

Understanding Farmer Perspectives on Climate Change Adaptation and Mitigation: The Roles of Trust in Sources of Climate Information, Climate Change Beliefs, and Perceived Risk

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Abstract

Agriculture is vulnerable to climate change and a source of greenhouse gases (GHGs). Farmers face pressures to adjust agricultural systems to make them more resilient in the face of increasingly variable weather (adaptation) and reduce GHG production (mitigation). This research examines relationships between Iowa farmers' trust in environmental or agricultural interest groups as sources of climate information, climate change beliefs, perceived climate risks to agriculture, and support for adaptation and mitigation responses. Results indicate that beliefs varied with trust, and beliefs in turn had a significant direct effect on perceived risks from climate change. Support for adaptation varied with perceived risks, while attitudes toward GHG reduction (mitigation) were associated predominantly with variation in beliefs. Most farmers were supportive of adaptation responses, but few endorsed GHG reduction, suggesting that outreach should focus on interventions that have

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adaptive and mitigative properties (e.g., reduced tillage, improved fertilizer management).

Keywords

adaptation, agriculture, climate change, mitigation, risk

Global climate change is widely viewed as one of the most significant challenges facing society today. Agriculture is vulnerable to climate shifts and a significant source of the greenhouse gases (GHGs) that are driving those changes (Beddington et al., 2012; Intergovernmental Panel on Climate Change [IPCC], 2007; National Research Council [NRC], 2010a). Long-term shifts in annual averages and seasonal patterns of precipitation, temperature, and humidity, as well as more erratic and extreme weather events leading to increased risk of floods, drought, and fire are anticipated for the future (Coumou & Rahmstorf, 2012; Hatfield et al., 2011). Predicted impacts on agriculture include redistribution of water availability and compromised quality, increased soil erosion, and decreased crop productivity (Howden et al., 2007; McCarl, 2010), which present immediate and localized economic risks to farmers. In contrast, production of GHGs has effects across the larger landscape that are not readily apparent at short time scales. It is estimated that agriculture contributes between 10% and 15% of global anthropogenic GHG emissions including nitrous oxide (N₂O), methane (CH₄), and carbon dioxide (CO₂); (Climate Change Position Statement Working Group, 2011; IPCC, 2007). Thus, climate-change-related threats to agriculture represent threats to quality of life at local and global scales, and calls for the development of adaptation and mitigation strategies for agriculture are increasing in their urgency (e.g., Coumou & Rahmstorf, 2012; Howden et al., 2007; McCarl, 2010).

Literature on adaptation and mitigation of natural hazards finds that behavioral responses to hazards depend in large part on risk perception, or “beliefs about the existence and characteristics of a natural hazard” (Nigg & Mileti, 2002, p. 280). In other words, behavior change is influenced by perceptions of the risks associated with a given natural hazard, which are mediated by beliefs about (1) the existence of the hazard and (2) its characteristics. Perceived risk among individuals or collectivities, while a critical determinant of willingness to prepare for or mitigate natural hazards, is often at odds with objective assessments of risk (Nigg & Mileti, 2002). Because perceptions of risk are socially constructed and transmitted, differences in

worldviews, personal experiences, expectations about technology, trust in institutions, and other factors can influence awareness and understanding of hazards and decisions and actions (or inaction) in response (Slovic, 2009).

Beliefs and risk perceptions regarding climate change are particularly unsettled. Whereas scientific understanding of climate change is firmly established—it is occurring, it is due primarily to human activities, and it poses potentially serious risks to human society and natural systems (NRC, 2010b)—public understanding of the phenomenon varies widely (Maibach, Roser-Renouf, & Leiserowitz, 2009; Weber, 2010). In recent reviews of research on public understanding of climate change, Weber and Stern (2011) and others (Kahan, Jenkins-Smith, & Braman, 2011; Leiserowitz, 2006; McCright & Dunlap, 2011b) highlight a number of factors that explain variance in U.S. public perspectives on the issue. Climate change is difficult for a general public to understand because the causes (GHGs) are invisible and signals and impacts are diffuse and difficult to predict or interpret correctly, especially at local levels and human time scales (Gleick, 2012; Weber & Stern, 2011). In addition, whereas climate science is based on *analytical processing* of large amounts of carefully collected data, individuals tend to base judgments and decisions on *associative and affective models* of cognition that are evolutionarily older and rooted more in feeling than in scientific facts (Marx & Weber, 2012; Slovic, 2009; Weber & Stern, 2011). Furthermore, formation of attitudes toward relatively new, emerging attitude objects such as climate change may be more strongly influenced by values and worldviews than by objective data (Weber & Stern, 2011). Finally, because climate change is difficult to understand based on personal experience, the public must rely on indirect sources of information on climate change, which can be manipulated by actors with disparate interests (Kahan et al., 2011; McCright & Dunlap, 2010; Weber & Stern, 2011). Moreover, these factors have led to a

public confronted with complex physical phenomena that cannot be understood without mediated knowledge, subject to normal cognitive and affective limitations, and surrounded by a politicized struggle to shape understanding that is amplified by polarized media that offer knowledge claims congenial to selected audiences' goals, values, and worldviews. (Weber & Stern, 2011, p. 322)

The resulting uncertainty and variance in understandings have eroded public support for climate policy and retarded action.

While the U.S. general public's understanding of climate change has been studied in some depth, little research has examined farmer perceptions about climate change and accompanying risk (Barnes & Toma, 2012). Farmers are the group on which the tasks of climate change adaptation and mitigation in

agriculture will mainly fall (Berry, Rounsevell, Harrison, & Audsley, 2006). However, farmer attitudes toward the actions that might be required to adapt agriculture to changes in climate as well as decrease agriculture's GHG emissions are largely unknown. As Howden et al. (2007) emphasize, if farmers do not believe that climate change is happening or do not perceive it as a threat, they will not likely undertake adaptive or mitigative actions. Given the evidence that belief in and perceived risks from hazards are necessary (but not sufficient) conditions for action, and the predicted threats that climate change poses to sustainable production of food and energy, an improved understanding of farmer beliefs and risk perceptions associated with climate change is urgently needed. In particular, it is critically important to understand what factors shape attitudes toward responses to climate change (Dunlap, 2010).

