Climatic Change (2013) 118:551–563
DOI 10.1007/s10584-013-0700-0

Farmer beliefs and concerns about climate change and attitudes toward adaptation and mitigation: Evidence from Iowa

J. Gordon Arbuckle Jr. · Lois Wright Morton · Jon Hobbs

Received: 14 February 2012 / Accepted: 17 January 2013 / Published online: 9 February 2013

Abstract Agriculture is both vulnerable to climate change impacts and a significant source of greenhouse gases. Increasing agriculture's resilience and reducing its contribution to climate change are societal priorities. Survey data collected from Iowa farmers are analyzed to answer the related research questions: (1) do farmers support adaptation and mitigation actions, and (2) do beliefs and concerns about climate change influence those attitudes. Results indicate that farmers who were concerned about the impacts of climate change on agriculture and attributed it to human activities had more positive attitudes toward both adaptive and mitigative management strategies. Farmers who believed that climate change is not a problem because human ingenuity will enable adaptations and who did not believe climate change is occurring or believed it is a natural phenomenon—a substantial percentage of farmers—tended not to support mitigation.

1 Introduction

Global climate change is widely viewed as one of the most significant challenges facing society today. Agriculture, upon which society depends for the food, feed, and fiber that enable sustainable livelihoods, is one of the sectors that is most vulnerable to shifts in climate (IPCC 2007a; NRC 2010). The 2008 extreme rain events and floods in the US Midwest, the 2010 heat and drought in Russia, and the 2010 floods in Pakistan are recent examples of weather-related disruptions of agriculture that led to extraordinary impacts on global food prices and food insecurity for millions of people (IFPRI 2010). Food production is vulnerable to climate shifts because crops and cropping systems are adapted to local conditions: slight perturbations such as temperature fluctuations at critical points in crop

Electronic supplementary material The online version of this article (doi:10.1007/s10584-013-0700-0) contains supplementary material, which is available to authorized users.

J. G. Arbuckle Jr. (✉)
Department of Sociology, Iowa State University, 303C East Hall, Ames, IA, USA
e-mail: arbuckle@iastate.edu

L. W. Morton
Department of Sociology, Iowa State University, 317C East Hall, Ames, IA, USA

J. Hobbs
Department of Statistics, Iowa State University, 3419 Snedecor Hall, Ames, IA, USA

development can have substantial impacts on productivity (Hatfield et al. 2011). Climate change also threatens the long-term capacity for food production through increased soil erosion and reduced soil fertility (Lal et al. 2011). The certainty of increased need for food to feed a burgeoning global population and the uncertainty of the short- and long-term impacts of climate change on agriculture combine to make efforts to enhance the resilience of agricultural systems a top societal priority (IFPRI 2010).

Agriculture is also a major contributor of the greenhouse gases (GHGs) nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2) (Climate Change Position Statement Working Group 2011; IPCC 2007b). Application of synthetic nitrogen fertilizers, a critical input in modern farming systems, results in direct and indirect emissions of N_2O (Lal et al. 2011). Agriculture contributes substantial volumes of CH_4 to the atmosphere through enteric fermentation in ruminant animals, farm animal wastes, and other sources (Climate Change Position Statement Working Group 2011). While agriculture can contribute substantially to carbon storage in soil and plant biomass, current production systems are a significant emitter of CO_2. Moreover, it is estimated that agriculture contributes between 10 and 15 % of global anthropogenic GHG emissions (Climate Change Position Statement Working Group 2011; IPCC 2007b).

The recognition that climate-change related threats to agriculture also represent threats to quality of life on a global scale has led to an increasing amount of attention to adaptation and mitigation strategies for agriculture (e.g., Howden et al. 2007; McCarl 2010). Calls for adaptive action have acknowledged that farmers are both among the most vulnerable groups to climate change and the ones on whom the task of adapting to climate change and mitigating agriculture's contribution to it largely falls (Berry et al. 2006). At the same time, farmer willingness and capacity to respond to climate change is a social process based on the social construction of the risks and vulnerabilities of increasingly variable climate conditions. The farmer is a critical decision maker if agricultural lands are to be effectively managed to adapt to changing climate conditions. Adaptation and mitigation are two basic, but distinctly different responses. Farmer attitudes toward these two general responses to climate change must be understood if climatologists, scientists, policymakers, and others are to effectively support adaptive and mitigative actions in agriculture.

