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Perceptions and responses to climate policy risks among California farmers

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48 climate change (Fischer et al., 2005; Tol, 2002) and the policy structures that may be needed to
49 assist the agricultural community in adaptation (Howden et al., 2007; Smit and Skinner, 2002)
50 and mitigation (Smith et al., 2007). This paper proposes that existing research has
51 underemphasized a key feature of adaptation: how farmers perceive and respond to *climate*
52 *policy risk*. The concept of policy risk is defined as a regulation or policy that may present
53 economic, environmental or social risks to an individual or enterprise. In the context of
54 agriculture, climate policy risk is the potential threat posed by climate change regulations or
55 policies to mitigate or adapt to climate change.

56 We study climate policy risk in the local context of farmer attitudes and decision-making
57 in Yolo County, California. Our global capacity for responding to climate change requires
58 understanding how policies across multiple scales affect the local daily activities and perceptions
59 of individuals (Ostrom, 2010) and how those local activities scale up to influence global
60 outcomes (Wilbanks and Kates, 1999). In California, farmers are contending with the local
61 development of county climate action plans (Haden et al., In Press) in conjunction with the state-
62 wide cap and trade program AB-32 (California Air Resources Board, 2008), which though it
63 doesn't include agriculture, does allow for a carbon offset market that may provide financial
64 incentives for agricultural mitigation (California Air Resources Board, 2011; De Gryze et al.,
65 2009). Nationally, policies require some large farms to report their greenhouse gas emissions
66 (United States Environmental Protection Agency, 2009). California is not anomalous- farmers
67 across the globe deal with multiple policy risks that influence their decisions and collectively
68 scale up to affect the global food supply, environment, and agricultural markets in an
69 increasingly global world (e.g. (Cassells and Meister, 2001; Miho, 2003; van Meijl et al., 2006).

70 This concept of climate policy risk builds upon a growing body of work in energy policy
71 and management to assess how investors and firms may respond to climate policy risks. Yang
72 et al. (2008) examine how climate policy risks and uncertainty drives investors behavior in their
73 choice of different energy generation options as a result of price changes. Related work shows
74 how renewable energy investors respond to policy risks related to renewable energy policies,
75 which affect their investment potential in a given region (Lüthi and Wüstenhagen, 2012; Nemet,
76 2010). Like these decision-makers in other sectors, changes in climate policy directly affect the
77 overall risk portfolio faced by farmers in terms of the costs, benefits, and uncertainty around
78 different decisions.

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

94 climate policy risks and non-climatic drivers should be more adequately considered when
95 assessing climate change attitudes and behaviors.

97 2. Methods and Place

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

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

123 Table 1 reports the complete list of questions, variables, scales, and their descriptive
124 statistics used in this analysis. Two dependent variables were used to measure responses to
125 climate policy risks: *Regulation Concern* (i.e. a farmer's concern for climate change regulations
126 and economic impacts) and *Government Program Participation* (i.e. willingness to participate in
127 a climate change incentive program). Regulation Concern was determined with a factor analysis
128 using principal component factors with varimax rotation, which indicated a single factor
129 solution with factor loadings significantly greater than a cut-off of .40 (Costello and Osborne,
130 2005). We created a scale to combine questions measuring similar latent concepts to average
131 responses (*Regulation Concern*, $\alpha=0.72$) (Clark and Watson, 1995), which had a Cronbach's α
132 coefficient higher than .70, a generally accepted cut-off point for reliability (Nunnally, 1978).

133 A number of independent variables were considered including *Climate Change*
134 *Experience*, *Past Policy Experience*, *Climate Change Belief* and *Climate Change Risk*. *Past*
135 *Policy Experience* was measured by assessing a farmer's overall perspective on four past
136 environmental policies (Table 2). Farmers were asked to consider four questions for each policy
137 as described in Table 1 (*Regulation Environment*, $\alpha=0.69$, *Regulation Time*, $\alpha=0.77$, *Regulation*
138 *Cost*, $\alpha=0.74$, *Regulation Balance*, $\alpha=0.73$). A factor analysis was also conducted as described
139 above, which determined that each of the four questions grouped together across environmental

140 policies. In other words, farmers tended to have the same general opinions about whether
141 environmental policies were effective, expensive, time consuming, or balanced in their approach.
142 Each question formed its own scale (i.e. *Regulation Environment, Regulation Time, Regulation*
143 *Cost, Regulation Balance*) that together formed the observed variables related to the latent
144 variable *Past Policy Experience*. Other independent variables included *Climate Change*
145 *Experience* measured using a farmer's perceived change in water availability over time in Yolo
146 County and *Climate Change Belief* and *Climate Change Risk* as latent variables compiled
147 through several questions indicated in Table 2.