This study examines the complex relationships between farmer beliefs about climate change, risk perceptions, trust in key institutions, and attitudes toward adaptive and mitigative actions. It does so through analysis of data from a state-wide survey of Iowa farmers to answer the following research questions: (1) Do farmers believe that climate change is occurring, and if so, to what do they attribute it?; (2) Does differential trust in agricultural and environmental interest groups influence those beliefs?; (3) Do variations in farmer understanding of climate change influence levels of perceived risk?; (4) Do levels of perceived risk predict support for adaptive and mitigative action?; and, (5) Do predictors of support for adaptive action differ from predictors of support for mitigation? We use structural equation modeling (SEM) to assess the relationships between trust, belief, perceived risk, and support for action.

Beliefs, Perceived Risk, Trust, and Responses to Climate Change

Because there is a paucity of literature on farmers' understandings of and response to climate change, we draw on the burgeoning body of research that examines the general public's beliefs, attitudes, policy preferences, and behaviors associated with climate change to inform our analysis. Much of this research has built on the "values-beliefs-norms" (VBN) framework for analyzing relationships between environmental concerns and behavior (e.g., Brody, Grover, & Vedlitz, 2012; Dietz, Dan, & Shwom, 2007). The VBN framework was developed primarily by Stern and colleagues (Dietz, Fitzgerald, & Shwom, 2005; Stern, 2000) to help frame the investigation of relationships between pro-environmental behaviors and key explanatory variables such as personal values, beliefs, attitudes, and norms. The model

proposes a causal chain of several categories of variables that together explain a substantial amount of variance in environmentally significant behavior. Loosely described, the categories are personal values; beliefs, including environmental worldviews; understandings of the causes and consequences of environmental problems; personal capacity to address those problems; and personal norms or sense of moral obligation to take action (Stern, 2000, p. 412).

The VBN's environmentally oriented synthesis of a number of other behavioral models (e.g., the theory of planned behavior [Ajzen, 1991]) has proved useful in conceptualizing and analyzing the determinants of pro-environmental behavior (Dietz et al., 2005). We look to the VBN literature, particularly that which has focused on public response to climate change, as a reference and guide to the development of a conceptual framework specific to our research questions about the relationships between trust in agents of influence, beliefs about climate change, perceived risk, and support for adaptive and mitigative responses in agriculture.

Beliefs About Climate Change and Support for Action

Individuals' beliefs about the world and their place in it are central to most major behavioral models. The expectancy-value (EV) model (Fishbein, 1963), the theory of planned behavior (Ajzen, 1985), and the VBN theory (Stern, 2000), all posit that beliefs provide the foundation from which attitudes toward objects and actions are formed, and those attitudes can be highly predictive of behaviors. It is critical to recognize, however, that beliefs may not be scientifically based and may vary substantially between individuals and groups. Indeed, "they may be irrational, based on invalid or selective information, be self-serving, or otherwise fail to correspond to reality," but nevertheless "form the cognitive foundation for many of our responses to aspects of that world" (Ajzen & Gilbert Cote, 2008, p. 290). This observation is particularly salient in relation to beliefs about climate change given the variance in U.S. public understanding of the phenomenon (Maibach et al., 2009; Weber & Stern, 2011).

Studies examining the relationships between beliefs about climate change and behavior or policy support have used varied and generally indirect measures of belief. Dietz et al. (2007) used two measures of "climate change information" consisting of (1) number of times respondents had obtained information specifically about climate change from various sources including newspapers, magazines, television, and the like and (2) a scale measure of

how “well informed” about climate change respondents considered themselves to be. O’Connor, Bord, and Fisher (1999) and O’Connor, Bord, Yarnal, and Wiefek (2002) measured belief in climate change through a single-scale item rating the likelihood that average global temperatures would rise over the following 50 years, and measured understanding of causes through an index of several 3-point scales assessing the perceived role of several potential causes of climate change (e.g., heating and cooling homes). Zahran, Brody, Grover, and Vedlitz (2006, p. 779) used two climate change “knowledge” variables. The first was measured through true/false responses to two statements: “Nitrous oxide is a greenhouse gas” and, “The major cause of increased atmospheric concentration of greenhouse gases is burning of fossil fuels.” Brody et al. (2012) used an index measure constructed from five true/false statements about climate change and its causes, including items regarding scientific certainty about sea-level rise and increases in global precipitation, whether fossil fuels increase atmospheric concentration of GHGs, and whether N_2O is a GHG.

Findings on the relationships between these varied dimensions of belief and support for action have been mixed. Dietz et al. (2007) found no relationship between exposure to sources of information or self-rated knowledge about climate change and support for climate change policy. O’Connor et al. (1999) found belief that global average temperature would rise over the next 50 years and knowledge of the causes of “global warming” to be positive predictors of policy support. On the other hand, O’Connor et al. (2002) found no associations between belief in temperature rise and policy support or expressed likelihood of engaging in voluntary GHG-reducing behaviors, but did find positive relationships between understanding of causes and both of those variables. Zahran et al. (2006) found a correlation between climate change policy support and knowledge about GHGs. Brody et al. (2012), on the other hand, detected no relationship between their larger set of climate knowledge/causes scale and willingness to adopt climate change mitigation behavior. Such studies have provided valuable insight into the role that different dimensions of climate change beliefs may play in shaping responses to climate change. However, variability in the measures used has made synthetic interpretation of results difficult.

Given that erroneous public understanding of climate change has been proposed as an important roadblock to public action (Weber & Stern, 2011), it may be that inconsistencies in the measurement of public understanding of climate change is a barrier to better understanding of the relationships between beliefs and behavior/policy support. While use of straightforward measures of beliefs about climate change and its causes are common in public polling on the issue (e.g., Leiserowitz, Maibach, & Roser-Renouf, 2011)

or used as dependent variables (e.g., McCright & Dunlap, 2011a), they are rarely used as predictors of policy support or behavior. Thus, most attempts to improve our understanding of the links between beliefs about climate change and behavioral and policy responses have used indirect rather than direct measures of belief and attribution. In other words, measures such as knowledge that N_2O is a GHG may not be robust proxies for overall beliefs about whether climate change is occurring and what its causes are. As noted above, direct measures of belief and attribution have been used in surveys: It is known that some people strongly believe that climate change is occurring and attribute it to human activity, others do not believe that it is happening, and still others are uncertain (e.g., Maibach et al., 2009). Such direct measures of climate change belief are not, however, commonly employed as predictors in multivariate modeling of behavior, support for policy, or other social action.