While many recognize that it is important to understand farmer attitudes toward responses to climate change, very little research effort has been focused on this area (Barnes and Toma 2011). As Barnes and Toma (2011) note, much of the empirical investigation of farmer responses to climate change has been conducted in developing country contexts. The few developed country studies have focused on the conceptual level rather than empirically examining potential responses (e.g., Adger et al. 2007), or have created typologies through factor or cluster analyses that group respondents according to characteristics (e.g., Barnes and Toma 2011). While these studies are highly valuable and informative, rigorous multivariate analysis of the relationships between farmer perspectives on climate change and their support for or opposition to adaptive and mitigative action and governance is lacking.

A critical part of this puzzle is perceived vulnerability. As Howden et al. (2007) emphasize, if farmers (1) do not believe that climate change is occurring and/or (2) do not perceive it to be a threat to their livelihoods, they will not likely act to adapt to or mitigate climate change. They maintain that farmer concerns about the impacts of climate change are key to successful adaptation and mitigation. Yet, little research has examined farmer perceptions of vulnerability, much less the relationship between such concerns and adaptive and mitigative actions. This paper presents an analysis of the complex relationships between farmer beliefs about climate change, concerns about vulnerability, and perspectives on both adaptive and mitigative actions.

Adaptation and mitigation are very different concepts, however. Adaptation is defined as "…adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change" (IPCC 2001, 879). Mitigation in a climate change context "…means implementing policies to reduce GHG emissions and enhance sinks" (IPCC 2007b, 818). As such, adaptation to climate change represents an adjustment in response to perceptions of vulnerability with intent to reduce risks to the farming operation. Mitigation, on the other hand, requires farmers to acknowledge, at least tacitly, that human activity is an underlying cause of climate change, and potentially act to attenuate causes. This research (1) assesses farmer attitudes toward key adaptive and mitigative actions in agriculture and (2) examines the factors that predict support for or opposition to such actions.

2 Methods

2.1 Study context

The study focuses on farmers in the state of Iowa in the US upper Midwest. This region, also referred to as the Corn Belt, contains some of the most fertile agricultural land in the world. While the Corn Belt encompasses a fraction of US farmland, it produces over half of all US corn (sp. Zea mays) and soybean (sp. Glycine max) (NASS 2009, 2011). Iowa has long been the top producer of corn and soybean in the US (USDA ERS; NASS 2011). It is also a state that has increasingly experienced extreme weather events that have had adverse impacts on agricultural production and the natural resource base (ICCIC 2011).

Weather changes attributed to climate change in Iowa include warmer winters, longer growing seasons, higher dewpoint temperatures, higher annual streamflow, and more frequent extreme weather events (ICCIC 2011). Some of these changes—such as a longer growing season—may be favorable to Iowa agriculture. Others, such as increased early-season rainfall, dew-points, and temperatures, can 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 and Cruse 2011). Iowa had experienced all of these in the years leading up to the survey, incidence of extreme rainfall and flooding, in particular, and thus represents an excellent setting for research on farmer attitudes toward adaptation and mitigation in agriculture.

2.2 Data

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 %.

2.3 Research questions, variables included in the model, and hypotheses

Two related research questions guide this research: (1) do Iowa farmers support actions aimed at climate change adaptation and mitigation; and, (2) are beliefs and concerns about climate change associated with support for or opposition to those activities. Analysis focuses

primarily on the relationships between three measures of attitudes toward adaptive and mitigative activities and variables that measure farmer beliefs regarding climate change and concerns about potential impacts on Iowa agriculture. This section introduces the variables employed in the analyses, provides descriptive statistics, and outlines the hypothesized relationships between the dependent and independent variables.

2.3.1 Dependent variables

Adaptation Two dependent variables measure support for adaptation to climate change and one measures support for mitigation. All three variables consist of statements that elicited farmer agreement or disagreement on a five-point scale from strongly disagree (1) to strongly agree (5). The two adaptation statements focused specifically on potential responses to intensification of rainfall, a primary impact of climate change predicted for Iowa (ICCIC 2011). The first, "Iowa farmers should take additional steps to protect their land from increased precipitation," measures belief that farmers ought to prepare farmland for potential future increases in precipitation (PROTECT). In the Iowa context, such protective steps consist of establishment or improvement of conservation practices including grassed waterways, terraces, and riparian buffers (Kling et al. 2007) many of which are also promoted as adaptive and/or mitigative actions for agriculture (Lal et al. 2011). A majority of farmers (62 %) agreed or strongly agreed that farmers should take additional steps to protect land (Table 1).