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

163 The results of our SEM should be considered in the context of our population- a rural region
164 made up of a small group of farmers. While some researchers argue the sample is too small for
165 robust estimation of SEM models (MacCallum and Austin, 2000), others suggest SEM can
166 perform well even with sample sizes less than 100 (Iacobucci, 2010) and small sample sizes are
167 especially acceptable where the population size is limited such as in our case (Schreiber et al.,
168 2006). According to Kim (2005) our sample size fits the minimum required as determined by
169 our degrees of freedom (df=123) and RMSEA (0.056). Given the smaller sample size of our
170 study we report several fit statistics beyond a χ^2 since it may be significantly influenced by
171 sample size (Boomsma, 1982; Fan et al., 1999). For this reason we also report the CFI and
172 RMSEA, which have been shown to be the least affected by sample size compared to other SEM
173 fit statistics (Fan et al., 1999).

174

175 **3. Theoretical and Policy Background**

176 Drawing on the public opinion and climate change literature (e.g. (Bray and Shackley,
177 2004; Brulle et al., 2012; Dietz et al., 2007; Krosnick et al., 2006; Leiserowitz, 2006)), we focus
178 on three core hypotheses related to responses to climate policy risks. First, we expect that
179 perceptions of climate *change* risk will have a direct influence on responses to climate *policy*
180 risks. Farmers who believe that climate change is risky are more likely to support and participate
181 in policies that aim to address climate change. Several existing social science frameworks
182 support this hypothesis by demonstrating that environmental behaviors (including policy
183 support) are more likely to occur when an individual believes there is a problem and that it
184 presents risks (Grothmann and Patt, 2005; Krosnick et al., 2006; Lubell et al., 2007; Stern et al.,
185 1999). Individuals that believe in global warming and its associated risks are more likely to

186 support policies and engage in behaviors to ameliorate global warming (Krosnick et al. (2006)
187 and Lubell et al. (2007); Haden et al. (2012)) . Consistent with this concept, we also expect a
188 direct relationship between the two dependent variables, *Government Program Participation* and
189 *Regulation Concern*. Farmer’s with higher concern for future regulations are hypothesized to be
190 less likely to participate in a government incentive program for climate change since it may be
191 viewed as risky by some farmers due to unknown returns for adopting new practices.

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

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

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

226 In fact, despite anticipated impacts (Jackson et al., 2012; Southworth et al., 2000), there is
227 a perception among many agricultural producers in the United States that agriculture has not and
228 will not be affected by climate change (Arbuckle et al., 2011; Morello, 2012). Some local
229 agricultural producer groups, grower organizations, and non-profits have encouraged climate
230 adaptation and mitigation. However, there remains national-level resistance to climate change
231 from major farm organizations who assert that producers face the greatest climate change threats

232 from policies (American Farm Bureau, 2012), which may be viewed as burdensome by farmers.
233 This may be particularly true for policies developed without adequate input from the agricultural
234 community. In California farmers have been directly exposed to developing climate change
235 policies as discussed in the introduction. At the same time, farmers have seen an increase in
236 environmental regulations over the past several decades that have shifted management strategies
237 and required new economic investment in infrastructure or equipment (Table 2). We suggest,
238 based on the psychological distance theory, that these local policies are “closer” (temporally,
239 geographically and socially per Liberman and Trope (2002)) and more tangible to farmers than
240 the biophysical impacts of climate change and will have a greater effect on climate change
241 attitudes and responses to climate policy risks.

242 **4. Descriptive Results**

243 *4.1 Responses to Climate Policy Risks*

244 Figure 1 reports the average level of concern for various climate-related impacts, and
245 shows that farmers believe government regulations are the greatest climate risk they face in the
246 future. On a scale from 1 (not concerned) to 4 (very concerned) more regulation had the highest
247 level of concern (mean = 3.44) while temperature related impacts like fewer winter chill hours
248 (mean = 1.68) and warmer summer temperatures (mean = 1.86) were of lesser concern. Water
249 related issues were of moderate concern, with less reliable surface and groundwater (mean= 2.54,
250 2.60, respectively) more concerning than extreme events like more severe drought (mean = 2.35)
251 or flooding (mean= 1.84).

