EVALUATING THE COGNITIVE DRIVERS AND DETERRENTS OF ADAPTATION IN THE IOWA-CEDAR WATERSHED

by

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This research explores the relationship between the cognitive variables perceived risks, perceived barriers, perceived self-efficacy, and perceived hazard experience with farmer support for adaptation and the agreement between farmer perceptions with observed climate conditions of drought and excess precipitation. Climate conditions were evaluated using monthly Standardized Precipitation-Evapotranspiration Index (SPEI) values from 1950 to 2014. The remaining variables were measured using a closed ended survey of corn and soybean farmers (N =276) in the Iowa-Cedar Watershed. The relationships were evaluated using Spearman's Rank Order Correlation (ρ), frequency distributions, and probability analysis. Perceived barriers were found to be a significant predictor of support for adaptation. Transformational adaptations were less supported by farmers than incremental adaptations. Farmers expressed more concern for finances than any other risks or barrier. The majority of farmers reported low to moderate risks to drought and precipitation with high efficacy to cope to future impacts. Lastly, climate conditions indicate that there were more frequent and extreme precipitation events than drought events and that farmer perceptions of climate are consistent with observed climate conditions. However, while climate change projections indicate increased weather extremes in the future, farmers perceive no change in risks. It is unclear whether or not farmers are actually equipped to handle future threats to their crops. Future research should address this problem by conducting a longitudinal study to observe farmers' perception prior to and after experiencing extreme events.

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INTRODUCTON

The voluntary and diffused nature of farm management decisions, coupled with changes in climate, produce a great degree of uncertainty in the future state of U.S. agriculture. Continuous population growth has resulted in increased pressure on natural resources and processes. In order to keep up with the demands of a growing population, more fossil fuels are being burned releasing gasses known to contribute to climate change. Simultaneously, flora that assists in carbon sequestration is being extracted. While there is no novelty in a changing climate, the rate at which change occurs can prove quite problematic.

1.1 Problem Statement

Due the inherently risky nature of agriculture, farmers are accustomed to making critical decisions to improve the stability of their farming system. Resilience refers to the capacity to cope with a hazardous event in ways that maintain a system's essential functions (IPCC 2014). However, climate change literature suggests that the rate and intensity at which change can occur might overwhelm farmers' ability to mentally or financially cope to climate change (Arbuckle et al. 2014; Arbuckle, Morton, and Hobbs 2013; Bradshaw, Dolan, and Smit 2004; Brown, Bridle, and Crimp 2016; Grothmann and Pratt 2003; and Head et al. 2011). Therefore, extending hazard-mitigating support in a proactive, rather than reactive manner, is critical to insuring the continued productivity of the U.S. agricultural sector. One approach that can be used to improve agricultural resilience is adaptation or the process of adjustment to actual or projected climate and its effects (IPCC 2014). Foremost, appropriate agricultural adaptation programs and policy emanate from understanding farm management decisions (Klein, Schipper, and Dessai 2005; Knowler and Bradshaw 2007; Kok and de Coninck 2007).

Despite the potential to increase the resilience of agriculture to climate change, application of adaptive measures has been slow (FEMA 2016; Leggett and Lattanzio et al. 2016; OMB 2016; and Schipper 2006). Concerns for the increased vulnerability of the agricultural sector and finite funding for programs aimed at reducing the consequences of agricultural vulnerability have heightened the need for understanding the complex relationship between farmer perceptions and farmer support for adaptation in order to provide targeted policy and outreach that would produce the most agricultural resilience. Ultimately, failure to understand factors that influence and impede support for adaptation may result in a less desirable agricultural production system, reduced human health, and diminished environmental quality.

1.2 Study Purpose and Nature

A large amount of research has been devoted to both modeling climate and human behavior. Both aspects are critical in estimating and planning for the future impacts of climate change to agriculture. More specifically, climate modeling identifies potential alterations to the climate conditions, upon which agriculture is fundamentally dependent. Conversely, modeling human behavior provides insight as to how farmers might respond to climate change projections. Although these two kinds of models are complementary, they are often presented as dualistic approaches. This research evaluates the relationship of both social and climate factors in order to further contribute to the understanding of farm management decisions. This insight is necessary for improving support for adaptation programs and funding, which have been historically lacking.

The purpose of this two phase study is to examine the relationship between farmer perceptions and farmer support for climate change adaptation practices. The first phase is a quantitative exploration of farmers' perceived risks to drought, excess precipitation, and crop price volatility; farmers' perceived barriers to implementing adaptation; farmers' perceived ability to cope with future risks; and how farmers' perceived risks and barriers relate to support for adaptation by evaluating a cross-sectional survey of 276 farmers in the Iowa-Cedar Watershed. The second phase uses the moisture metric Standardized Precipitation Evapotranspiration Index (SPEI) to understand agricultural climate conditions that have transpired from 1950 to 2014 and compare past climate conditions to both farmer risks perceptions and self-reported crop loss from past weather events.

The primary analysis uses a Pearson rank-order correlation that relates the predictor variables of perceived risks and perceived barriers to adaptation. For this study, the predictor variable "perceived risks" is defined as the degree of belief by a farmer that climate induced hazards threaten crop production, and the predictor variable "perceived barriers" is generally defined as any obstacle which the farmer believes constrains their ability to implement a form of adaptation. The criterion variable "adaptation" is defined as any practice that can be implemented in order to reduce current or future impacts of climate change to the agricultural sector. In addition, supplementary analysis includes a frequency distribution of the mediating variable "perceived self-efficacy" and a comparison of the mediating variable "perceived hazard experience" with the mediating variable "climate conditions" in order to better understand the relationship between farmers' perceptions of climate and observed climate conditions. For the purposes of this study, "perceived self-efficacy" is defined as the farmers' belief that they have the knowledge to cope with the potential threat of weather extremes to the future productivity of their farm. Furthermore, “perceived hazard experience” is defined as the farmers’ recollection of past weather events that have reduced their crop yields by at least 30%. Lastly, “climate conditions” refers to the observed moisture (SPEI) between 1950 and2014.

1.3 Research Questions

1. What are farmers’ perceived risks and how do they relate to support for adaptation?
2. What are farmers’ perceived barriers and how do they relate to support for adaptation?
3. Do farmers in Iowa-Cedar watershed believe they have the ability to cope (self-efficacy) with increased precipitation, drought, and price crop volatility?
4. Do observed climate conditions help explain farmer risks perceptions to drought and increased precipitation, perceived self-efficacy, and perceived hazard experience?

1.4 Study Significance

This study contributes to knowledge about farmer decision making practices that can be used to inform adaptation programs and policies. In addition, this study adds to the limited knowledge on the influence of perceived barriers on support for adaptation. Furthermore, this study expands on research regarding the agreement between actual and perceived climate conditions.

1.5 Overview

Chapter 2 introduces the primary impacts of climate change on Midwestern agriculture in section 2.1, followed by an overview of the approaches to addressing climate change in section 2.2. Next, section 2.3 provides a brief review of deficiencies in agricultural funding and policy for adaptation. Section 2.4 provides a review of previous research that has evaluated farmer support for implementing adaptation and how this research will extend upon previous studies. Section 2.5 reviews definitional differences and synergies between perceived barriers and perceived limits. Section 2.6 suggest additional factors to consider when examining support for adaptation. Finally, section 2.7 assesses the limitations to perceptions and how they can reinforce with supplementary data.

Chapter 3 outlines the reasoning and procedures utilized to evaluate the research questions. First, section 3.1 provides an overview of the area in which the survey data was collected and the climate data was restricted to. Next, sections 3.2 and 3.3 provide background information about the survey data as well as the climate data. Section 3.4 provides the sample demographic and farming characteristics and compares them to the farming population in U.S. and Iowa. Section 3.5 explains data manipulation for the variables adaptation, perceived risks, perceived barriers, self-efficacy, perceived hazard experience, and climate conditions. Section 3.6 lists the research questions that are evaluated in chapter 4. Finally, section 3.7 describes the statistical techniques that are used in order to answer the research questions.

Chapter 4 displays statistical information for the variables adaptation, perceived risks, perceived barriers, perceived self-efficacy, perceived hazard experience, and climate conditions in text, tabular, and graphic forms. Section 4.1 contains the descriptive statistics and frequency distribution for the responses to the questions regarding support for adaptation. Similarly, section 4.2 contains the descriptive statistics and frequency distribution for responses to the questions regarding perceived risks and the correlation between adaptation and perceived risks. Section 4.3 contains the descriptive statistics and frequency distributions for responses to the questions regarding perceived barriers and the correlation between adaptation and perceived barriers.

Section 4.4 contains the frequency counts for farmer responses pertaining to the question on self-efficacy. Section 4.5 contains the frequency counts for farmer recollection of crop loss to drought and precipitation extremes. Lastly, section 4.6 contains the probability of a severe or extreme precipitation or drought occurrence for the time periods 1950 – 2004 and 2005 – 2014.

Lastly, chapter 5 summarizes key findings, study limitations and recommendations for future research, and revisits the purpose for this research. First, section 5.1 provides answers to the research questions. Next, section 5.2 discusses limitations to the study and provides recommendations for future research. Finally, section 5.3 concludes with a summary of key findings and implications.

CHAPTER 2

LITERATURE REVIEW

This chapter introduces the primary impacts of climate change on Midwestern agriculture in section 2.1, followed by an overview of the approaches to addressing climate change in section 2.2. Next, section 2.3 provides a brief review of deficiencies in agricultural funding and policy for adaptation. Section 2.4 provides a review of previous research that has evaluated farmer support for implementing adaptation and how this research will extend upon previous studies. Section 2.5 reviews definitional differences and synergies between perceived barriers and perceived limits. Section 2.6 suggest additional factors to consider when examining support for adaptation. Finally, section 2.7 assesses the limitations to perceptions and how they can reinforce with supplementary data.

2.1 Midwest Climate Change

Climate change is a human exacerbated naturally occurring process that is projected to impact agricultural yields. While increased levels of carbon dioxide and increased temperatures are expected to improve short-term crop yields, projected changes in the frequency, intensity and duration of extreme precipitation events are expected to reduce crop yields (Melillo, Richmond, and Yohe 2014; Xu, Twine, and Girvetz 2016; and Zipper et al. 2016). For example, considering past climate conditions, Zipper et al. 2016 found Midwest corn and soybean crops to have the strongest yields compared to other U.S. regions during the time period of 1958 to 2007.However, when also considering future climate change scenarios, climate models indicate yield decreases up to 20% by the end of the 21st century (Ummernhofer et al. 2015 and Xu, Twine, and Givrvetz 2016). More specifically, climate change models project lower crop yields as a result of increasing excess precipitation compared to historic conditions (Dai et al. 2016; Smith et al. 2013; Trent 2014; and Villarini, Smith, and Vecchi 2013).

Increased precipitation, particularly precipitation extremes, negatively impact yield production. Crop growth is sensitive to weather extremes which result in rapid changes in soil moisture conditions, increased erosion, increased evaporation and transpiration, and reductions in daytime maximum temperature (Dai et al. 2016; Pryor et al. 2014; and Zipper et al. 2016). In the case of Iowa, characteristic shallow water tables and poorly drained soils have served as a buffer against drought but with increased precipitation these characteristics hinder rather than promote crop production (Zipper et al. 2016). Furthermore, while the primary impact of climate change on agriculture is yield loss, yield reductions are followed by a host of secondary impacts including economic instability, soil erosion, and food insecurity. In order to reduce or prevent these potential outcomes, the U.S. government has heavily invested in climate change programs.

2.2 Climate Change Approaches

Climate change programs fall under the two primary categories of mitigation and adaptation. First, mitigation is broadly defined as any action taken to reduce human contributions to climate change (Melillo, Richmond, and Yohe 2014). This can include setting standards to reduce the amount of greenhouse gasses that are emitted into the atmosphere and increasing the number of carbon sinks. Adaptation is any effort to reduce vulnerability to climate change impacts. In contrast, efforts that increase vulnerability are regarded as maladaptive (Niemeyer, Petts, and Hobson 2005). Furthermore, implementing adaptation involves either incremental or transformative approaches. Incremental adaptation is defined as extensions of preexisting actions and behaviors to reduce climatic impacts (Kates, Travis, and Wilbanks 2012). Transformational adaptation refers to a substantial change in the type, scale, or intensity of actions and behaviors (Kates, Travis, and Wilbanks 2012). In other words, transformational adaptations completely alter a system whereas incremental adaptations simply modify it. Unlike mitigation, appropriate adaptive measures are largely unknown and highly debated as a result of climate uncertainty. The principal difference between mitigation and adaptation is that the focus of mitigation is on the causes of climate change whereas adaptation focuses on the outcomes of climate change.

Although mitigation and adaptation are regarded as equally important, initial climate change discourse gave precedence to mitigation for several reasons. First, mitigation alone was believed to possess the ability to prevent the effects of climate change (Biesbroek, Swart, and van der Knaap 2009; Liu, Vedlitz, and Alston 2008; Schipper 2006). Second, there was a fear that adaptation would undermine mitigative efforts (Klein, Schipper, and Dessai 2005; Locatelli et al. 2015; Pielke 1998; Schipper 2006). More specifically, adaptation would be used as justification for not taking mitigative action. Lastly, adaptation was believed to occur naturally, therefore government intervention was considered unnecessary (Klein, Schipper, and Dessai 2005; Schipper 2006).

