; O'Connor et al., 1999).

The influence of risk perceptions on responses to climate policy risks requires further consideration. First, farmers with higher climate change risk concerns are more likely to be concerned about future climate change regulations. Though not intuitive, this is likely connected to the high concern farmers expressed for regulation and economic climate-related risks (Figure 1). Their awareness of climate change vulnerability may lead them to expect new government policies that could affect their farming practices and operations. If farmers are considering climate change risks in an economic or policy context it is consistent that they would be concerned about future climate change regulations. The establishment of California's landmark climate change policy more than five years prior coupled with a number of recent environmental policies has likely affected climate change attitudes and opinions about future regulations, as was expected by Lorenzoni et al. (2005). This conclusion also confirms the Hurwitz and Peffley literature (1987; 1993; 1985) examining how broad abstract risks influence specific policy attitudes, suggesting that this hierarchical model is applicable to systems beyond foreign policy as was originally applied.

Climate change risk had the greatest effect on likelihood to participate in a government climate change program, indicating that risk communication may be an important way to increase climate change program participation. For example, the communication of tangible risks can make events more concrete and inspire greater action and support (Leiserowitz, 2006).

Surprisingly, government program participation was not significantly affected by past policy experiences. A farmer's concern for future climate change policies and their negative experience with past policies do not influence their likelihood to participate in a government incentive program. It appears that farmers may be able to overlook negative experiences or perceptions if the government provides the right incentive to do so. Using the government carrot rather than a stick to encourage action on climate change could garner widespread support and participation, particularly if combined with other policy strategies (Niles and Lubell, 2012; Wilson, 1996). As indicated by one farmer, "*If regulation and goals are set that are paired with incentive type efforts that provide assistance to farmers to make the transitions and change that they need to make, you do see farmers changing and you do see change happening*." As Adger (2005) mentioned, climate change adaptation encompasses "*taking advantage of new opportunities*." Since our results found that a significant minority of farmers do think that climate change offers opportunities for agriculture, these farmers may see government incentive programs as one key element of this.

A novel finding is that farmers' past experience with local policy is a much stronger predictor of climate change attitudes than personal experience with biophysical climate change impacts. Local climate change policies may be more psychologically close to farmers in our region than biophysical impacts. Our data suggests that farmers mostly think the climate has stayed the same over their farming careers with the exception of water availability (Haden et al., 2012). This lack of experience with major climate change impacts can cause people to see climate change as a low-probability event with few risks (Weber, 2006). Farmer's perceptions of risk are not only biophysical - they are deeply entrenched in policy and economics as these may have significant direct impacts on their farming systems (Howden et al., 2007; Smit and Skinner, 2002). Our data shows that farmers with a negative past policy experiences were more likely to have climate change risk concerns. Thus farmers in this region are to a large extent viewing climate change through a policy lens. For farmers with negative views of previous environmental policies, climate change risks may seem more severe if they are envisioning them to be heavily weighted towards policy and regulation.

At the same time, negative past policy experiences also resulted in less climate change belief. From an adaptation perspective, experience with past environmental policies provides a baseline set of expectations to evaluate climate change policies, even when the past policies addressed different issues. For policymakers this is crucial, because it demonstrates that policy perceptions linger –potentially for decades- and significantly influence other environmental perceptions.

However, it is important to consider broader individual values such as political ideology may influence both the formation of beliefs about climate change and perceptions of past environmental policies (Kahan et al., 2012). Though our paper did not measure ideology, future research should consider the overall structure of climate change belief systems, and how core values can constrain the formation of more specific beliefs.

Conclusion

We extend the use of the term "climate policy risks" to capture how farmers perceive and respond to future climate change policies. Our work shows that climate policy risk is the largest threat perceived by farmers, and is linked systematically to past environmental policy experiences as well as overall views on climate change. We show that climate change policies are more psychologically close to farmers than biophysical climate change impacts in this region. Theoretically, we demonstrate that abstract risks affect specific policy concerns in a climate change context and that research should incorporate climate policy risks into understanding climate change attitudes and behavior.

Integration of policy experiences on climate change belief, risk and behaviors further suggests that policy experiences should also be more systematically considered across climate change and environmental behavior research. Though much environmental and climate change behavior literature has considered policy support or perceptions as a major dependent variable (Barr, 2007; Steg et al., 2011; Stern et al., 1999) it is not often utilized as an independent variable. Better incorporation of policy experiences and attitudes into frameworks as an independent variable could begin with the New Ecological Paradigm (Dunlap et al., 2000; Dunlap and

Vanliere, 1978) often utilized in social environmental behavior research. We are also cognizant that future research focused on understanding climate change mitigation and adaptation could include additional measures to better understand the social, economic, and policy aspects of climate change. Indeed, this study only considers climate change policies and economic impacts and does not consider many other potential socio-economic aspects of climate change that could be assessed through additional studies (Frank et al., 2011).

From an applied perspective, three outcomes can be identified for improving climate change awareness and action in agricultural communities in California and globally as governments begin and continue implementation of climate change mitigation and adaptation efforts. First, risk perceptions, not climate change beliefs, may be more important than previously recognized. Focusing communication and outreach efforts on quantifying and explaining a broader range of potential risks to farmers and society may produce a greater shift towards adaptation and mitigation behaviors and policy responses. Communicating these risks in a way that minimizes fear and considers the local context and local people's stories can be particularly useful (Haden et al., 2012; O'Neill and Nicholson-Cole, 2009; Roeser, 2012; Spence and Pidgeon, 2010). Effective efforts should integrate the strengths of the natural and social sciences to best predict, gauge and communicate climate change risks (Lorenzoni et al., 2005). This means that risk communication within the agricultural community may be different across regions and places and must engage directly with farmers, further highlighting the need for place-based research initiatives.

Second, though past policy perceptions strongly influence a farmer's concern for future policies, they do not reduce their interest in participating in government programs. Programs that aim to work with the agricultural community to incentivize voluntary practice change can make participation more attractive and financially sound (Walford, 2002; Wilson and Hart, 2000). This can achieve a win-win situation where farmers can achieve environmental benchmarks with appropriate resources and time to enable effective adoption (Semenza et al., 2008). Programs that provide technical assistance or compensation to change practices may be a positive opportunity for agricultural communities to address climate change and help offset the transaction costs associated with changing practices (Falconer, 2000). Ideally, such programs would deal with both mitigation of greenhouse gas emissions and adaptation to ensure that farm production and food security continues despite changing conditions.

Finally, the past matters. The numerous environmental policies that California farmers have faced in the past several decades have influenced the way that they perceive climate change. From the perspective of many farmers, climate change policies might mandate costly changes in farming practices without perceived benefits to their operations or livelihoods, as is the case with other environmental policies. Voicing skepticism about climate change and its human causes may be one way to shield their enterprises from the perceived impacts associated with additional regulation. Policymakers should be cognizant of how climate change policies interact with other policies to influence policy opinions, which can in turn affect belief systems (Crabtree et al., 1998).

While economic incentives may be an effective option for short term behavior change (Spence and Pidgeon, 2009), a continuing dialogue is necessary to shift policy and climate change perspectives over time. Engagement with the agricultural community in the creation of environmental policies may help to prevent “lag effects”, where farmer’s perceptions of environmental policies continue to affect their concern and response to future environmental issues (in our case up to thirty years later). This might be best achieved through dialogue with farmers and agricultural communities particularly from policymakers, who can significantly affect climate change beliefs (Brulle et al., 2012). Integration of farmers into specific policy development activities related to climate change is a crucial step to begin to address negative past perceptions of environmental policies by including them in the policy process (Few et al., 2007; Reed, 2008).

This study sheds light on responses to climate policy risks in the broader effort to reduce greenhouse gas emissions and adapt agro-ecosystems to climate change. Importantly, this work highlights the need for place-based research and outreach activities that can frame climate change risks, opportunities and policies in local contexts to gain the greatest community support. However, multiple policies across scales may be most effective for climate change mitigation and adaptation (Ostrom, 2010) and climate policy risk research is necessary to understand how such policies will affect local and global decisions. To this end, further work is needed to understand how past policy experiences and climate policy risk responses are relevant in other cropping and rangeland systems, policies, cultures, and regions with varying biophysical impacts from climate change. Comparative studies across multiple regions can further assess and compare how these variables may affect the adaptive capacity of farming systems that may be influenced significantly by climate change policies. This work can contribute bottom-up understanding of local and regional drivers of behavior change that can facilitate potential international policy solutions to address climate change. These efforts can build upon this work to better understand the diverse climate change adaptation and mitigation strategies of farmers and agricultural communities in a way that appropriately considers climate policy risks and farmer perspectives from the local to global scale.

Table 2.1 Model Scales and Variables with Measures of Reliability. Scales and variables are listed in the order in which they appear in the results. Italics indicate sub-sections of a question (e.g. for past policy experience each policy for each question is italicized.)

Scales and Variables	Question/Statement	Scale	Eigenvalue	Factor Loadings	Cronbach Alpha
Regulation Concern	How concerned are you about the following climate related risks and the future impact they may have on your farming operations during your career?	Four Point Scale (1= Not Concerned, 4= Very Concerned)	1.94		0.72
	More government regulations			0.90	
	High fuel and energy prices			0.73	
	Government regulations will make it more difficult to adapt to the risks posed by climate change	Five Point Scale (1=Strongly Disagree, 5= Strongly Agree		0.78	
Government Program Participation	I would participate in government incentive programs for climate change mitigation or adaptation	Five Point Scale (1= Strongly Disagree, 5= Strongly Agree)	--- ---	--- ---	--- ---
Past Climate Experience	*Local* ***water availability*** *has _______ over the course of your farming career.*	Three Point Scale (1 = Increased, 2 =Stayed the same, 3 = Decreased)	--- ---	--- ---	--- ---
Past Policy Experience	Based on the yes/no responses of the following four policies aggregated together to create four separate scales	Seven point scale ranging from 0 to 1, accounting for all possible averages based on each question for the four policies. Individual questions are binomial yes, no responses.			
Regulation Environment	Effectively improves the environment:		2.19		0.69
	Pesticide Use Reporting			0.76	
	Water Quality Conditional Waiver Program			0.81	
	Rice Straw Burning Regulations			0.72	
	Stationary Diesel Engine Emissions Regulations			0.67	
Regulation Time	Reporting requirements are too time consuming:		2.55		0.77
	Pesticide Use Reporting			0.71	
	Water Quality Conditional Waiver Program			0.83	
	Rice Straw Burning Regulations			0.79	
	Stationary Diesel Engine Emissions Regulations			0.86	
Regulation Cost	Requires changes in practices or equipment that are impractical or too costly:		2.17		0.74
	Pesticide Use Reporting			0.70	
	Water Quality Conditional Waiver Program			0.83	
	Rice Straw Burning Regulations			0.73	
	Stationary Diesel Engine Emissions Regulations			0.68	
Regulation Balance	Effectively balances the interests of both the public and farmers:		2.37		0.73
	Pesticide Use Reporting			0.70	
	Water Quality Conditional Waiver Program			0.80	

Table 2.1 Model Scales and Variables with Measures of Reliability. Scales and variables are listed in the order in which they appear in the results. Italics indicate sub-sections of a question (e.g. for past policy experience each policy for each question is italicized.)

Scales and Variables	Question/Statement	Scale	Eigenvalue	Factor Loadings	Cronbach Alpha
	Rice Straw Burning Regulations			0.84	
	Stationary Diesel Engine Emissions Regulations			0.73	
Climate Change Belief	The global climate is changing	Five Point Scale (1= Strongly Disagree, 5= Strongly Agree)	---	---	---
	Average global temperatures are increasing		---	---	---
	Human activities such as fossil fuel combustion are an important cause of climate change		--- ---	--- ---	--- ---
Climate Change Risk	Climate change poses risks to agriculture globally	Five Point Scale (1= Strongly Disagree, 5= Strongly Agree)	---	---	---
	Climate change presents opportunities for agriculture globally		---	---	---
	Climate change presents more risks than benefits to agriculture		---	---	---
	Climate change presents more risks than benefits to agriculture in Yolo County.		--- ---	--- ---	--- ---

Table 2.2 Existing Regional Environmental Policies Relevant to Yolo County Farmers

Regulation	Year Enacted	Description
Pesticide Use Reporting	1990	Requires all agricultural pesticide use to be reported monthly to the county agricultural commissioner and subsequently the California Department of Pesticide Regulation (California Department of Pesticide Regulation, 2000).
Rice Straw Burning	1991	Under the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991, burning of rice straw was reduced by approximately 75% in 10 years. Current law allows for farmers to burn a maximum of 25% of their fields only when significant disease is present (California Air Resources Board, 2010).
Water Quality Conditional Waiver Program	2003	Requires farmers that discharge waste from irrigated lands to obtain a conditional waiver and implement best management practices to protect water systems(Central Valley Regional Water Quality Control Board, 2003).
Stationary Diesel Engine Emissions	2007	Established emission limits for new and in-use stationary diesel engines used in agriculture. Emission limits become more stringent over time (California Air Resources Board, 2007).

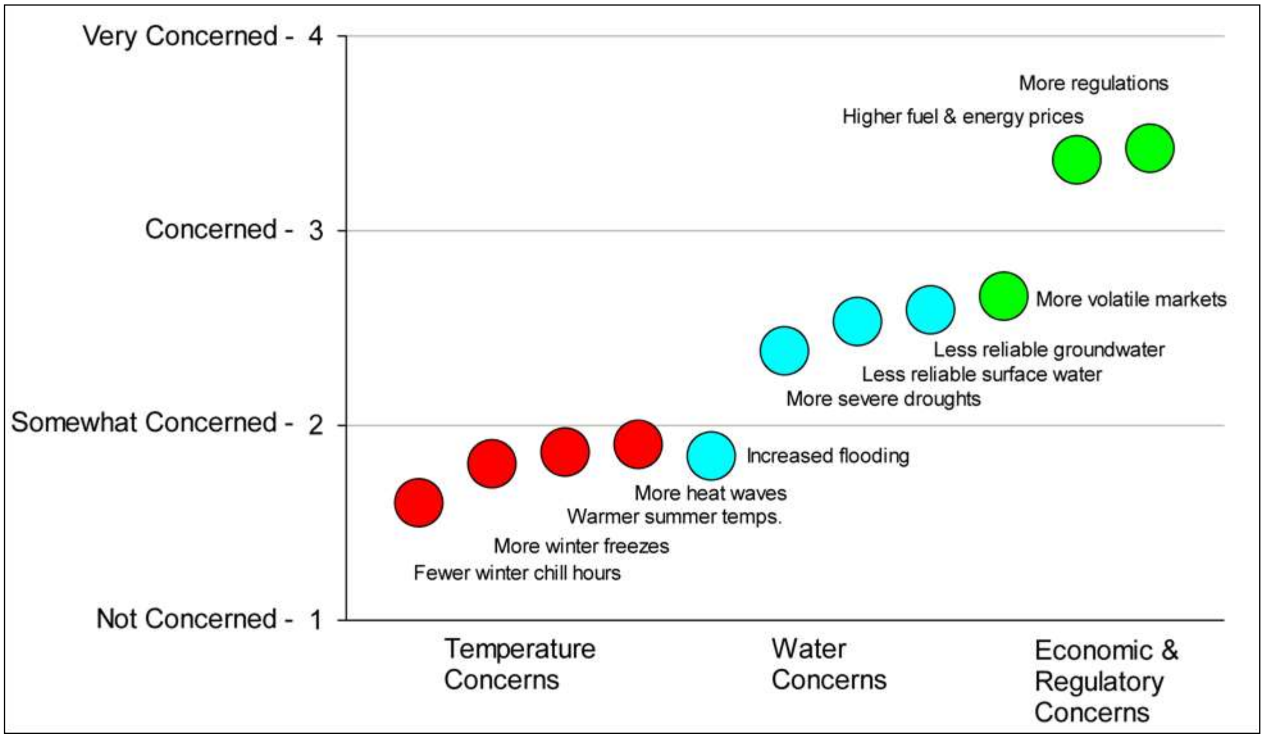


Figure 2.1 Average Level of Concern for Local Climate Change Impacts. Farmers' responses to the question, "How concerned are you about the following climate-related risks and the future impact they may have on your farming operations during your career?" Responses are ranked on a four point scale ranging from very concerned to not concerned.