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

266 *4.2 Climate and Policy Experience*

267 Farmers have perceived changes in water availability over time in Yolo County (*Climate*
268 *Change Experience*). A minority (43 percent, n=68) of farmers felt that water availability had
269 decreased over time while approximately 47% (n=74) felt it had stayed the same. Less than
270 1% of farmers felt that water availability had increased (n=1) and nearly 10% (n=15) were unsure
271 about the status of water availability over time.

272 When asked to consider specific environmental policies, farmers tended to have more
273 favorable perspectives of policies in existence the longest. For the pesticide use reporting
274 program and the rice straw burning regulations (implemented in 1990 and 1991, respectively)
275 46% (n=70) and 43% (n=57) of farmers felt these policies were improving the environment.
276
277

278 This is contrasted with only 24% (n=36) and 36% (n=51) agreeing with this statement for the
279 water quality conditional waiver programs and stationary diesel engine emission regulations
280 (implemented in 2003 and 2007, respectively). Similar trends were observed for whether the
281 policies required significant practice or equipment changes perceived to be impractical or costly.
282 Only 17 and 20% felt this was true for the older policies (pesticide use reporting and rice straw
283 burning, respectively) compared with 27% (n=40) and 51% (n=65) for water quality conditional
284 waivers and diesel engines. Older policies were also perceived to better balance farmer and
285 public interests as many farmers discussed the most recent issue of diesel engine regulations
286 without mentioning other past policies. One farmer stated,

287
288 *“The California Air Resources Board does not understand agriculture and how you have*
289 *a dirty engine that serves a purpose on several square miles of farmland for just a few*
290 *hours a year and you have to get rid of that engine and drop 30 or 40 grand for a brand*
291 *new engine, which will be obsolete again in a few more years. They don’t realize how*
292 *that can break a farm.”*
293

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

300 301 *4.3 Climate Change Belief and Risk*

302 As previously discussed (Haden et al., 2012; Jackson et al., 2012) farmers in Yolo
303 County hold a range of views related to climate change belief and risk (Figure 2). During
304 interviews, one farmer remarked *“What I think is changing is that the weather has been so*
305 *unpredictable in the last ten years, and sometimes these events we get seem like they’re larger,*
306 *stronger events than we’ve historically had.”* Several farmers expressed that the potential
307 impacts of climate change were likely not occurring on time-scales that are currently influencing
308 their decisions. One farmer expressed uncertainty about climate change: *“I believe it’s*
309 *happening. I think it’s gonna be pretty slow and I don’t know if I’ll see it in my career actually*
310 *effect my crops. And if I do see it, you won’t even really be able to say, ‘Yeah that was because*
311 *of climate change”*. An additional farmer noted, *“For me, to be concerned about it (climate*
312 *change) at my level and at my point, I don’t think it’s useful for me. I have other more important*
313 *things that affect my business or my family that I want to spend time on versus something that*
314 *could happen ten thousand years from now.”* Perhaps in part because of these perceived long-
315 term time horizons, farmers expressed high confidence when asked about their ability to adapt to
316 the possible risks posed by climate change. Seventy-six percent of farmers stated confidence in
317 their ability to adapt to climate change compared with only 8% of farmers stating pessimism for
318 their adaptive potential. One farmer said, *“I think that with the years of experience in farming*
319 *that we have, I think we know how to deal with problems. I think farmers in general are fairly*
320 *adaptable.”* Another farmer echoed these sentiments saying, *“I still have to be a farmer just like*
321 *I’ve always been and I’ll have to react to it [climate change] and adapt to it. But that’s been my*
322 *business. In agriculture you’re dealing with the weather, that’s what you have to deal with.”*
323

324 4.4 *Structural Equation Model*

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

333

334 4.4.1 *Climate Change Belief/Risk → Climate Change Risk Responses*

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

344

345 4.4.2 *Climate and Policy Experience → Climate Change Belief/Risk*

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

361

362 4.4.3 *Climate and Policy Experience → Climate Change Policies*

363 The direct influence of *Climate Change Experience* on *Regulation Concern* and
364 *Government Program Participation* was less straightforward. While farmers who believed that
365 water availability had decreased over time were more concerned about future climate change
366 policies ($\beta= .18, p \leq .05$), they tended to be less likely to participate in a government incentive
367 program for climate change mitigation and adaptation ($\beta= -.13, p \leq .10$). Though we predicted
368 that *Past Policy Experience* would affect both *Government Program Participation* and future
369 *Regulation Concern*, only the relationship to *Regulation Concern* was significant ($\beta= -.75, p \leq$