Perceived Risk

Perceived risk has been a central focus of research on response to climate change. Risk perception corresponds to beliefs about “adverse consequences for valued objects” (AC) and is central to the VBN framework (Stern, 2000, p. 412). Risk perception has generally been measured as an individual’s assessment of the potential health, economic, and general environmental consequences of climate change at local, regional, and global levels (Brody et al., 2012; Brody, Zahran, Vedlitz, & Grover, 2008; Dietz et al., 2007; Leiserowitz, 2006; O’Connor et al., 1999, 2002; Zahran et al., 2006). Results of empirical research examining the relationships between perceived risk and public responses to climate change have been consistent in terms of significance and predictive power. Whether the dependent variable is mitigation policy preferences (Dietz et al., 2007; Leiserowitz, 2006; Zahran et al., 2006) or mitigative behavioral intentions (O’Connor et al., 1999, 2002), perceived risk has consistently been found to be among the strongest positive predictors of support for climate change policy and behavior. The few studies that have included measures of “objective” risk (e.g., Brody et al., 2008, 2012; Zahran et al., 2006) have reported that *perceptions* regarding the severity of risk associated with climate change outweigh objective risk factors such as proximity to the coast as determinants of climate policy support.

Although findings have been consistent, it is important to take into account that perceptions of risk from climate change may vary with understanding and knowledge of the phenomenon. Perceived risk is an affect heuristic, based on experiential learning and emotional response to external stimulus (Slovic, 2009; Weber & Stern, 2011), and influenced by factors that may

cause over- or under-estimation of risk. The tendency toward associative and affective processes and reliance on mediated information creates vulnerability to competing climate change frames put forth by interest groups (Weber & Stern, 2011), and suggests that the potential influence of such groups should be examined.

Trust in Institutional Actors

In an increasingly globalizing and specializing society, we are ever more dependent on what Giddens (1990) termed *abstract* or *expert* systems. This is especially true for potentially globalized phenomena such as nuclear war or ecological catastrophe that people cannot “opt out of” (Giddens, 1990, p. 84). Such large-scale phenomena necessarily place the responsibility for management of associated risks on large, complex institutional contexts (Freudenburg, 1993). As society has become progressively more reliant on expert systems to manage risk, trust in the capacity of those systems and their component agencies and organizations to fulfill their mandate has come to have a significant influence on perceptions of large-scale risk (Freudenburg, 1993; Kahan et al., 2011). While “the central tendency is to see most such technological systems as having worked properly, the vast majority of the time” (Alario & Freudenburg, 2003, p. 199), periodic failures that cause harm can also lead to questioning of the ability “of institutional actors to carry out their responsibilities with the degree of vigor necessary to merit the societal trust they enjoy” (Alario & Freudenburg, 2003, p. 200). Thus, perceptions of the seriousness of risks depend in large part on the degree to which we trust actors in expert systems to manage them appropriately (Freudenburg, 1993; Kahan et al., 2011).

As Dietz et al. (2007) noted, people who make decisions under conditions of uncertainty and imperfect knowledge tend to look to trusted institutions for guidance, and level of trust correlates with public acceptance of policy response. However, social actors who profit from the *status quo* can seek to influence discourse and the shaping of knowledge (Dietz, Frey, & Rosa, 2002). The issue of climate change, in particular, has been highly contested, especially in the United States, with varied actors seeking to frame the issue and potential responses in ways that favor their interests (Weber & Stern, 2011). While institutions such as the U.S. Environmental Protection Agency (USEPA), the IPCC, and the U.S. National Climate Assessment (NCA) have worked to inform society about the risks of and potential responses to climate change, some interest groups have mounted substantial counter-efforts to “manufacture uncertainty” regarding the phenomenon and shape discourse about how society should or should not respond (Dunlap & McCright, 2010). Predominant strategies include “denial of global warming, the denial of its

anthropogenic sources and the denial of its seriousness” (Dunlap & McCright, 2010, p. 240). Such mediation of information by interest groups has muddled public understanding of climate change and retarded public action (Weber & Stern, 2011).

The recognition that public understanding of climate change is mediated by intermediary sources has led to the use of variables measuring trust in such entities as predictors of policy support. Zahran et al. (2006) found that confidence in the competence of the EPA, the National Oceanographic and Atmospheric Administration (NOAA), and the IPCC to “solve the problem of climate change” predicted support for climate change policy. Dietz et al. (2007) found that generalized trust in government agencies and scientists working for the government was a positive predictor of climate policy support, while trust in industry (oil companies, coal companies, and scientists working for industry) was negatively associated. O’Connor et al. (1999) found the degree to which survey respondents believed that government is a “helpful” institution predicted higher levels of willingness to endorse climate change mitigation policy. Thus, research suggests that trust in entities that are working to address climate change is associated with support for climate change policy, while trust in actors that have historically opposed action on climate change (i.e., industry) is associated with negative attitudes toward such action.

Adaptation and Mitigation in Agriculture

Climate change adaptation and mitigation in agriculture are related concepts, but have important biophysical, economic, and conceptual differences that may affect farmer attitudes toward action. Adaptation is defined as “initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects” (IPCC, 2007, p. 809). Adaptation has always been central to farming, and over millennia farmers have generally been adept at adapting agriculture to a changing environment (Organisation for Economic Co-operation and Development [OECD], 2012). Although farmers manage at multiple scales, their adaptation decisions are primarily driven by private benefits reaped in the here and now (Jackson et al., 2010). Examples of adaptation of agriculture to the impacts of climate change might include adjustments in planting dates, crop varieties, drainage systems, and land management regimes to maintain yields and soil fertility. In the U.S. Midwest, commonly recommended adaptive actions include increased use of practices such as minimization of tillage and use of cover crops to protect soils from erosion and build soil organic matter (Lal et al., 2011). Such practices have relatively observable, immediate impacts, such as reduced

vulnerability, that accrue largely to the individual farmer or landowner who adopts them (Walthal et al., 2012). Thus, adaptation strategies are familiar and have tangible individual-level benefits.