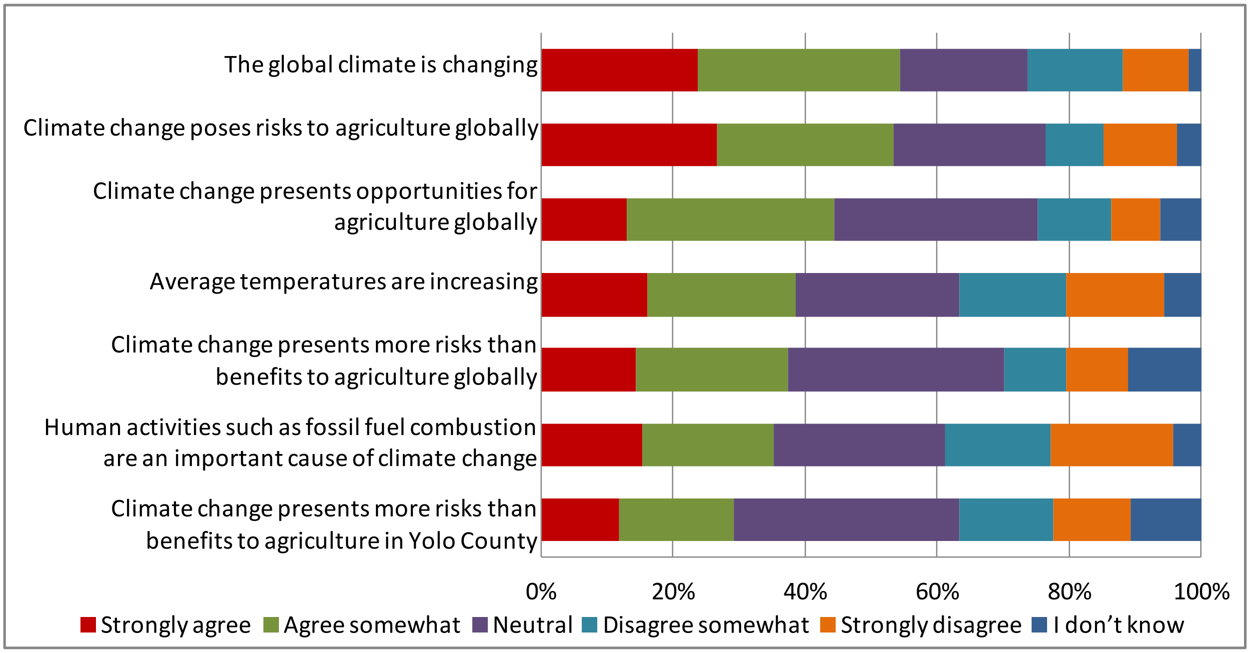


Figure 2.2 Yolo County Farmers' Perspectives on Climate Change. Statements are ranked in descending order by total level of agreement.

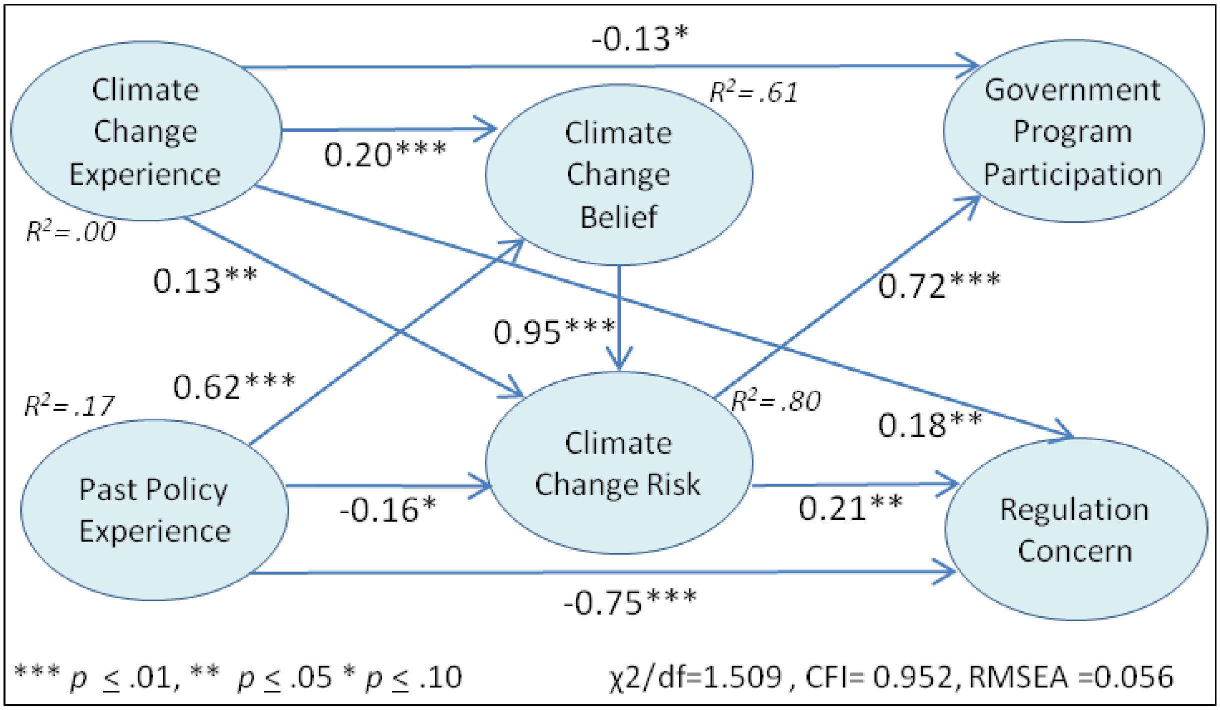


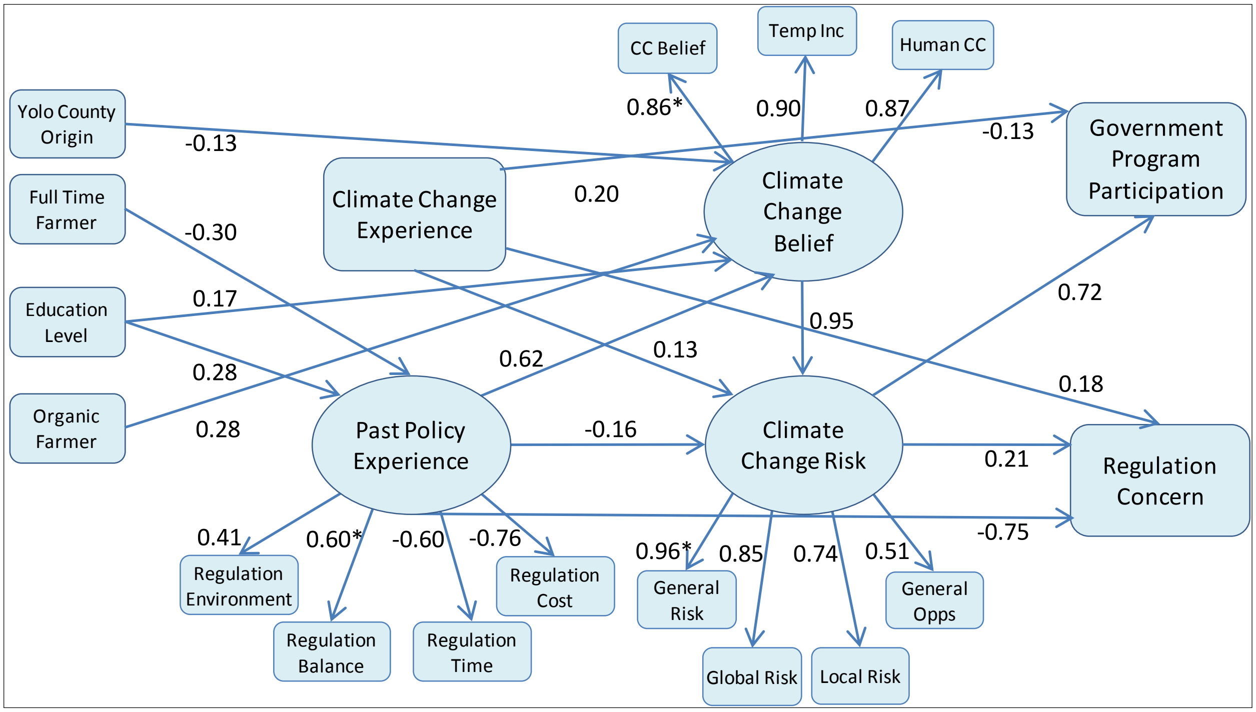
Figure 2.3 Significant Pathways in the Structural Equation Model. Significant demographic and farm characteristics including organic status, education level, whether a farmer was full time, and local origin were also included in this model but are not shown. A full structural equation model showing all observed and latent variables can be found in the supplemental materials.

Supplementary Materials for
Perceptions and Responses to Climate Policy Risks Among California Farmers

Supplementary Table S2.1 Full Significant Model Results Including Demographic and Observed Variables

Path	Standardized Coefficient	T Value[1]	Standard Error[1]
Education--> Past Policy Experience	0.279***	3.048	0.015
Education--> Climate Change Belief	0.174***	2.697	0.049
Full Time Farmer --> Regulation Perception	-0.305***	-3.34	0.046
Organic Farmer --> Climate Change Belief	0.281***	4.714	0.171
Yolo County Origin --> Climate Change Belief	-0.133**	-2.299	0.13
Past Policy Experience--> Climate Change Belief	.621***	5.556	0.507
Past Policy Experience--> Balance Regulation Scale[2]	0.596	----	----
Past Policy Experience--> Cost Regulation Scale	-0.761***	-6.279	0.200
Past Policy Experience--> Time Regulation Scale	-0.601***	-5.380	0.200
Past Policy Experience--> Environment Regulation Scale	0.412***	5.998	0.116
Past Policy Experience--> Government Concern Scale	-0.753***	-5.457	0.502
Past Policy Experience--> Climate Change Risk	-0.161*	-1.831	0.448
Past Climate Experience--> Government Incentive Program	-0.128*	-1.864	0.164
Past Climate Experience--> Regulation Concern Scale	0.177**	2.346	0.125
Past Climate Experience-->Climate Change Belief	0.199**	3.111	0.132
Past Climate Experience--> Climate Change Risk	0.131**	2.469	0.124
Climate Change Belief--> Climate Change Risk	0.953***	9.982	0.108
Climate Change Belief--> Global Climate Change Belief[2]	0.861	----	----
Climate Change Belief-->Temperatures Increasing	0.903***	14.870	0.072
Climate Change Belief--> Human Climate Change	0.869***	11.998	0.089
Climate Change Risk--> Climate Change Agriculture Risk[2]	0.956	----	----
Climate Change Risk--> Global Climate Change Agriculture Risk	0.845***	15.494	0.051
Climate Change Risk--> Local Climate Change Agriculture Risk	0.742***	11.772	0.061
Climate Change Risk--> Climate Change Agriculture Opportunities	0.507***	6.824	0.067
Climate Change Risk--> Regulation Concern Scale	0.211**	2.1	0.071
Climate Change Risk--> Government Incentive Program	0.717***	10.182	0.072
$\chi2$/df=1.509 , CFI= 0.952, RMSEA =0.056			

*** $p \leq .01$, ** $p \leq .05$ * $p \leq .10$
[1] T Values and Standard Errors are based on non-standardized coefficients from the complete statistically significant model
[2] Latent variables influencing multiple variables have one variable fixed at one. As such, these variables have unstandardized coefficients equal to one and therefore do not have standard errors or t values associated with them.



Supplementary Figure S2.1 Complete structural equation model showing observed and latent variables. Asterisks indicate observed variables held constant in order to estimate latent variables. Results suggest that organic farmers and those with higher levels of education were more likely to believe in climate change while those from Yolo County originally were less likely to believe in climate change. Full time farmers were less likely to have positive past environmental policy perceptions (likely because they have had to contend with the greatest number of regulations) while farmers with higher education levels were more likely to have positive views of past environmental policies.

Niles, M.T., Lubell, M.N., Brown, M. How Limiting Factors Drive Agricultural Adaptation to Climate Change. Submitted to Agriculture, Ecosystems, & Environment.

How Limiting Factors Drive Agricultural Adaptation to Climate Change

Abstract

Consensus is growing that agriculture is vulnerable to climate change and adaptation responses are necessary to minimize impacts. Nonetheless, the diversity of potential impacts, agro-ecological contexts and regional capacity for change make understanding adaptation behaviors challenging and ensure that climate change adaptation will not be the same across all contexts. Considering this heterogeneity, this paper aims to develop a theoretical approach to connect agroecosystem diversity with farmer decision-making in the context of agricultural adaptation to climate change. We combine the ecological principle of Liebig's Law of the Minimum with the Psychological Distance Theory to suggest how adaptation behaviors vary across regional contexts. We argue with our limiting factors hypothesis that limiting factors within a farm system (water or temperature impacts) influence the adoption of adaptation practices differently across regions and farm systems. Limiting factors varied across farm systems and regions, based on historical climate changes, agroecological contexts, infrastructure and adaptation capacity. Using farmer survey data from New Zealand we show that limiting factors mediate the effect of past climate experiences on the adoption of adaptation strategies differently in two regions with water acting as a limiting factor in Hawke's Bay and water and temperature as a limiting factor in Marlborough. This suggests that farmers perceive and respond to climate change in part due to their personal experiences with climate change and the limiting factors within their system. Such results are relevant for the development of regional adaptation strategies, effective policies and targeted climate change communication.

Introduction

There is emerging consensus that agriculture is vulnerable to climate change and that adaptation strategies are urgently needed to assist in minimizing climate impacts (Rosenzweig et al., 2013). Increasing the adaptive capacity of agriculture requires a better understanding of the drivers and barriers for adoption of climate-smart practices (Howden et al., 2007). While a significant body of research exists to assess the adoption of innovations (Rogers, 2003) and conservation practices in agriculture (Prokopy et al., 2008), emerging research seeks to understand what drives the adoption of climate change adaptation and mitigation practices among farmers (Arbuckle et al., 2013a; Arbuckle et al., 2013b; Barnes and Toma, 2012). A major challenge is that climate change adaptation is not a one-size fits all phenomenon; adaptation strategies and farmer responses will vary across regions (Berry et al., 2006) based on agroecological contexts, socio-economic factors (Adger et al., 2009), climatic impacts, and existing infrastructure and capacity. Despite this heterogeneity, there is little understanding of how varying ecological contexts within a given region influences farmer decision-making on adaptation strategies. This paper aims to address this gap by theoretically linking the agro-ecological context of climate change with farmer decision making focusing on the drivers and barriers for adopting adaptation strategies to assist communities and policymakers in devising targeted adaptation strategies (Howden et al., 2007).

We link the agro-ecological system and farmer decision-making by combining a classic ecological principle, “Liebig’s Law of the Minimum” with the theory of “psychological distance” (Liberman and Trope, 2008) to suggest that adaptive behaviors within an agricultural system are influenced by the most limiting factor. Based on these existing theories, we develop and apply a "Limiting Factors Hypothesis" to climate change adaptation by assessing how farmer's past climate experiences influence their concern for future climatic limiting factors (water and temperature) and in turn, their likelihood to adopt adaptation behaviors. This hypothesis became evident from our previous work with California farmers, which demonstrated that adaptation decisions were most responsive to experiences and concerns about water availability (Haden et al., 2012), which historically is the most limiting factor in California's Mediterranean climate (Schlenker et al., 2007; Tanaka et al., 2006).

Here we aim to more systematically develop the limiting factors hypothesis and apply it in two regions of New Zealand that have different agro-ecological and climate contexts, and therefore different limiting factors that translate into farmer adaptation decisions. We focus on two New Zealand farming regions (Marlborough and Hawke's Bay) and farm system types (sheep/beef and viticulture), which have had varying climatic changes and infrastructure responses. We predict that in Marlborough, a region known for its wine production, temperature will be a key limiting factor for climate change given previous temperature-related climatic changes, wine's temperature sensitivity, and its already established irrigation infrastructure. Conversely, in Hawke's Bay, we hypothesize that water will be the climatic limiting factor and driver of adaptation behaviors given a history of drought, and the prevalence of sheep/beef systems that lack irrigation and water infrastructure. We compare these two farm system types across both regions using multiple mediation models to test for the direct and indirect effects of limiting factors, global climate concerns, and climate change experiences on adaptation behaviors (Figure 1).