The second adaptation statement, "Iowa farmers should increase investment in agricultural drainage systems (tile, ditches) to prepare for increased precipitation," (DRAIN) is particularly salient for Iowa farmers given the hydrological history and current profile of Iowa's most productive agricultural lands. Prior to European settlement, much of Iowa consisted of humid prairie whose soils contained extraordinary amounts of organic matter (Mutel 2007). These rich soils were largely unsuitable for agriculture, however, until artificial drainage systems were constructed beginning in the late 1800s. The drainage of the state, an engineering feat that prior to WWI equaled the cost of the construction of the Panama Canal (Peterson and Englehorn 1946, 23), unlocked extraordinary productivity and made Iowa a leading agricultural state (Peterson and Englehorn 1946; SCS 1983). Thus, 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. Forty-six percent of participants agreed or strongly agreed that Iowa farmers should increase investment in drainage to prepare for increases in rainfall (Table 1).

Table 1 Percentage distributions for dependent variables

Variable name	Item	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
PROTECT	Iowa farmers should take additional steps to protect their land from increased precipitation.	4.3 %	11.3 %	22.8 %	52.3 %	9.3 %
DRAIN	Iowa farmers should increase investment in agricultural drainage systems (tile, ditches) to prepare for increased precipitation.	4.5 %	14.4 %	35.5 %	39.3 %	6.3 %
MITIGATE	Government should do more to reduce the nation's greenhouse gas emissions and other potential causes of climate change.	14.2 %	22.4 %	30.5 %	24.9 %	8.0 %

Mitigation The third dependent variable measures farmer support for action to mitigate the causes of climate change (MITIGATE). There are a number of policy measures that are commonly considered and/or implemented to reduce GHG emissions in agriculture. Three of the most widely recognized options are legislative mandates to reduce emissions, emissions taxes, and market-based cap and trade (CAST 2011). Because each of these options requires substantial government intervention to implement, we use a general measure of support for government action to address the anthropogenic causes of climate change.

Farmers were provided with the statement, "Government should do more to reduce the nation's greenhouse gas emissions and other potential causes of climate change," and asked to rate their agreement on a five-point scale from strongly disagree to strongly agree. It is important to reiterate that support for mitigation implies an acceptance that humans are causing climate change (at least to some extent), and that changes in human behavior are needed to reduce those contributions. Support for government action implies agreement that collective action is necessary to incentivize, regulate, or otherwise induce those changes in behavior. Thirty-three percent of participants agreed that government should take action to curb human contributions to climate change (Table 1).

2.3.2 Independent variables

Perceived vulnerability and concern Concern about the impacts of climate change on agricultural livelihoods is hypothesized to be a critical arbiter of farmer support for adaptive or mitigative actions (Howden et al. 2007). Attitudes can be strong predictors of behaviors or acceptance of ideas (Ajzen 1991; Dietz et al. 2005). Studies of agricultural conservation practice adoption have found positive associations between awareness of environmental problems, attitudes toward potential solutions, and willingness to adopt those solutions (Prokopy et al. 2008). Furthermore, it is when situations come to be perceived as problems that attitudes regarding potential ameliorative actions are more predictive of behavior change (McCown 2005).

Four variables measuring constructs of concerns about the potential impacts of climate change on a five-point agreement scale (strongly disagree = 1 and strongly agree = 5) are included in the model. Three of these variables are combined into a summative scale that measures overall concern about potential negative impacts of climate change on agriculture. The three statements and their percentage distributions are provided in Table 2. The summative scale for the three items, labeled "CONCERN," has a Cronbach's alpha reliability coefficient of 0.86, indicating a highly acceptable level of internal consistency. The scale ranges from 3 (very low concern) to 15 (very high concern), with a mean of 9.5.

Human ingenuity A second measure of concern is a single statement: "Climate change is not a big issue because human ingenuity will enable us to adapt to changes" (INGENUITY). This item was developed from the "New Environmental Paradigm (NEP)" literature that has long examined human-environment relations (see Dunlap 2008). Specifically, the item draws 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 et al. 2000, 432). The item measures, on a five point scale ranging from strongly disagree (1) to strongly agree (5), the degree to which farmers believe that "human ingenuity" will reduce threats from climate change by facilitating adaptation to changes. Thirty-three percent of farmers agreed with the statement, and the mean score for the item was 3.0 (Table 2).

