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Perceptions and responses to climate policy risks among California farmers

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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

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1. 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., 2007). 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.

2. 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., 2012). 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*, $\alpha = 0.72$) (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*, $\alpha = 0.69$, *Regulation Time*, $\alpha = 0.77$, *Regulation Cost*, $\alpha = 0.74$, *Regulation Balance*, $\alpha = 0.73$). 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).

3. 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., 2002; 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., 2012; 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.

4. Descriptive Results

4.1 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."*

4.2 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.

4.3 Climate Change Belief and Risk

As previously discussed (Haden et al., 2012; Jackson et al., 2012) 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."*

4.4 *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.

4.4.1 *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*.

4.4.2 *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 (β= .62, $p \leq .01$) but tended to be less concerned about future climate change risks (β= -.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.

4.4.3 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 (β= .18, $p \leq .05$), they tended to be less likely to participate in a government incentive program for climate change mitigation and adaptation (β= -.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 (β= -.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*.

5. 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.

6. 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.

Figures and Tables

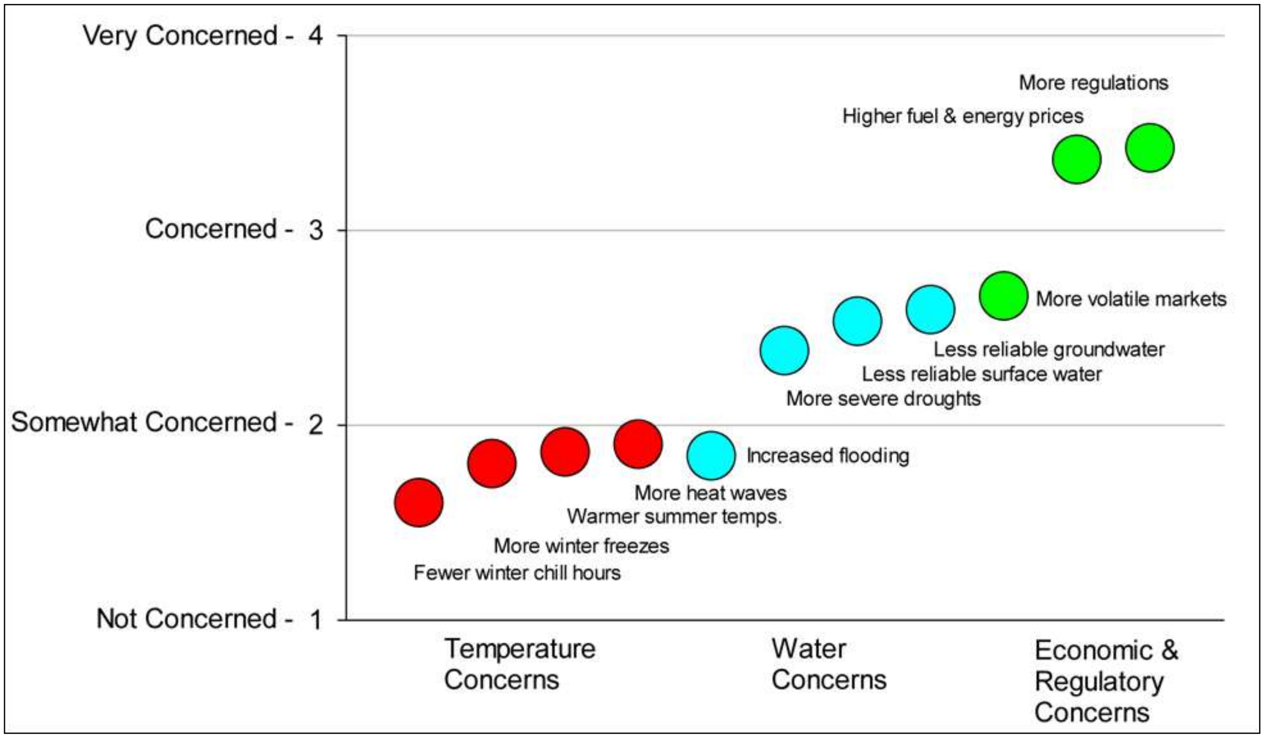

Figure 1. Average Level of Concern for Local Climate Change Impacts. Farmers' responses to the question, "How concerned are you about the following climate-related risks and the future impact they may have on your farming operations during your career?" Responses are ranked on a four point scale ranging from very concerned to not concerned.