In order for mitigation efforts to be successful, carbon dioxide levels must peak at 350 ppm within the next few decades or exhibit a steady decline for the terminus of the century to insure global-average temperature increases remain below 2°C (Melillo, Richmond, and Yohe 2014; UNEP 2016). More recently, the Paris Treaty Agreement called for actions to keep temperatures from rising more than 1.5°C (Leggett and Lattanzio 2016; UNEP 2016). However, due to a combination of delayed and unsuccessful mitigative efforts, confidence in the sole use of mitigation diminished and support for adaptive measures increased (Schipper 2006). With decreases to the carbon dioxide budget, stronger action is required to reduce climate change impacts (UNEP 2016). Schipper (2006) identified 3 schools of thought about climate change modeled after the schools of thought developed by Kates (1997). First, the limitationist, who believe that reducing greenhouse gasses is of chief concern (Kates 1997; Schipper 2006). Second, the adaptationist, who believe that nature and market forces are resilient to slow changes in climate (Kates 1997; Schipper 2006). Lastly, the realists, who believe that adaptive action is just as critical as mitigative action (Schipper 2006). Despite the gained recognition of adaptation as a method for alleviating climatic impacts, there are still huge policy and funding disparities between mitigation and adaptation.

2.3 Funding and Policy

According to the 2013 Federal Climate Change Expenditures Report, funding for adaptation is virtually non-existent. From 2001 to 2014 an estimated $130 billion was spent addressing climate change (Leggett, Lattanzio, and Bruner 2013). However, funding for adaptation only emerged as recently as 2010 (Leggett, Lattanzio, and Bruner 2013). The 2014 presidential request for the Climate Change Related Budget Authority outlines climate change priorities of the nation. Clean energy technology received the largest support accounting for 68% of the requested funds (Leggett, Lattanzio, and Bruner 2013). The U.S. Global Change Research Program received the second largest support accounting for 23% of the requested funds (Leggett, Lattanzio, and Bruner 2013). Next, International Climate Change Assistance is the third largest request accounting for 8% of the requested funds. Adaptation (1%) is the lowest of the requested funds. Furthermore, existing resources do not provide assistance to farmers to implement adaptation.

The United States Department of Agriculture (USDA) provides funding and assistance to farmers who suffer from natural disaster-induced losses and for installing or updating hazard reducing technology through programs such as Emergency Watershed Protection (EWP), Emergency Conservation Program (ECP), Agricultural Management Assistance (AMA), Conservation Stewardship Program (CSP), and Environmental Quality Incentives Program (EQIP). Unfortunately, programs that provide assistance for implementing hazard reducing technologies are specific to conservation practices. The remaining USDA disaster assistance programs only provide reactive rather than proactive assistance. The Federal Emergency Management Agency (FEMA) also provides assistance through the Stafford Act Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation (PDM). While these programs may not appear to relate to adaptation, FEMA defines hazard mitigation as “any action taken to reduce or eliminate long-term risks to people and property from natural hazards” and includes adaptation and disaster preparedness as eligible activities (FEMA 2016). However, individuals cannot directly apply to the programs which further complicates the process of receiving assistance. Furthermore, HMGP only applies to communities under a disaster declaration and PDM does not support agricultural related impacts (FEMA 2016). By and large, investments are concentrated in adaptation research and planning rather than implementation. The most notable example is the Agriculture and Food Research Initiative (AFRI), which received $350 million for fiscal year 2016 to investigate topics such as new adaptive approaches for the agricultural sector (USDA 2016). There appear to be no enacted policies that provide funding or support to proactively combat weather-related yield loss with adaptation.

Currently, the Federal Crop Insurance Program (FCIP) can be seen as the largest of the disaster assistance programs for agriculture. The FCIP is a permanently authorized public-private partnership between the U.S. Department of Agricultural Risks Management Agency (RMA) and 18 private insurance companies (Shields, 2015; O'Connor, 2013). The FCIP was first authorized in 1938 to address the devastation of the Dust Bowl but has since then become a method of reducing the financial impacts associated with yield loss, which can be climate-induced (Shields, 2015). In 2014, almost 300 million acres were covered under the FCIP, 70% of which were corn, soybean, wheat, and cotton crops (Shields, D. A. 2015). At an average annual cost of $4 billion, the FCIP is the costliest of the farm safety-net programs (O'Connor C. 2013; Shields, D. A. 2015). In 2008, the FCIP reached a record high with over $8 billion in in indemnities (O'Connor, 2013). This record was quickly broken in 2011 and again in 2012 with combined indemnities totaling $30 billion (O'Connor, 2013). In 2012, about 75% ($13 billion) of crop insurance indemnities were a result of drought with the highest claims geographically distributed in the U.S. Midwest (O'Connor, 2013). The FCIP seems to address the impacts of climate change on agriculture, it is not a sustainable method in that it heavily depends on taxpayer-paid subsidies.

FCIP costs are largely dependent on farmer participation, climate, and crop prices. In general, crop insurance programs are subject to the adverse selection problem, where high-risks farmers are more willing to participate than low-risks farmers because costs are too high to produce any benefit (Shields 2014; Shields 2015; and Wright 2014). In order to avoid the adverse selection problem, the FCIP introduced premium subsidies to attract farmers with fewer risks (Wright 2014). An average of 60% of premium costs are paid by the government except in the case of catastrophic coverage where the premium cost is completely paid for by the government (Shields 2015). Premium subsidies comprise the largest expenses of the FCIP, which totaled $6.3 billion in 2014 (Shields 2015). Furthermore, from 2005 to 2014 the program accumulated $8,460 million in revenues and $8,948 million in losses with 87% of losses occurring on the years 2011 and 2012 (Shields, 2015). The years the FCIP obtained the most loss are the same years that climate extremes reduced crop yields. Furthermore, FCIP only assists with financial consequences of yield loss and does not help prevent yield loss. Indeed, some would argue that the FCIP encourages loss. More specifically, "the program reduces the incentive for farmers to manage farm risks and environmental problems, and reduces their motivation to adapt to a changing environment" (Wright, 2014). As climate will become more uncertain in the future, it is likely to increase the cost of the FCIP program. No matter the amount of the approved FCIP funding, government support is not infinite and preventative adaptation measures should be considered. Smart investments in adaptation could reduce farmer dependency on FCIP and other disaster assistance programs.

Although the full effect of climate change is unlikely to be realized in the next century, climate change impacts have already begun. For example, in 2008 record flooding occurred in the Iowa-Cedar Watershed as well as other parts of the Midwest resulting in damages exceeding $5 billion (NWS 2009). Extensive damage occurred as a result of infrastructure that was not equipped to handle such an anomaly. Only four years later, the Midwest was plagued by another extreme weather event. In 2012, a drought resulted in an estimated $12 billion in damages before the drought peaked (NOAA 2013). In a span of four years, these two events resulted in over $17 billion of damages in the Midwest alone. The 2012 drought also resulted in corn yields which were 26% below expected, the lowest in a decade (NWS 2009). Furthermore, the fiscal year 2017 budget indicates the intent to reduce FCIP program cost by $16 billion in the next decade (OMB 2016). However, without yield-protecting adaptation strategies indemnity payments are likely to increase. If this is the level of damage that occurs at the onset of climate change, the

U.S. cannot afford to withstand damages that accompany an ill-equipped population faced with unprecedented weather extremes.

2.4 Evaluating Adaptive Support

Increased climate variability has prompted an evaluation of agricultural vulnerability to climate change. Assessing agricultural vulnerability requires knowledge of both potential climate change impacts and how farmers will respond to those impacts. While climate modeling is extensive, research regarding farmer responses is less common. Although climate modeling has contributed substantially to understanding change, it can only project climate impacts. Conversely, by evaluating farmer cognition, suggestions can be offered to improve resilience to climatic impacts. Due to the voluntary nature of agricultural management decisions, understanding what influences farmer decisions is critical. As such, a series of demographic variables along with hazard experience, climate change belief, risks perception, and efficacy have been evaluated to assess their relationship with adaptation support.

Adaptive support refers to the willingness of a farmer to implement a type of adaptation on the land they manage. Factors that influence adaptive support can be considered cognitive or demographic. Cognitive variables explore the thoughts and beliefs of farmers whereas demographic variables are useful in understanding socio-economic drivers of behavior. To further elaborate, previous research evaluating demographic factors often explored traits exhibited by communities, farms, and farmers. For example, community characteristics include variables such as accessibility of information, support from community leaders, and neighborhood participation (Knowler and Bradshaw 2006; Reimer and Prokopy 2013). Furthermore, farm characteristics include variables such as farm size, land tenure, and production type (Knowler and Bradshaw 2006; Reimer and Prokopy 2013). Lastly, farmer characteristics include variables such as age, education, and gender (Knowler and Bradshaw 2006; Reimer and Prokopy 2013).

While individual studies have been able to find significant relationships between specific variables and support for adaptation, when collectively reviewed these studies produced contradictory results. For example, some studies have found that educated farmers did not show support for adaptation (Pannel et al 2006; van Dijl, Grogan, and Borisova 2015; and Wilson, Howard, and Burnett). In contrast, a study conducted by Lambert et al. (2007) found an association between high levels of education and positive support for adaptation. Furthermore, Burton (2014) determined that there were positive, negative, and ambiguous relationships between variables such as age, gender, education, and experience and adaptation. Inconsistent findings suggest that the use of demographic characteristics to explain adaptation can be misleading. As a result, the evaluation of farmer cognition has gained prominence.

While there is an infinite number of possible cognitive factors, hazard experience, climate change belief, perceived risks, and self-efficacy are most prevalent. First, hazard experience refers to the farmer accounting for weather extremes occurring on their land. Generally, farmers who report hazard experience tend to support adaptation (Morton et al. 2015). In other words, farmers who do not experience weather extremes or detrimental loss from weather extremes do not see a need for alternative practices. Second, climate change belief refers to the agreement with the existence of climate change and its attribution to natural or anthropogenic induced causes. Multiple studies have found higher adaptive support for farmers who believed in anthropogenic climate change (Arbuckle et al. 2015; Arbuckle et al. 2013; Safi et al. 2012). Third, perceived risks refers to the level of harm farmers believe climate change will have on agriculture. Perceived risks has been found to be a significant predictor of support for adaptation (Arbuckle et al. 2015; Morton et al. 2015). Lastly, efficacy refers to the belief that human actions will produced a desired end result such as agricultural resilience. Farmers with strong beliefs in high efficacy did not support mitigation efforts (Arbuckle, Morton, and Hobbs 2013). Namely, farmers did not support reducing greenhouse gasses because they believed in their ability to adapt to climate change.

Interestedly, not only has perceived risks been linked to adaptation but the factors that appear to have a relationship with adaptation also have a relationship with perceived risks. More specifically, perceived risks has been linked to hazard experience, climate change belief, and efficacy. For example, farmers who experienced significant losses from climate induced hazards also expressed higher levels of risks perception (Menapace et al. 2015). Furthermore, higher levels of risks perception were found among farmers who believed in climate change and anthropogenic causes of climate change (Arbuckle et al. 2014; Arbuckle et al. 2013; Menapace et al. 2015). Lastly, as self-efficacy increased, perceived risks was found to decrease (Arbuckle et al. 2014). These relationships mirror those found for adaptive support. The similarities between perceived risks and support for adaptation suggest a strong relationship between the two variables.

While these studies imply a clear relationship between perceived risks and support for adaptation, the results are limited. More specifically, previous research conducted on Midwest farmers has only evaluated perceived risks due to increased precipitation. Since climate change is projected to cause a number of weather variations affecting crops and costs of production, the sole evaluation of increased precipitation provides an incomplete picture of perceived risks faced by farmers. Given the dependence on rain of Midwest agriculture, perceived drought risks should also be evaluated. Combined with exogenous factors, the yield losses potentially resulting from climate variability might also affect crop prices. Therefore, this study poses the first question: What are farmers perceived risks to increased precipitation, drought, and crop price variability?

2.5 Understanding Barriers

Previous research has predominately evaluated factors that influence adaptive support. However, even farmers who support adaptive action may not be able to act because of additional factors that inhibit their ability to do so. If agricultural resilience is to be achieved, factors that deter adaptation must also be evaluated. There is a growing literature evaluating potential barriers to adaptation within the area of climate change research. Financial barriers are often found to constrain support for adaptation (Archie et al. 2014; Biesbroek et al. 2011; and Brown, Bridle, and Crimp 2016). For example, a survey of 32 Nebraska farmers who were a part of either Nebraska Sustainable Agriculture Society or Nebraska Organic Crop Improvement Society was conducted in 2005 (Knutson et al. 2011). This survey used a paired sample test to analyze reported barriers to reducing drought risks. Lack of capital and profit maximization were identified as the two largest barriers to adaptation. While Knutson et al. (2011) reviewed what farmers perceived as barriers to adaptation, they did not evaluate the relationship between perceived barriers and farmer support for adaptation. Therefore, this study poses the second question: What is the relationship between perceived barriers and adaptive support among farmers in the Iowa-Cedar watershed?