Whereas adaptation has long been integral to agriculture, climate change mitigation is a relatively new attitude object. Mitigation is defined as “technological change and substitution that reduce resource inputs and emissions per unit of output” (IPCC, 2007, p. 818). In agriculture, mitigation is focused primarily on reducing GHG emissions and/or increasing carbon sequestration and storage (IPCC, 2007). In contrast to adaptation action, the potential benefits of mitigation action are uncertain, entail substantial lag time, and accrue globally rather than locally (Walthal et al., 2012). Because the benefits of mitigative action are diffuse, much of the public discussion related to GHG production and mitigation to reduce emissions has focused on *collective* responses by civil society, private sectors, and, especially, government bodies (World Bank, 2012). In agriculture, too, major proposed strategies to induce GHG reduction have focused on collective, government-led responses including legislative mandates to reduce emissions, emissions taxes, and cap and trade regimes (Council for Agricultural Science and Technology [CAST], 2011).

Hence, while adaptation and mitigation policy and action are responses to threats from climate change, they are fundamentally different. Whereas adaptation is generally initiated at the local level by individuals or communities in reaction to specific threats, mitigation action tends to be initiated at the international or national levels and managed by government bodies (Klein et al., 2007). Furthermore, the rationale for mitigation in agriculture is almost entirely predicated on the assumption that human production of GHGs is the primary driver of climate change. Thus, while adaptation in agriculture is relatively routine—farmers continuously adapt to changing conditions regardless of beliefs about climate change—attitudes toward and willingness to support mitigative action are likely influenced largely by beliefs about climate change and the role of human activities as a cause.

Hypotheses

The literature reviewed above indicates that beliefs about climate change and perceptions of associated risks can be important predictors of public support for climate change action. Furthermore, evidence suggests that the mediating influence of actors that attempt to shape the framing and debate over climate change and societal responses should be accounted for in analyses of public understanding of climate change. Based on this previous research, for this study of Iowa farmers, we propose two models that posit pathways of

effect-prioritized relationships between trust in agricultural and environmental interest groups as sources of climate change information, beliefs about climate change and its causes, the perceived risks of climate change for agriculture, and support for (1) adaptive or (2) mitigative responses to climate change among Iowa farmers.

Our specific hypotheses are as follows:

Hypothesis 1a (H1a): Trust in agricultural interest groups will be negatively associated with belief in human-induced climate change;

Hypothesis 1b (H1b): Trust in environmentally oriented interest groups will be positively associated with belief in human-induced climate change;

Hypothesis 2 (H2): Belief that climate change is occurring will be positively associated with perceptions regarding risks to agriculture;

Hypothesis 3 (H3): Higher levels of perceived risk will predict stronger support for adaptation responses to climate change;

Hypothesis 4 (H4): Belief that climate change is occurring and caused by human activity will have a direct, positive effect on support for mitigation policy.

Method

Study Context and Data Collection

The study focuses on farmers in the state of Iowa, the top U.S. producer of corn and soybean (U.S. Department of Agriculture National Agricultural Statistics Service [USDA NASS], 2012). Climate change-related shifts in long-term weather patterns predicted for the state include warmer winters, longer growing seasons, higher dew point temperatures, higher annual stream flow, and more frequent extreme weather events (Iowa Climate Change Impacts Committee [ICCIC], 2011). While changes such as a longer growing season may be favorable to Iowa agriculture, others could lead to negative impacts such as increased soil erosion, delays in planting or crop damage, higher incidence of pests and disease, and heat-induced pollination problems (Hatfield et al., 2011; Rogovska & Cruse, 2011). Iowa has experienced many of these in recent years (ICCIC, 2011), and thus represents a suitable context for research on farmer attitudes toward adaptation to such impacts.

Agriculture also emits a disproportionately high percentage of Iowa's overall GHGs relative to other states. Whereas agriculture directly generates about 7% of US GHGs through activities such as enteric fermentation in ruminant livestock, manure management, and use of nitrogen fertilizers (USEPA, 2013, p. 6-1), in 2011, direct emissions of GHGs from agriculture

comprised 26% of Iowa's overall GHG emissions (Iowa Department of Natural Resources [IDNR], 2012, p. 3). Fifty-nine percent of agricultural GHGs stemmed from soil management for grain production and the balance from livestock production and waste (IDNR, 2012, p. 5). These activities primarily generate the potent GHGs CH₄ and N₂O, which have "global warming potentials" 21 and 310 times that of CO₂, respectively (Forster et al., 2007, p. 212). Thus, Iowa also provides an appropriate context for examining farmer attitudes toward mitigation action.

The data for this research were collected through the 2011 Iowa Farm and Rural Life Poll (IFRLP), an annual statewide survey of Iowa farmers conducted by Iowa State University Sociology Extension. Iowa Agricultural Statistics administers the survey following a survey–postcard–survey mailing protocol. The 2011 survey was mailed to 2,030 farmers in February 2011. Useable surveys were received from 1,276 farmers, for a response rate of 63%.

A note regarding the sample is warranted. The original survey panel was a random sample drawn from the Census of Agriculture master list, and the survey panel is periodically refreshed with random samples from this list to address attrition due to retirement and other factors. Because the IFRLP focuses so heavily on agricultural activities, many smaller-scale "farmers" who are sampled because they could potentially produce US\$1,000 in sales (the USDA definition of farm), but do not actually farm, choose not to participate because the surveys do not apply to them. A comparison of 2011 IFRLP and 2007 Census of Agriculture statistics shows that this process has led to an IFRLP sample bias toward larger scale farmers. IFRLP farmers operated an average of 402 ac in 2011, compared with 331 ac among the 2007 census population. A comparison of farm sales finds that 15.2% of IFRLP farmers had 2011 gross farm sales of less than \$10,000, compared with 38.6% of the 2007 Census population. At the other end of the sales spectrum, 48.2% of IFRLP farmers had 2011 sales greater than \$100,000, compared with 35.6% for the 2007 census population (USDA NASS, 2009). While this bias toward larger scale farmers might be seen as a liability for some research efforts, for this study it is considered an asset because larger scale farms operate a disproportionate amount of acreage. For example, whereas only 39% of Iowa farms generate \$100,000 or more in gross sales, they operate 83% of farmland acreage (USDA NASS, 2009). Thus, our findings regarding attitudes toward adaptation and mitigation activities are biased toward farmers who generate a larger proportion of Iowa's agricultural production and farm operations that are reflective of mainstream, conventional agricultural systems in the Upper Midwest.