Connecting Ecological and Psychological Theories

Liebig's Law of the Minimum, originally applied in agriculture but now broadly used in ecological research, states that an organism's growth is limited by its most scarce resource (von Liebig, 1855). We argue that an agricultural system's adaptation to climate change is fundamentally hindered by, and vulnerable to, the most limiting factor within the system. In this study there is a clear link between limiting factors and productivity in a climate change context because both water and temperature impacts can fundamentally impact the growth potential of a crop or animal. However, limiting factors will vary across regions and agro-ecological systems.

In fact, climatic factors are just one type of limiting factors that farmers contend with and farmers certainly make decisions based on other agronomic and socio-economic limiting factors. For example, a farmer's debt load may have a profound effect on their ability to implement irrigation, which may help them respond to water as a limiting factor. We hope that future work can assess the interaction of these potential factors and examine the limiting factors hypothesis in other agronomic and socio-economic contexts as well. The limiting factors hypothesis is consistent with the idea that farmers must adapt to multiple constraints in order to maximize their productivity and desired outcomes (Lubell et al., 2013). As such, it can be considered a subset of the broader work in adaptive management of agricultural systems, for it enables understanding about the link between climatic variables and farmer decision-making.

We connect Liebig's Law of the Minimum with the Psychological Distance Theory to suggest that limiting factors will have a strong influence on climate change attitudes and behaviors because they are psychologically "closer" to the community that is forced to contend with them.

Psychological distance and the related construal level theory (Liberman and Trope, 2008) suggests that events perceived to be "closer" to an individual (temporally, geographically, socially, and in certainty) are more salient and have a stronger proximate influence on individual decisions (Spence et al., 2012). Many have argued that reducing the psychological distance of climate change and making it more personal and relevant can increase the potential for behavior change (Kates and Wilbanks, 2003; Leiserowitz, 2007; Lorenzoni and Pidgeon, 2006; Nicholson-Cole, 2004; Scannell and Gifford, 2013). As such, personal experience with climate events can influence climate change attitudes and behaviors (Brody et al., 2008; Haden et al, 2012; Spence et al., 2011). Emerging research also suggests that recent climatic and weather events can strongly influence individuals' climate change perceptions and beliefs (Hamilton and Stampone, 2013; Rudman et al. 2013; Zaval et al., 2014).

Here we argue that a farmer's future climate concerns are oriented towards the most limiting climatic factor within their system as informed by previous weather and climate events. Because farmers must repeatedly contend with limiting factors in a particular agro-ecological context, their attitudes have a higher cognitive "availability" (Kahneman, 2011). These limiting factors in turn mediate the relationship between past climate experiences and potential adoption of adaptation practices.

Place Context and Hypotheses

Hawke's Bay, New Zealand

Hawke's Bay sits on the central east side of New Zealand and is the 5th and 3rd largest region for sheep and beef production respectively in New Zealand. It also produces horticultural crops and is the 2nd largest wine grape growing region, though it produces four times fewer grapes than Marlborough (Statistics New Zealand, 2012). Hawke's Bay has been historically plagued by water shortages in part because it is bordered by mountain ranges, which shelter it from prevailing westerly winds, resulting in a fairly low mean annual rainfall (less than 1000mm). It has one of the lowest number of rain days in the North Island of New Zealand (Fowler et al., 2013). Despite this climate, Hawke's Bay doubled the amount of hectares given permits to take surface water between 1999 and 2010 (Hawke's Bay Regional Council). The region has also proposed the development of the Ruataniwha water storage scheme, a project with 91 million m^3 storage capacity to address chronic water shortages in the area.

These regional water shortages have been exacerbated in recent years as Hawke's Bay has contended with four years of consecutive droughts between 2006-2009 (Hawke's Bay Regional Council). Rainfall records were significantly below average particularly for the September to April timeframe within these years, and many areas of Hawke's Bay experienced extreme drought conditions receiving less than half their normal rainfall. As a result, there were decreased flows (significantly below average) for the region's rivers as well. Long-term data analysis of 11 regional sites showed that the majority (9/11) of these sites experienced below average mean monthly flow between 2004-2009 from the long-term average (Hawke's Bay Regional Council, 2009a, b). In addition to these recent events, climate projections for Hawke's Bay suggest that such events are likely to continue in the future, and the region is expected to see a decrease in annual average rainfall and frost frequency (National Institute for Water and Atmosphere, 2008). Hawke's Bay pastoral farming is particularly sensitive to precipitation changes given its reliance on rain-fed pasture, and future climate scenarios suggest an overall average decrease in pasture productivity as a result of decreased rainfall (Fowler et al., 2013).

Given the context of these recent events, we suggest that drought and water scarcity are a significant concern for Hawke's Bay sheep and beef farmers, and we expect that water will be the limiting factor in Hawke's Bay. Climatically, we suggest that 1) the historical relationship that farmers have with drought has made water a fundamentally "closer" phenomenon; and 2) climate projections for the future indicate that water will continue to be a major issue as average annual rainfall will decrease and droughts will worsen. However, in addition to these climatic factors, land use and agronomic factors within the region also suggest that water will be a limiting factor. The dominant land use in the region is sheep and beef, which is largely rain-fed and vulnerable to climate variability, particularly droughts (Fowler et al., 2013). As a result, sheep and beef farmers have limited adaptive capacity to deal with water shortages. We do not expect to find that water is a limiting factor for viticulture in the region, which has large irrigation infrastructure in place to handle water shortages.

Marlborough, New Zealand

Marlborough, located at the top of the South Island, grows sixty-five percent of all wine grapes in New Zealand. Between 2007 and 2012, wine grape acreage in Marlborough increased 32%. Related to this expansion is the growth in irrigation between 1999 and 2010 from 6,300 to 55,000 hectares- an increase of more than 700% (New Zealand Ministry for the Environment, 2010). Despite the expansion of irrigation, some areas of Marlborough are seasonally water limited due to high evapotranspiration rates and reliable water can remain a challenge

(Marlborough District Council, 2012). More than 86% of wine grapes grown in Marlborough in 2012 were sauvignon blanc (Wine Marlborough New Zealand, 2012). As a result of a unique "terroir" (wine attributes that result from the environment in which a grape is grown), (Van Leeuwen and Seguin, 2006) New Zealand sauvignon blanc has become widely known around the world for the highly distinct characteristics of the Marlborough region (Parr et al., 2007). Sauvignon blanc requires lower average temperatures than many other varieties (Jones, 2003), and growers in the region are driven to maintain its current flavor profile given its international fame (Sturman and Quénol, 2013).

Climatically, Marlborough is unique compared to other regions of New Zealand including Hawke's Bay. While overall New Zealand has seen a general decrease in frost days over the past century (Salinger and Griffiths, 2001), Marlborough has experienced increased frosts and an increased temperature range not seen in other parts of New Zealand in the past several decades (Sturman and Quénol, 2013). These events can be damaging to the wine industry dominant in Marlborough since frosts can influence wine grape yield and quality, particularly if the frosts come at a late date with bud burst or fruiting. Furthermore, the increased temperature range that has been observed in Marlborough in recent years threatens to influence the quality of sauvignon blanc wine that has a lower temperature threshold compared to other varieties like the red varieties dominant in Hawke's Bay. In the future, Marlborough is expected to see an increase in droughts, wetter summers and autumns, and up to 2°C warming by 2090 (Mullan et al., 2008)

As a result of the described climatic conditions and agronomic characteristics of the region's wine industry, we predict that temperature will be the limiting factor in Marlborough for several reasons: 1) air temperature is the major cause for inter-annual variations in wine quality (Sturman and Quénol, 2013), and Marlborough viticulture is heavily focused on the temperature sensitive variety sauvignon blanc; 2) the increased prevalence of frosts and temperature range in the past has made temperature issues "closer" to growers within the region; and 3) though droughts may increase in the future, irrigation infrastructure is significant within the region, providing growers with opportunities for controlling water.

Materials and Methods

A total of 20 interviews were conducted across the regions in 2012 with farmers and stakeholders. Interviews were used to assist with the development and adaptation of the survey, which was previously implemented among growers in Yolo County, California in 2011 (Haden et al., 2012; Jackson et al., 2012a; Niles et al., 2013). The survey was changed for local context including relevant practices and language; however, much of the survey was the same and future work will compare farmer responses across the regions.

The survey was implemented via telephone with assistance from ResearchFirst, a professional survey company based in Christchurch, New Zealand utilizing their database of farmers from census and other databases. The survey was piloted among ten farmers outside of the two target regions. A stratified sample was used for the survey allowing for responses within the region to be consistent with the land use type of those areas. Data were collected between August and October 2012. A total of 490 farmers responded to the survey (n= 177 in Marlborough, n= 313 in Hawke's Bay), with a total response rate of 40%.

We conducted a factor analysis which yielded a single factor solution with factor loadings significantly higher than 0.40, a generally accepted cut-off point (Costello and Osborne, 2005). We used the factor analysis to construct four scales: local water concerns, local temperature concerns, global climate change concerns and climate change adaptation practices. Local water and temperature concern scales each measure the concern for future climate-related impacts for each limiting factor. The global climate change concern scale measures a farmers' belief in climate change and its potential risks. Our dependent variable, the likely adoption of climate change adaptation practices, was a scale aggregated across six different potential adaptation strategies. Each scale achieved an internal reliability (Cronbach's alpha) higher than 0.70 (Nunnally, 1978).

We considered farmers' perceptions of the changes of eight past climate experiences – summer temperature, winter temperature, annual rainfall, water availability, drought, flooding, wind, and slips (landslides). Despite an analysis, climate experiences did not yield into factor solutions or scales with acceptable loadings or Cronbach's alpha. As a result, all eight climate experiences were treated as individual variables. Table 1 gives further detail on variable statistics and reliability measures across the models.

To test for how climate experiences affect climate change concerns (local and global) and thus the adoption of adaptation practices we built a series of multiple mediation models for each of the dominant farm types within a region (Marlborough viticulture= 65%, n=155; Hawke's Bay sheep/beef= 81%, n=239). The mediation models were designed to test for how the eight different climate change experiences influenced a farmer's limiting factors and global climate change concerns, and how these affected the adoption of adaptation practices. We also tested for a direct effect of climate change experiences on the adoption of adaptation practices. We tested the viticulture and sheep/beef models in both regions to control for farm system type. In running these series of models we aimed to test for the interaction effects of farm type, region and limiting factor.

We utilized bias-corrected bootstrapped (n=1000) confidence intervals (95% confidence) to test for indirect mediation effects within our models (Preacher and Hayes, 2008). Mediation occurs if the reported confidence intervals do not contain zero (Fritz and MacKinnon, 2007) and we built off of work by Zhao et al.(2010) suggesting that a direct effect is not necessary to prove indirect mediation effects. We used bias corrected bootstrapped results because they have been found to perform the best with regards to power and Type I error results (Briggs, 2006) particularly for multiple mediation models and smaller sample sizes (Preacher and Hayes, 2008). Since we had eight separate independent variables (each climate experience) and two separate local concerns/limiting factors mediators (temperature and water concerns) we ran 16 models for each farm system (viticulture, sheep/beef) in both regions for a total of 64 models. Supplementary Table 1 provides the coefficients, and bias-corrected bootstrapped confidence intervals for each model we ran. We aggregated total indirect effects across all models for a farm system and region to determine the cumulative effect of a limiting factor on farmer adoption of adaptation behaviors. Across all 64 models we found no significant mediation effects of past climate experiences on global climate change concerns and then on the adoption of adaptation practices, so these results are not reported.

Results

Climate Changes

Across both regions, farmers indicated that they have observed a number of changes in the climate and extreme events over time (Figure 2). In particular, there are notable differences between Marlborough and Hawke's Bay with regards to water related events and availability. In Marlborough, 47% of farmers believe that annual rainfall has increased over time while only 33% believe so in Hawke's Bay. As well, 44% of farmers in Marlborough suggest that flooding and water availability have increased (44% and 18% respectively), but in Hawke's Bay only 34% believe flooding has increased and only 11% believe water availability has increased. This trend is also observed in perceptions of drought- more than 21% of Hawke's Bay farmers believe drought has increased, while only 8% of Marlborough farmers have observed an increase in drought.

Trends in temperature and other extreme events are less diverse. Thirty-six percent and 12% of farmers in both regions believe winter temperatures and summer temperatures have increased respectively. However, a plurality also believes that summer temperatures have decreased (30% in Hawke's Bay and 42% in Marlborough). Wind frequency and intensity was perceived to have increased by 11% of Hawke's Bay farmers and 18% of Marlborough farmers. Finally, 21% of Hawke's Bay farmers and 26% of Marlborough farmers believed that the frequency and/or intensity of slips (landslides) had increased.

Future Concerns and Limiting Factors

Figure 3 shows the average level of stated future concern (1= not concerned, 4= very concerned) for water and temperature limiting factors across all farmers in the two regions. Overall the average level of future concern across the five water issues was higher than for temperature concerns in both regions (average water concerns in Marlborough= 2.56, Hawke's Bay=2.48; average temperature concerns in Marlborough=2.22, Hawke's Bay= 2.09). However, comparing water and temperature concerns across the two regions was not statistically significant ($p < 0.05$) indicating that overall there are not clear differences in these climate change concerns across the two regions. Despite this, our model results provide evidence that these same concerns have different impacts in the way they interact with farmers' past climate experiences to drive the adoption of adaptation practices.

Model

Figure 4 shows the cumulative total indirect effects (significant and non-significant, $p < 0.05$) derived from multiple mediation models to test the effect of past climate experiences, global climate change concerns, and local limiting factors on the adoption of agricultural adaptation practices. Across all of the models we did not find any significant indirect effects from the "global pathway" of past climate experience, global climate change concerns and the adoption of agricultural adaptation practices. However, we do find evidence for our hypothesis that water is the limiting factor driving adaptation behaviors in Hawke's Bay. Water as a mediating limiting factor has the greatest indirect effect on the adoption of adaptation practices among sheep/beef farmers while temperature has no influence.

In Marlborough, we do not find evidence for our hypothesis that temperature is the only limiting factor for viticulture. Instead, we find that the combined effect of temperature across viticulture and sheep/beef systems has an overall more significant effect compared to water (total significant indirect effects from temperature=0.501 compared to 0.262 for water); however, temperature was not the only limiting factor in the viticulture industry as we hypothesized. Wine grape growers water concerns also indirectly influenced the adoption of adaptation behaviors, though to a lesser extent. Conversely, sheep/beef farmers in Marlborough are only influenced by temperature as a limiting factor in affecting their adoption of adaptation practices, which was unexpected given that water was the limiting factor for sheep/beef farmers in Hawke's Bay.

Discussion

Our work demonstrates a correlation between past climate change experiences, limiting factors (future climate concerns) and the adoption of agricultural adaptation practices. Importantly, we find no significant indirect effects of a "global" pathway where past climate experiences affect global climate change concerns and then the adoption of adaptation practices. These results are consistent with our previous work in California where we found through the same methods that past climate experiences influenced local future climate change concerns and in turn the adoption of adaptation practices (Haden et al., 2012). In our previous work we also did not find evidence that global climate change concerns influenced the adoption of adaptation practices; instead global climate change concerns influenced the adoption of mitigation behaviors. These results suggest that across agricultural contexts, countries and policies, there is consistent correlation between past climate experiences, local level concerns or limiting factors for the future, and the adoption of agricultural adaptation practices.

These results also demonstrate the applicability of a limiting factors hypothesis and the psychological distance theory. We find that limiting factors appear to be both regionally specific and farm system specific, often differing across both. As we predicted, our results suggest that water is a limiting factor in Hawke's Bay, where historical and future climate events coupled with the agroecological context of water infrastructure have made water a limiting factor for the sheep/beef farms in the region. The recent North Island drought in 2013 (which occurred after our data collection) provides some additional context as to why we observe water as a limiting factor for sheep/beef systems but not viticulture. The worst drought to hit the North Island of New Zealand since World War II, the 2013 drought caused an estimated NZ$2 billion in losses with devastating impacts on the area's sheep/beef farmers who had to de-stock their animals and purchase additional feed. These impacts also affected rural livelihoods spurring campaigns to encourage farmers to talk about possible mental health issues in an effort to thwart rural suicides (Hawke's Bay Regional Council, 2013).

On the contrary, wine grape growers in Hawke's Bay celebrated the best vintage in a century. Drought conditions coupled with the warm temperatures and clear skies helped concentrate flavors in grapes and increase quality (Rogers, 2013). The irrigation infrastructure for viticulture in the Hawke's Bay area made drought conditions easier to manage and adapt to compared with sheep/beef farmers who lacked the same capacity on a whole. In our interviews, we had one sheep and beef industry professional mention, *"If you ask most sheep and beef farmers, it will be a small minority even in the dry areas that have any irrigation at all."* As a result, the agroecological context and farm system as well as the available infrastructure for those systems influenced how two different industries responded to the drought.