Table 2 Means and percentage distributions for continuous covariates

Variable name	Item	Mean	Std Dev	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
CONCERN scale		9.5	2.8					
Item 1	I am concerned about the potential impacts of climate change on Iowa's agriculture.			9.5 %	16.6 %	31.0 %	32.3 %	7.7 %
Item 2	I am concerned about the potential impacts of climate change on my farm operation.			8.3 %	21.2 %	35.4 %	30.0 %	5.1 %
Item 3	I believe that extreme weather events will happen more frequently in the future.			5.3 %	14.0 %	34.6 %	36.9 %	8.7 %
INGENUITY	Climate change is not a big issue because human ingenuity will enable us to adapt to changes.	3.0	1.0	8.7 %	21.1 %	37.2 %	28.3 %	4.8 %
ROWCROP (acres)		350	480					
AGE (years)		64.5	11.0					

Beliefs about climate change and its causes should logically influence attitudes toward adaptive and/or mitigative actions to address it. Beliefs are generally conceptualized as understandings of the state of things in the world, or estimates of reality as individuals perceive it based on accumulated knowledge (Dietz et al. 2005; Wyer and Albarracin 2005). In turn, beliefs influence the formation of attitudes toward objects or actions (Kruglanski and Stroebe 2005) and behavioral decisions (McCown 2005).

A multi-dimensional variable that measures both beliefs about the existence of climate change as a phenomenon and attribution of cause is employed to model the relationship between beliefs about climate change and attitudes toward potential avenues of adaptation and mitigation. Study participants were directed to select one of five response options that best reflected their beliefs (variable labels in parentheses): climate change is occurring, and it is caused mostly by human activities (HUM); climate change is occurring, and it is caused equally by natural changes in the environment and human activities (HUMNAT); climate change is occurring, and it is caused mostly by natural changes in the environment (NAT); there is not sufficient evidence to know with certainty whether climate change is occurring or not (UNCERT); and, climate change is not occurring (NOCC).

A substantial majority of farmers (68 %) indicated that they believe that climate change is occurring (Table 3). Ten percent attributed climate change mostly to human activities. Thirty-five percent believed that climate change is occurring and caused equally by human activities and natural variation. Twenty-three percent attributed climate change primarily to natural causes. Slightly more than one-quarter (28 %) of farmers indicated uncertainty, and 5 % did not believe that climate change is happening.

Control variables Three variables are included as controls: acres of row crops (i.e., corn and soybeans) farmed (ROWCROP), age (AGE), and education (EDUC). These are included because they are standard measures of capacity to adopt conservation practices (Prokopy et al. 2008). Acreage farmed has generally been found to be positively related to conservation practice adoption. For this study, row crop acreage might also be considered to be a measure of exposure to climate change-related risk (i.e., waterlogging, soil erosion). Age has been associated with lower rates of practice adoption, while education is generally seen as a positive predictor. On average, participants were 65 years old, farmed 350 acres of row crops (Table 2), and 58 % had completed at least some college (Table 3).

2.3.3 Hypotheses

Our hypotheses regarding the relationships between attitudes toward adaptive and mitigative management and beliefs and concerns regarding climate change and its potential impacts are:

H1: *Concern* Apprehension about the potential negative impacts of climate change (CONCERN) will be positively associated with support for land protection (PROTECT), investment in agricultural drainage (DRAIN), and government efforts to reduce GHG emissions and other drivers of climate change (MITIGATE);

H2a: *Human ingenuity and adaptation* Belief that human ingenuity will facilitate adaptation to climate change (INGENUITY) will be positively associated with support for land protection (PROTECT), and investment in agricultural drainage (DRAIN);

H2b: *Human ingenuity and mitigation* Belief in the adaptive power of human ingenuity will be negatively related to government actions to reduce drivers of climate change (MITIGATE). The negative relationship between faith in human adaptive ingenuity and support for mitigation is proposed because the human exemptionalist paradigm is generally based on adapting to changes rather than changing behaviors that cause environmental problems;

H3a: *Beliefs about climate change* Belief that climate change is occurring (HUM, HUMNAT, NAT) will be positively associated with both adaptation variables (PROTECT and DRAIN); and,

H3b: *Beliefs about causes of climate change* Belief that climate change is occurring and attributable to humans (HUM, HUMNAT) will be positively related to support for