370 .01). We found that farmers who had a positive perception of local environmental policies were
371 much less likely to be concerned about future climate change policies. There was no significant
372 effect of *Past Policy Experience* on *Government Program Participation*.
373

374 5. Discussion

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

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

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

401 Surprisingly, government program participation was not significantly affected by past
402 policy experiences. A farmer's concern for future climate change policies and their negative
403 experience with past policies do not influence their likelihood to participate in a government
404 incentive program. It appears that farmers may be able to overlook negative experiences or
405 perceptions if the government provides the right incentive to do so. Using the government carrot
406 rather than a stick to encourage action on climate change could garner widespread support and
407 participation, particularly if combined with other policy strategies (Niles and Lubell, 2012;
408 Wilson, 1996). As indicated by one farmer, "*If regulation and goals are set that are paired with*
409 *incentive type efforts that provide assistance to farmers to make the transitions and change that*
410 *they need to make, you do see farmers changing and you do see change happening.*" As Adger
411 (2005) mentioned, climate change adaptation encompasses "*taking advantage of new*
412 *opportunities.*" Since our results found that a significant minority of farmers do think that
413 climate change offers opportunities for agriculture, these farmers may see government incentive
414 programs as one key element of this.

415 A novel finding is that farmers' past experience with local policy is a much stronger
416 predictor of climate change attitudes than personal experience with biophysical climate change
417 impacts. Local climate change policies may be more psychologically close to farmers in our
418 region than biophysical impacts. Our data suggests that farmers mostly think the climate has
419 stayed the same over their farming careers with the exception of water availability (Haden et al.,
420 2012). This lack of experience with major climate change impacts can cause people to see
421 climate change as a low-probability event with few risks (Weber, 2006). Farmer's perceptions of
422 risk are not only biophysical - they are deeply entrenched in policy and economics as these may
423 have significant direct impacts on their farming systems (Howden et al., 2007; Smit and Skinner,
424 2002). Our data shows that farmers with a negative past policy experiences were more likely to
425 have climate change risk concerns. Thus farmers in this region are to a large extent viewing
426 climate change through a policy lens. For farmers with negative views of previous
427 environmental policies, climate change risks may seem more severe if they are envisioning them
428 to be heavily weighted towards policy and regulation.

429 At the same time, negative past policy experiences also resulted in less climate change
430 belief. From an adaptation perspective, experience with past environmental policies provides a
431 baseline set of expectations to evaluate climate change policies, even when the past policies
432 addressed different issues. For policymakers this is crucial, because it demonstrates that policy
433 perceptions linger –potentially for decades- and significantly influence other environmental
434 perceptions. However, it is important to consider broader individual values such as political
435 ideology may influence both the formation of beliefs about climate change and perceptions of
436 past environmental policies (Kahan et al., 2012). Though our paper did not measure ideology,
437 future research should consider the overall structure of climate change belief systems, and how
438 core values can constrain the formation of more specific beliefs.

439

440 **6. Conclusion**

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

449 Integration of policy experiences on climate change belief, risk and behaviors further
450 suggests that policy experiences should also be more systematically considered across climate
451 change and environmental behavior research. Though much environmental and climate change
452 behavior literature has considered policy support or perceptions as a major dependent variable
453 (Barr, 2007; Steg et al., 2011; Stern et al., 1999) it is not often utilized as an independent
454 variable. Better incorporation of policy experiences and attitudes into frameworks as an
455 independent variable could begin with the New Ecological Paradigm (Dunlap et al., 2000;
456 Dunlap and Vanliere, 1978) often utilized in social environmental behavior research. We are
457 also cognizant that future research focused on understanding climate change mitigation and
458 adaptation could include additional measures to better understand the social, economic, and
459 policy aspects of climate change. Indeed, this study only considers climate change policies and

460 economic impacts and does not consider many other potential socio-economic aspects of climate
461 change that could be assessed through additional studies (Frank et al., 2011).