The cross-regional differences that we observed among the same farm types is likely because of historical changes, regional varieties, and mixed farm systems. Temperature was significant for Marlborough viticulturalists but not for Hawke's Bay potentially because the varieties in Hawke's Bay have a higher adaptive capacity for warming temperatures in the future. While sauvignon blanc dominates in Marlborough, red varieties like cabernet sauvignon are prolific in Hawke's Bay. These red varieties have higher average growing season temperatures (Jones, 2003) and research from major red wine growing regions indicates that warming temperatures historically have increased wine quality and grape yields (Nemani et al., 2001). On the contrary, as indicated earlier, Marlborough has seen an increased temperature range and frosts in recent decades, which could have a significant effect on sauvignon blanc that has a lower temperature threshold than many red varieties. During our interviews one viticulturalist from Marlborough summed up his concerns succinctly stating, *"Our biggest challenges probably don't revolve around rainfall presence or lack of, they revolve around temperature and fruit set and yield."*

The results that water was also a limiting factor for Marlborough viticulture was unexpected; however, can likely be explained by the existing irrigation context and the varieties grown in the region. White wine varieties can fare worse than red varietals in water stressed situations as aroma development is restricted (Peyrot des Gachons et al., 2005). Since the majority of wine grown in Marlborough is the white variety sauvignon blanc, water stress would likely influence these crops more than they would the dominant red varieties found in Hawke's Bay, where water as a limiting factor had no mediating effect. Furthermore, Marlborough has high evapotranspiration rates, and while irrigation has massively expanded, the region is very limited in its future capacity to expand water rights. In essence, the mere presence of irrigation does not necessarily guarantee that the Regional Council won't restrict water allocations for the future. Finally, we suggest that the temperature signal present among sheep/beef farmers in Marlborough and not in Hawke's Bay is likely in part because of mixed farming systems. The expansion of wine grapes into sheep/beef land in Marlborough means that many of these farmers also now grow wine grapes, which may be influencing how they perceive temperature concerns.

Our results indicate that farm system types alone may not determine climate change perspectives and behaviors; these systems are also imbedded in regions with varying climate experiences and impacts and infrastructure. The interaction of the two presents perhaps the greatest potential for assessing climate adaptation behaviors based on limiting factors. These results demonstrate how farmers' personal experiences with climate change are translated through limiting factors and future concerns to affect their behavior with both farm system and regional differences.

Application of this work to other regions and systems suggests several key factors for consideration. First, farmers' appear to be reacting and behaving in part because of limiting factors in their system. This limiting factors hypothesis is inherently connected to the concept of Liebig's Law of the Minimum: a farming system will be hindered by its most limited resource. In adapting to changing conditions, it makes sense both psychologically and ecologically that these are the effects farmers find to be most salient. These factors are psychologically "close" to them, having contended with them in the past, making them concerning issues for the future.

Given this historical nature, it is likely that a farm's limiting factor will be the single greatest adaptation issue for farmers. Within this context however, it is also important to recognize the role that infrastructure can play. The extensive irrigation capacity within viticulture, especially in Hawke's Bay where drought has been more prevalent, has appeared to provide wine grape growers with additional security and capacity to control water as they please within the drought context, given that water is still available. To the extent that irrigation or water storage is feasible within farming systems in Hawke's Bay, it may provide this additional capacity to assist farmers with future water shortages. However, the expansion of such infrastructure projects may also present challenges if water allocations are limited by institutions, or if such infrastructure enables land use change with additional environmental or social impacts.

If limiting factors are the most salient for farmers, it likely has significant implications for assessing how short-term responses can influence long-term adaptations and the subsequent policies that may be needed to accompany such actions (Howden et al., 2007). Frameworks like the Adaptation Cycle (Wheaton and Maciver, 1999) and Adaptation Action Cycle (Park et al., 2012) aim to assess what individuals adapt to, and these results corroborate other work (Spence et al., 2012) suggesting that psychologically close phenomena may actually change behavior. Our work can assist a region to understand what the limiting factors of a system may be and communicate potential risks to develop robust adaptation strategies, a need clearly articulated by Rosenzweig et al. (2013). This may also provide deeper perspectives for assessing a farmer's potential for short-term reactive incremental adaptation versus longer-term transformative adaptation as discussed by Park et al (2012). Limiting factors are likely the most immediate issue for a system and could result in short-term responses, which may actually hinder longer-term transformative adaptive strategies if it remains the sole focus of a farmer.

Second, it is crucial to recognize that, at least in our work, limiting factors will not be defined by either a region itself or the farm system type as a whole; rather, there is an interaction of the two. Even in a small country like New Zealand, local differences in climate change are possible and require regional focus and planning (Sturman and Quénol, 2013). Broad agricultural adaptation strategies for a given farm system or country therefore may be fruitless if they don't consider heterogeneity among farm types within a given region or consider how ecological contexts affect all farm system types more broadly. While climate change mitigation strategies may be aggregated and determined at a larger scale given its global nature, our work suggests that regional and local-based adaptation strategies will likely be the most effective.

Finally, we believe it is time to join together ecological and social/psychological theories and apply them to real-world data to advance work in climate change adaptation. Though many have highlighted the need to make climate change work more multidisciplinary (Howden et al., 2007; Swim et al., 2011), empirical examples of joining disciplines and theories to actually link ecological contexts with decision-making to predict behaviors are scarce. By doing so here, we couple climatic data, ecological and psychological concepts to assess how farmers may change their behavior based on both Mother Nature and human nature. Additional work could also be done to more completely link our psychological data with regional environmental data through agent-based modeling, which we hope to do in the future.

Conclusion

This paper has aimed to address a gap in theory linking ecological contexts with farmer decision-making within climate change adaptation by using empirical data to assess the factors that drive the adoption of adaptation strategies. Agricultural adaptation to climate change is crucial not just for farmers, rural communities, and economic sustainability but for a growing population and global food security (Schmidhuber and Tubiello, 2007). Though significant attention has been given to agricultural adaptation in the developing world (Bryan et al., 2009; Mertz et al., 2009), fewer papers have looked at developed country adaptation across varying farm system types. Through our limiting factors hypothesis, we demonstrate both theoretically and empirically the correlation between climatic experiences, climatic limiting factors and the adoption of adapting behaviors. Coupling ecological and psychological theories demonstrates that the limiting factors within a given region, farm system, or both are the most relevant, as they are both psychologically and ecologically "close" to a farmer. As such, they are indirectly mediating how farmers translate their past climate experiences into future behaviors.

Of course we recognize that this work is thus far limited to only two regions in New Zealand and our work in California and additional analysis across many other agro-ecological systems is needed to determine whether the limiting factors hypothesis can be broadly applied. More explicit modeling through agent-based simulations can assist researchers in coupling environmental and climatic data with farmer perceptions and behaviors. We also intend to explicitly test whether global concerns mediate the relationship between past climate experiences and the adoption of mitigation behaviors as our previous work has demonstrated. Researchers, regional planners, and policymakers can build on this work by utilizing a more interdisciplinary approach for climate change adaptation decision-making and working with farmers and rural communities to assess the most limiting factors and related adaptation practices for a given region and farm system.

Table 3.1 Model Variable Means and Measures of Reliability

Variable	Question/Statement	Scale	Eigenvalue	Factor Loadings	Cronbach Alpha	Mean	Standard Error
Perceived Change in Local Climate (Independent)	*Local _____ (see below) has (increased, stayed the same, decreased) over the course of your farming career*						
	Summer temperature	Three Point Scale (1 = Increased, 2 =Stayed the Same, 3 = Decreased				1.755	0.032
	Winter temperature					2.244	0.032
	Annual rainfall					2.338	0.028
	Water availability					2.028	0.023
	Frequency and/or duration or drought					1.885	0.032
	Frequency and/or duration of flooding					2.301	0.029
	Frequency and/or severity of wind					1.92	0.027
	Frequency of slips					2.188	0.027
Local Water Concerns (Mediator)	*How concerned are you about the following climate related risks and the future impact they may have on your farming operations during your career?*		2.90		0.82		
	More severe droughts	Four Point Scale (1= Not Concerned, 4= Very Concerned)		0.78		2.636	0.497
	Change in timing, intensity or frequency of rainfall events			0.79		2.591	0..459
	Less reliable surface water supply			0.72		2.663	0.054
	Increased frequency or intensity of flooding			0.78		2.418	0.051
	Increased frequency or intensity of slips or erosion			0.73		2.224	0.054
Local Temperature Concerns (Mediator)	*How concerned are you about the following climate related risks and the future impact they may have on your farming operations during your career?*		2.22		0.73		
	Fewer winter chill hours	Four Point Scale (1= Not Concerned, 4= Very Concerned)		0.74		1.972	0.046
	Increase in frequency or intensity of frost			0.66		2.199	0.052
	Warmer temperatures			0.82		2.082	0.043
	More frequent heat waves			0.76		2.303	0.048
Global Climate Change Concerns (Mediator)	*Indicate your level of agreement with the following statements*		2.91		0.82		
	The global climate is changing	Five Point Scale (1= Strongly Disagree, 5= Strongly Agree)		0.76		3.424	0.056
	Average global temperatures are increasing			0.76		3.106	0.052
	Human activities such as fossil fuel combustion are an important cause of climate change			0.78		3.218	0.057
	Climate change poses risks to agriculture globally			0.80		3.777	0.052
	Climate change presents more risks than benefits to agriculture globally			0.71		3.409	0.48

Table 3.1 Model Variable Means and Measures of Reliability

Variable	Question/Statement	Scale	Eigenvalue	Factor Loadings	Cronbach Alpha	Mean	Standard Error
Climate Change Adaptation Practices (Dependent)	*If the future climate in Hawke's Bay/Marlborough resulted in more extreme weather or changes in water and temperature, which of the following management strategies would you use beyond what you currently do?*		3.12		0.78		
	Participate in a community irrigation scheme	Six Point Scale (1= Very Unlikely, 5= Very Likely, 6= Already Use)		0.74		2.779	0.084
	Concentrate river water on a smaller percentage of acreage			0.74		2.248	0.07
	Pump more groundwater			0.65		2.396	0.066
	Drill more wells or seek alternative water sources			0.71		2.466	0.67
	Build water storage facilities			0.72		3.351	0.076
	Adopt a water monitoring technology			0.77		3.894	0.087

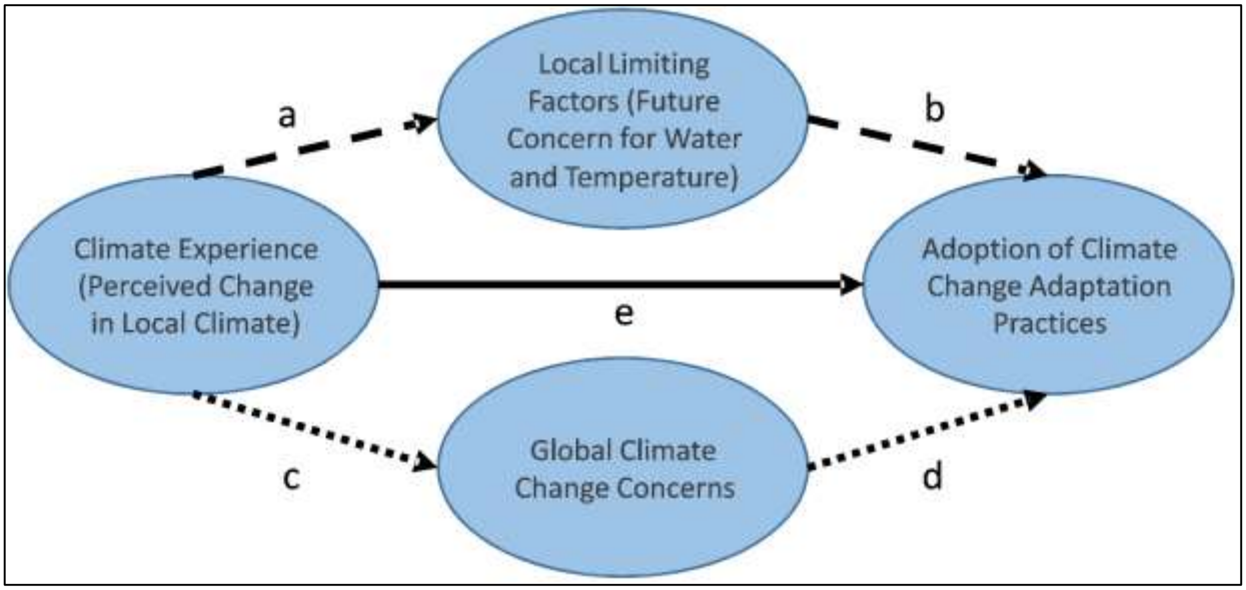


Figure 3.1 A sample multiple mediation model. The "limiting factors pathway" (dashed (a, b)) is hypothesized to be significant and tests for the indirect effect of local limiting factors (future climate concerns for either water or temperature impacts shown in Figure 2) mediating climate experience on adoption of adaptation practices. The dotted "global pathway" below (c,d) tests for the indirect effect of global concerns mediating climate experience on adoption of adaptation practices. The solid line (e) tests for a direct effect of climate experiences on the adoption of adaptation practices.

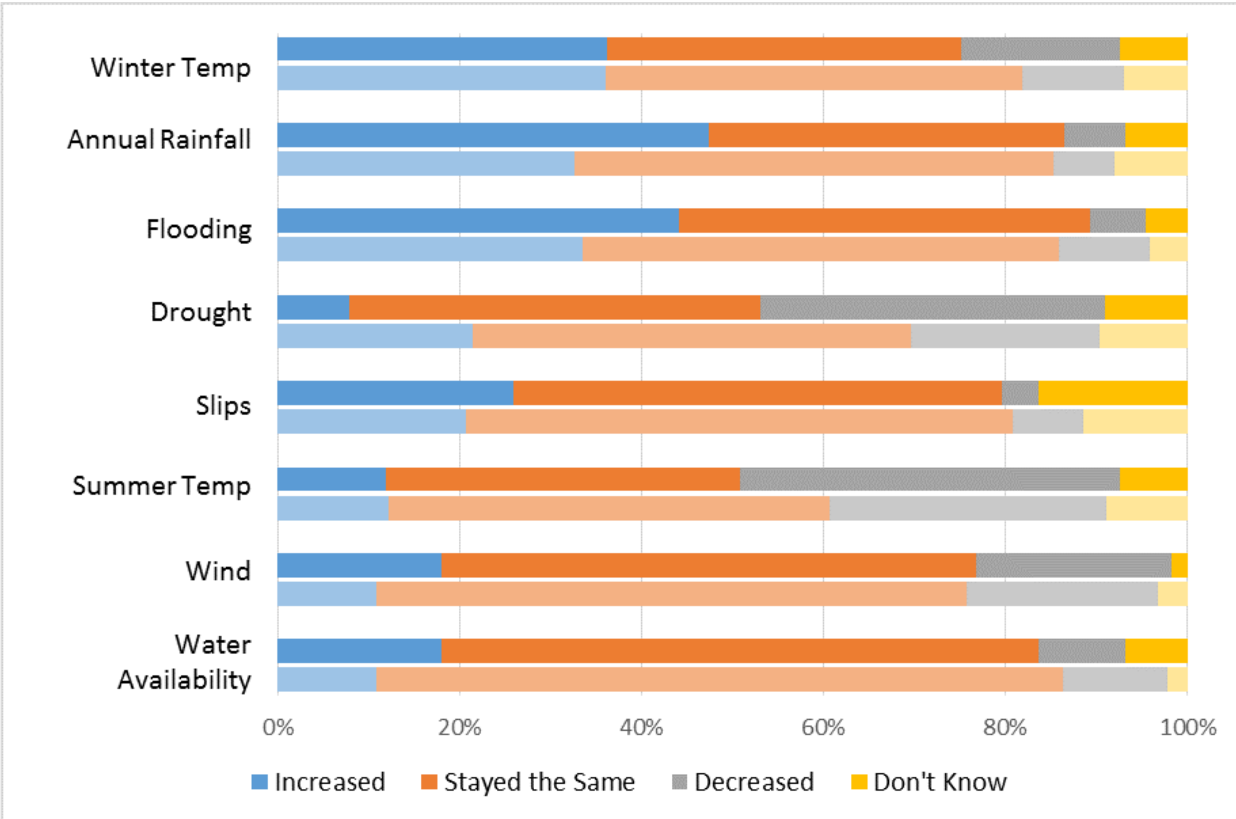


Figure 3.2 Perceived Changes in Climate Over Time. Darker color bars on top represent Marlborough farmer responses while lighter color bars on the bottom represent Hawke's Bay farmer responses.