The evaluation of barriers to adaptation is equally as important to understanding management decisions as identifying influences to adaptation. More specifically, farmers' perceived risks and perceived barriers can be considered counterparts because high levels of risks have been found to promote adaptation, whereas a large number of barriers have been found to diminish adaptation. Therefore, evaluating both adaptation risks and barriers provides a more complete picture of management decisions. For instance, if only evaluating factors that promote adaptation, identifying a farmer with high financial and production risks could lead to the false assumption that adaptation adoption will occur. However, this approach does not account for instances where the farmer is willing to adapt but likewise does not possess the means to adapt. Conversely, the sole evaluation of adaptation barriers could lead to the false assumption that if all barriers are overcome, adaptation will take place (Moser and Ekstrom 2010). However, even if there are no barriers to adaptation, if a farmer does not consider adaptation to be necessary, it will not take place. Surprisingly, studies on barriers to adaptation are more limited in the literature than those on influences of adaptation, and the evaluation of both is even less common.

Because the literature on these issues is in its infancy, a consensus on what constitutes as a barrier to adaptation has yet to be reached. While some studies use terms “barrier” and “limit” synonymously, others distinguish between the two. More specifically, some scholars consider barriers as surmountable, and limits as absolute (Moser and Ekstrom 2010). Although this distinction suggests a clear divide between adaptations obstacles, a more recent study suggests a greater interplay between the two terms. Namely, depending on factors such as time and technological advances barriers can become limits, and limits can become barriers (Barnett et al. 2015). In addition to factors that influence or impede adaptation, there are other elements which must be considered.

2.6 Key Considerations

In order to consider adaptation activities, first, farmers must recognize that climate is changing. Climate change is associated with higher uncertainty and higher uncertainty is difficult to manage. Farmers have been found to perceive no or decreasing climate change despite their stated beliefs in climate change. For example, a study in Yolo County, California found that farmers perceived no change between past and future temperatures and to a lesser extent perceived a decrease in temperature (Haden et al. 2012). In turn, the lack of perceived change was associated with lower concern for temperature-related impacts (Haden et al. 2012). In contrast, farmers who perceived increased variability in water availability also had increased concerns for future water availability (Haden et al. 2012). In other words, perceived climate change has been linked to concern for climate-related impacts. This relationship suggests that farmers who do not perceive an increase in climate variability are unconcerned with future impacts to their farm, and thus unlikely to support adaptation. Therefore, question 1 will be extended to measure the perceived temporal change for increased precipitation, drought, and crop price volatility risks.

Second, farmers must also attribute observed atmospheric changes to climate. A study of central Arizona farmers found that the majority of farmers who experienced water scarcity attributed it primarily to increased water demand and limited water supply (Eakin et al. 2015). Simply put, water scarcity was considered more of an infrastructure problem than an issue of drought. Similarly, a study of New South Wales farmers revealed that while farmers perceived changes in drought, they did not attribute differences to climate change (Head et al. 2011). By definition, adaptations are adjustments made to combat current or expected climate-related impacts. Therefore, if a connection between the observed change and climate change is not made, farmers are unlikely to support adaptation.

Lastly, farmers must believe in their ability to manage climate change risks. There are two approaches to dealing with climate change risks. The first approach is strategic and it supports the belief that climate-induced impacts can be controlled by human actions (Head et al. 2011). In contrast, the relative approach to risks supports the belief that climate-induced impacts cannot be controlled by human actions (Head et al. 2011). If farmers do not believe that their actions could reduce climate change impacts, they are unlikely to invest in adaptation. Therefore, farmers who support adaptation follow the strategic approach to managing climate change risks. Farmers' belief in their ability to manage climate change risks is more popularly referred to as efficacy or human ingenuity. Farmer efficacy will be measured by posing the question: Do farmers in Iowa-Cedar watershed believe they have the ability to cope with increased precipitation, drought, and price crop volatility?

2.7 Limits of Perceptions

It is often assumed that perceptions mirror actual conditions. As discussed, a significant portion of management decision research is based on human factors such as demographic characteristics and cognitive factors. However, the majority of these factors are based on farmer perceptions. While perceptions provide key insights on the interworkings of the human mind, they do so with a great degree of uncertainty. For example, in 1975, Langer coined the phrase "illusion of control" in reference to his subjects indicating "higher success probability than objective probability warranted." Langer found that subjects could not differentiate between chance and skill determined events. This suggest that while farmers may report having little risks or a high ability to cope their actual risks and efficacy could be higher and lower respectively.

Furthermore, the uncertainty associated with perceptions is also subject to cognitive biases. More specifically, recent or vivid events are thought of as more likely (Grothmann and Pratt 2003). The disconnection between perceptions and scientific measurement has also been referred to as the halo effect (Brody, Peck, and Highfield 2004). Few studies have evaluated the relationship between actual scientific measurement (climate data) and farmer perceptions. For example, the relationship between seasonal daily extremes from 1971 to 2007 and support for adaptation in the Upper Midwest was tested by Morton et al. (2015) and found to be significant. Furthermore, the relationship between monthly mean surface water from 1971 to 2000 and Nevada farmer risks perception has also been tested and no relationship was identified (Safi, Smith, and Liu 2012). In order to better understand the reliability of farmer responses regarding climate change a fourth question is posed: Do observed climate conditions help explain farmer risks perceptions to drought and increased precipitation, perceived self-efficacy, and perceived hazard experience?

2.8 Summary

There is an established relationship between risks perceptions and adaptation. However, this relationship has only been evaluated in the general sense. This research will expand upon previous literature by evaluating the relationship between various climate induced risks types and specific adaptations. An understanding of the drivers of adaptation is equally important as understanding the deterrents of adaptation. As such, this study will also evaluate the relationship between perceived barriers and adaptation. Lastly, the evaluation of both human and natural contributions is also critical to understanding farmer support for adaptation. Therefore, actual weather conditions will be compared to farmers' reported experience with crop-reducing weather extremes in order to identify any synergies between the two.

CHAPTER 3

METHODS

Chapter 3 outlines the reasoning and procedures utilized to evaluate the research questions. First, section 3.1 provides an overview of the area in which the survey data was collected and the climate data was restricted to. Next, sections 3.2 and 3.3 provide background information about the survey data as well as the climate data. Section 3.4 provides the sample demographic and farming characteristics and compares them to the farming population in U.S. and Iowa. Section 3.5 explains data manipulation for the variables adaptation, perceived risks, perceived barriers, self-efficacy, perceived hazard experience, and climate conditions. Section 3.6 lists the research questions that are evaluated in chapter 4. Finally, section 3.7 describes the statistical techniques that are used in order to answer the research questions.

3.1 Study Area

The study area is the Iowa-Cedar River watershed, which encompasses the Latitudes 43˚58’ N to 41˚09’ N and the Longitudes 93˚39’ W to 91˚01’ W (ICWICT 2014, Fig. 3.1.1). This region consists of two southeasterly flowing tributaries to the Mississippi River, spanning an area of 12,620 square miles (ICWICT 2014). The river basin transects two states with 90% of the basin located in Iowa and 10% in Minnesota (ICWICT 2014). Typical climate conditions follow the characteristics of a humid continental climate with extremes of both heat and cold (ICWICT 2014). Since settlement, the land cover types of prairie grass and forest have been replaced by row agriculture (ICWICT 2014). Principal crops include corn, soybeans, hay, and oats (ICWICT 2014).With over 90% of the total land area dedicated to agricultural production, this region is highly susceptible to climate change impacts (ICWICT 2014).

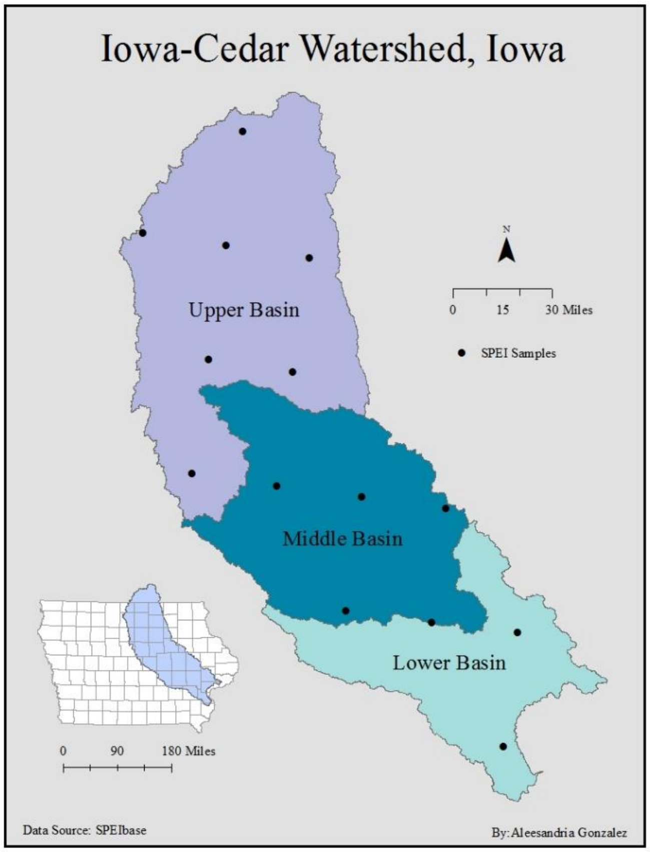


Figure 3.1.1. Study Area

3.2 Survey Data

A cross-sectional survey funded by the National Science Foundation (NSF) was distributed by the United States Department of Agriculture National Agricultural Statistics Service (USDA-NASS) to corn and soybean farmers in the watershed, and 276 surveys were returned. The survey consists of 62 closed-ended questions used to identify and evaluate the effects of weather variability on farmers' long-terms goals and adaptation.

3.3 Climate Data

Standardized Precipitation Evapotranspiration data (SPEI) was gathered from the Spanish National Research Council (CSIC). In raster form, the SPEI dataset has a spatial resolution of 0.5°, however the data was downloaded in .exl format ,where each SPEI values represents the centroid of each 0.5° pixel. Every .exl file contained the SPEI values for each centroid at 1 to 48 month time scales and a temporal range from 1950 to 2016. There are various calculations for SPEI depending on the parameters used. The SPEI values used in this study were calculated by Vicente-Serrano et al. (2010) using the following method:

First, global precipitation and temperature obtained from the Climatic Research unit (CRU) TS3 dataset was used to compute a climatic water balance (D):

$$D = P - PET,$$

where D is the difference between monthly precipitation (P, mm) and the Thornthwaite method for potential evapotranspiration (PET, mm). PET is a measure of maximum moisture used by crops when sufficient moisture is available (Hernandez and Uddameri 2014). The Thornthwaite method of estimating PET is considered less rigorous than alternative methods because of its low parameter requirements (Begueria et al. 2014; Vicente-Serrano et al. 2010; and Vicente-Serrano, Begueria, and Lopez-Moreno). However, a comparison of the Thornthwaite, Hargreaves, and Penman-Monteith PET calculation methods show that the Thornthwaite method showed a significant positive high correlation with each other especially at shorter time scales (Begueria et al. 2014). Furthermore, difference in SPEI values obtained with less parameters had similar temporal variability (Begueria et al. 2014).

Next, the computed D values were then aggregated to various time scales:

$$D_n^K = \sum_{i=0}^{k-1} (P_{n-i} - PET_{n-i}), n \geq k,$$

Finally, the *D* data series were then fit to a log-logistic probability distribution function (For additional detail regarding SPEI computation see Vicente-Serrano et al. 2010).

SPEI represents gains and losses to the water budget. More specifically, SPEI determines moisture deficits (negative values) and surpluses (positive values) using the historic average (zero) of the cumulative moisture (Hernandez and Uddameri 2014; Yang et al. 2016). SPEI is relatively new compared to other climate indices; however, SPEI was selected because of its advantages over other drought indices. For example, SPEI considers the effect of global warming by including temperature as a parameter. Including temperature allows the index to account for increased evapotranspiration with increased temperatures (Hernandez and Uddameri 2014;Vicente-Serrano et al. 2010; Vicente-Serrano, Begueria, and Lopez-Moreno 2010; Yang et al. 2016; Zipper et al. 2016). While SPEI is similar to the Standardized Precipitation Index (SPI), SPEI has been found to better correlate with anomalies, more conservatively indicate drought, and better capture summer drought (Begueria et al. 2014; Hernandez and Uddameri 2014). These attributes are notable because this research is concerned with excess precipitation and drought anomalies associated with climate change during the time period associated with corn and soybean production (Vicente-Serrano, Begueria, and Lopez-Moreno 2010). Based on previous studies it is expected that SPEI values for the Iowa-Cedar Watershed will indicate increased precipitation compared to historic conditions (Dai et al. 2016; Smith et al. 2013; Trent 2014; and Villarini, Smith, and Vecchi 2013). The creators of the SPEI did not specify specific data ranges for drought and moisture interpretation. As such, research implementing the SPEI index have variable and sometimes conflicting attribution of SPEI values to the intensity of moisture deficits and surpluses. For simplification, this study will adopt the SPEI classification system used by Hernandez and Uddameri (2014). In this system SPEI within the range -1 to 1 are considered normal, -1 to -1.99 represent extremely dry conditions (1 to 1.99 for extremely wet), and <-2 represent severely dry conditions (>2 for severely wet).