Table 3 Observed frequencies for categorical covariates

Variable name	Category	Percentage
BELIEF		
HUM (1)	Climate change is occurring, and it is caused mostly by human activities	10.1
HUMNAT (2)	Climate change is occurring, and it is caused equally by natural changes in the environment and human activities	34.6
NAT (3)	Climate change is occurring and it is caused mostly by natural changes in the environment	23.3
UNCERT (4)	There is not sufficient evidence to know with certainty whether climate change is occurring or not	27.6
NOCC (5)	Climate change is not occurring	4.5
Education level		
EDUC (0)	No college, high school diploma or less	42.3
EDUC (1)	Some college or college degree	57.7

public action to mitigate causes (MITIGATE), while belief that it is occurring but attributable to natural causes (NAT), is not occurring (NOCC), or there is insufficient evidence (UNCERT), will be negatively associated with support for mitigation.

2.4 Statistical approach

The goal of our statistical model is to identify important relationships among beliefs about the existence of climate change, concern about impacts, and attitudes toward different types of action in response to climate change. We analyze responses for the dependent variables using a cumulative logit model, also known as proportional odds logistic regression (Agresti 2007). The cumulative logit model is a useful option when the response variable consists of ordered categories, such as the five-level agreement scale for the climate change action items. Denote y_i as the response of subject i to each dependent variable. The possible responses are defined as

$$y_i = \begin{cases} 1 \text{ if subject i chooses Strongly Disagree} \\ 2 \text{ if subject i chooses Disagree} \\ 3 \text{ if subject i chooses Uncertain} \\ 4 \text{ if subject i chooses Agree} \\ 5 \text{ if subject i chooses Strongly Agree} \end{cases} \quad (1)$$

The response follows a multinomial distribution with individual cumulative probabilities $p_{i,j} = \Pr[y_i \leq j]$. That is, $p_{i,j}$ is the probability that subject i responds in category j or below. The cumulative logit model allows the log-odds of these probabilities to be functions of covariates $\mathbf{x}_i$, according to

$$\log\left(\frac{p_{i,j}}{1-p_{i,j}}\right) = \alpha_j - \mathbf{x}_i^{'}\beta \quad (2)$$

The cumulative logit model is fit for PROTECT, DRAIN, and MITIGATE. The covariates used in each model include CONCERN, INGENUITY, the five BELIEF categories (HUM, HUMNAT, NAT, UNCERT, NOCC), and the three control variables (ROWCROP, AGE, EDUC). The models are estimated via maximum likelihood, and individual covariates are tested for significance via a likelihood ratio test (Agresti 2007). A bootstrap procedure is used to estimate predicted response probabilities $\widehat{\pi}_{i,j} = \Pr[y_i = j]$ and confidence intervals for different combinations of the covariates.

3 Results

Table 4 summarizes the cumulative logit model fits for each of the three dependent variables. The table includes estimates and standard errors for each component of β, the coefficients for the covariates. The p-values from a likelihood ratio test for significance of each of the predictors are indicated with asterisks. There is a single test for the collective inclusion of the categorical predictors (the five BELIEF categories and EDUC).

3.1 Adaptation

Model 1 PROTECT Two of the covariates—CONCERN and AGE—are significant predictors of farmer support for additional actions to protect farmland from increased precipitation (Table 4). The coefficient for CONCERN is positive, indicating that farmers who were more

Table 4 Estimates, standard errors and likelihood ratio tests for coefficients in the proportional odds logistic regression models 1–3

	Model 1: PROTECT		Model 2: DRAIN		Model 3 MITIGATE	
Predictor	Estimate	SE	Estimate	SE	Estimate	SE
CONCERN (scale)	0.602***	0.033	0.428***	0.029	0.384***	0.029
INGENUITY	0.09	0.07	0.32***	0.07	−0.58***	0.07
BELIEF (2-HUMNAT)	−0.06	0.23	0.19	0.21	−1.24***	0.23
BELIEF (3-NAT)	0.06	0.26	−0.03	0.24	−2.39***	0.26
BELIEF (4-UNCERT)	0.09	0.26	0.08	0.24	−2.00***	0.26
BELIEF (5-NOCC)	−0.24	0.38	−0.17	0.37	−3.03***	0.40
ROWCROP	−0.000009	0.00013	0.00043***	0.00013	0.00003	0.00013
AGE	0.018***	0.006	−0.001	0.005	0.017***	0.005
EDUC (1-Some College)	0.06	0.12	−0.33**	0.12	−0.25*	0.12
Nagelkerke R^2	0.418		0.264		0.534	

*$p<0.05$; **$p<0.01$; ***$p<0.001$

concerned about the impacts of climate change were more likely to agree that farmers should take additional steps to protect their land from increased precipitation.[1] This result is consistent with hypothesis H1. The positive coefficient for AGE indicates that older farmers were more likely to agree that Iowa farmers should take protective action. The hypotheses that INGENUITY and BELIEF that climate change is occurring would be positive predictors of support for protective action (H2a, H3a) are not supported.