Variables in the Model

Trust in institutional actors as sources of climate change information was measured through a five-point construct-specific scale ranging from strongly distrust (1) to strongly trust (5) applied to a number of agencies, organizations, and other groups. The list was based on several public opinion polls, especially Leiserowitz, Maibach, and Roser-Renouf (2009), with the addition of a number of agriculture-specific actors. Survey research examining the relationship between trust and climate change response has generally focused on entities that promote societal responses to climate change (e.g., the EPA or IPCC in Zahran et al., 2006). To our knowledge, only Dietz et al. (2007) included groups that could be expected to have positive and negative influences on beliefs regarding climate change. Like Dietz et al. (2007), we include groups that in general are *not* supportive of societal action on climate change. Our variables focused on trust *specific to climate information* rather than on generalized trust in agencies, organizations, or corporate interest groups (Table 1).

Following McCright and Dunlap's (2010) analysis of interest groups that attempt to shape discourse and knowledge about climate change, its causes, and potential impacts, and in line with hypotheses H1a and H1b, we categorize a diverse range of groups as *environmentally oriented interests* and several groups as *agricultural interests*. Six entities and actors in the environmental interest category were included in the survey: "federal agencies," "state agencies," "conservation organizations," "environmental organizations," "scientists," and "the mainstream news media." All of these categories of actors have been associated with beliefs that climate change is occurring, that it is caused at least in part by human activity, and that society needs to adapt and/or mitigate in response (see Dietz et al., 2002; Freudenburg & Muselli, 2010; McCright & Dunlap, 2010).

Mainstream agricultural interest groups have long opposed climate change policy. Farm groups, principal among them the influential American Farm Bureau Federation, have consistently voiced opposition to climate legislation (American Farm Bureau Federation, 2012; Dunlap, 2010; Iowa Corn Growers Association, 2011; Union of Concerned Scientists, 2010; Winter, 2010). We include three general categories of agriculture-related entities that represent agricultural interests: "farm groups," the "farm press," and "agribusiness companies" (Table 1).

Beliefs about climate change and its causes are measured through ordered responses to a single question that combines belief and attribution. Beliefs regarding climate change and its causes are often measured through a two-stage question set that first ascertains beliefs about whether the phenomenon

Table 1. Trust^a Variables: Summary Statistics.

Label	Item	M	SD	Strongly distrust (%)	Somewhat distrust (%)	Neither trust nor distrust (%)	Somewhat trust (%)	Strongly trust (%)
<i>Trust in agricultural interests (AG)</i>								
AG1	Farm groups	3.2	0.9	3.7	15.7	40.5	36.4	3.6
AG2	The farm press	3.1	0.9	5.2	17.9	42.7	32.2	1.9
AG3	Agribusiness companies	2.9	0.9	6.9	22.4	46.5	22.9	1.3
<i>Trust in environmental interests (ENV)</i>								
ENV1	Scientists	3.2	1.0	4.9	17.7	35.8	34.3	7.4
ENV2	Conservation organizations	2.9	1.0	10.6	22.9	33.9	30.2	2.3
ENV3	State agencies	2.8	1.0	9.5	28.2	34.8	25.2	2.3
ENV4	Federal agencies	2.6	1.1	18.0	30.7	28.4	20.9	2.1
ENV5	Environmental organizations	2.3	1.1	28.9	29	23.5	15.7	2.3
ENV6	The mainstream news media	2.2	1.0	30.9	31.3	28.6	8.6	0.6

^aIntroductory text: "Thinking about the following agencies, organizations, and groups, how much do you trust or distrust them as sources of information about climate change and its potential impacts?"

Table 2. Observed Frequencies for Climate Change Belief.

Variable	Category ^a	Proportion (%)
NOCC (1)	Climate change is not occurring.	4.6
UNCERT (2)	There is not sufficient evidence to know with certainty whether climate change is occurring.	27.0
NAT (3)	Climate change is occurring and it is caused mostly by natural changes in the environment.	23.0
HUMNAT (4)	Climate change is occurring, and it is caused equally by natural changes in the environment and human activities. ^b	35.0
HUM (5)	Climate change is occurring, and it is caused mostly by human activities.	10.4

^aThe survey items were preceded by the text, “There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs about climate change.”

^bResponse Category 4, which allowed respondents to attribute climate change to both human and natural causes, was included because polling has consistently found that survey respondents volunteer this response (e.g., Leiserowitz et al., 2009, 2011).

is occurring, and second establishes beliefs about attribution (e.g., Leiserowitz et al., 2009, 2011). We combine belief about the existence of climate change and its causes into a single ordinal question to allow modeling of variance associated with conceptually ordered combinations of belief and attribution and testing of the hypothesis that perceived risks associated with climate change and support for societal response will vary according to those ordered combinations (Table 2).

Perceived risks associated with climate change are measured through four items that were measured on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Three items elicited responses about potential impacts of climate change on agriculture. One item was developed from the New Environmental Paradigm (NEP) literature (see Dunlap, 2008), specifically drawing on the “human exemptionalist” thread of that literature highlighting a widely held belief that “. . . humans—unlike other species—are exempt from the constraints of nature” (Dunlap, Van Liere, Mertig, & Jones, 2000, p. 432). The item measures the degree to which farmers believe that human ingenuity will reduce threats from climate change by facilitating adaptation to changes (Table 3).

Support for adaptive and mitigative responses to climate change was measured through three items, measured on a 5-point scale ranging from 1 (*strongly*

Table 3. Perceived Climate Risk and Climate Change Action Items.