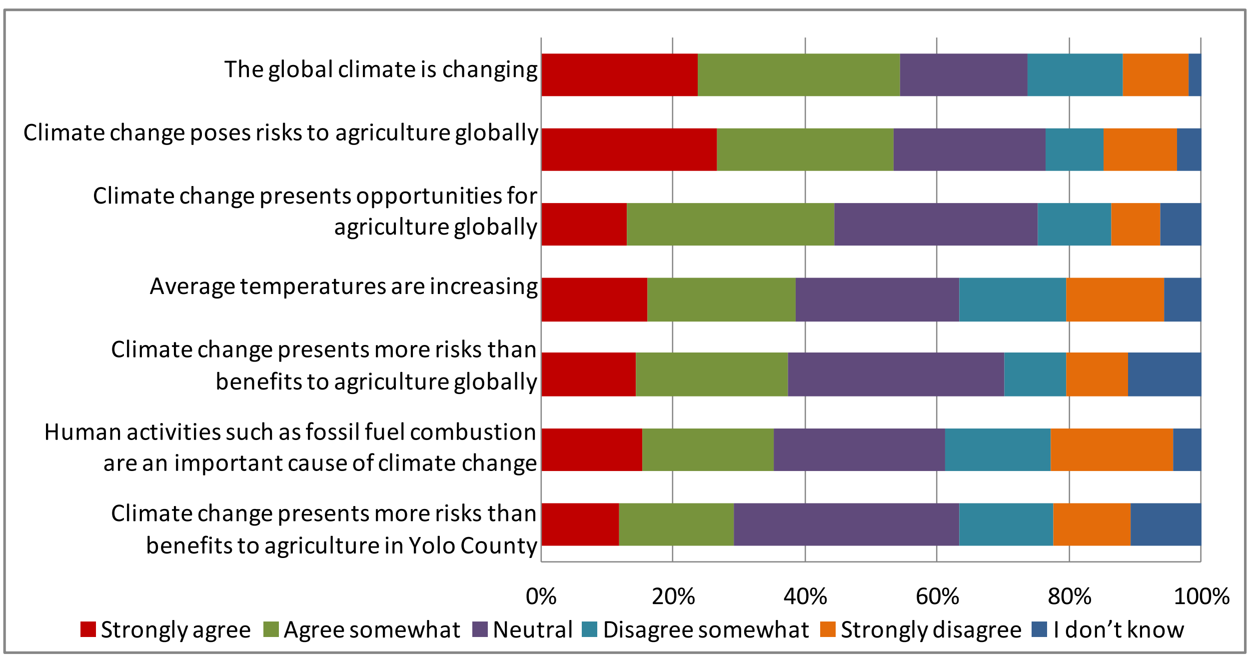

Figure 2. Yolo County Farmers' Perspectives on Climate Change. Statements are ranked in descending order by total level of agreement.

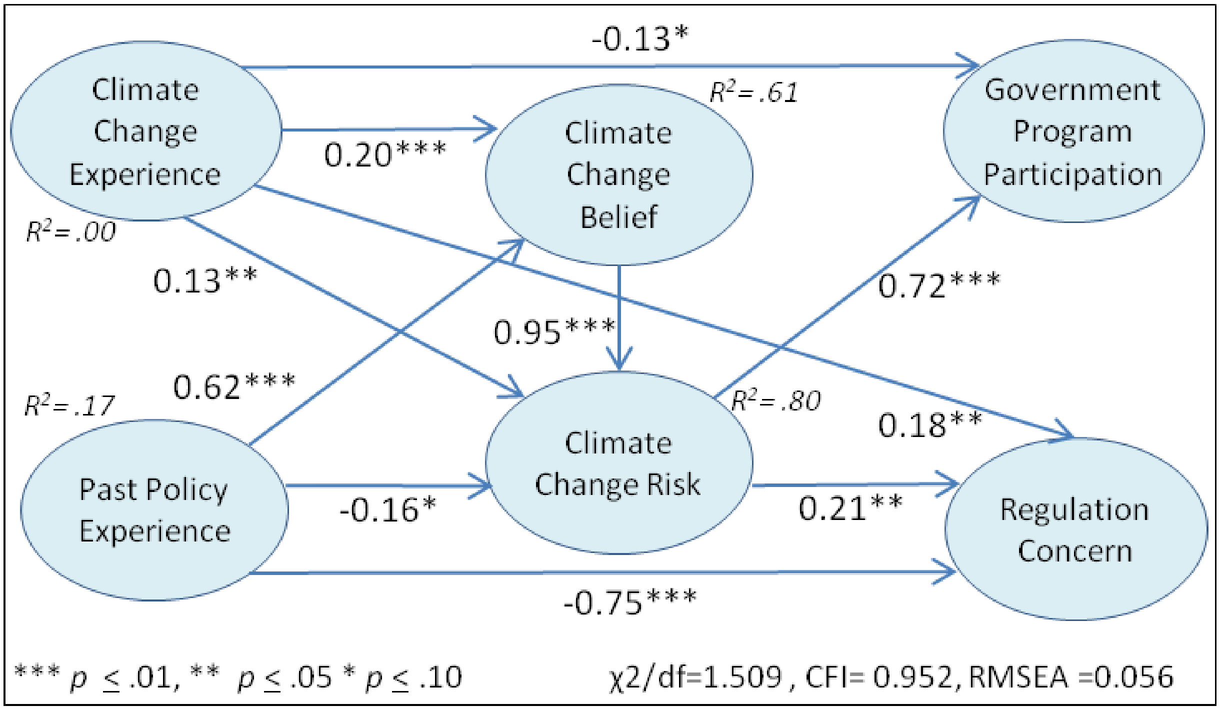

Figure 3. Significant Pathways in the Structural Equation Model. Significant demographic and farm characteristics including organic status, education level, whether a farmer was full time, and local origin were also included in this model but are not shown. A full structural equation model showing all observed and latent variables can be found in the supplemental materials.

Table 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=Strongl Disagree, 5= Strongly Agre		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				
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:	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.	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	
	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		---	---	---
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 globally		---	---	---
	Climate change presents more risks than benefits to agriculture in Yolo County.		---	---	---

Table 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).

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