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

476 Second, though past policy perceptions strongly influence a farmer's concern for future
477 policies, they do not reduce their interest in participating in government programs. Programs
478 that aim to work with the agricultural community to incentivize voluntary practice change can
479 make participation more attractive and financially sound (Walford, 2002; Wilson and Hart,
480 2000). This can achieve a win-win situation where farmers can achieve environmental
481 benchmarks with appropriate resources and time to enable effective adoption (Semenza et al.,
482 2008). Programs that provide technical assistance or compensation to change practices may be a
483 positive opportunity for agricultural communities to address climate change and help offset the
484 transaction costs associated with changing practices (Falconer, 2000). Ideally, such programs
485 would deal with both mitigation of greenhouse gas emissions and adaptation to ensure that farm
486 production and food security continues despite changing conditions.

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

496 While economic incentives may be an effective option for short term behavior change
497 (Spence and Pidgeon, 2009), a continuing dialogue is necessary to shift policy and climate
498 change perspectives over time. Engagement with the agricultural community in the creation of
499 environmental policies may help to prevent "lag effects", where farmer's perceptions of
500 environmental policies continue to affect their concern and response to future environmental
501 issues (in our case up to thirty years later). This might be best achieved through dialogue with
502 farmers and agricultural communities particularly from policymakers, who can significantly
503 affect climate change beliefs (Brulle et al., 2012). Integration of farmers into specific policy
504 development activities related to climate change is a crucial step to begin to address negative

505 past perceptions of environmental policies by including them in the policy process (Few et al.,
506 2007; Reed, 2008).

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

Figures and Tables

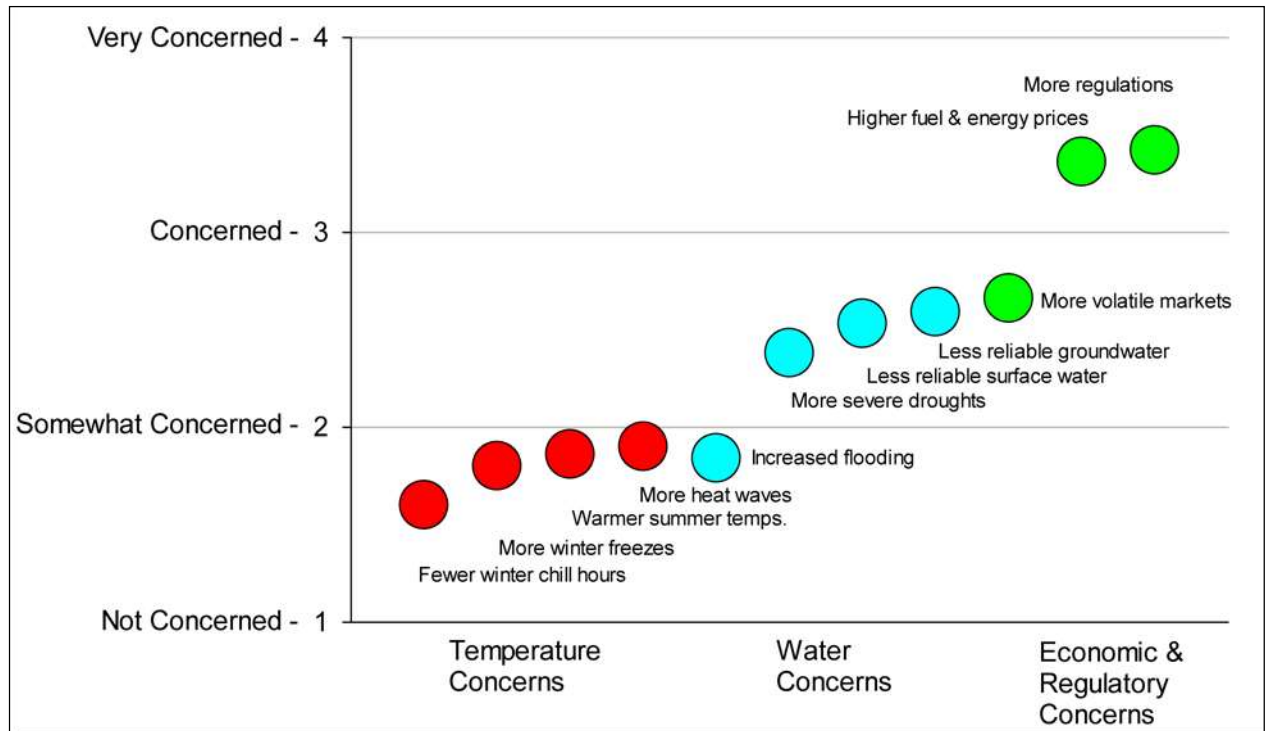


Figure 1. Average Level of Concern for Local Climate Change Impacts. Farmers' responses to the question, "How concerned are you about the following climate-related risks and the future impact they may have on your farming operations during your career?" Responses are ranked on a four point scale ranging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