3.4 Sample and Population Characteristics

Farmers who reported receiving more than 50% of their gross household income during the time period of 2010 to 2014 were considered to rely on farming as a primary source of income. According to survey results, 61% of farmers rely on farming as a primary source of income; this is slightly higher than the percent for Iowa farmers (54%) and U.S. farmers (48%) (USDA 2012). The average reported age range of farmers in the survey was 55-64. This is comparable to the average age for Iowa Farmers (57) and U.S. farmers (58) which both fall within the survey range (USDA 2012). The respondents make significantly more income from farm-related sources compared to Iowa and the U.S. More specifically, the average response for income was choice 3 ($100,000 – $249,000) compared to $34,812 in Iowa and $22,840 in the U.S. (USDA 2012). This indicates the likelihood of a nonresponse bias. However, the low average income in the USDA statistics is due to their definition of “farm” and consequently operators, since a “farm” is such if it generates over a $1,000 in revenue.

The study respondents are 93% male, which is comparable to the population of farmers in the state of Iowa, which is 93% male and the U.S. which is 86% male (USDA 2012). Of the 180,834 operated acres, 63% are installed with artificial drainage which is comparable to the 41% of farmland that is installed with artificial drainage (tile drainage) in Iowa (USDA 2012). In contrast, only 4% of U.S. farmland is installed with artificial drainage (tile drainage) (USDA 2012). This could be a result of soil texture or it may be because drainage is less useful where there is irrigation and complex topography uncharacteristic of the flat rainfed system found in the

Iowa-Cedar basin. Irrigation is low in the U.S., Iowa, and the Iowa-Cedar watershed with less than 5% of total acres irrigated (USDA 2012). In 2012, 72% of farmers reported receiving government payments for drought which is comparable to the number of government payments received in the state of Iowa for 2012 (78%) (USDA 2012). In contrast, only 38% of U.S. farmers reported receiving government payments for 2012 (USDA 2012). Furthermore, the amount of government payments is higher in the study region then national payments. Apart from the use of drainage, study characteristics are consistent with those found in Iowa and U.S. agriculture, indicating that the sample is representative of the overall farming population in Iowa, and that findings from this study may be relevant beyond the scope of the study region.

3.5 Study Variables

The following section discusses the coding scheme and survey questions used for the variables adaptation, perceived risks, perceived barriers, perceived self-efficacy, and perceived hazard experience. Furthermore, this section describes the manipulation of SPEI values obtained freely from SPEIbase for the variable climate conditions. In this study, perceived risks and perceived barriers are predictive variables for the criterion variable adaptation, while the variables perceived self-efficacy, perceived hazard experience, and climate conditions can be thought of as mediating variables.

3.5.1 Adaptation

Support for adaptation by farmers under increased weather variability is measured using 5 questions. First, “How frequently would severe drought or rain events that reduce your yield by 50% need to occur for you to install conservation drainage?” Second, “How frequently would severe drought or rain events that reduced your yield by 50% need to occur for you to install irrigation?” Third, “How frequently would severe drought or rain events that reduced your yield by 50% need to occur for you to adopt practices that increase organic material in the soil?” Fourth, “How frequently would severe drought or rain events that reduce your yield by 50% need to occur for you to plant perennial monoculture crops (for example, switchgrass or miscanthus for cellulosic ethanol)?” Lastly, “How frequently would severe drought or rain events that reduced your yield by 50% need to occur for you to seek off-farm income?” For all 5 questions, farmers selected from 1 of the following 10 answer choices a) annually b) every 2 years c) every 5 years d) every 7 years e) every 10 years f) I would never adopt g) I have adopted already h) this is not relevant to me i) unsure j) other. The responses for these questions were recoded to follow a Likert-type question (see table 3.5.1). Items a-c were grouped into the category “unlikely to adapt” and items d and e were grouped into the category “likely to adapt”. This classification is based on the assumption that farmers who require more frequent weather-related yield loss to be willing to implement a form of adaptation are less likely to support adaptation than farmers who require less frequent weather-related yield loss to be willing to implement a form of adaptation. More specifically, farmers that will adapt if 50% yield loss occurred every 7 to 10 years are more supportive of adaptation than farmers that will adapt if 50% yield loss occurred every 1 to 5 years. Items f and h were grouped into the category “I will not adapt.” Item g was renamed “adapted” and item i was renamed “neither likely nor unlikely to adapt.” Lastly, item j was recoded as an error. The resulting categories were then coded in ascending order from 1) I will not adapt to 5) Adapted.

Table 3.5.1. Adaptation Coding Scheme

Before	Transition	After
Annually; Every 2 years; Every 5 years	Every 1 to 5 years	Unlikely to adapt (2)
Every 7 years; Every 10 years	Every 6 to 10 years	Likely to adapt (4)
I would never install' This is not relevant to me	I would not install	I will not adapt (1)
I have already installed	→	Adapted (5)
Unsure	→	Neither likely or unlikely to adapt (3)
Other	→	Error

Considering the projected climate changes for the Midwest, adaptations specific to precipitation, drought, and crop price volatility are evaluated. More specifically, the adaptation measures studied include conservation drainage, irrigation, increased organic material in the soil, planting perennial monoculture crops, and seeking off-farm employment. It is expected that farmers who perceive higher risks for increased precipitation will express higher support for adaptations such as conservation drainage which would help with increased precipitation. Similarly, it is expected that farmers who perceive higher risks for drought will express higher support for adaptations such as irrigation which would assist with increased drought. Lastly, it is expected that farmers who perceive higher risks for crop price volatility will express higher support for adaptations such as seeking off-farm income which would provide more reliable sources of income. However, it is also expected that support for adaptation will be higher for incremental adaptations than transformational adaptations. Of the evaluated adaptations, planting perennial monoculture crops was the only adaptation considered transformational by Varble

(2014). However, the low use of irrigation in Iowa-Cedar watershed classifies this practice as a transformational adaptation.

Evaluating specific adaptations relative to risks type provides a level of detail not seen in other studies. This approach provides insight as to how farmers feel about specific adaptations as opposed to the general concept of adaptation. This distinction is key because the evaluation of adaptation in general may skew results, misguiding efforts to assist with improving farmers' resilience to climate change. For example, consider if policy makers identified the adaptations conservation drainage, irrigation, and seeking off-farm income as viable adaptations for their community. A survey is then implemented to determine if farmers are willing to adapt. Since the study does not look at each adaptation individually, results are dependent on a hypothetical average of all three adaptations. Furthermore, suppose findings from the study indicate that farmers are against adaptation. However, farmers are actually just against irrigation and conservation drainage, but supportive of seeking off-farm income. However, the question cannot account for this level of detail. The same can be said about the evaluation of climate change risks. Still, the use of specific adaptations and multiple risks types at a perceived temporal scale is not common in the literature. The lack of specification to types of adaptation and risks may be due to the desire to maximize the application of findings to regions outside the study area. However, a highly generalized analysis may not prove beneficial for real-world applications.

3.5.2 Perceived Risks

Perceived risks is measured using 3 Likert-type questions for increased precipitation risks, drought risks, and crop price volatility risks. First, for the question "How serious is the risks to productivity on your farm currently", possible responses were from 1) no risk to 5) extreme risk. Second, for the question “Compared to current conditions, how serious is the risk to productivity from 2005 to 2014”, possible responses ranged from 1) much less serious than current” to 5) much more serious than current. Lastly, for the question “Compared to current conditions, how serious is the risk to productivity for 2015 to 2024”, possible responses also ranged from 1) much less serious than current” to 5) much more serious than current. Since the risks questions already follow a Likert question format, further manipulation of the responses is not necessary. Evaluating current risks perceptions relative to perceived past and future risks perceptions allows for considering a temporal aspect of risks perception, which is unique to this study.

3.5.3 Perceived Barriers

Corresponding to the 5 adaptations, perceived barriers are measured using 5 Likert-type questions. The possible responses are as follows 1) not at all, 2) a little, 3) some, 4) a lot, 5) don’t know, 6) does not apply. The evaluated barriers are finances, time, insufficient proof of benefit, hard to integrate or use with a farming system, lack of equipment, lack of professional support, and environmental concerns. Farmers that respond with “don’t know” and “does not apply” were coded as an error and the remaining responses were left unchanged. It is expected that the perceived barriers for the transformational adaptations planting perennial monoculture crops and irrigation will be higher than the perceived barriers for the incremental adaptations conservation drainage, increasing organic material in the soil, and seeking-off farm income.

3.5.4 Perceived Self-efficacy

Corresponding to the 3 risks types, self-efficacy was measured using 3 Likert-type questions which read as “I have adequate knowledge to cope with the potential threat of … to the productivity of my farm in the future.” The possible responses were as follows: 1) strongly disagree 2) disagree 3) neutral 4) agree 5) strongly agree. It is expected that farmers with a high level of self-efficacy will have lower risks perceptions than farmers with low self-efficacy.

3.5.5 Perceived Hazard Experience

Perceived hazard experience is measured using two survey questions. First, “to the best of your recollection, during the 10-year period 2005 through 2014, how many droughts have reduced your crop yields by 30%?” Similarly, the second question reads, “To the best of your recollection, during the 10-year period 2005 through 2014, how many droughts or excess precipitation events have reduced your crop yields by 30%?” Both questions use the following coding scheme: 1) 0, 2) 1-2, 3) 3-5, 4) 6-7, 5) 8 or more, 6) unknown.

3.5.6 Climate Conditions

For the purpose of this work, “climate conditions” refers to SPEI values. Monthly SPEI values for the months April through November over the time period of 2005 to 2014 are organized by geographic position in a new. exl file. Monthly SPEI values are selected because shorter time scales more accurately depict moisture conditions at the agricultural scale. Furthermore, the months April through November are selected because those months encompass typical planting and harvesting dates for corn and soybean grown in Iowa. The ten-year time period is chosen because this is the same time period in which farmers were asked to base their responses to climatic perceptions in the survey. SPEI values from 1950 to 2004 were also evaluated to determine how climate conditions from 2005 to 2014 compare to historic climate conditions.

3.6 Research Questions

1. What are farmers' perceived risks and how do they relate to support for adaptation?
2. What are farmers' perceived barriers and how do they relate to support for adaptation?
3. Do farmers in the Iowa-Cedar watershed believe they have the ability to cope (self-efficacy) with increased precipitation, drought, and price crop volatility?
4. Do observed climate conditions help explain farmer risks perceptions of drought and increased precipitation, perceived self-efficacy, and perceived hazard experience?

3.7 Statistical Approaches

In order to partially answer questions 1 and 2, frequency tables for adaptations, barriers, and risks were produced in SPSS and transferred into Microsoft Excel in order to generate stacked bar charts that show the percent of farmers with a particular response. While stacked bar graphs provide an overview of conditions in the study area, they are unable to account for associations between variables. As such, the relationship with perceived risks and perceived barriers (questions 1 and 2) were assessed using Spearman's rank correlation. Spearman's rank correlation measures the association between two variables (Mohanty and Misra 2016). The general equation for Spearman's rank correlation is as follows:

$$\rho = 1 - \frac{6\sum D^2}{N(N^2 - 1)}$$

Where *D* is the difference between paired ranks and *N* is the number of paired ranks.

Spearman's rank correlation is the non-parametric equivalent of Pearson's correlation, meaning that it does not make assumptions about the distribution of the population (Mohanty and Misra 2016). While parametric statistics are generally preferred to non-parametric statistics, Spearman's rank order correlation is an alternative to Pearson's correlation when working with ordinal rather than continuous variables (Mohanty and Misra 2016) Compared to Pearson's correlation, values for Spearman's rank correlation tend to be smaller unless the sample size is less than 30 (Mohanty and Misra 2016). Like Pearson's correlation, Spearman's rank correlation ranges from -1 to 1, where 0 represents no correlation and values departing from zero indicate the strength and the direction of the relationship (Mohanty and Misra 2016). SPSS was set to test the following at a significance levels (α) of 0.01 and 0.05:

H_o: $\rho = 0$; there is no correlation

H_a: $\rho \neq 0$; there is a correlation

At an α of 0.05, a statistically significant Spearman rank correlation indicates that if the null hypothesis were true, there is less than a 5% probability that the sample results would have arisen. Similarly, an α of 0.01, a statistically significant Spearman rank correlation indicates there is less than a 1% probability of obtaining the sample results were the null hypothesis true. Like for questions 1 and 2, question 3 is evaluated using a stacked bar graph that is created by produced frequency table in SPSS and transferring the output into Excel.

Lastly, question 4 is evaluated by comparing the calculated probabilities for extreme and severe drought and precipitation events for 1950 – 2004 and 2005 – 2014 to farmers' perceptions of risks, hazard experience, and self-efficacy. More specifically, there are 14 SPEI sampling locations (fig. 3.2.1) within the Iowa-Cedar watershed. Of these locations, 7 are in the Upper basin, 5 are in the Middle basin, and 2 are in the Lower basin. For each basin, the sample locations were averaged into a single SPEI value for the months March-November. Frequency tables were generated in order to count the occurrence of extreme and severe drought and excess precipitation SPEI values. Probabilities were generated by dividing each count by the total number of months a severe or extreme value occurred. Farmers perceived hazards experience was determined by generating frequency tables in SPSS and transferring the results into Excel in order to generate bar graphs that show the percent of farmers responding to the questions on the number of times flood or drought had reduced their yields by 30%.