Label	Item	M	SD	Strongly disagree (%)	Disagree (%)	Uncertain (%)	Agree (%)	Strongly agree (%)
RISK1	I am concerned about the potential impacts of climate change on Iowa's agriculture.	3.2	1.1	9.4	16.1	31.4	35.2	8.0
RISK2	I am concerned about the potential impacts of climate change on my farm operation.	3.3	1.0	5.6	14.0	34.7	36.9	8.9
RISK3	I believe that extreme weather events will happen more frequently in the future.	3.0	1.0	8.5	20.4	35.8	30.2	5.1
RISK4	Climate change is not a big issue because human ingenuity will enable us to adapt to changes.	3.0	1.0	8.8	21.1	37.4	28.0	4.8
PROTECT	Iowa farmers should take additional steps to protect their land from increased precipitation.	3.5	1.0	4.2	10.8	23.3	52.2	9.5
DRAIN	Iowa farmers should increase investment in agricultural drainage systems (tile, ditches) to prepare for increased precipitation.	3.3	0.9	4.4	14.2	36.0	38.9	6.4
MITIGATE	Government should do more to reduce the nation's greenhouse gas emissions and other potential causes of climate change.	2.9	1.2	14.2	21.9	30.7	25.0	8.2

disagree) to 5 (*strongly agree*), gauging the degree to which participants support specific adaptation and mitigation actions. Two items focused on adaptation responses specific to a major predicted impact of climate change on Iowa agriculture: increased incidence of precipitation (ICCIC, 2011). The first item, "Iowa farmers should take additional steps to protect their land from increased precipitation," focuses on protection of agricultural land from increases in rainfall. Extreme rain events in 2008 and 2010 resulted in significant, widespread erosion across Iowa (Cox, Hug, & Bruzelius, 2011), raising awareness of the issue and a potential need to act. The second adaptation statement, "Iowa farmers should increase investment in agricultural drainage systems (tile, ditches) to prepare for increased precipitation," is particularly salient for Iowa farmers given the hydrological history and current profile of Iowa's most productive agricultural lands. Artificial drainage of Iowa's humid prairie, the soils of which contain extraordinary amounts of organic matter (Mutel, 2007), facilitated cultivation of these highly fertile soils and made Iowa a leading agricultural state (Peterson & Englehorn, 1946; Soil Conservation Service [SCS], 1983). Drainage represents a longstanding engineered solution to the problem of "excess" water in Iowa, and a logical adaptive strategy for maintaining productivity in the face of future increases in precipitation.

The mitigation item, "Government should do more to reduce the nation's greenhouse gas emissions and other potential causes of climate change," is a general statement that measures farmer support for public action to address the anthropogenic causes of climate change. It reflects the fact that mitigation is generally initiated by government bodies (Klein et al., 2007) and that major proposals for mitigation action in agriculture are government-led (CAST, 2011). Support for mitigation implies an acceptance that human activity is a driver of climate change and collective action is necessary to incentivize, regulate, or otherwise induce changes in behavior.

Analytical Approach

We use structural equation modeling (SEM) to test the study's hypotheses. Structural equation models are a versatile class of models for characterizing multivariate relationships. The general SEM combines factor analysis and regression models to allow structural relationships among latent variables (Bollen, 1989). We construct two multivariate models that draw on SEM techniques. Specifically, these models contain relationships among latent variables that represent trust in agricultural and environmental interests, belief in and attribution of climate change, perceived climate risks, and support for action. Model 1 investigates support for adaptive action, and Model 2 investigates support for mitigative action.

The variables used in the analysis all consist of ordered response categories. Since traditional SEM methodology incorporates covariance structures assuming continuous responses, we modify the SEM approach to appropriately account for the discrete but ordered nature of the data (Kim, Das, Chen, & Warren, 2009). Briefly, the approach links the observed responses to unobserved continuous variables through an ordinal probit model, and these continuous variables then form a SEM. This allows for efficient estimation, which we accomplish through Bayesian analysis. Further model and estimation details can be found in the online appendix.

Two models are developed to test the hypothesized relationships between trust, beliefs, perceived risks, and support for climate change adaptation and mitigation responses. Both models examine hypotheses H1a and H1b through a structural regression of beliefs about climate change on trust in agricultural and environmental interests as sources of information about climate change. In addition each model includes a structural path from beliefs about climate change to perceived risks to test H2. The response variable for Model 1 is support for adaptation (H3). The dependent variable for Model 2 is support for mitigative action (H4).

Results

Descriptive Statistics for the Variables in the Model

Responses for the nine items that comprise the two *trust* variables—trust in agricultural and environmentally oriented entities, respectively, as sources of information about climate change—varied substantially. Among the agricultural interests, the percentage of farmers who indicated at least some trust ranged from 40% for “farm groups” to 24% for “agribusiness companies” (Table 1). Among environmentally oriented groups, “scientists” were the most trusted (42%) and the mainstream news media were the least trusted (9%).

Results for the *climate change belief and attribution* variable revealed that most farmers (68%) believed that climate change is occurring (Table 2). Attribution of cause varies substantially, with just 10% believing climate change is mostly attributable to human activities. Slightly more than one third believed that it is caused by natural changes and human activities equally, and 23% believed it is mostly due to natural variation. Furthermore, a sizable proportion of farmers believed there is not enough evidence to determine if it is occurring (27%) or it is not happening at all (5%).

Summary statistics for the four items that measure *perceived risks* associated with climate change are presented in Table 3. The items that elicited the highest levels of agreement were concern about impact on the respondents’

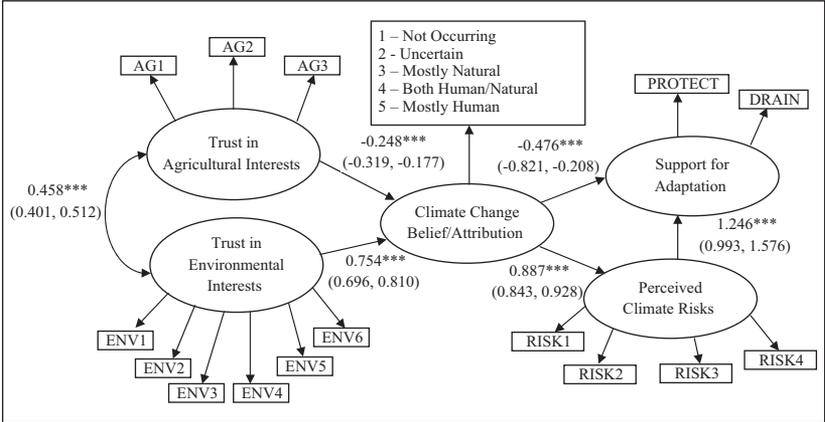


Figure 1. Model 1: Adaptation path diagram and standardized structural coefficients with 95% credible intervals in parentheses.