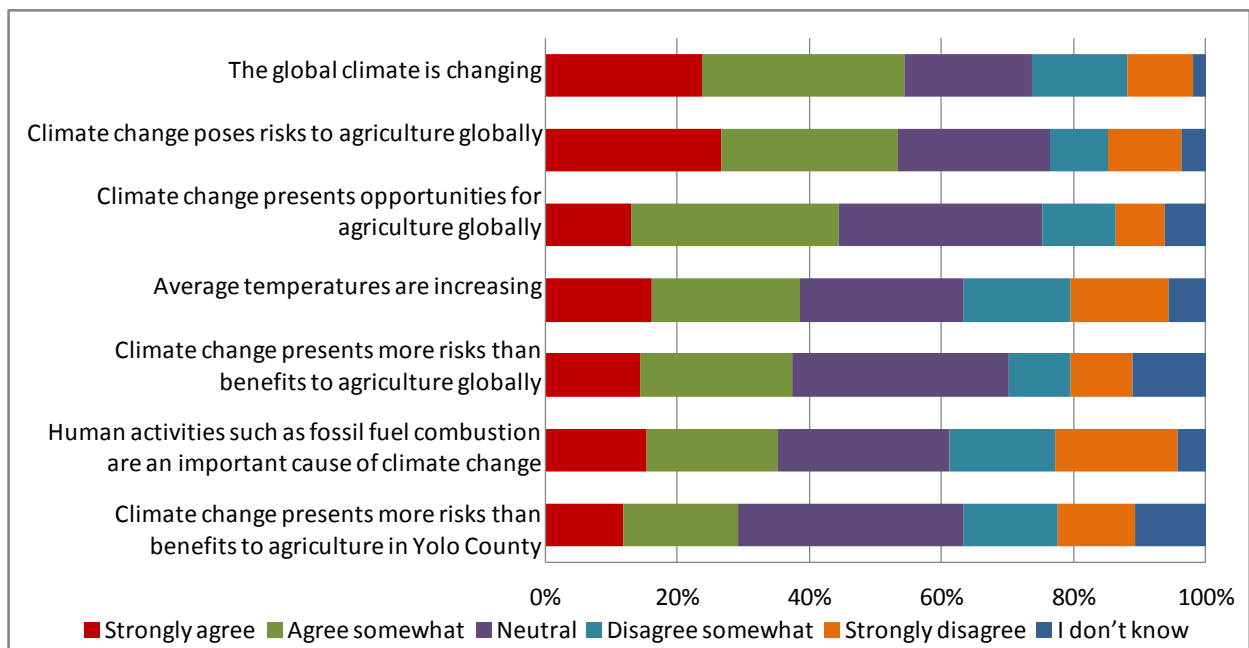


Figure 2. Yolo County Farmers' Perspectives on Climate Change. Statements are ranked in descending order by total level of agreement.