3.8 Summary

A series of summary statistics, frequency distributions, correlation test, probabilities, and frequency counts were used to evaluate farmer support for the adaptations: conservation drainage, irrigation, increasing organic material in the soil, planting perennial monoculture crops, and seeking off-farm income. More specifically, the relationship between perceived risks and perceived barriers to adaptation was tested using correlation. Furthermore, the interrelationships between adaptations, perceived risks, perceived barriers, and self-efficacy were examined using frequency distributions. Lastly, the agreement between perceived risks, reported hazard experience, and observed climate conditions was evaluated using data from 1950 to 2014 and probability analysis.

CHAPTER 4

RESULTS & DISCUSSION

4.1 Adaptation

Prior to exploring how cognitive drivers and deterrents might relate to farmer support for adaptation, it is important to first identify farmer support for adaptation in the Iowa-Cedar watershed. For instance, in all cases except increasing organic material in the soil, a greater percentage of farmers disfavored adaptation than percentage of farmers that favored adaptation (fig. 4.1.1). In ascending order, increasing organic material in the soil, conservation drainage, seeking-off farm income, planting perennial monoculture crops, and irrigation are the least opposed to most opposed adaptations (table 4.1.1). This finding is consistent with the expectation that transformational adaptations would receive less favor from farmers than incremental adaptations (Kates, Travis, and Wilbanks 2012; Varble 2014). More specifically, the transformational adaptations of planting perennial monoculture crops and irrigation were most opposed by farmers in the watershed. In contrast, the incremental adaptations of increasing organic material in the soil, conservation drainage, and seeking off-farm income were least opposed by farmers in the watershed.

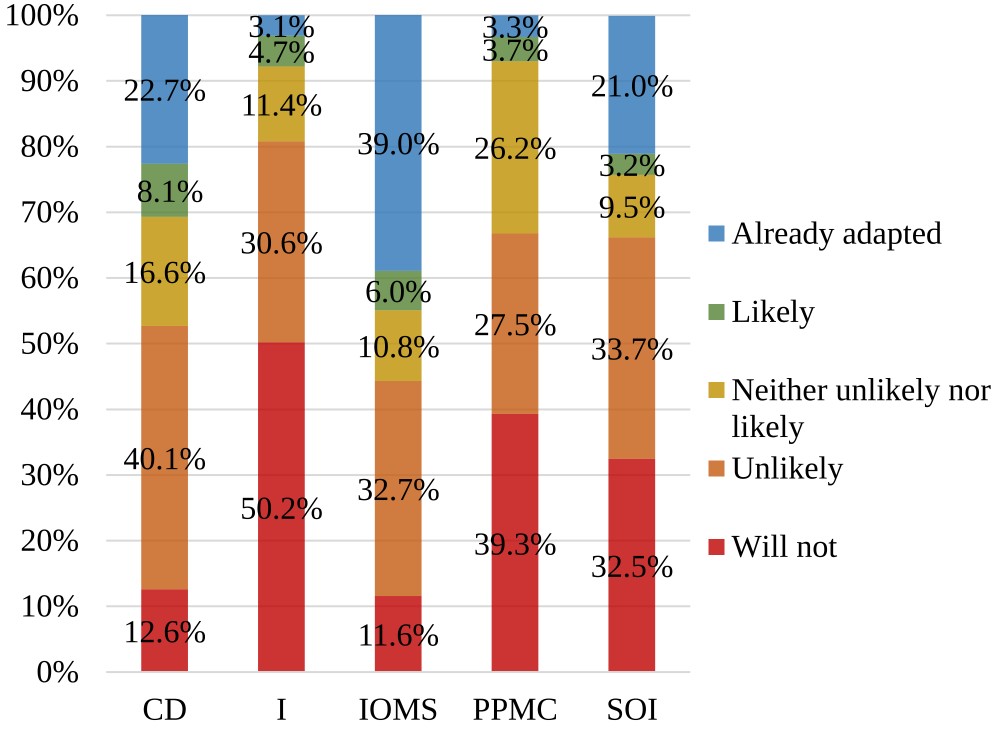
Table 4.1.1. Adaptations Descriptives

CD	Mean	2.88 (2)
	SD	1.373 (3)
	N	247
I	Mean	1.80 (5)
	SD	1.025 (1)
	N	255
IOMS	Mean	3.28 (1)
	SD	1.530 (5)
	N	251
PPMC	Mean	2.04 (4)
	SD	1.049 (2)
	N	244
SOI	Mean	2.46 (3)
	SD	1.495 (4)
	N	252

Note: CD = Conservation Drainage; I = Irrigation; IOM = Increasing Organic Material in Soil; PPM = Planting Perennial Monoculture Crops; SOI = Seeking Off-farm Income.

As a result of diverse social and climate agricultural system characteristics, the distinction between an incremental adaptation and transformational adaptation also varies. By definition, farmers have experience with actions classified as incremental and have little to no experience with actions classified as transformational. While irrigation and planting perennial monoculture crops are considered transformational adaptations for Iowa-Cedar watershed, this would not be the case in the Western U.S. where irrigated farming is prominent or for farming regions which already grow perennial crops for biofuel production. Therefore, it is important to re-evaluate this classification based on the known characteristics of the region. Furthermore, it is also important to note that these classifications are not fixed. Over time, what was once considered an incremental adaptation can become a transformational adaptation and vice versa.

There is some corroboration in the literature for our findings on the level of support for the adaptations conservation drainage, irrigation, increasing organic material in the soil, planting perennial monoculture crops, and seeking off-farm income. In large part, this is due to the fact that not many studies have looked at specific adaptations. For example, conservation drainage was the second most supported adaptation. No other study has included conservation drainage, though Arbuckle, Morton, and Hobbs (2013) found Iowa farmers expressed strong support (46%) for implementing artificial drainage. However, two years later only 36% of Iowa farmers



Note: CD = Conservation Drainage; I = Irrigation; IOMS = Increase Organic Material in Soil; PPMC = Plant Perrenial Monoculture Crops; SOI = Seek Off-farm Income.

Figure 4.1.1. Adaptating with Crop Loss of 50%

supported artificial drainage (Arbuckle, Morton, and Hobbs 2015). Furthermore, an earlier survey of the Iowa-cedar watershed showed artificial drainage to be one of the least supported adaptations (Varble 2014). Irrigation is the least supported adaptation. However, most Florida farmers showed support for irrigation (van Dijl, Grogan, and Borisova 2015). Similarly, the previous study of the Iowa-Cedar basin reported irrigation as the most favored adaptation. The same study found comparable support for planting perennial monoculture crops and seeking off-farm employment. However, increasing organic material was found to have less support in Varble (2014) than for this study which found increasing organic material in the soil to have the most support. The differences between these studies could be attributed to variations in sampling techniques. For example, Varble (2014) contained almost no respondents who identified as farmers whereas this study only considered farmers. Furthermore, van Dijl, Grogan, and Borisova 2015 might show greater support for irrigation because agricultural crops and practices are remarkably different than those found in the Iowa-cedar watershed.

4.2 Perceived Risks

In attempt to understand the cognitive drivers and deterrents of farmer support for implementing hazard reducing adaptations four questions were examined. First, what are farmers' perceived risks and how do they relate to support for adaptation? The majority of farmers reported current drought risks as small with less concern for future drought risks than past drought risks (table 4.2.1). Comparatively, current excess precipitation and price volatility risks are higher with more concern for future risks than past risks (fig. 4.2.1, fig. 4.2.2, and fig. 4.2.3). Therefore, it is expected that farmers will show the greatest support for adaptations that alleviate crop price volatility and excess precipitation. The evaluated adaptations can alleviate multiple risks types. For example, conservation drainage is designed to retain water during low precipitation conditions and release water during high precipitation conditions. Revisiting figure 4.1.1, farmers show stronger support for adaptations that alleviate both drought and excess precipitation risks. Farmers also show the least support for irrigation which only alleviates drought risks. This suggests, that farmers tend to favor adaptations that alleviate conditions which pose a greater threat.

Table 4.2.1. Risks Descriptives

		Past	Current	Future	Total
Drought	Mean	3.06	2.37	2.97	8.40 (3)
	SD	.921	.868	.821	
	N	263	263	259	
Excess Precipitation	Mean	3.00	2.74	3.12	8.86 (2)
	SD	.849	.844	.730	
	N	266	266	266	
Price Volatility	Mean	2.94	3.41	3.54	9.89 (1)
	SD	.955	.954	.841	
	N	264	262	263	
Total	Mean	9.00 (2)	8.52 (3)	9.63 (1)	

With exception to current crop price volatility risks, more famers are less concerned with the potential drought and excess precipitation risks to their farm currently then farmers who are more concerned. This finding contradicts previous studies which found a greater number of farmers where concerned with the potential impacts of climate change then farmers who were unconcerned with the potential impacts of climate change (Arbuckle, Morton, and Hobbs 2013; Arbuckle, Morton, and Hobbs 2015). This suggest that Iowa-Cedar farmers are less concerned with weather extremes then Iowa farmers in general. Furthermore, while other studies found risks perceptions to be higher in the future, farmers in the Iowa-Cedar watershed perceived little change in future risks perceptions compared to current conditions (Arbuckle, Morton, and Hobbs 2015; Menapace, Colson, and Raffaelli 2015; Niles, Lubell, and Brown 2015). Farmers in the Iowa-Cedar watershed might have perceived little change in risks as a result of lack of past experience with drought, excess precipitation, and price crop volatility or only positive experiences with these risks.