Model 2 DRAIN Four covariates are significant predictors of farmer support for increased investment in agricultural drainage to prepare for increased precipitation: CONCERN, INGENUITY, ROWCROP, and EDUC (Table 4). Consistent with H1 and H2a, both CONCERN and INGENUITY are strongly associated with support for additional investment in agricultural drainage to prepare for future increases in rainfall.[2] The positive coefficient for ROWCROP indicates that farmers who had more cropland, which would likely benefit from drainage, were more apt to favor additional investment in drainage systems. The hypothesis that BELIEF in climate change would be a positive predictor (H3a) is not supported.

3.2 Mitigation

Model 3 MITIGATE All three of the primary covariates are significant predictors of variation in support for government mitigation of climate change (Table 4). Consistent with H1, CONCERN is a positive predictor of government action to address causes of climate change (MITIGATE). Consistent with H2b, INGENUITY is a negative predictor of MITIGATE, meaning that farmers who believed more strongly that climate change is not a major issue because human ingenuity will facilitate adaptation tended not to support government mitigation actions.

The relationship between the categorical variables measuring BELIEF in climate change and its causes and MITIGATE also aligned with expectations. In concordance with hypothesis H3a,

[1] Online Resource 1 further illustrates the relationship between CONCERN and PROTECT.
[2] Online Resource 2 further illustrates the relationships between CONCERN, INGENUITY and DRAIN.

farmers who believed that climate change is occurring and attributable mostly to humans (HUM) or that climate change is happening and caused equally by humans and natural variations in the environment (HUMNAT) were more likely to agree that government should pursue mitigation than farmers whose responses fell into the remaining three categories. Conversely, farmers who believed that climate change is due mostly to natural variation (NAT) and those who did not believe that climate change is occurring at all (NOCC), or were uncertain (UNCERT) were less likely to support government mitigative action (H3b).[3]

4 Discussion and conclusions

Recognizing that effective adaption and mitigation in agriculture depends to a large degree on farmer willingness and capacity to pursue such actions (Howden et al. 2007; McCarl 2010), this research sought to (1) understand farmer beliefs and concerns regarding climate change, and (2) assess the relationships between those beliefs and concerns and attitudes toward adaptive and mitigative actions. Beliefs and perceived vulnerability are critical arbiters of action (or inaction) among farmers (McCown 2005; Morton 2011). We hypothesized that farmer beliefs about climate change and the degree to which farmers feel that climate change threatens their livelihoods would predict differential responses toward adaptation and mitigation. The results of our analysis largely support our hypotheses and provide important understandings about how farmers think about climate change and how those views might shape the potential for effective adaptation to and mitigation of climate change in agriculture.

4.1 Adaptation

Adaptation to climate change is a response to perceived vulnerability with intent to reduce risks to the farm operation. Our findings indicate that perceptions of climate risk are central to farmer attitudes toward adaptation. Concern about the potential negative impacts of climate change was a significant predictor of both support for additional protective action and investment in agricultural drainage to adapt to increases in precipitation.

Beliefs about climate change, however, were not significantly associated with farmer attitudes toward adaptive action. This finding suggests that adaptive responses can occur without engaging farmer belief systems about climate causality. In other words, Iowa farmers' stated beliefs about climate change—whether the changes are natural cycles, human induced, some combination of natural and human, or simply not occurring—appear to be substantially less important as a predictor of support for adaptation than expressed concern about impacts. It is not clear why this is the case. Perhaps the perceptions of risk and concern that are central to farmer decisions to adapt (or not) do not require that the farmer acknowledge the underlying causes or source of the risk.