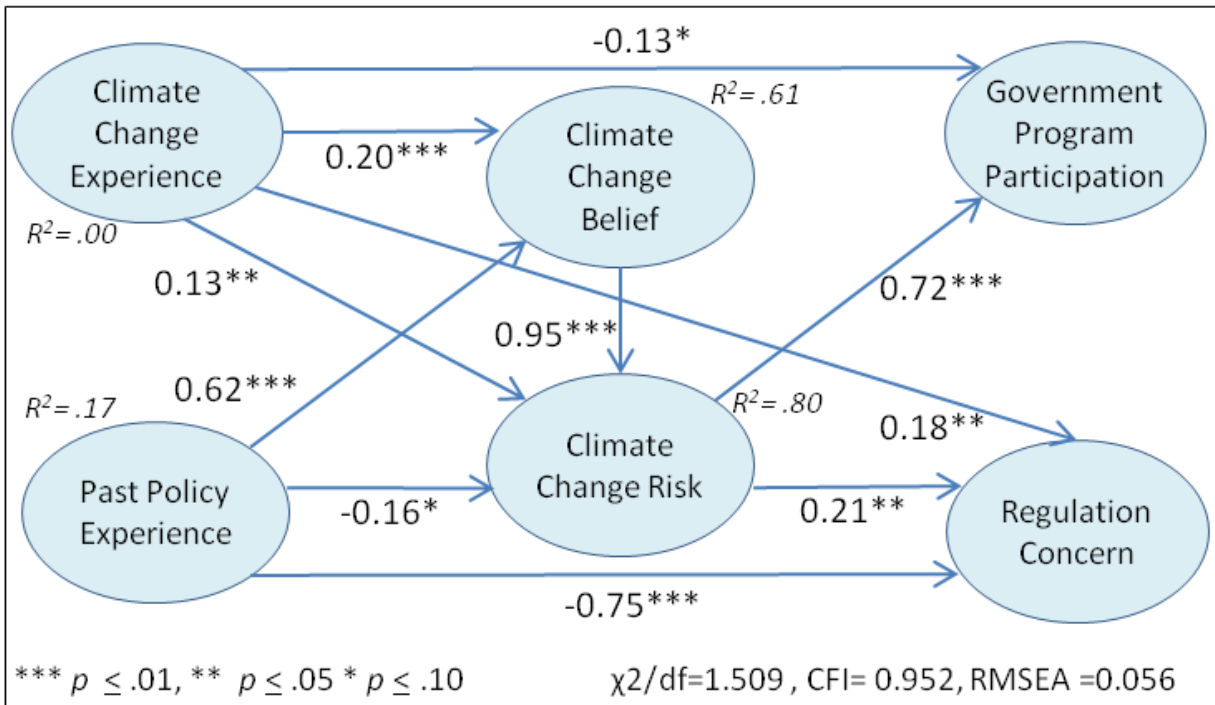


Figure 3. Significant Pathways in the Structural Equation Model. Significant demographic and farm characteristics including organic status, education level, whether a farmer was full time, and local origin were also included in this model but are not shown. A full structural equation model showing all 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? <i>More government regulations</i> <i>High fuel and energy prices</i> Government regulations will make it more difficult to adapt to the risks posed by climate change | Four Point Scale (1= Not Concerned, 4= Very Concerned) Five Point Scale (1=Strongly Disagree, 5= Strongly Agree) | 1.94 | 0.90 0.73 0.78 | 0.72 |
| 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 | <i>Local water availability has _____ over the course of your farming career.</i> | 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: <i>Pesticide Use Reporting</i> <i>Water Quality Conditional Waiver Program</i> <i>Rice Straw Burning Regulations</i> <i>Stationary Diesel Engine Emissions Regulations</i> | | 2.19 | 0.76 0.81 0.72 0.67 | 0.69 |
| Regulation Time | Reporting requirements are too time consuming: <i>Pesticide Use Reporting</i> <i>Water Quality Conditional Waiver Program</i> <i>Rice Straw Burning Regulations</i> <i>Stationary Diesel Engine Emissions Regulations</i> | Seven point scale ranging from 0 to 1, accounting for all possible averages based on each question for the four policies. | 2.55 | 0.71 0.83 0.79 0.86 | 0.77 |
| Regulation Cost | Requires changes in practices or equipment that are impractical or too costly: <i>Pesticide Use Reporting</i> <i>Water Quality Conditional Waiver Program</i> <i>Rice Straw Burning Regulations</i> <i>Stationary Diesel Engine Emissions Regulations</i> | Individual questions are binomial yes, no responses. | 2.17 | 0.70 0.83 0.73 0.68 | 0.74 |
| Regulation Balance | Effectively balances the interests of both the public and farmers: <i>Pesticide Use Reporting</i> <i>Water Quality Conditional Waiver Program</i> <i>Rice Straw Burning Regulations</i> <i>Stationary Diesel Engine Emissions Regulations</i> | | 2.37 | 0.70 0.80 0.84 0.73 | 0.73 |
| Climate Change Belief | The global climate is changing Average global temperatures are increasing Human activities such as fossil fuel combustion are an important cause of climate | Five Point Scale (1= Strongly Disagree, 5= Strongly Agree) | --- | --- | --- |
| Climate Change Risk | Climate change poses risks to agriculture globally 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. | Five Point Scale (1= Strongly Disagree, 5= Strongly Agree) | --- | --- | --- |

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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