*p < .05. **p < .01. ***p < .001.

own operations (46% agreement) and on Iowa agriculture in general (43%). Thirty-five percent of farmers indicated belief that extreme weather would become more common in the future. On the other hand, 33% agreed that climate change is not a big issue because human ingenuity will enable us to adapt to changes.

Results showed substantial levels of support for both adaptation-related items. About two thirds of respondents agreed that farmers should take steps to protect their land, and 45% agreed that investment in agricultural drainage systems should be stepped up (Table 3). Support for government actions to mitigate climate change through GHG reduction was lower, with 33% of farmers in agreement with that statement.

Structural Relationships: Trust, Belief, and Perceived Risk

The structural coefficients for Models 1 and 2 are presented on their respective paths in Figures 1 and 2, respectively. The Tucker–Lewis goodness-of-fit index (TLI) measures the incremental improvement in a model’s fit to the observed covariance structure over a null model and typically ranges from 0 to 1 (Tucker & Lewis, 1973). For the Bayesian analysis, the posterior mean TLI can be computed from samples of the posterior distribution. The TLI for Model 1 is 0.784, and the TLI for Model 2 is 0.783, suggesting adequate fits. The models show key similarities in the relationships among trust, climate change belief, and perceived risk. The correlation between the two trust

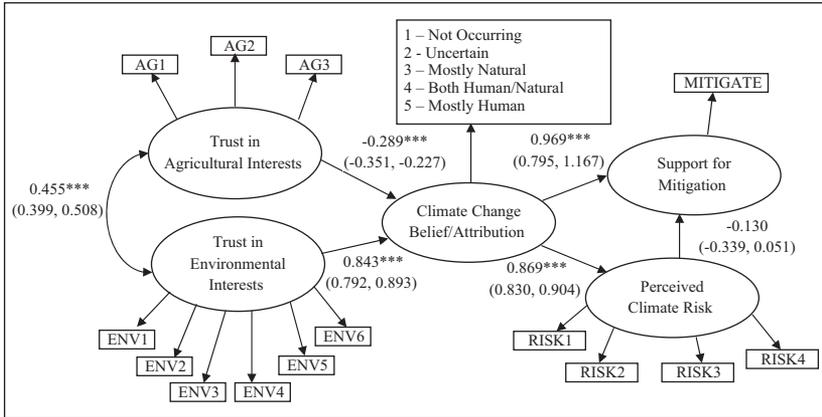


Figure 2. Model 2: Mitigation path diagram and standardized structural coefficients with 95% credible intervals in parentheses.

* $p < .05$. ** $p < .01$. *** $p < .001$.

constructs (0.46) is measured to control for generalized trust, or the degree to which individuals tend to trust others (Hammar & Jagers, 2006).

Regression coefficients for climate change belief and attribution were significant. Trust in environmentally oriented interests is positively associated with belief, meaning that respondents who expressed trust in these groups as sources of information about climate change were more likely to believe that climate change is occurring and attributable to human sources. An opposite but somewhat weaker relationship was found between trust in agricultural interests and climate change belief. Respondents who expressed higher levels of trust in agricultural interests were relatively more likely to be uncertain or not believe that climate change is occurring. These structural coefficients support H1a and H1b.

Furthermore, these mediated understandings of climate change had a direct effect on perceived risk. The significant and positive path coefficient between belief and perceived risk in both models indicates that farmers who believe climate change is occurring and associated with human activity expressed substantially higher levels of concern. These structural relationships between belief and perceived climate risk support H2.

Belief, Perceived Risk, and Adaptation

In turn, beliefs about climate change and perceived risks were related to farmer support for adaptive actions. Model 1 incorporates support for

adaptive action as a response variable, and models both direct and indirect effects of beliefs on support for adaptive action (Figure 1). The coefficient for the path from perceived risk to support for adaptive action is positive and significant, indicating that individuals with higher than average levels of perceived risk tend to have higher levels of support for adaptation. Although smaller in magnitude, the coefficient measuring the direct effect of belief on support for adaptation is negative and significant. However, the paths from belief to perceived risk and from risk to adaptation are significant and positive. The total effect is positive, indicating a strong indirect effect on support for adaptation through perceived risk. In other words, farmers who had higher scores on the ordinal climate change belief scale *and* perceived higher risks of negative impacts were more likely to endorse adaptive action. Overall, the model indicates that endorsement of adaptive action was associated primarily with higher levels of perceived risks. This result supports H3.

Belief, Perceived Risk, and Mitigation

Model 2's response variable is support for government action to reduce GHG emissions (Figure 2). The coefficient measuring the relationship between climate change belief and support for mitigation is positive and significant. This suggests that belief in climate change and attribution to human activities is associated with stronger support for government mitigation policy. On the other hand, the coefficient measuring the indirect effect through perceived risk is not significant.

The positive, direct effect of belief on support for mitigation indicates that farmers who believe that climate change is occurring tended to agree that public action on GHG reduction is appropriate, and those farmers who attribute climate change to human activity agree more strongly. These results support H4. Furthermore, the results suggest that trust in agricultural and environmentally oriented groups as sources of information about climate change have negative and positive indirect effects, respectively, on support for mitigation through climate change belief. The lack of significance for the path from perceived risk to mitigation suggests that risk perception does not mediate support for government action on GHGs.

Discussion

As concerns about the impacts of climate change on the long-term productivity of Iowa's soil resource base (Cox et al., 2011), awareness of Iowa agriculture's disproportionate contribution to the state's GHG emissions (IDNR, 2012), and exhortations to adapt to changes in climate and reduce

GHG emissions (e.g., Hatfield et al., 2011; Lal et al., 2011) mount, it is increasingly important that effective strategies to assist the agricultural community be developed. Dunlap (2010) posed several related questions that are central to this complex issue:

... will farmers ... respond more to climate-change messages from universities and USDA, or to those from [other interest groups]? Will they interpret problematic weather as evidence of long-term climate change, and accept that they must learn to adapt, or dismiss it as a “bad year” produced by natural cycles? ... how can the importance of responding to climate change be conveyed convincingly to farmers? (p. 24)

This study begins to answer these pressing questions, and our findings have practical implications that can inform efforts to improve adaptation and mitigation efforts in Iowa and across the Corn Belt. The findings that trust in agricultural and environmental actors is associated with farmers’ beliefs about climate change, and those variations in belief structure are related to risk perceptions and attitudes toward action point to potential pathways for such outreach. In particular, the divergence of results on farmer attitudes toward adaptation and mitigation actions indicate that different approaches to outreach strategies will be required for these related but distinct responses to climate change.