4.2 Mitigation

The relationships between beliefs about climate change, concerns about its impacts, and support for mitigation efforts appear to be more complex. Concerns about negative impacts

[3] Online Resource 3 further illustrates the relationships between BELIEF, CONCERN and MITIGATE.

are positively related to endorsement of government action to curb GHG emissions and other sources of climate change. The results for the mitigation model differ from the adaptation models in two substantial ways, and these differences have policy and programming implications. First, belief that climate change is not problematic because human ingenuity will enable sufficient adaptation is a negative predictor of support for mitigation. This result is consistent with the human exemptionalist stance, "that human ingenuity [is] the ultimate resource and that environmental and resource problems [can] easily be dealt with via science and technology" (Dunlap 2008, 14), rather than through changes in behaviors that led to problems in the first place.

Second, beliefs about the existence and causes of climate change are highly significant predictors of support for government action to address the causes of climate change. Farmers who believed that climate change is happening and primarily attributable to human activity were much more likely to back the collective response that government mitigation efforts represent than those who believed that climate change is a natural phenomenon or that it is not occurring. In other words, the substantial proportion of farmers who did not believe that humans are to blame for climate change or did not believe in climate change tended not to support action to modify human behavior in response.

4.3 Implications, limitations, and conclusion

The results of this study indicate that many Iowa farmers believed that climate change is occurring and believe that steps leading to adaptation should be pursued. At the same time, most farmers did not agree that mitigation, at through by government action, is an avenue that should be followed. Thus, our findings suggest that farmers would be more responsive to outreach focused on adaptation strategies rather than mitigation actions. On the other hand, it is important to recognize that the substantial minority of Iowa farmers who do believe that climate change is happening and due at least in part to human activity appear to be more open to mitigation action.

This study has a number of limitations. Our data are drawn from Iowa farmers whose cropping systems are mostly the highly mechanized, chemical intensive, corn-soybean rotations that predominate in the US Corn Belt, so results may not be generalizable to farmers who live in different geographic regions and employ different farming systems. Further, our dependent variables encompass attitudes toward only two adaptation strategies and one general mitigation approach; our belief and concern variables may not be significantly associated with other types of adaptation or mitigation actions. Future research might examine farmer attitudes toward more specific types of adaptation and mitigation actions. Different mitigation approaches, for example, could imply different costs and benefits for agricultural producers. It is important to understand how farmer support might vary among such strategies as taxation, regulation, and cap and trade. Lastly, this is only a snapshot in time. Longitudinal research tracking farmer experiences with climate change and shifts in beliefs, attitudes, and actions could also yield important insights to guide the development of public policy tools.

Limitations notwithstanding, this study represents one of the first efforts to examine the relationships between farmer beliefs and concerns about climate change and attitudes toward adaptive and mitigative management in agriculture. If society is to employ adaptation and mitigation measures necessary to maintain agricultural productivity and resilience, it is critical that we continue to develop our understanding of how farmers view those measures.

Acknowledgments This research was supported by the Iowa Agriculture and Home Economics Experiment Station and the United States Department of Agriculture National Institute for Food and Agriculture-funded Cropping Systems Coordinated Agricultural Project: Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems project (Award No. 2011-68002-30190).

References

Adger WN, Agrawala S, Mirza MMQ, Conde C, O'Brien K, Pulhin J, Pulwarty R, Smit B, Takahashi K (2007) Assessment of adaptation practices, options, constraints and capacity. In: Parry ML, Canziana OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group ii to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, pp 717–743

Agresti A (2007) An introduction to categorical data analysis. John Wiley & Sons, Hoboken

Ajzen I (1991) The theory of planned behavior. Organ Behav Hum Decis Process 50(2):179–211

Barnes, A, Toma L (2011) A typology of dairy farmer perceptions towards climate change. Clim Change Published online: 31 August

Berry PM, Rounsevell MDA, Harrison PA, Audsley E (2006) Assessing the vulnerability of agricultural land use and species to climate change and the role of policy in facilitating adaptation. Environ Sci Pol 9:189–204

CAST (2011) Carbon sequestration and greenhouse gas fluxes in agriculture: challenges and opportunities. Council for Agricultural Science and Technology, Ames

Climate Change Position Statement Working Group (2011) Position statement on climate change. Working Group Rep. ASA, CSSA, and SSSA, Madison

Dietz T, Fitzgerald A, Shwom R (2005) Environmental values. Annu Rev Environ Resour 30:335–372

Dunlap RE (2008) The new environmental paradigm scale: from marginality to worldwide use. J Environ Educ 40(1):3–18