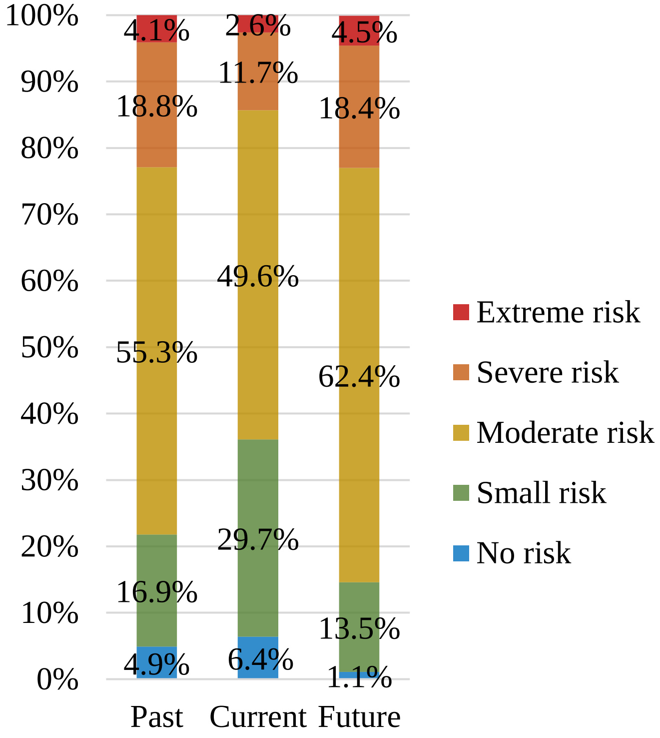


Figure 4.2.1. Perceived Excess Precipitation Risks

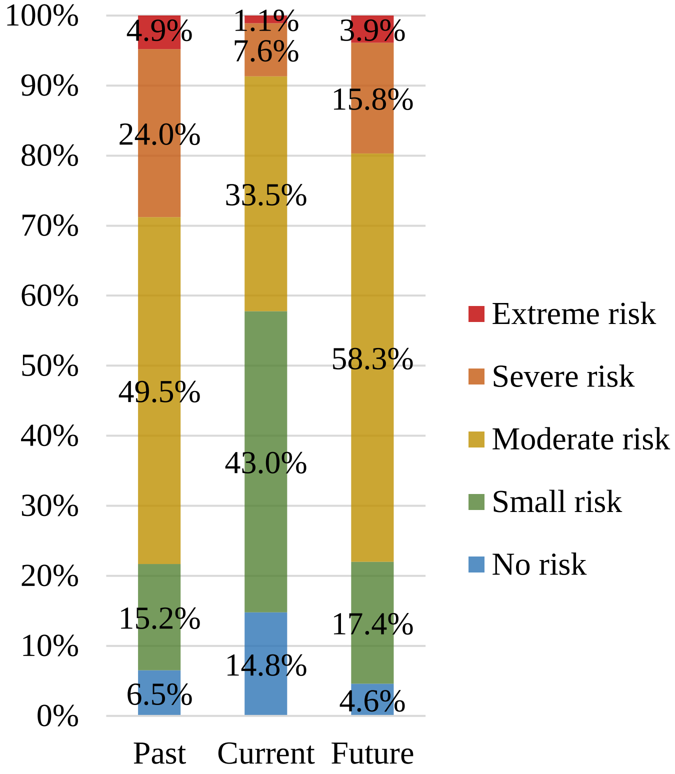


Figure 4.2.2. Perceived Drought Risks

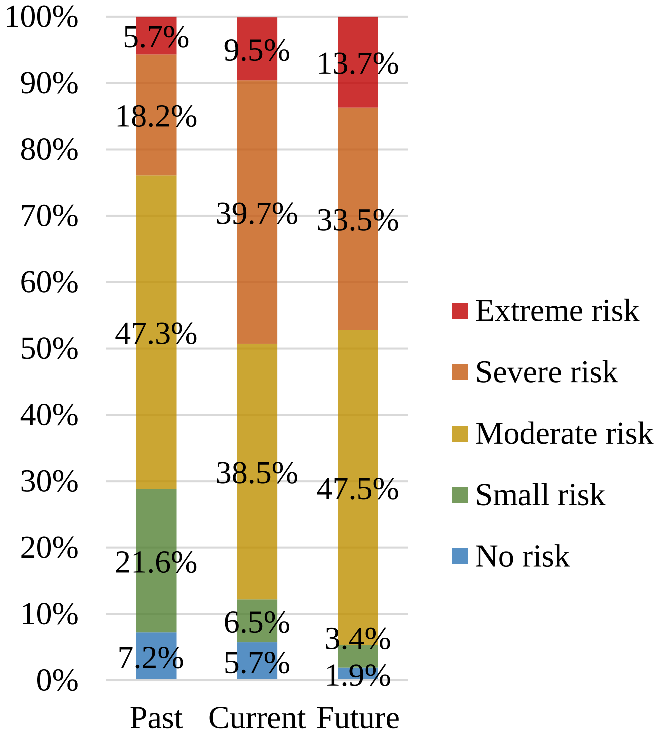


Figure 4.2.3. Perceived Crop Price Volatility Risks

When it comes to the relationship between risks perceptions and support for adaptation there are more significant relationships for current risks than for past or future risks (Table 4.2.2). This may be because farmers were asked to describe their past and future risks relative to current conditions. Asking the farmers to describe their past and future risks relative to their perceptions of current risks gives increased emphasis on current conditions. The relationship between support for conservation drainage and current excess precipitation has greater significance than current price volatility or past excess precipitation risks. With an $\alpha = 0.01$ current drought risks are the only significant relationship between perceived risks and support for irrigation. There are no significant relationships between perceived risks and support for increasing organic material in the soil. It appears that while increasing organic material in the soil is the most preferred adaptation is it not influenced by farmers' risks perceptions. The relationship between support for planting perennial monoculture crops and future price volatility has greater significance than current and future excess precipitation risks or current drought risks. This suggest that concerns for the price volatility of corn and soybean crops, the primary crops grown in Iowa-Cedar watershed, have farmers considering alternative crops. For seeking off-farm income current excess precipitation risks had a slightly stronger relationship than current price volatility risks. Overall, there appears to be either no relationship or a weak relationship between perceived risks and adaptation. Contrary to expectations, perceived risks was a poor predictor of adaptive support (Arbuckle, Morton, and Hobbs 2013; Arbuckle, Morton, and Hobbs 2015; Wilson, Howard, and Burnett 2014). The few significant relationships that exist between perceived risks and support for adaptation are weak. This finding extends the research on the relationship between perceived risks and support for adaptation.

Table 4.2.2. Risks and Adaptations Correlations

		Drought			Excess precipitation			Price Volatility		
		Past	Current	Future	Past	Current	Future	Past	Current	Future
CD	ρ	.023	.013	-.005	.153*	.198**	-.053	-.031	.147*	-.009
	Sig.	.720	.840	.933	.016	.002	.410	.626	.021	.888
	N	243	242	241	246	246	245	246	246	246
I	ρ	-.007	.212**	-.035	-.021	.039	-.027	-.037	-.013	.000
	Sig.	.913	.001	.589	.735	.547	.665	.557	.021	.995
	N	251	250	248	254	253	253	254	246	254
IOMS	ρ	.046	.027	-.024	.066	.085	.039	.000	.046	.084
	Sig.	.471	.670	.708	.297	.184	.540	.984	.473	.187
	N	247	246	244	249	248	248	251	249	250
PPMC	ρ	.098	.136*	.028	.107	.160*	.127*	.001	.020	.168**
	Sig.	.129	.036	.673	.097	.013	.048	.989	.756	.009
	N	240	239	237	242	241	241	243	241	242
SOI	ρ	.079	.028	.040	.035	.157*	.035	.032	.142*	.063
	Sig.	.215	.662	.531	.581	.013	.586	.620	.025	.320
	N	246	246	243	249	249	249	249	247	248

** Correlation is significant at the 0.01 level.
 * Correlation is significant at the 0.05 level.
Note: CD = Conservation Drainage; I = Irrigation; IOM = Increasing Organic Material in Soil; PPM = Planting Perennial Monoculture Crops; SOI = Seeking Off-farm Income.

4.3 Perceived Barriers

Another area of investigation was the relationship between farmers' perceived barriers and support for adaptation. Overall, farmers perceive the largest constrains to be finances and time and the lowest constrains to be lack of professional support and environmental concern (table 4.3.1). Furthermore, finances received elevated responses for conservation drainage and irrigation (fig. 4.3.1 – fig. 4.3.5). This is likely a reflection of the high infrastructure cost associated with these two adaptations which is not typically found with the remaining adaptations of increasing organic material in the soil, planting perennial monoculture crops, and seeking off-farm income. Irrigation was perceived to have the most constraints to implementing adaptation, while increasing organic material in the soil was perceived to have the lowest constraints. This suggest that farmers perceived more barriers to adaptations they are not willing to implement.

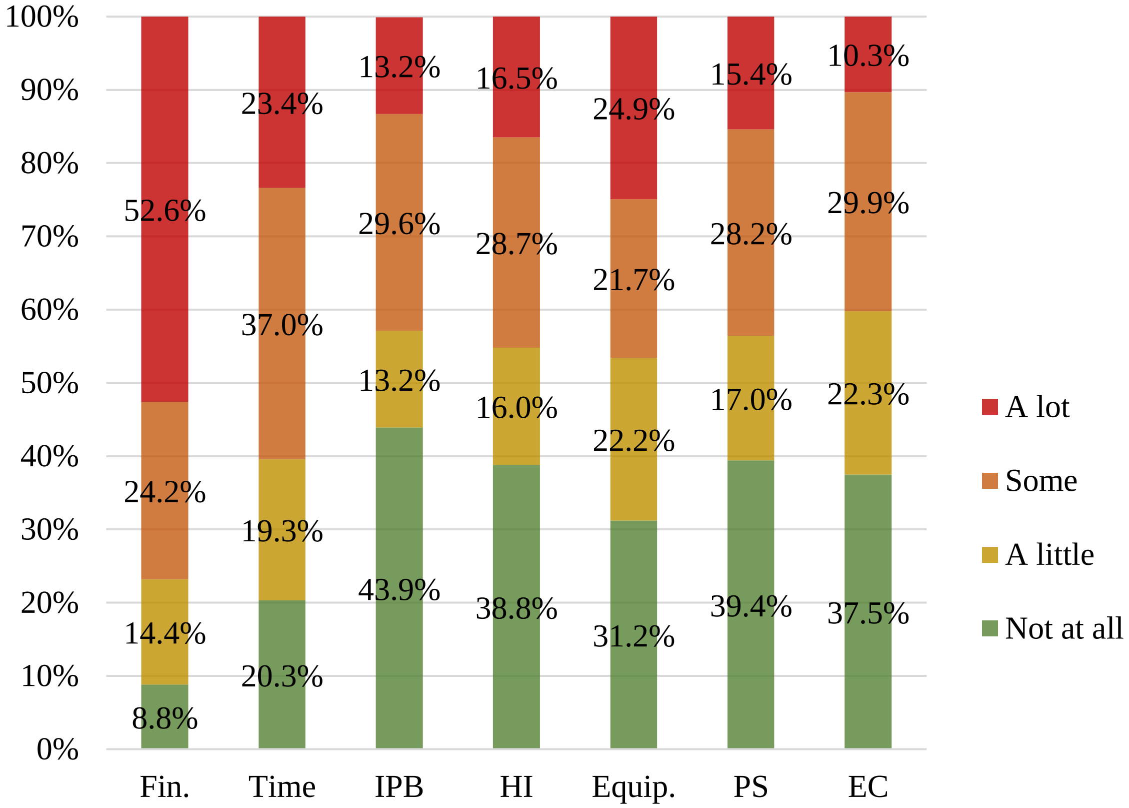
Consistent with previous findings, finances were one of the most reported barriers reported by farmers (Archie et al. 2014; Biesbroek et al. 2011; Eakin et al. 2016). Most of the relationships between perceived barriers and support for adaptation contradict the relationships in Varble 2014. More specifically, while farmers in the Iowa-Cedar watershed reported the most perceived barriers to irrigation, Varble found irrigation to have little barriers (2014). Similarly, farmers in the watershed reported the lowest barriers to increasing organic material in the soil. However, increasing organic material in the soil was one of the highest perceived barriers (Varble 2014). Nevertheless, the perceived barriers for planting perennial monocultures and seeking off-farm income are comparable to this study. The sample population obtained by Varble consisted primarily of non-farmers including participants in watershed management groups, members of the Iowa Cedar Taskforce, and community members (2014). This suggest that non-farmers in this region have starkly different perceptions then the farming community.

Table 4.3.1. Perceived Barriers Descriptives

		Fin.	Time	IPB	HI	Equip.	PS	EC	TRM
CD	Mean	3.20	2.64	2.12	2.23	2.40	2.20	2.13	16.92(3)
	SD	.993	1.055	1.121	1.136	1.170	1.123	1.037	
	N	215	192	189	188	189	188	184	
I	Mean	3.36	2.56	2.39	2.70	2.96	2.54	2.56	19.1(1)
	SD	1.023	1.126	1.196	1.230	1.200	1.171	1.157	
	N	163	152	152	158	155	149	157	
IOMS	Mean	2.25	2.06	1.95	1.98	2.05	1.98	1.85	14.2(5)
	SD	1.108	1.049	1.044	1.057	1.035	1.029	1.036	
	N	182	183	174	178	175	171	172	
PPMC	Mean	2.84	2.41	2.70	2.79	2.64	2.54	2.13	18.05(2)
	SD	1.198	1.124	1.194	1.170	1.212	1.149	1.148	
	N	144	146	141	149	148	145	144	
SOI	Mean	2.58	2.88	2.12	2.70	2.05	2.00	1.82	16.15(4)
	SD	1.253	1.144	1.081	1.159	1.142	1.081	1.085	
	N	146	149	127	137	109	114	110	
TCM	Mean	14.23(1)	12.55(2)	11.28(5)	12.4(3)	12.1(4)	11.26(6)	10.49(7)	

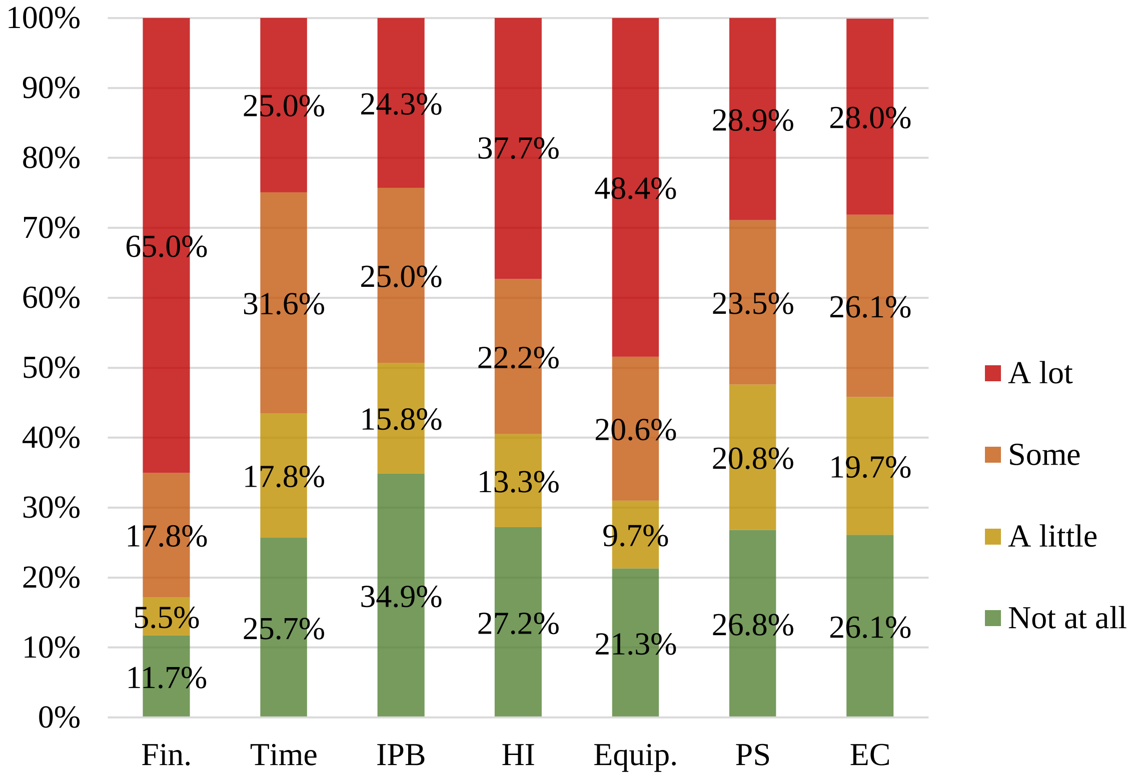
Note: CD = Conservation Drainage; I = Irrigation; IOM = Increasing Organic Material in Soil; PPM = Planting Perennial Monoculture Crops; SOI = Seeking Off-farm Income; TCM = Total Column Mean; Fin. = Finances; IPB = Insufficient Proof of Benefit; HI = Hard to Integrate; Equip. = Lack of Equipment; PS = Lack of Professional Support; EC = Environmental Concern; TRM = Total Row Mean.