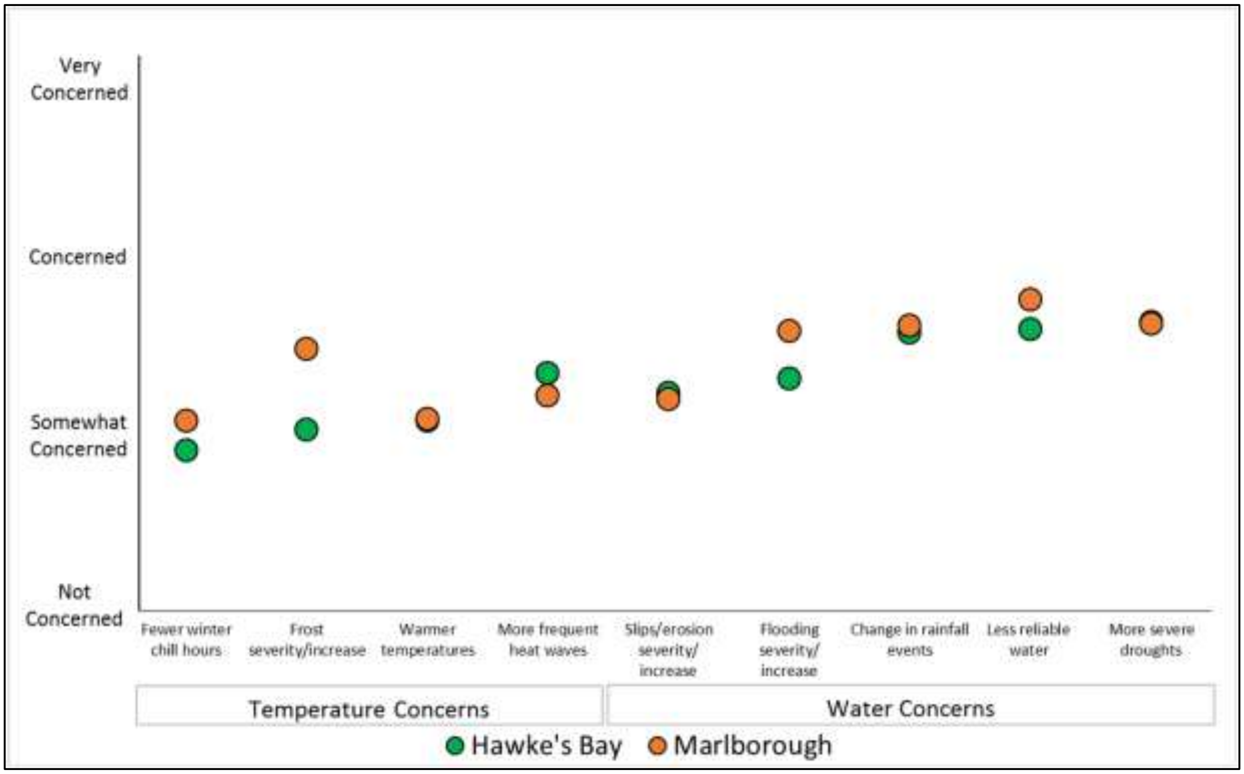


Figure 3.3 Mean Levels of Concern for Future Temperature and Water Climate Risks ("Limiting Factors"). The events listed for each type of concern make up the aggregate mediating variables for temperature and water limiting factors in the multiple mediation models. There were no statistically significant differences across the two regions and limiting factors collectively on average; however, the difference shown between Marlborough and Hawke's Bay for increased frost and flooding is statistically significant individually ($p < 0.05$).

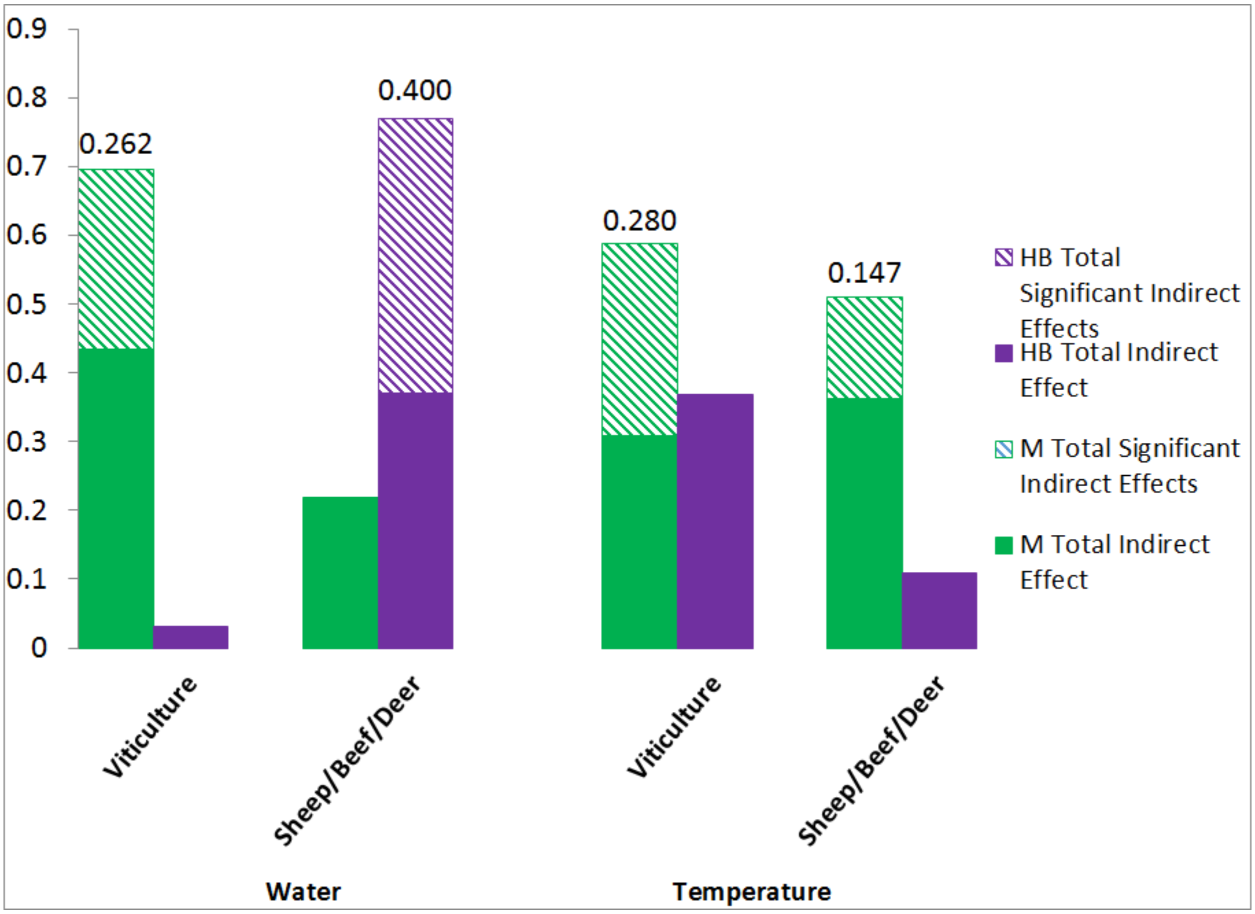


Figure 3.4 Total Indirect Effects of Water and Temperature Limiting Factors Across Farm Types and Regions. Marlborough results are indicated in green on the left side of the pairings while Hawke's Bay results are indicated in purple on the right side of the pairings. Data labels show the total statistically significant ($p < 0.05$) indirect effects across the eight models ran for each farm system, region and limiting factor (if no label, there were no statistically significant effects). These results are only for the limiting factors pathway, as the relationships between past climate experiences, global climate change concerns and the adoption of adaptation practices was insignificant across all models.

Supplementary Materials for
"How Limiting Factors Drive Agricultural Adaptation to Climate Change"

Supplementary Table S3.1 Multiple Mediation Model Results

Model Type			Climate Change Experiences (coefficients and bootstrapped confidence interval in parentheses)								Indirect Effects	
Limiting Factor	**Region**	**Farm System**	**Summer Temp**	**Winter Temp**	**Water Availability**	**Annual Rainfall**	**Drought**	**Flood**	**Wind**	**Slips**	**Total Indirect Effects**	**Total Significant Indirect Effects**
Water	Marlborough	Sheep/Beef	0.020 (-0.0338, 0.1230)	-0.001 (-0.0832, 0.0821)	0.025 (-0.0438, 0.2027)	0.046 (-0.008, 0.1727)	0.048 (-0.0226, 0.1706)	0.017 (-0.0604, 0.1146)	0.063 (-0.0062, 0.2076)	0.058 (-0.0125, 0.2610)	0.218	0.000
		Viticulture	0.033 (-0.0316, 0.1245)	0.035 (-0.0179, 0.1331)	0.075* (0.0034, 0.1901)	0.022 (-0.0642, 0.1460)	0.059 (-0.0283, 0.1868)	0.074* (0.0015, 0.1948)	0.023 (-0.0406, 0.1241)	0.113* (0.0022, 0.3111)	0.434	0.262
	Hawke's Bay	Sheep/Beef	0.034* (0.0000, 0.0948)	0.050* (0.0073, 0.1204)	-0.007 (-0.0803, 0.0586)	-0.023 (-0.0785, 0.0246)	0.080* (0.0267, 0.1690)	0.095* (0.0339, 0.1976)	0.043* (0.0005, 0.1290)	0.098* (0.0315, 0.2000)	0.370	0.400
		Viticulture	0.044 (-0.1510, 1.7301)	0.031 (-0.3207, 2.1685)	0.045 (-0.1455, -.8914)	-0.015 (-1.454, 0.4885)	-0.024 (-1.6378, 0.1556)	-0.014 (-0.8987, 0.2135)	-0.037 (-1.5435, 0.2295)	-0.0004 (-0.4807, 0.7207)	0.030	0.000
Temperature	Marlborough	Sheep/Beef	0.009 (-0.0636, 0.1094)	0.051 (-0.0047, 0.1949)	0.058* (-0.0013, 0.1758)	0.051 (-0.0118, 0.1636)	0.089* (0.0157, 0.2615)	0.041 (-0.0143, 0.2046)	0.074 -(0.0026, 0.2323)	-0.011 (-0.1567, 0.0838)	0.362	0.147
		Viticulture	0.011 (-0.0677, 0.0879)	0.058* (0.0054, 0.1912)	0.074* (0.0002, 0.2364)	-0.019 (-0.1518, 0.0600)	0.068 (-0.0041, 0.1971)	0.076* (0.0090, 0.2323)	0.072* (0.0047, 0.2036)	-0.032 (-0.2601, 0.1409)	0.308	0.280
	Hawke's Bay	Sheep/Beef	0.036 (-0.0251, 0.0984)	-0.001 (-0.0736, 0.0707)	0.001 (-0.0706, 0.0857)	-0.023 (-0.0864, 0.0339)	0.041 (-0.0071, 0.1145)	0.031 (-0.0294, 0.1106)	0.029 (-0.0160, 0.1015)	-0.006 (-0.0742, 0.0479)	0.108	0.000
		Viticulture	0.056 (-0.2564, 0.9353)	0.073 (-0.4752, 1.268)	0.210 (-0.5128, 1.0236)	0.047 (-0.4826, 0.7287)	-0.001 (-0.6330, 0.2101)	-0.091 (-0.6834, 0.2569)	0.029 (-0.4287, 0.4639)	0.046 (-0.4823, 1.4519)	0.369	0.000

* Indicates significance ($p < .05$). Water availability and annual rainfall scales were reversed to be consistent with climate risk direction.

Niles, M.T., Lubell, M.N., Brown, M., Dynes, R. Assessing farmer support for the New Zealand Emissions Trading Scheme. Submitted to Climatic Change.

ASSESSING FARMER SUPPORT FOR THE NEW ZEALAND EMISSIONS TRADING SCHEME

Abstract

New Zealand is embarking on a unique climate change policy experiment, in which they were initially proposing to include agriculture as part of their emissions trading scheme (ETS). Unlike most developed countries, but similar to many developing countries, agriculture is the largest source of greenhouse gas (GHG) emissions in New Zealand. Farmers and agricultural communities are thus an important component of any mitigation policy and have already been affected by the ETS and associated costs. In this paper we apply the psychological distance theory to understand how climate change experiences, beliefs, perceived capacity to reduce emissions, and cost barriers influence farmer support for the New Zealand ETS. We use empirical data from a farmer survey in Marlborough and Hawke's Bay (n=490) conducted in 2012 to demonstrate that cost perceptions are the largest barrier to New Zealand ETS support from farmers. Perceived capacity to reduce GHGs and climate change beliefs and risk perceptions also directly influence policy support. We discuss the need for continued research for cost-effective agricultural mitigation options that will increase farmer's perceptions of their capacity to reduce emissions and thus potentially their support for climate change policies like the ETS.

Introduction

A broad body of literature and theories exist that aim to assess how individuals perceive and respond to environmental issues. Individual perceptions and behaviors are crucial to understand in the context of environmental problems because they can aggregate to represent broader social norms and acceptance of pro-environmental behaviors or policy support. To reduce global greenhouse gas (GHG) emissions requires cooperation at multiple policy levels (Ostrom, 2010) and individual-level support for varying policy tools. While national-level efforts can reduce emissions through command and control regulations, individual behaviors aggregate to produce a significant component of a nation's GHG emissions. Furthermore, public support for climate change policies is a key concern for policymakers (Whitmarsh et al., 2013). Understanding the motivations of individuals to adopt climate change mitigation behaviors or to support national level climate change policies is thus important to encourage more rigorous commitments to GHG reductions at the international level (Deryugina, 2013; Smith and Leiserowitz, 2014).

New Zealand has recently embarked on a policy experiment to implement an emissions trading scheme (ETS), which was originally proposed to be the first in the world to include agricultural emissions. New Zealand is unique because, unlike most developed countries, agriculture accounts for the largest portion of the county's GHG emissions- 47% of total emissions (Moyes, 2008; New Zealand Ministry for the Environment, 2011). Though agriculture has not yet been included in the ETS, farmer support for the ETS has been a major point of contention within the country. In this paper we aim to assess the barriers for policy support for an emissions trading scheme (ETS) among New Zealand farmers through the psychological distance theory, which has previously been applied to understand how distant versus proximate climate change events and concerns influence individual mitigating behaviors (Haden et al., 2012; Spence et al., 2011). Here we apply the theory to understand specific support for the New Zealand ETS, which began implementation in 2008. We argue that while climate change experiences and belief/risk perceptions are important precursors for supporting an emissions trading scheme, perceived capacity to reduce emissions, and cost barriers are equally important in determining climate change policy support.

The international community continues to grapple with global frameworks that are effective at reducing GHG emissions. In part, this struggle is related to the failure of some countries like the United States to sign onto international treaties and agreements and the inability of such existing strategies to effectively reduce global GHG emissions. The Kyoto Protocol, first established in 1997, has failed to reduce GHG emissions in many signatory countries despite wide participation (Aichele and Felbermayr, 2013). While some regions have achieved significant reductions (for example, Eastern Europe), many others have failed to reduce their total emissions over 1990 levels (Lau et al., 2012). The net result is that in most countries GHG emissions have changed little or continued to rise (Olivier et al., 2012), and it is likely that GHG emissions will continue to rise in the near-term (Hof et al., 2013). The failure of both signatory and non-signatory nations to achieve marked emission reductions is complicated, yet grounded in individual behaviors and policy support among citizens.

Since agriculture contributes roughly 14% of total global GHG emissions, farmers' behavior and their policy support are important to understand for climate change mitigation (Smith et al., 2007a). Examining how New Zealand farmers perceive the ETS and what drives or prevents their support for this policy is relevant for policymakers at a range of jurisdictions. For New Zealand policymakers, this work is crucial since agriculture is the largest source of domestic emissions, and New Zealand has recently pulled out of the Kyoto extension to examine other policy options. However, beyond New Zealand, this work is also particularly relevant for other agricultural nations including developing countries that have a significant portion of their emissions from agriculture. As demand for meat and its byproducts is slated to grow especially in the developing world, policymakers throughout the world will face rising agricultural GHG emissions (Pelletier and Tyedmers, 2010) and have reason to understand farmers' perceptions of climate change policies in order to mitigate climate change.