Dunlap RE, Van Liere KD, Mertig AGT, Jones RE (2000) Measuring endorsement of the new ecological paradigm: a revised NEP scale. J Soc Issues 56(3):425–442

USDA Economic Research Service (USDA ERS) (2010). 2010 State Fact Sheets: Iowa. USDA Economic Research Service. http://www.ers.usda.gov/StateFacts/IA.htm. Accessed 15 May 2011

Hatfield JL, Ort D, Thomson AM, Wolfe D, Izaurralde RC, Boote KJ, Kimball BA, Ziska LH (2011) Climate impacts on agriculture: implications for crop production. Agron J 103(2):351–370

Howden SM, Soussana JF, Tubiello FN, Chhetri N, Dunlop M, Meinke H (2007) Adapting Agriculture to Climate Change. Proc Natl Acad Sci 104(50):19691–19696

IFPRI (2010) Food security, farming, and climate change: Scenarios, results, policy options. International Food Policy Research Institute, Washington

Iowa Climate Change Impacts Committee (ICCIC) (2011) Climate change impacts on Iowa 2010. Office of Energy Independence, Des Moines

IPCC (2001) Climate change 2001: impacts, adaptation and vulnerability. Cambridge University Press, Cambridge

IPCC (2007a) Climate Change 2007: synthesis report. In: Pachauri RK, Reisinger (eds) Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change. Intergovernmental Panel on Climate Change, Geneva

IPCC (2007b) Climate change 2007: mitigation of climate change. contribution of working group III to the fourth assessment Report of the Intergovernmental Panel on Climate Change, 2007. Intergovernmental Panel on Climate Change, Geneva

Kling CL, Rabotyagov S, Feng H, Jha M, Parcel J, Gassman P, Campbell T (2007) Conservation practices in Iowa: historical investments, water quality and gaps. Final Report. Center for Agricultural and Rural Development, Iowa State University, Ames

Kruglanski AW, Stroebe W (2005) The influence of beliefs and goals on attitudes: issues of structure, function, and dynamics. In: Albarracin D, Johnson BT, Zanna MP (eds) The handbook of attitudes. Psychology Press, New York, pp 323–368

Lal R, Delgado JA, Groffman PM, Millar N, Dell C, Rotz A (2011) Management to mitigate and adapt to climate change. J Soil Water Conserv 66(4):276–285
McCarl BA (2010) Analysis of climate change implications for agriculture and forestry: an interdisciplinary effort. Clim Change 100(1):119–124
McCown RL (2005) New thinking about farmer decision makers. In: Hatfield JL (ed) The farmer's decision. Soil and Water Conservation Society, Ankeny, pp 11–44
Morton LW (2011) Citizen involvement. In: Morton LW, Brown SS (eds) Pathways for getting to better water quality: the citizen effect. Springer Science+Business, New York
Mutel C (2007) The emerald horizon: the history of nature in Iowa. University of Iowa Press, Iowa City
National Research Council (NRC) (2010) Adapting to the impacts of climate change: America's climate choices. National Academies Press, Washington
Peterson JB, Englehorn AJ (1946) The soil that grows the crops. In: Members of the Staff of the Iowa State College and the Iow Agricultural Experiment Station (ed) Century of farming in Iowa. The Iowa State College Press, Ames, pp 18–31
Prokopy LS, Floress K, Klotthor-Weinkauf D, Baumgart-Getz A (2008) Determinants of agricultural best management practice adoption: evidence from the literature. J Soil Water Conserv 63(5):300–311
Rogovska N, Cruse RM (2011) Climate change consequences for agriculture in Iowa. In: Climate change impacts on Iowa 2010. Office of Energy Independence, Des Moines, IA
Soil Conservation Service (SCS) (1983) Des Moines River Basin study: drainage report. United States Department of Agriculture, Des Moines
U.S. Department of Agriculture National Agricultural Statistics Service (NASS) (2009) 2007 census of agriculture. U.S. Department of Agriculture National Agricultural Statistics Service, Washington
U.S. Department of Agriculture National Agricultural Statistics Service (NASS) (2011) Crop production 2010: summary. United States Department of Agriculture, Washington
Wyer RS Jr, Albarracín D (2005) Belief formation, organization, and change: cognitive and motivational influences. In: Albarracín D, Johnson BT, Zanna MP (eds) The handbook of attitudes. Psychology Press, New York, pp 273–322