Varble did not explore which barriers were most reported. Here, finances and time are the most reported barriers whereas lack of professional support and environment concern are the least reported barriers. Providing financial assistance and time saving practices could help remove farmers' apprehension toward adaptations. Furthermore, this suggest that farmers are either unconcerned for the environmental damage that adaptation can cause, or that farmers do not believe adaptations will negatively influence the environment. This also suggests that farmers believe they have adequate support from professionals or they need not consult professionals because they are well informed. Lastly, perceived barriers were found to be a significant predictor of adaptive support. In other words, as a farmers perceived barriers increased, their support for adaptation decreased. The findings pertaining to this relationship add to the fields of climate change, adaptation, and farm-management.



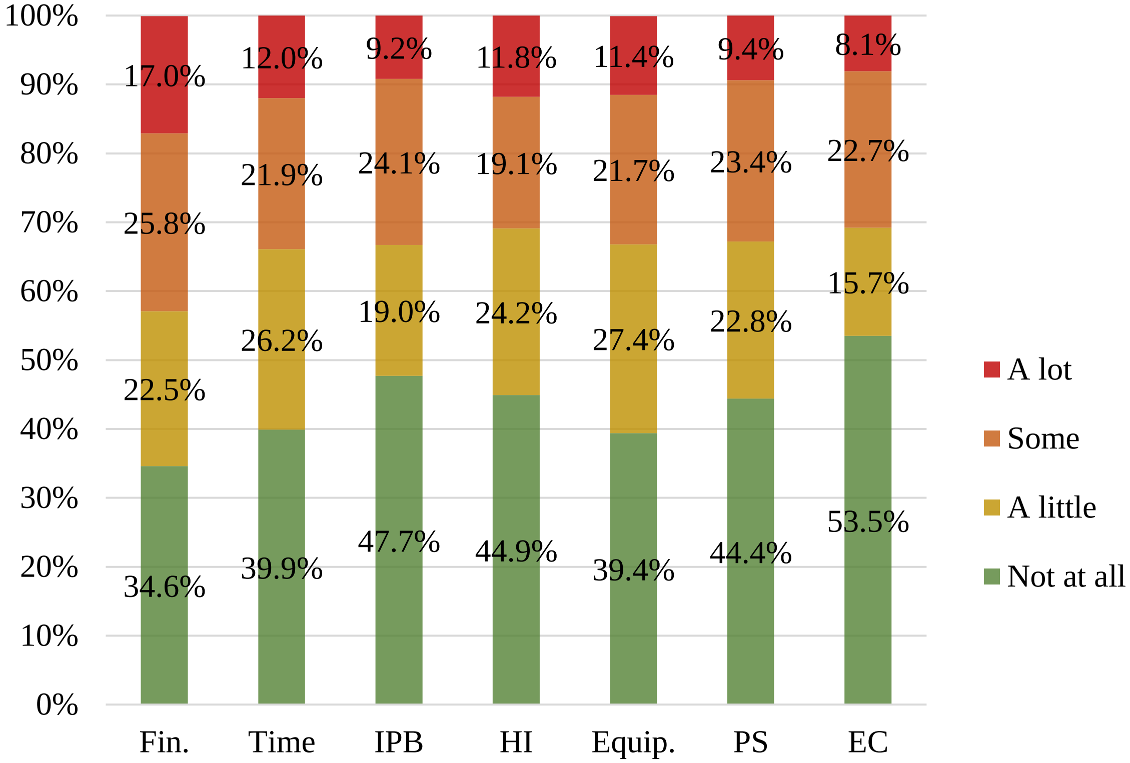
Note: Fin. = Finances; IPB = Insufficent Proof of Benefit; HI = Hard to Integrate; Equip. = Lack of Equipment; PS = Lack of Professional Support; EC = Environmental Concern.

Figure 4.3.1. Perceived Conservation Drainage Barriers



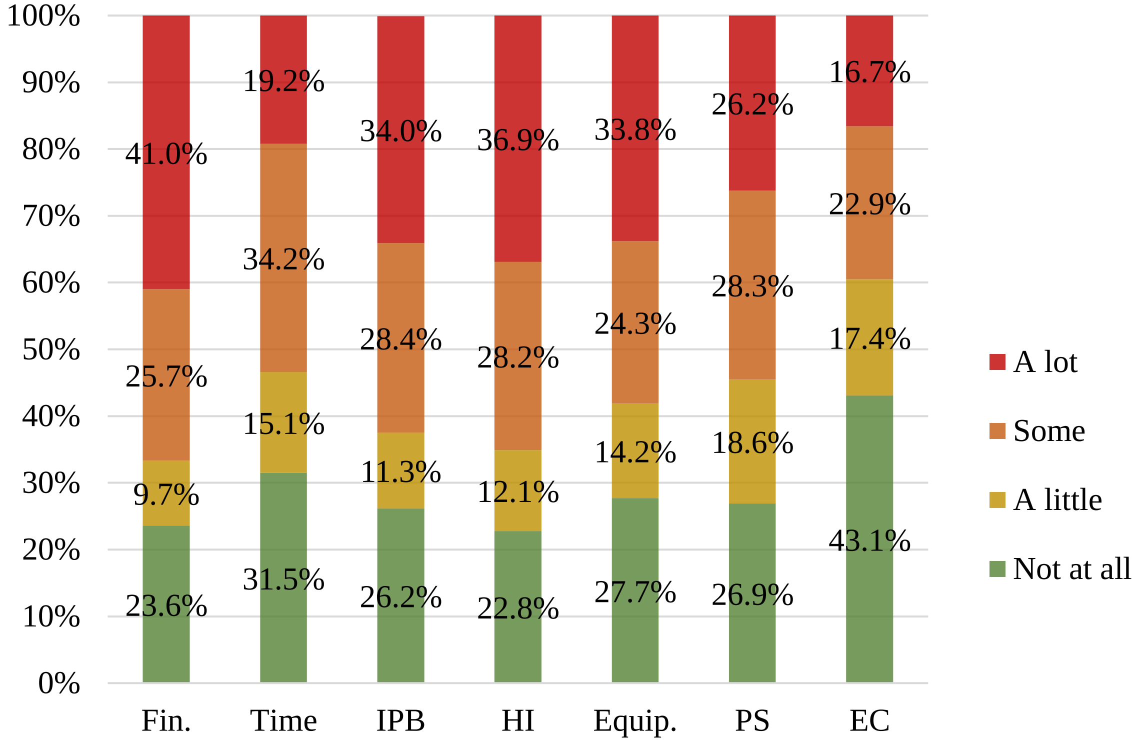
Note: Fin. = Finances; IPB = Insufficient Proof of Benefit; HI = Hard to Integrate; Equip. = Lack of Equipment; PS = Lack of Professional Support; EC = Environmental Concern.

Figure 4.3.2. Perceived Irrigation Barriers



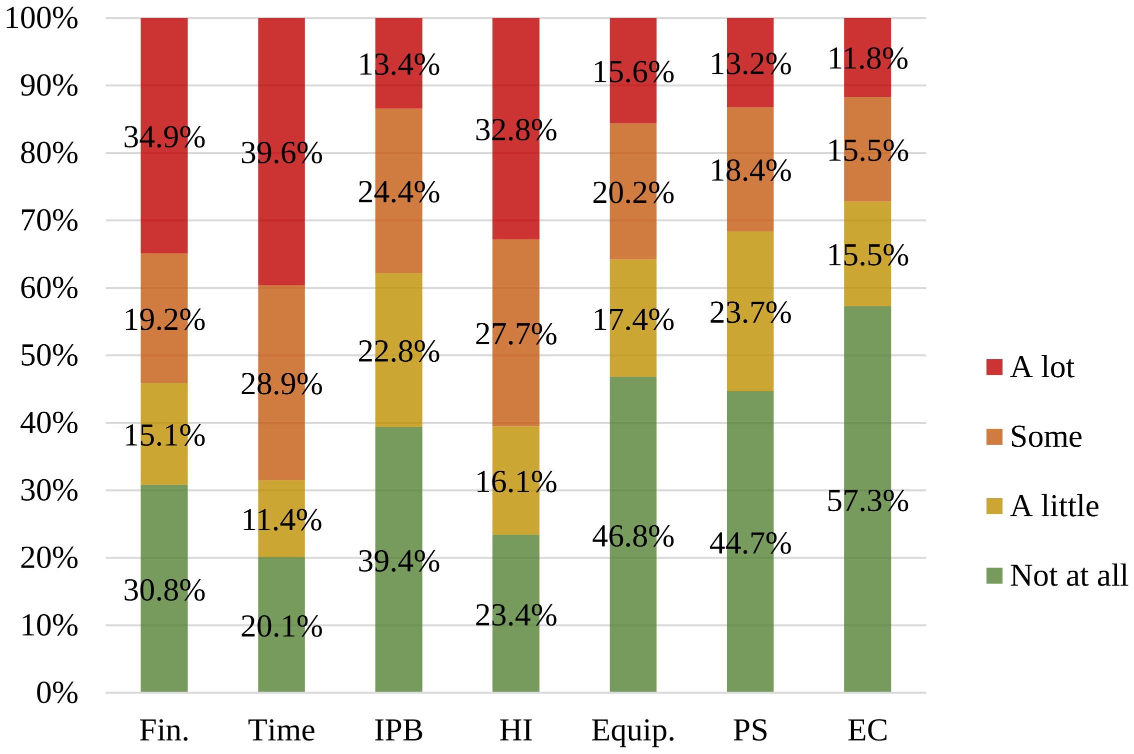
Note: Fin. = Finances; IPB = Insufficent Proof of Benefit; HI = Hard to Integrate; Equip. = Lack of Equipment; PS = Lack of Professional Support; EC = Environmental Concern.

Figure 4.3.3. Perceived Increasing Organic Materials in Soil Barriers



Note: Fin. = Finances; IPB = Insufficient Proof of Benefit; HI = Hard to Integrate; Equip. = Lack of Equipment; PS = Lack of Professional Support; EC = Environmental Concern.

Figure 4.3.4. Perceived Planting Perennial Monocultures Barriers



Note: Fin. = Finances; IPB = Insufficent Proof of Benefit; HI = Hard to Integrate; Equip. = Lack of Equipment; PS = Lack of Professional Support; EC = Environmental Concern.

Figure 4.3.5. Perceived Seeking Off-farm Income Barriers

Perceived barriers are a better predictor of adaptive support than perceived risks (table 4.3.2). As expected, the relationships between barriers and support for adaptation are negative. This indicates that as perceived barriers increase, support for adaptation decreases. All barriers had a similar number of significant relationships with support for adaptation. Conservation drainage had a higher significant relationship with insufficient proof of benefit than the other significant relationships with lack of professional support, time, and finances. All perceived barriers showed similar significance with the adaptations irrigation and planting perennial monoculture crops at $\alpha = 0.01$, with lack of equipment ant hard to integrate being the strongest relationships. With exception to finances, all barriers show similar significant relationships with increasing organic material in the soil, with the barriers hard to integrate, lack of equipment, and Insufficient proof of benefit. It seems odd that most preferred and most implemented adaptation would have a significant relationship with these particular barriers since many farmers have already increased organic material in the soil. Seeking off-farm income showed similar significant relationships with lack of professional support and environmental concern at an $\alpha = 0.01$. While lack of professional support while looking for an off-farm job seems like a reasonable barrier, environmental concern seems odd. Perhaps the off-farm jobs farmers are considering will harm the environment, however this still seems strange. Unfortunately, these findings cannot be compared to previous studies because this seems to be the first attempt to understand the relationship between perceived barriers and support for adaptation.

Table 4.3.2. Perceived Barriers and Adaptations Correlations

		Fin.	Time	IPB	HI	Equip.	PS	EC
CD	ρ	-.132*	-.134*	-.187**	-.117	-.112	-.168**	-.047
	Sig.	.041	.038	.004	.070	.084	.010	.468
	N	242	240	236	241	239	238	239
I	ρ	-.316**	-.289**	-.291**	-.340**	-.345**	-.299**	-.323**
	Sig.	.000	.000	.000	.000	.000	.000	.000
	N	245	243	241	244	244	244	245
IOMS	ρ	-.100	-.147*	-.182**	-.218**	-.201**	-.145*	-.153*
	Sig.	.119	.022	.005	.001	.002	.024	.017
	N	243	243	240	241	241	242	242
PPMC	ρ	-.208**	-.244**	-.305**	-.278**	-.269**	-.248**	-.217**
	Sig.	.001	.001	.000	.000	.000	.000	.001
	N	231	231	227	232	231	231	231
SOI	ρ	-.007	-.072	-.073	-.092	-.134*	-.169**	-.168**
	Sig.	.913	.274	.265	.158	.041	.009	.010
	N	236	236	234	235	234	236	236

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.
Note: CD = Conservation Drainage; I = Irrigation; IOM = Increasing Organic Material in Soil; PPM = Planting Perennial Monoculture Crops; SOI = Seeking Off-farm Income; Fin. = Finances; IPB = Insufficient Proof of Benefit; HI = Hard to Integrate; Equip. = Lack of Equipment; PS = Lack of Professional Support; EC = Environmental Concern.