Theoretical Background

The psychological distance theory is an emerging framework to consider how climate change perceptions and experiences translate into potential behavioral change. Here we propose to extend this theory to examine its relevance in predicting support for climate change policies, specifically the New Zealand ETS. Psychological distance refers to the way people perceive events and their potential proximity to them. This distance can be across multiple dimensions including social, temporal, geographic, and certainty contexts. Events that are "closer" to an individual are those perceived to have the most likely impact and thus have the greatest potential to influence behavior (Liberman and Trope, 2008). As the psychological distance of an issue increases, the construal-level processes that guide perceptions become more abstract and less concrete (Liberman et al., 2002a; Liberman and Trope, 2008). These more distant events are less likely to influence action taken by individuals (Leiserowitz, 2005).

In the context of climate change, this theory has been applied to analyze how distant versus proximate perceptions of climate change influence individual behaviors and perceptions. Individual experiences with extreme events or those perceived to be related to climate change have been used as a proxy for an individual's psychological distance of climate change. Spence et al. (2011) demonstrated that individuals who had experienced a flood were more likely to be concerned about climate change, have increased notions to mitigate climate change, and less uncertainty about climate change, which mediated the willingness to adopt mitigation strategies. Related, Spence et al. (2012) also demonstrated that the psychological distance of climate change was positively associated with willingness to reduce energy use both directly and indirectly mediated by concern for climate change. On the contrary, Whitmarsh (2008) did not establish a relationship between flooding experience and willingness to adopt mitigation strategies. In New Zealand, individuals that considered local level climate change impacts related to sea-level rise were more willing to adopt a range of mitigating behaviors like using public transportation and flying less (Evans et al.). Research on California farmers demonstrated that local level climate change concerns mediated the effect of climate change experience on the adoption of adaptation behaviors while global level concerns affected mitigation behaviors. These results were consistent with the psychological distance theory and construal-level constructs in that global concerns were associated with globally relevant behaviors (mitigation, which confers global benefits) while local concerns influenced adaptation behaviors (many private, local benefits) (Haden et al., 2012).

What is less understood in the context of psychological distance is whether the theory can be applied to also understand support for climate change policies in addition to individual-level behaviors. In short, do climate change events influence how individuals perceive climate change and are willing to support policy action for climate change mitigation? While individual-level adaptation and mitigation behaviors are necessary to combat and manage for climate change, a wide range of strategies will be necessary to mitigate climate change including legislation

(Arbuckle et al., 2013b; Jones, 2003). An important link between individual behaviors and legislation is the support of individuals for climate change policies (Deryugina, 2013), which can make policies more attractive and tangible for policymakers. Thus far, the psychological distance theory has been applied minimally to understand climate change policy support rather than individual behavioral changes. We have previously applied the psychological distance theory in this context among California farmers and found that past climate and environmental policy experiences influenced climate belief and risk perceptions, which then affected a farmer's potential support or concern for climate change policies (Niles et al., 2013). However, this work considered a farmer's support for theoretical climate change policies and programs rather than those already in place as is the case in this New Zealand study.

Previous work has also established a significant relationship between climate change belief/risk perceptions and climate change policy support (Dietz et al., 2007; Leiserowitz, 2006) and individual-level behavior change (Bord et al., 2000; Haden et al., 2012). However, two key barriers to climate policy support emerge from a diversity of studies: 1) the potential cost and impact of the policy on an individual; and 2) the "powerlessness" or capacity perceived by individuals in their ability to reduce GHG emissions. Individuals are more likely to support policies that aren't perceived to have a direct "pocketbook effect" on them and are less personally burdensome. People are often highly receptive to policies that regulate industries or increase fuel efficiency standards but are particularly adverse to perceived taxes (Arbuckle et al., 2013a; Dietz et al., 2007; Leiserowitz, 2006; Wheaton and Maciver, 1999).

A perceived inability to mitigate the problem or a sense of powerlessness has also been linked to a lack of individual behavior change or policy support in a broader environmental context such as that proposed by the Theory of Planned Behavior and the Values, Beliefs, and Norms Theory (Ajzen, 1991; Haller and Hadler, 2008; Stern, 2000; Zahran et al., 2006). In a collective action problem such as climate change, where individual actions without the participation of a broader group are unable to have a meaningful impact, this sense of powerlessness may be even greater (Aitken et al., 2011). Spence et al. (2011) found that an individual's perceived ability to reduce GHG emissions was a mediating variable between their climate experiences and mitigating behaviors in the context of psychological distance (Spence et al., 2011). Related, recent work by Smith and Leiserowitz (2014) demonstrates that hope is positively associated with an increase in climate change policy support. Conversely, a sense of powerlessness is also likely to translate into rejection for climate change policies; if individuals feel that their nation has little capacity to influence the global impact of climate change, they may have a sense of powerlessness at the national level, possibly in addition to the individual level. Powerlessness may be even further compounded by a potential economic cost or individual burden as suggested above, which can make behavior change or policy support even less tangible (Aitken et al., 2011).

This paper aims to expand the body of literature examining support for an *existing* climate change policy through the lens of the psychological distance theory, specifically aiming to understand how climate experiences influence climate belief/risk perceptions and whether cost impacts and powerlessness are key barriers. By assessing the New Zealand ETS, we also aim to broaden the literature of climate change policy support by examining climate change policies that have already been implemented and had a potential impact. Many existing climate change policy studies ask about theoretical policies and potential impacts rather than existing policies (Zahran et al., 2006).

New Zealand Context

New Zealand has been a significant and unique player in international climate change treaties. A signatory to the first round of the Kyoto Protocol in 2008, New Zealand established the first ETS in the world proposing to require agriculture to participate because it is the single largest source of domestic GHGs. Approximately 65% of these emissions are from livestock enteric fermentation (digestive processes that produce GHGs as a byproduct) and more than 20% of agricultural GHGs result from manure and pasture based animal production. As a result, animal production is one of the largest contributors to New Zealand's total GHG emissions, making animal producers and processors an important policy target for reducing emissions (New Zealand Ministry for the Environment, 2011). The ETS intends to encourage behavior change towards activities that emit fewer emissions by issuing emission allowances and setting up a payment system for emissions (New Zealand Government, 2010). Though mandatory emissions reporting began among agricultural processors in 2012, current policy has delayed the implementation of the ETS into agriculture. Nevertheless, other sectors of the economy are included in the ETS that affect agricultural operations including fuel, energy, transport costs, and forestry.

The delay of implementation of the ETS into agriculture was, in part, the result of protests organized by farmers and the agricultural sector, largely over concerns about increased costs (Bennett, 2010). This concern for increased costs is particularly acute in New Zealand, as farmers have not been supported by government subsidies since the 1980s. Agriculture and forestry account for 70% of New Zealand's export market, which inherently leaves farmers vulnerable to price changes and at the mercy of international market prices (MInistry for Primary Industries, 2013). New Zealand's export market has been in part predicated on a "clean and green" image that has been used by some within government as a justification for implementing an ETS (Ministry for the Environment, 2001). The New Zealand Government Climate Change website states, "As well as helping New Zealand do its fair share in cutting emissions, the NZ ETS will strengthen the country's clean green brand – an important issue for a small trading nation like New Zealand as international markets and consumers increasingly demand environmentally friendly products" (Ministry for the Environment, 2013b) Nevertheless, the export driven nature of the agricultural economy and the lack of farm subsidies means that any rise in cost at the farm level has a direct impact on farmers. As price takers in an international marketplace, New Zealand farmers largely lack a safety net or alternative markets to minimize rising costs. As such, we expect cost barriers to be particularly important for farmer support of the ETS.

Methods

Seventeen interviews were conducted in 2010 and 20 interviews were conducted in 2012 with farmers, policymakers, and agricultural industry representatives in Marlborough and Hawke's Bay, New Zealand. Interviews were used to assist with the development and adaptation of a survey, which was previously implemented among growers in Yolo County, California, in 2011 (Haden et al., 2012; Jackson et al., 2012a; Niles et al., 2013). The survey was changed for local context including relevant practices and language; however, much of the survey was the same and future work will compare farmer responses across the regions.

The survey was implemented via telephone with assistance from ResearchFirst, a professional survey company based in Christchurch, New Zealand, utilizing their database of farmers from census and other databases. The survey was piloted among ten farmers outside of the two target regions. A stratified sample was used for the survey allowing for responses within the region to be consistent with the land use type of those areas. Data were collected between August and October 2012. A total of 490 farmers responded to the survey (n= 177 in Marlborough, n= 313 in Hawke's Bay), with a total response rate of 40%.

Using Stata we conducted a confirmatory factor analysis using principle components, which yielded single factor solutions with factor loadings significantly higher than 0.40 (Table 1), a generally accepted cut-off point (Costello and Osborne, 2005). These factor loadings assisted us in building a structural equation model (SEM) (Supplementary Figure 1) in AMOS by providing a clear understanding about what questions were linked to the same latent constructs. Both "Cost Barriers" and "Regulation Concern" were latent variables in our model with three separate influencing questions, as confirmed by our factor analysis. "Climate Belief/Risks" was comprised of six different questions that we developed into a scale that averages farmer responses across all six questions into one value, which was appropriate given its high internal validity (Cronbach α= 0.83). Structural equation modeling allows for simultaneous testing of direct and indirect effects on variables within the model and can adjust for measurement error. We constructed a SEM using maximum likelihood estimation with missing data to enable AMOS to use all survey data information available to maximize the potential sample size and also eliminate potential biases that can result from listwise or pairwise deletions (Dietz et al., 2007).

We ran a total of six separate models to account for six different types of "Climate Experience" including Summer Temperature, Winter Temperature, Water Availability, Drought, Flood, and Wind. Despite our efforts to group together these climatic events into smaller groups (e.g. temperature, water, or extreme events), a factor analysis did not yield single factor solutions. As a result, we ran the same model with six varying climate experiences in order to capture the variability that these different events may have on a farmer's climate change beliefs and ETS support. Testing six different climatic events can provide greater understanding about whether there are common themes present across a diversity of different climate change impacts and phenomena. This is particularly important in agriculture since diverse agroecosystems may have different potential impacts from temperature, water, or extreme events. Furthermore, the psychological distance theory as applied in a climate change context has typically considered a single type of climatic event in their analysis. This more robust approach can provide insight into whether all types of climatic events have similar effects on individuals' climate change beliefs and subsequent support for the ETS.

Table 1 details all of the questions and latent variables in the model. "I don't know" responses were excluded from the structural equation analysis because of issues assigning them a numerical number within a scale, but are reported in the descriptive statistics of the results section. In addition, we also controlled for age, organic certification, and whether a farmer was full-time. We report a number of different fit statistics including Chi-square, degrees of freedom, comparative fit index (CFI), and root mean square error approximation (RMSEA). In particular, the CFI and RMSEA have been shown to be less influenced by sample size than other fit statistics (Fan et al., 1999).

Results

Policy Support

Overall, farmers expressed an overwhelming concern with climate change regulations and the New Zealand ETS (Supplementary Figure 2). Sixty-eight percent of farmers disagreed or strongly disagreed that New Zealand should have implemented an ETS. Only about 16% of respondents agreed or strongly agreed that New Zealand should have an ETS. Similar responses were found for whether agriculture should be included in the New Zealand ETS—63% disagreed or strongly disagreed that agriculture should be included in the ETS. However, more than 22% of farmers agreed that agriculture should be included in the ETS. Related, 90% of surveyed farmers were very concerned or concerned about future government regulations related to climate change—most likely the ETS.

Cost Barriers

Eighty-nine percent of farmers indicated that costs are very important or important when considering a new practice or technology. Despite this, there was greater variability about how costs are associated with environmental policy. Half of all surveyed farmers strongly agreed or agreed that environmental regulations make it harder to operate their farm efficiently and profitably, while 25% were neutral, 19% disagreed, and 5% strongly disagreed. When asked to reflect about the potential cost impact of the ETS (likely from the inclusion of fuel, energy and transport in the scheme), 47% strongly agreed or agreed they had experienced an increase in costs on the farm because of the ETS while 15% were neutral, 19% disagreed, and 12% strongly disagreed.

Climate Belief/Risks

As shown in Figure 1, the majority (52%) of farmers surveyed strongly agreed or agreed that the global climate is changing with 22% neutral and 21% strongly disagreeing or disagreeing. Fewer respondents strongly agreed or agreed that human activities were an important cause of climate change (41%), and even fewer (38%) strongly agreed or agreed that average global temperatures are increasing. Twenty-eight percent of respondents strongly disagreed or disagreed that global average temperatures are increasing, and 25% strongly disagreed or disagreed that humans are contributing to climate change.

Despite a broad range of perspectives on climate change belief, more than two-thirds (69%) of surveyed farmers strongly agreed or agreed that climate change poses risks to agriculture globally with only 14% strongly disagreeing or disagreeing. However, only 48% strongly agreed or agreed that climate change presents more risks than benefits to agriculture globally, and only 38% strongly agreed or agreed that climate change presents more risks than benefits to agriculture locally. Twenty-nine percent and 33% were neutral about climate change risks outweighing benefits globally and locally, respectively. Only 16% and 23%, respectively, strongly disagreed or disagreed that global risks outweigh benefits globally and locally.

Climate Change Experience

The majority of respondents perceived that overall the climate had stayed the same on six different measures (Supplementary Figure 3) (45% summer temperature, 43% winter temperature, 72% water availability, 47% droughts, 50% floods, 63% wind). Amongst the greatest perceived changes were an increase in flooding (37%) and winter temperature (36%). On the contrary, 34% felt that summer temperatures had decreased while 27% felt droughts had decreased.

Perceived Capacity

Slightly less than half of all respondents (49%) strongly agreed or agreed they were confident they could implement practices to reduce their GHG emissions. Twenty-two percent were neutral on the issue and 37% strongly disagreed or disagreed that they could confidently implement practices to reduce their GHG emissions.

Model Results

Figure 2 details the structural equation model results for summer temperature. With the exception of the varying climate experiences, nearly all regression coefficients were the same across all six models and the trends were the same. For this reason, we report all results for the effect of Climate Experience of Climate Change Belief/Risk, but only all other model results from summer temperature, which is representative of the relationships of all six models. Supplementary Table 1 details the specific coefficients and results for each model. Model fit statistics suggest that the models had acceptable to excellent fits (RMSEA 0.054- 0.066; CFI 0.838- 0.887). All of the Climate Experiences, except for wind, significantly affected Climate Change Belief/Risk. Perceived changes in summer temperature (b= 0.171), winter temperature (*b*= 0.105), water availability (*b*= -0.104), drought (*b*= 0.127), and flood (*b*= 0.108) all significantly influenced Climate Belief/Risk. These relationships were oriented towards farmers indicating that changes in Climate Experiences that were "riskiest" positively affected their climate change belief and risk perceptions. In most cases this was an "increase" in an event (increased temperatures, increased drought, etc.). However, this relationship was negative for water availability since farmers who believed water availability had decreased over time were more likely to be concerned about climate change and its risks. We also find a significant relationship of farmers' age on Climate Change Belief/Risks (*b*= -0.171) across all models with older farmers being less likely to believe in climate change and its risks. Farmers whose businesses are certified organic/biodynamic were also significantly more likely to believe in climate change (*b*= 0.101). Being a full-time farmer was associated with less Climate Change Belief/Risk across all models (*b*= -0.116).

Consistently across all models, a belief in climate change and its risks was associated with lower Cost Barriers (*b*= -0.326). As well, Climate Change Belief/Risk was positively associated with Perceived Capacity (*b*= 0.150); farmers who believed in climate change and its risks were more likely to believe they could reduce their GHG emissions through practices.

There was a significant, positive direct effect of Climate Change Belief/Risk on Climate Policy Support (*b*= 0.310). There was also a significant, positive effect of Perceived Capacity on Climate Policy Support, with farmers who had a high perceived capacity to reduce emissions being more likely to support policies (*b*= 0.253). On the contrary, there was a consistent negative effect of Cost Barriers on Policy Support (*b*= -0.334). Farmers who perceived cost barriers or had experienced cost impacts from the ETS were associated with less Climate Policy Support.