Trust in Key Actors and Climate Change Beliefs

Our findings on trust have important implications for outreach to farmers and the agricultural community. First, the results imply that Iowa farmers are heterogeneous in terms of whom they trust on climate change. Many farmers expressed trust in environmentally oriented organizations as sources of information about climate change (Table 1), and those farmers were more likely to believe that climate change is happening and due to human action, that it poses risks to agriculture, and that action should be taken. In other words, such farmers are concerned and open to adaptive and mitigative action.

On the other hand, farmers who express higher levels of trust in agricultural interests are less likely to believe in climate change, much less anthropogenic causes. These results provide evidence that the “manufacturing of uncertainty” that has played a role in shaping the general public’s beliefs about climate change (Dunlap & McCright, 2010) may also be at work in agriculture. As noted above, key agricultural interests have denied a connection between climate change and human activity; this study’s findings suggest that so-called “denial machine” tactics (Dunlap, 2010; Stuart et al. 2012) may have an impact on how farmers think about climate change. This result points to challenges and

opportunities: If farmers trust farm groups and the agricultural press for information on climate change, it is critical that the climate research and policy community engage more with these groups, especially the farm press. While this might be difficult given the reluctance of some actors to engage in discussion of climate change and potential responses, because these groups may influence farmer beliefs and attitudes, working with them is imperative.

Adaptation Approaches

Our results show that Iowa farmers largely endorse adaptive action focused on preparing for more extreme weather events. However, attitudes toward adaptation action were associated with beliefs and perceived risks; farmers who believed that climate change is occurring *and* perceived threats specific to farming were significantly more likely to support action to protect land from future extreme weather. In other words, our findings suggest that it is when farmers believe in climate change and perceive it as a “problem” that their willingness to take action is activated. These results also point to potentially important pathways for climate change outreach to farmers. Farming requires more constant adaptation to weather and other biophysical contextual conditions than most occupations, thus farmers are by necessity professional problem solvers (Nowak, 2013). Strategies that appeal to farmers’ creative responses to the problem of extreme weather may be effective avenues for outreach focused on adaptation.

The extreme weather events that have impacted Midwest agriculture (Cox et al., 2011) may be helping to move farmers and major agricultural actors toward a problematization of climate change. For example, a recent report from the 25×’25 Alliance Adaptation Workgroup, a collaboration among major agriculture, forestry, and environmental organizations, highlights the vulnerabilities that recent extreme events have exposed in dominant cropping systems and calls for major adaptation action in agriculture (25×’25 Adaptation Initiative, 2013). This signals an increasing openness to action on climate change among major agricultural actors. Our results showing substantial farmer support for adaptation action, considered together with evidence that mainstream agricultural organizations are beginning to address the need for climate adaptation, point to opportunities to engage farmers and those agricultural actors through the lens of adaptation.

Mitigation Approaches

The findings on mitigation, however, point to a much different dynamic and signal that support for mitigation and adaptation are activated in distinct

ways. Whereas support for adaptation seems to be related to the interplay between beliefs and perceived risks to agriculture, support for mitigation appears to be conditionally independent of perceived risks, and is associated primarily with belief that climate change is occurring (and due to human activity). Moreover, only one third of the farmers endorsed the item measuring support for government action on GHGs, and they were almost exclusively those who indicated that climate change is occurring and due to human activity. Consistent with our expectations and norm activation theory (Roser-Renouf & Nisbet, 2008; Stern, Dietz, Abel, Guagnano, & Kalof, 1999; Weber & Stern, 2011), it appears that only those farmers who assign blame to humans see value in societal efforts to reduce GHGs.

Another important finding was the lack of a statistically significant relationship between perceived risks to agriculture (e.g., “potential impacts on my farm operation”) and support for mitigation. Given that the mitigation variable measured support for government action in a general sense (not specific to agriculture), and that the perceived risk items were specific to agriculture, this result is perhaps not surprising. Whereas adaptive action such as investment in protective conservation practices can have immediate positive impacts at the individual farm level, perhaps neutralizing climate risk, the climate-related impacts of government action on GHGs are diffuse and long-term. Future research might use measures of perceptions of more global, collective risks in addition to local, individual risks to further test variations in scale associated with mitigation.

Our findings suggest that for a majority of farmers, outreach that focuses on mitigation will not likely resonate. Most Iowa farmers do not believe that human actions are responsible for climate change. Furthermore, farmer concerns about potential (local) risks to agriculture were not associated with endorsement of government action on GHGs.

Conclusion

The consensus view among scientists is that to maintain long-term societal food security, we urgently need to reduce agriculture’s vulnerability to predicted changes in climate and reduce GHG emissions (e.g., Hatfield et al., 2011; Lal et al., 2011). The results of this study show that Iowa farmers, in general, seem to be willing to adapt to changing climate conditions and view their responses as risk management strategies to maintain crop productivity. However, perceptions of mitigation activities by government are less straightforward. Farmers who believe that climate change is happening and primarily anthropogenic are more likely to favor government action on GHGs, yet they represent a small fraction of the farmers in our sample. Moreover, more than

half did not believe that climate change is occurring, were uncertain about its existence, or believed that it is primarily due to natural causes.

Our research suggests that farmers (and possibly the greater agricultural community) are more open to adaptation than mitigation. Farmers adapt for a living (OECD, 2012), and they pride themselves on their ability to solve problems (Nowak, 2013). Lobell, Baldos, and Thomas (2013, p. 1) offer a solution to addressing agriculture's contribution to GHG emissions in their findings that "broad-based efforts to adapt agriculture to climate change have mitigation co-benefits" and note that adaptation is often considerably less expensive than actions whose main purpose is mitigation. Many of the practices that reduce vulnerability of cropping systems most effectively—reductions in tillage, planting of a cover crop to hold soil during fallow periods, managing fertilizers more efficiently—can also have significant GHG-reducing properties (Lal et al., 2011). By using outreach strategies that focus on adaptive practices that reduce risks and GHG emissions, the dual goals of adaptation and mitigation could be pursued while engaging the majority of farmers who do not believe in anthropogenic climate change.

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