All of the observed variables influencing the latent variables Policy Support and Cost Barriers had significant effects (Supplementary Table 1).

Discussion

Our models suggest that the psychological distance theory can be expanded beyond individual mitigation behaviors to also understand how climate events influence climate change perceptions and support for climate change policies, specifically the New Zealand ETS. We find that personal experiences with climate change events influence a farmer's belief in climate change and their willingness to support the ETS. Simultaneously, we show consistently across all of our models that Cost Barriers and Perceived Capacity are two major barriers to support for the New Zealand ETS, with cost barriers being the largest influence. We find that the majority of farmers are very concerned about climate change regulations and do not support the ETS in mass, despite the fact that less than half of farmers have experienced a stated rise in costs as a result of the ETS. These discrepancies are likely related to farmers' perceptions that the ETS will potentially include agriculture eventually, which would have a much greater overall impact on their farming enterprises than current ETS regulations.

In five out of six of our models we demonstrate that personal experiences with climate change significantly influence a farmer's climate change belief and risk perceptions. These results suggest that a diversity of climatic events have a consistent influence on the way individuals perceive climate change and its risks. This is important to demonstrate empirically, since most previous studies have only considered one type of climatic event (e.g. floods for Whitmarsh (2008) and Spence et al. (2011)) or the effect of short-term and long-term temperature changes (Deryugina, 2013; Egan and Mullin, 2012; Joireman et al., 2010) and their influence on climate change belief and behaviors. Instead, here we demonstrate that multiple kinds of climate changes across temperature, water, and extreme events all have a significant effect on a farmer's climate change belief. Notably, changes in wind did not have a significant influence on farmers' climate change perceptions. It is worth noting that these results may be different than what would be observed among the general public given the reliance that farmers have on weather and climate and their direct interaction with climatic events for their livelihoods.

Farmers' stated climate change belief is somewhat different than those expressed by the general New Zealand population. Recent surveys found that 80% of the general population in New Zealand believed in climate change (Stuart, 2009). However, data related to the human contribution of climate change is very similar to the general public where surveys have found 41% (Stuart, 2009) and 38% believe that humans have a direct impact on the climate (TNS Conversa and New Zealand Institute of Economic Research, 2008). New Zealand farmers appear to be similar to farmers in California where this study was performed previously. Fifty four percent of California farmers believed that the climate was changing, 39% believed global average temperatures were increasing, and 35% believed in the human contribution to climate change (Niles et al., 2013). California is similar to New Zealand in that it has a statewide cap and trade program that may have similar impacts on farmers from fuel and transport costs. However, compared to other developed regions, New Zealand farmers appear to have a lower overall level of climate change belief. For example, 66% of farmers in Australia and 68% of corn farmers in the United States Midwest believe that the climate is changing (Prokopy et al., In Review).

That New Zealand farmers perceive the global risks to agriculture to be higher than local perceived risks is consistent with other studies that generally find that the public perceives societal risks to be higher than personal risks (Leiserowitz, 2006). There have been some studies that suggest that framing climate change in a global context may appeal to individuals to recognize their role in a broader global community and appeal to their potential for mitigation (Haden et al., 2012; Liberman and Forster, 2009). Our work suggests that New Zealand farmers perceive that while New Zealand agriculture may not be significantly affected by climate change, farmers in other parts of the world may face new risks from climate change. Communicating these risks to New Zealand farmers could be an approach to encourage mitigation if such appeals could tap into the goodwill potential of individuals to want to contribute to lessening global environmental impacts that will affect farmers elsewhere. However, this may be especially difficult for New Zealand policymakers given that New Zealand contributes only 0.14% of all global GHG emissions (United Nations Environment Programme, 2012). Nevertheless, given the reliance of New Zealand agriculture on international markets, such strategies could be effective if New Zealand's trading partners were expecting products consistent with the "clean and green" image of New Zealand.

In addition to climate change belief and risk perceptions, perceived capacity and cost barriers emerged as key obstacles for supporting the New Zealand ETS. Farmers that believe they have the capacity to reduce emissions are much more likely to support policies that would require them to do so like the ETS. However, slightly less than half of all farmers surveyed possess this perceived capacity. It is possible that these farmers are hopeful that they can reduce emissions and mitigate climate change- an attribute that Smith and Leiserowitz (2014) also found to be an important precursor for climate change policy support. Simultaneously, those that have stronger climate change beliefs were correlated with a much higher perceived efficacy, which is consistent with other results found among the general New Zealand population (Milfont, 2012).

Adopting mitigation practices in agriculture is particularly challenging because biological options to limit GHG emissions in agriculture remain limited. While individual households have many options to reduce GHG emissions (like driving less, taking public transport, or decreasing their energy use) agricultural mitigation strategies are still emerging. Limiting nitrogen fertilizers is an option to reduce nitrous oxide emissions, though this comes at a potentially high business cost when productivity may be reduced. Best practice use of nitrogen fertilizers and management of wet soils also have the capacity to reduce nitrous oxide emissions. Nitrification inhibitors were another option being explored in New Zealand (but have now been withdrawn from the market), though they are costly and have varying impacts in terms of emission reductions and yield impacts (Zaman et al., 2009). However, this issue is further compounded by the fact that the majority (68%) of the agricultural emissions in New Zealand are from livestock methane (Ministry for the Environment, 2013a), where very few mitigation options exist besides reducing herd sizes or increasing efficiency (Eckard et al., 2010).

This point was observed by many of the interviewees in 2010 and 2012. One member of the agricultural industry remarked,

> *"Mitigation options, I'm not sure that anybody sees anything substantial on the horizon in terms of a discrete technology…So no silver bullet or bullet of any kind really apart from what has been the sort of traditional tried and true method of becoming more efficient… So I think your average farmer is standing with bated breath."*

If and when cost effective strategies for mitigation are available for biological emissions, our work suggests that farmers may be more likely to support the ETS. Yet, at the present time, many farmers and those within the agricultural industry believe that there is little that can be done within the sector to reduce their emissions, which would essentially make the ETS a tax rather than a trading scheme. One interviewee stated, *"How do you incentivize behavior change when you don't have a solution? So, it just becomes a tax…so if it's gonna be a straight tax, then, just come out and say so."*

Overall, this model suggests that farmers may be more likely to support the ETS when several barriers are overcome. The largest potential barrier for policy support among New Zealand farmers is the perceived costs associated with regulations and the ETS. This result is somewhat different from previous work examining climate change policy support, where cost barriers had less influence. Zahran et al. (2006) found that climate risk perceptions and perceived efficacy (similar to Perceived Capacity here) were the largest drivers of climate policy support. This cost barrier may be particularly strong in New Zealand for multiple reasons: 1) the significant export market for New Zealand agriculture, which means that New Zealand farmers are largely price takers in an international marketplace and have an inability to pass on the potential costs of an ETS; 2) the high percent of GHGs at a national level from agricultural emissions (and thus the assumption that major changes would need to occur for agriculture to participate in the ETS); and 3) the lack of farm subsidies and government financial support for agriculture. Nevertheless, these results suggest that even though climate change belief is an inherent precursor for farmers' perceived capacity and cost barriers, if these can be overcome New Zealand policymakers are likely to see greater farmer support for the ETS.

Though focused on New Zealand, there are clear implications for other agricultural nations from this work. Thus far agriculture has not been included as part of major climate change negotiations in part because of its connection to food security and development and also because of a perceived lack of potential mitigation strategies. Nevertheless, the projected demand for meat, dairy, and their byproducts will increase agricultural GHG emissions (Pelletier and Tyedmers, 2010). If we seek to tackle global climate change, it may only be a matter of time before policymakers may be forced to consider agricultural and biological emissions. Our work demonstrates that key to obtaining farmers' support for climate change policies, specifically an ETS, is the perception that there are cost-effective strategies that farmers can implement to reduce their emissions. This highlights a significant need for continued research for agricultural mitigation strategies particularly for livestock.

Conclusion

Obtaining support of individuals for climate change policies is necessary to ensure their success and viability to reduce GHG emissions. As such, it is important to understand what influences individuals to support or reject different policy options so that policymakers may work to overcome barriers. Through this study we have examined the support of New Zealand farmers for the existing ETS and determined that cost barriers are the single greatest obstacle to policy support. Related, farmers' perceived inability to be able to reduce their own GHG emissions at a farm-level is another important barrier. In sum, New Zealand farmers largely do not support the ETS because they don't believe they have cost-effective mitigation strategies to assist them in navigating and responding to the policy.

Our work also demonstrates that the psychological distance theory is an appropriate way to consider how personal experiences with climate change affect climate belief and risk perceptions and subsequent climate change policy support. We show that a number of different kinds of climate change phenomena influence climate change belief and risk perceptions. Of course the application of this work is specific to a particular type of climate change policy, an emissions trading scheme, which is likely to have a significant impact on New Zealand farmers. Applying the psychological distance theory to other regions and case studies can further elicit whether similar relationships exist with other kinds of climate change policies and across other individuals who may not be as heavily affected by climate change policies from a financial perspective. Nevertheless, this study suggests that as more people associate climatic events with global warming and climate change, these associations may have positive effects on their belief and risk perceptions of climate change and increase support for climate change policies. We encourage additional research in a diversity of contexts to determine empirically whether this holds true.

Table 4.1 Model Scales and Variables with Measures of Reliability. Scales and variables are listed in the order in which they appear in the results. Italics indicate a prompting question.

Latent Variable	Observed Variable	Question/Statement	Scale	Eigenvalue	Factor Loadings
Climate Policy Support		*How concerned are you about the following climate related risks and the future impact they may have on your farming operations during your career?*	Four Point Scale (1= Very Concerned, 4= Not Concerned)	1.82	
	Government Regs	More government regulations		---	0.46
	NZ ETS	New Zealand should have implemented an Emissions Trading Scheme (ETS) to reduce greenhouse gas emissions	Five Point Scale (1= Strongly Disagree, 5= Strongly Agree)	---	0.90
	Ag NZ ETS	Agriculture should be included in the New Zealand ETS		---	0.90
Cost Barriers				1.31	
	Env Reg Profit	Environmental regulations make it harder to operate my farm efficiently or profitably	Five Point Scale (1= Strongly Disagree, 5= Strongly Agree)	---	0.73
	Increased Costs	I have experienced an increase in costs on the farm because of the New Zealand ETS		---	0.71
	Cost	If considering the adoption of new practices or technologies how important is the cost?	Five Point Scale (1= Not Important, 5= Very Important)	---	0.52
Climate Belief/Risks			Five Point Scale (1= Strongly Disagree, 5= Strongly Agree)	2.70	
		The global climate is changing			0.67
		Average global temperatures are increasing			0.65
		Human activities such as fossil fuel combustion are an important cause of climate change			0.70
		Climate change poses risks to agriculture globally			0.75
		Climate change presents more risks than benefits to agriculture globally			0.67
		Climate change presents more risks than benefits to agriculture in the local region.			0.58
Climate Change Experience		*Indicate whether the following have changed over time:*	Three Point Scale (1= Decreased Over Time, 2= Stayed the Same, 3= Increased Over Time)	---	
		Summer temperature			---
		Winter temperature			---
		Water availability			---
		Frequency and/or duration of drought			---
		Frequency and/or duration of flooding			---
		Frequency and/or intensity of wind			---
	Perceived Capacity	I feel confident that I can implement practices to reduce my greenhouse gas emissions	Five Point Scale (1= Strongly Disagree, 5= Strongly Agree)	---	---

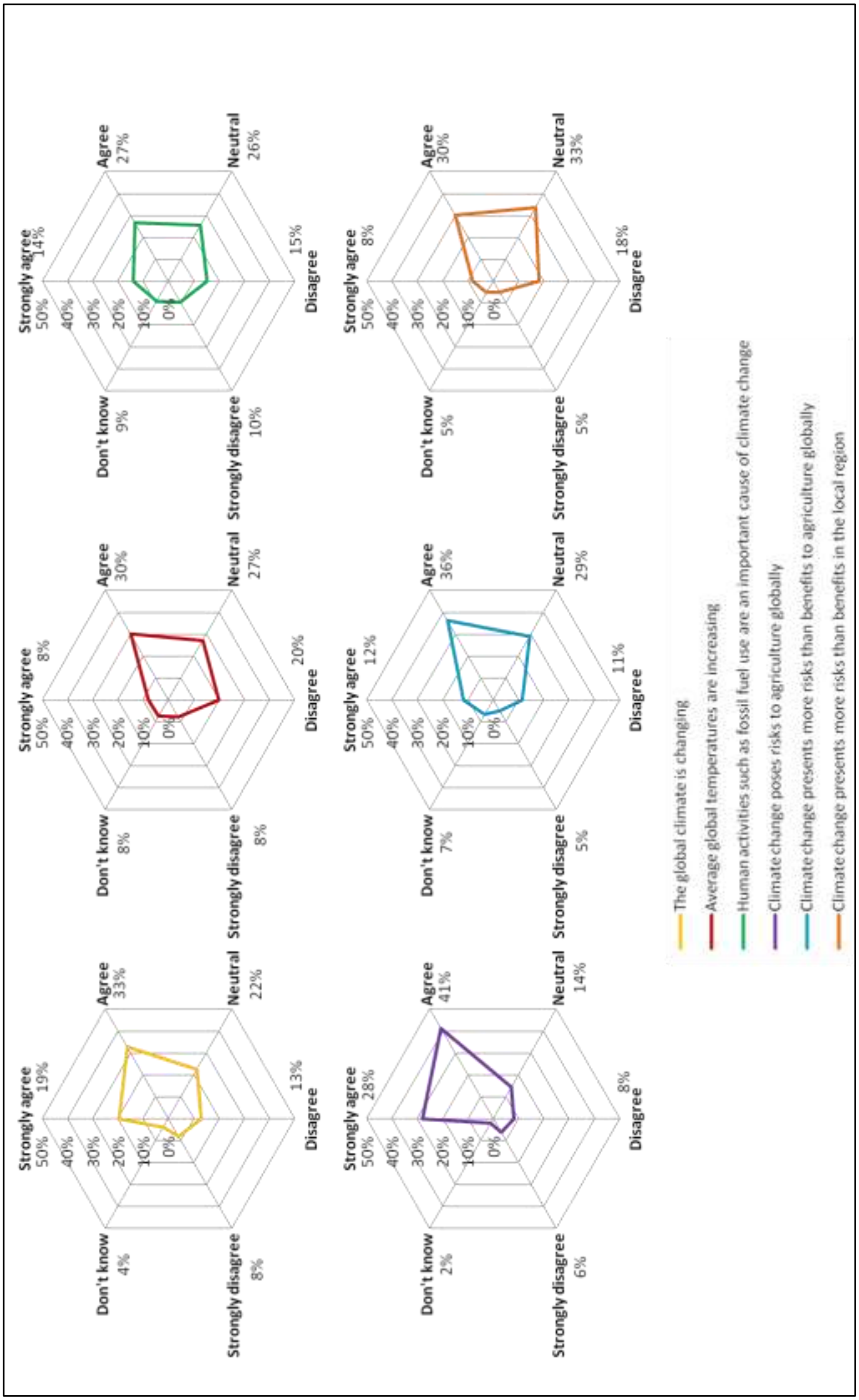


Figure 4.1 New Zealand farmer climate change belief and risk perceptions.

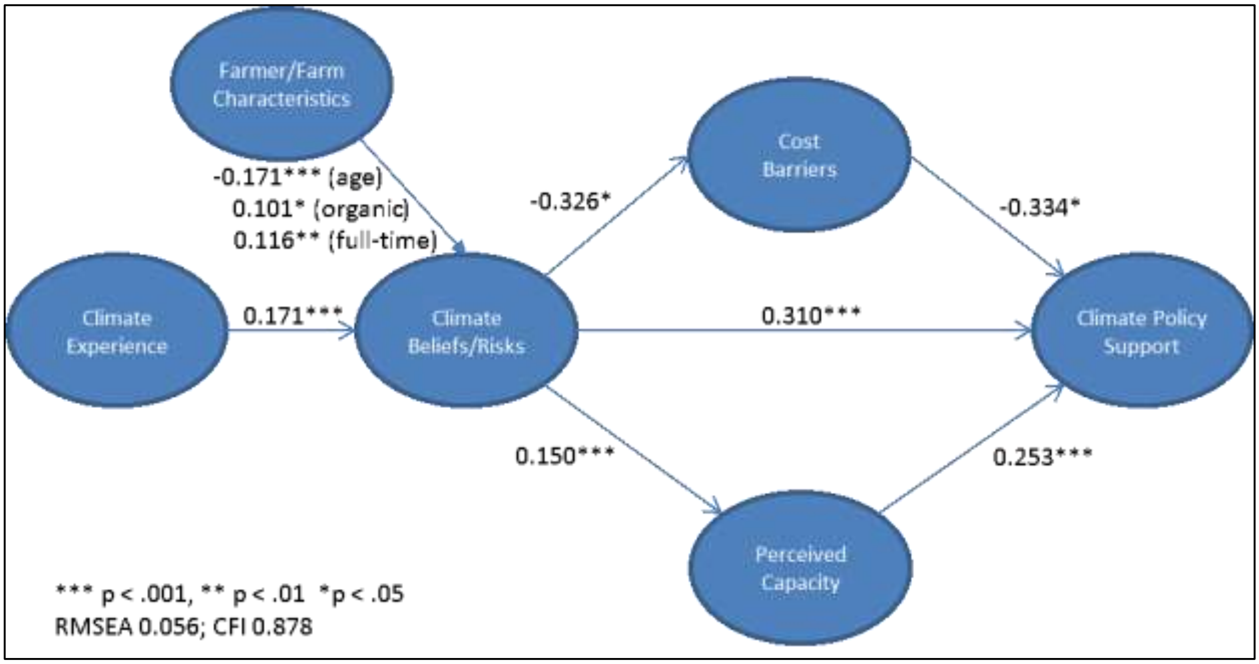
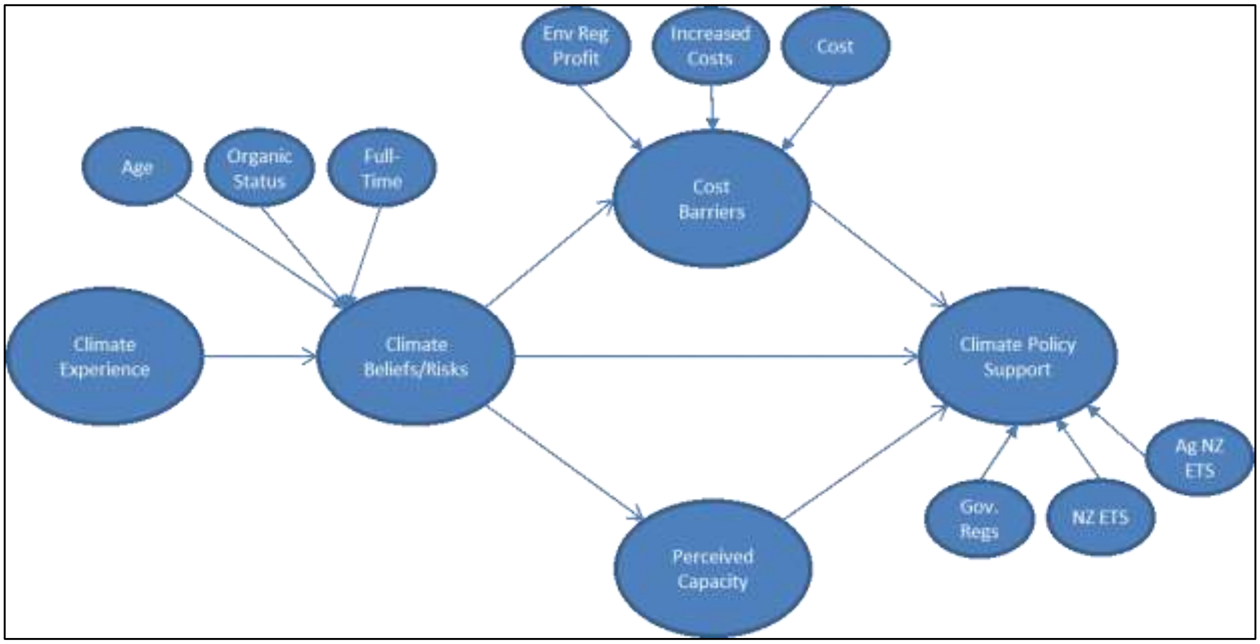


Figure 4.2 Structural equation modeling results for summer temperature. Model results were consistently the same direction and significance across all six models, with some variation in climate experience. All model results are reported in Supplementary Table 1.

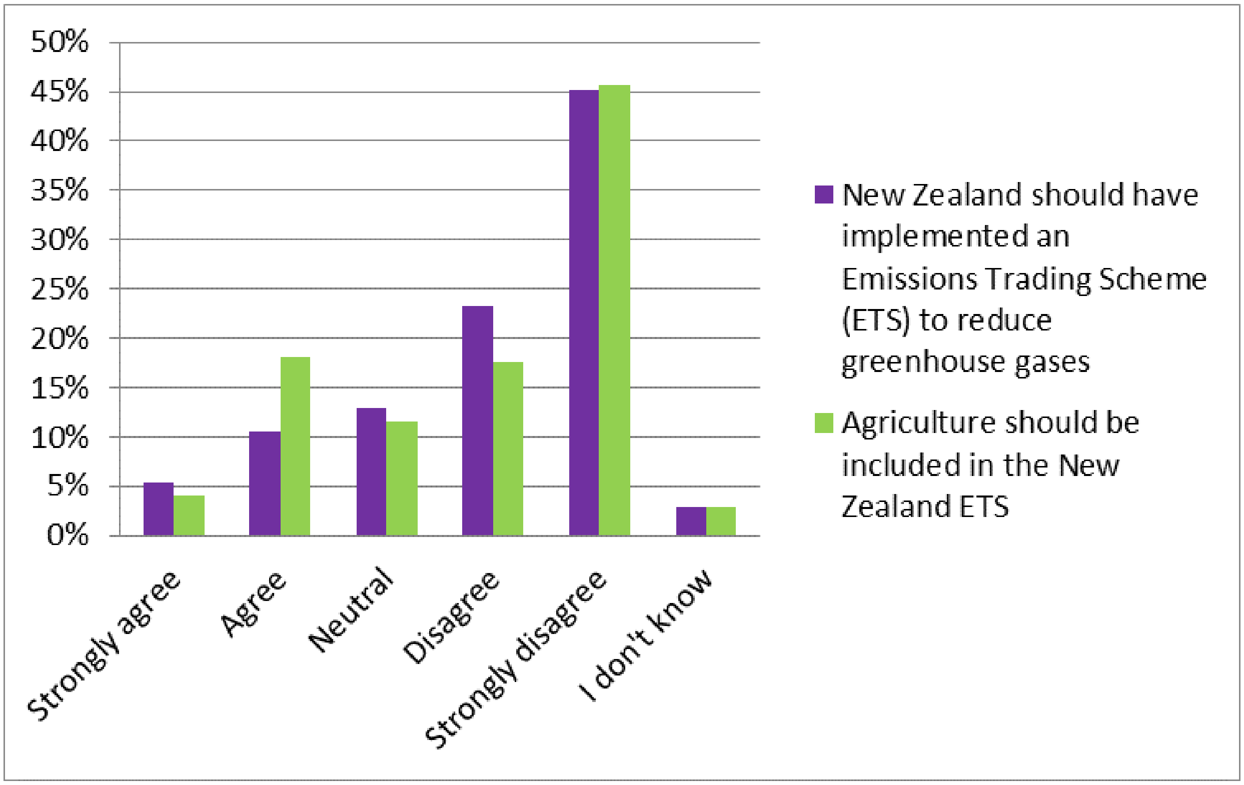
Supplementary Table S4.1. Model Pathway Standardized Regression Coefficients and Fit Statistics

Pathway	Model 1: Summer Temperature	Model 2: Winter Temperature	Model 3: Water Availability	Model 4: Drought	Model 5: Flood	Model 6: Wind
Climate Experience--> Climate Belief/Risks	0.171***	0.105*	-0.104*	0.127**	0.108*	0.046
Age --> Climate Belief/Risks	-0.171***	-0.175***	-0.178***	-0.178***	-0.162***	-0.178***
Organic Status--> Climate Belief/Risks	0.101*	0.094*	0.098*	0.098*	0.079	0.097*
Full Time Status--> Climate Belief/Risks	-0.116**	-0.108*	-0.104*	-0.123**	-0.096*	-0.104*
Climate Belief/Risks--> Cost Barriers	-0.326*	-0.325*	-0.326*	-0.326*	-0.324*	-0.326*
Climate Belief/Risks--> Perceived Capacity	0.150***	0.150***	0.150***	0.151***	0.150***	0.150***
Climate Belief/Risks--> Policy Support	0.310***	0.310***	0.310***	0.311***	0.309***	0.310***
Cost Barriers--> Policy Support	-0.334*	-0.334*	-0.334*	-0.334*	-0.334*	-0.334*
Perceived Capacity--> Policy Support	0.253***	0.253***	0.253***	0.253***	0.253***	0.253***
NZ ETS--> Policy Support	0.866***	0.866***	0.866***	0.866***	0.866***	0.866***
Ag NZ ETS--> Policy Support	0.825***	0.825***	0.825***	0.825***	0.824***	0.825***
Government Regs--> Policy Support	-0.251***	-0.251***	-0.251***	-0.251***	-0.251***	-0.251***
Cost--> Cost Barriers	0.192***	0.192***	0.192***	0.193***	0.192***	0.192***
Increased Costs--> Cost Barriers	0.495**	0.495**	0.495**	0.495**	0.495**	0.495**
Env Reg Profit --> Cost Barriers	0.479**	0.479**	0.479**	0.479**	0.479**	0.479**
$\chi 2$	130.488	133.118	122.887	160.753	154.393	124.917
DF	51	51	51	51	51	51
CFI	0.878	0.873	0.887	0.838	0.845	0.883
RMSEA	0.056	0.057	0.054	0.066	0.064	0.054

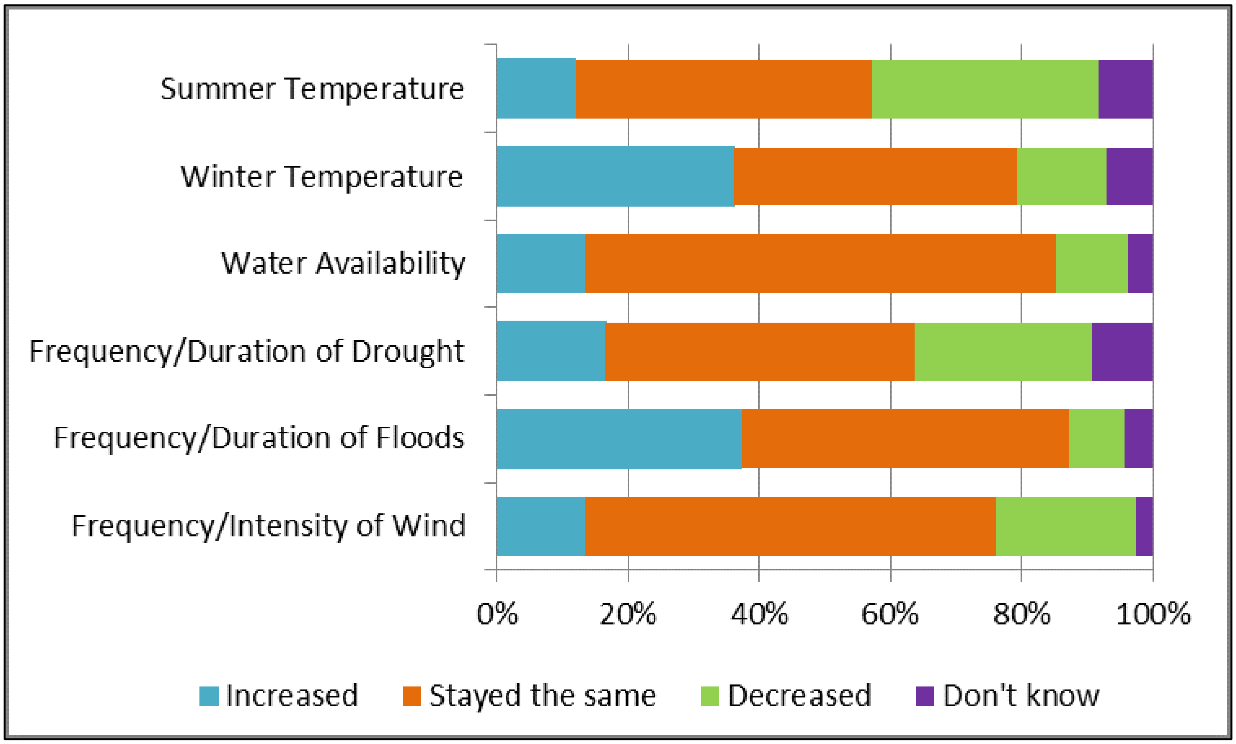
*** $p \leq .001$, ** $p \leq .01$ * $p \leq .05$



Supplementary Figure S4.1. Full structural equation model including latent and observed variables.



Supplementary Figure 2. Policy support for the New Zealand Emissions Trading Scheme (ETS). Overall, 68% of farmers did not think New Zealand should have an ETS and 63% felt that agriculture should not be included.



Supplementary Figure S4.2. Perceived changes in climate over time.

Conclusion

Combating global climate change and adapting to its potential impacts will require a diversity of actors and policy instruments. Farmers and agricultural communities are one important component of successful mitigation and adaptation strategies, and they are uniquely poised to adopt practices that have the potential to both mitigate emissions and adapt to future conditions. Through applying the psychological distant theory, this body of work demonstrates how and why farmers are influenced to adopt climate change practices. This work confirms across multiple regions that farmers, like other sectors of the population as has been shown elsewhere (Evans et al.; Spence et al., 2011), are driven to change their behavior and support policies in part because of events that are psychologically close to them. The psychological distance of climate change is thus highly personal, and likely regionally or locally specific.

This local consideration for the psychological distance of climate change has been demonstrated consistently across this dissertation. Farmer's perceptions and experiences with climate change influence their beliefs in climate change and in turn go on to indirectly affect their likelihood to adopt mitigating and adapting behaviors and support climate change policies. However, this work has also suggested that the psychological distance theory can also be applied in a climate change context to understand other factors that may influence climate change perceptions and responses. In Chapter 2 I show how environmental policy experiences- deemed to be psychologically close to farmers- influence their climate change beliefs and behaviors more than actual climate change experiences. This theme is continued in Chapter 3 when I explore how climate change experiences that are psychologically close to a farmer influence the way that they perceived the future psychological distance of climate change and how this varies across agroecosystems and regions in part because of historical climate events. In Chapters 2 and 4 I expand the concepts of psychological distance further to show how it can be applied to understand farmer support for climate change policies across both regions.

However, despite the localized focus of the psychological distance theory, this work also demonstrates how the psychological distance of climate change can be considered in a global context. In Chapter 1, I demonstrate that the global concerns farmers have about climate change are those that positively influence the adoption of mitigation behaviors, not adaptation behaviors. I suggest that this is largely due to the match in construals of global concerns with globally oriented behaviors as would be typical of mitigating strategies. This is also demonstrated further in Chapter 3, when I find no effect of global climate change concerns on the adoption of adaptation behaviors, consistent with Chapter 1.

The implications of this work are relevant for a diversity of stakeholders. For those seeking to encourage the adoption of climate change strategies and/or support of climate change policies, this work suggests that there are a number of factors at play. The way in which individuals perceive climate change events directly influences their likelihood to believe that climate change is happening and perceive its risks, which directly affects behavioral change and policy support. Simultaneously, a number of demographic factors also influence climate change belief, including age, education level, and farm characteristics. The way that farmers perceive other environmental policies also affects the extent to which farmers acknowledge climate change. These same factors also influence the ways that farmers perceive future changes and the concerns they have for the future. Other factors such as perceived capacity and cost continue to be major barriers for policy support.

The psychological distance theory provides a platform for current and future research that enables greater understanding about how individuals perceive climate change at varying levels and how this influences their individual behaviors as well as their support for climate change policies. Since this is the first body of work to apply the psychological distance theory to agricultural decision makers, additional work is necessary. Particularly given the close proximity that farmers have to climate and weather, as well as their reliance on the climate and weather for economic livelihood, they are an important subgroup with whom to apply the psychological distance theory. Additional comparisons are needed across other regions, particularly by beginning to apply the theory to both developed and developing world farmers, to determine whether similar theories hold true. Continued research can provide agricultural communities and policymakers with additional knowledge about the specific strategies that can help farmers transition to climate-smart agriculture and the most effective communication options for discussing climate change with farmers.

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