4.4 Perceived Self-efficacy

As for whether farmers in Iowa-Cedar watershed believe they have the ability to cope with increased precipitation, drought, and price crop volatility, the majority of farmers believe they have the knowledge to cope with future threats to productivity on their farm (fig. 4.4.1). Farmers' strong self-efficacy could explain the low to moderate risks perceptions expressed by farmers. If farmers feel they can avoid disasters, they are likely to not Feel at risks. Consistent with farmers perceived risks, more farmers reported they did not have the knowledge to cope with future price crop volatility. While famers responded in similar ways for future drought and excess precipitation risks.

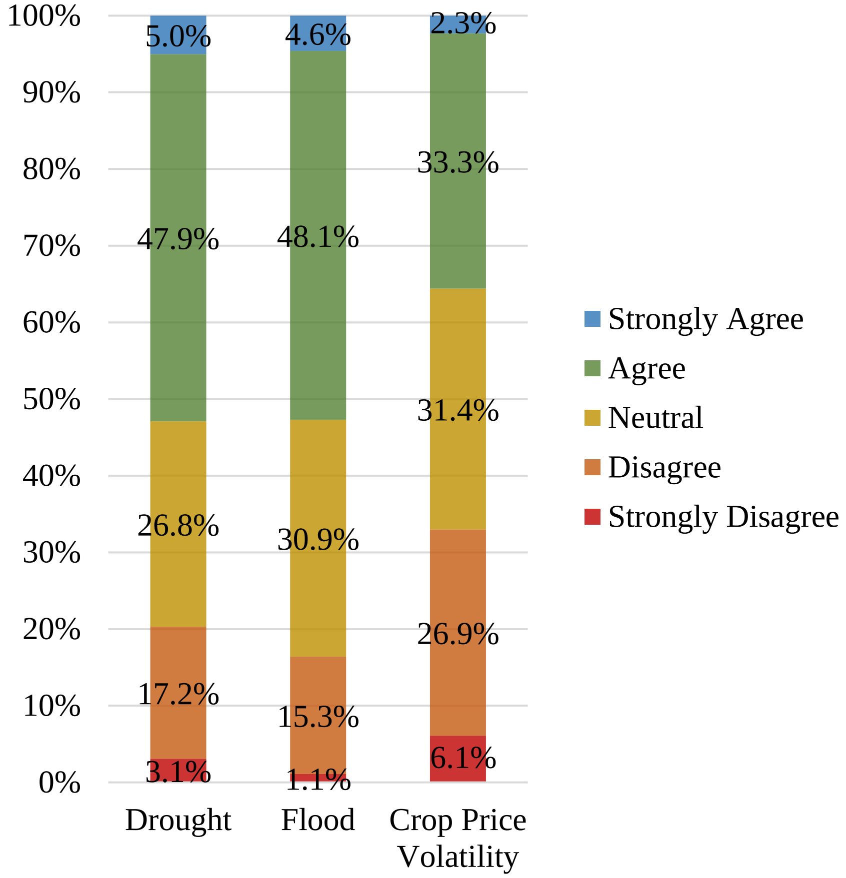


Figure 4.4.1. Knowledge to Cope with Future Risks

Consistent with previous studies, farmers in the Iowa-Cedar watershed believe they have the ability to cope with the future threat of drought and excess precipitation (Arbuckle et al. 2014; Arbuckle, Morton, and Hobbs 2013; Arbuckle, Morton, and Hobbs 2016; Brown, Bridle, and Crimp 2016; Eakin et al. 2016; and Varble 2014). For example, Eakin et al. (2016) found that 54% of farmers believed they have the knowledge to protect their land from drought. This study adds to existing knowledge to farmers' perceived ability to cope. In previous work, farmers' perceived ability to cope was only evaluated for weather extremes, but this study also evaluated farmers' perceived ability to cope with crop price volatility. Unlike with drought and excess precipitation, farmers in the Iowa-Cedar watershed did not believe they possess the knowledge to cope with price crop volatility. This suggests that farmers are more confident in their ability to manage weather than the market. Furthermore, this suggest that farmers feel informed on weather related risks. Since the farmers rates the ability to cope on their knowledge, it may be beneficial to provide farmers with additional resources to deal with price volatility.

4.5 Perceived Hazard Experience

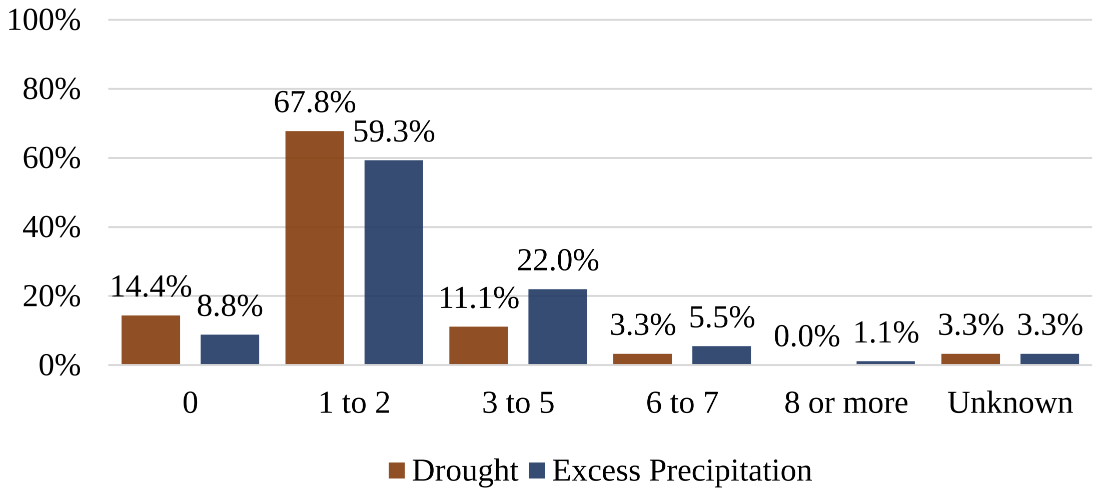


Figure 4.5.1. Perceived Crop Loss in the Upper Basin

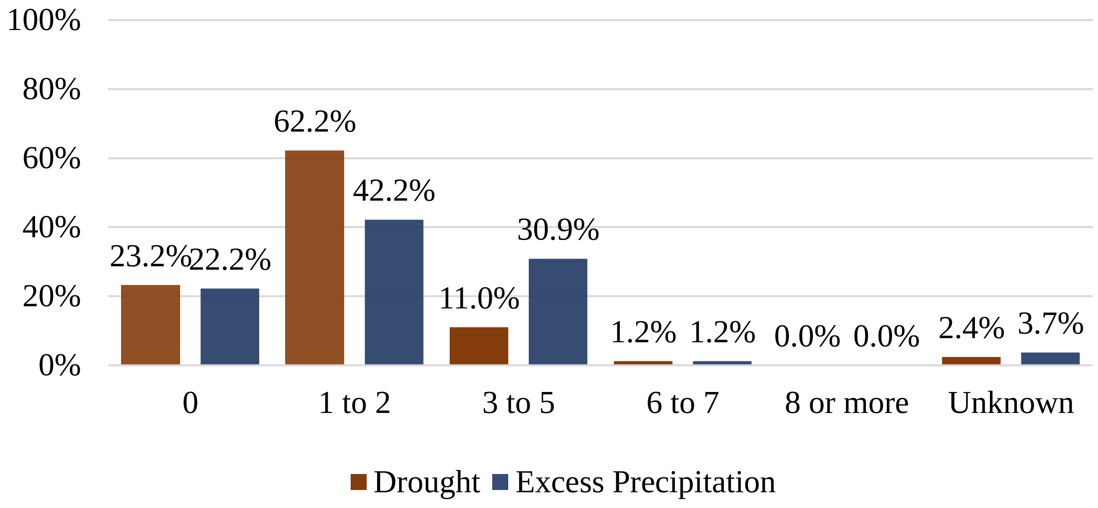


Figure 4.5.2. Perceived Crop Loss in the Middle Basin

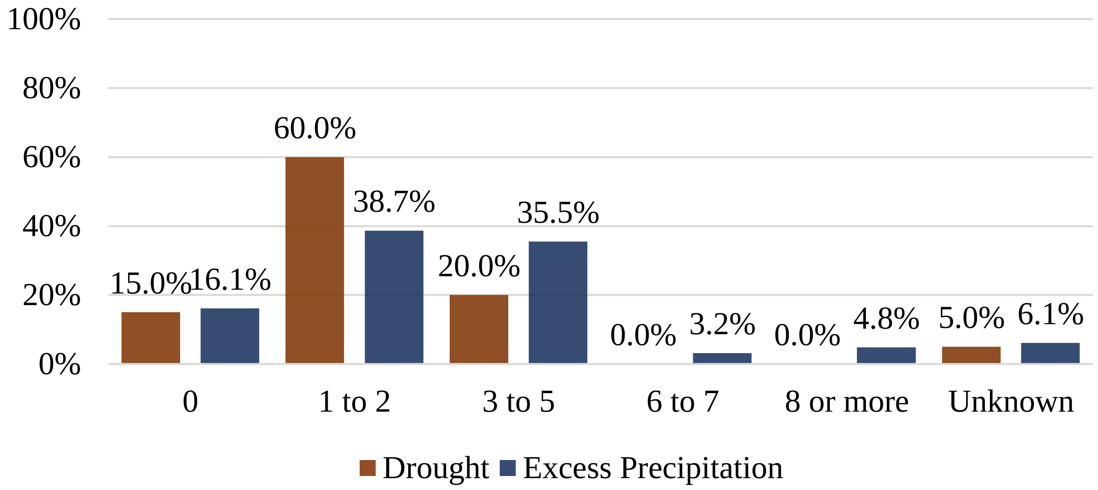


Figure 4.5.3. Perceived Crop Loss for the Lower Basin

For all basins farmers reported experiencing more excess precipitation than drought events. Most famers reported experiencing 1 to 2 precipitation or drought events in the time period of 2004 to 2014 that reduced their crop yields by 30%. Less than 10% of farmers' report experiencing more than 5 drought or excess precipitation events that reduced their crop yields by 50%. Farmers in each basin responded in similar ways.

4.6 Climate Conditions

The last question related to whether observed climate conditions help explain farmer risks perceptions to drought and increased precipitation, perceived self-efficacy, and perceived hazard experience. Overall, the Upper, Middle, and Lower basins of the Iowa-Cedar Watershed experienced more precipitation events than drought events during the time period from 2005 to 2014 compared to 1950 to 2004. Consistent with the observed climate conditions farmers excess precipitation risks were higher than their drought risks. Based on the observed climate conditions it is expected that farmers would report drought risks to be higher and excess precipitation to be lower in the past. However, over 50% of farmers reported past and future risks to be the same as their current risks.

While farmers may be exposed to less drought and greater precipitation during currently than historically their risks levels may remain stationary because climate conditions did not negatively impact their farm. According to farmers perceived hazard experience during the time period from 2005 to 2014 excess precipitation caused greater yield loss than drought. While this is also consistent with the observed climate conditions of the region, it still does not explain why farmers have stagnant risks perceptions. Even if farmers experience loss from hazards, if they feel they have the ability to cope in the future their risks levels can be low. Farmers reported similar responses for their ability to cope to future drought and precipitation. Farmers high-self efficacy could help explain why farmers perceived future drought and excess precipitation to be the same as current. However, these results are unable to explain why farmers perceive past drought and excess precipitation risks similar to current risks. Furthermore, these results can also be explained by the fact that farmers may have implemented adaptations which help with excess precipitation that are not accounted for with this study. For example, this study only examines conservation drainage and not tile drainage which the majority (63%) of Iowa farmers reported using (USDA 2012). The principal difference between the two forms of artificial drainage being that conservation drainage captures (drought) and releases (excess precipitation) water to assist with precipitation extremes and traditional tile drainage only releases excess water. Overall these results show that changes in precipitation do not equate to changes in risks to these changes.

Observed climate conditions indicate more excess precipitation events in the Iowa-Cedar Watershed then drought events (fig. 4.5.1 – fig. 4.5.3). This is consistent with previous research on Midwest farmers (Arbuckle et al. 2014; Morton et al. 2015). A study by Varble also found that the majority of farmers reported experiencing 1 to 2 drought events in the past ten year and more farmers reported loss from excess precipitation (2014). Furthermore, climate models have also shown an increase in precipitation for the Midwest (Dai et al. 206; and McFadden and Miranowski 2016). While past experience has been found to be a significant predictor of farmer risks perception, these findings suggests that other factors such farmers' perceived ability to cope and perceived hazard experiences (Menapace, Colson, and Raffaelli 2015). Furthermore, observed climate conditions do show some correspondence with farmers' perceptions. For example, the probability of severe drought and extreme and severe precipitation was higher for the time period 2005 – 2014 than the time period 1950 – 2004. However, the probability of occurrence for severe drought and extreme precipitation are approaching the probability that is expected from random chance. Furthermore, the probability of occurrence for extreme drought decreased in 2005-2014 compared to 1950 – 2014. These probabilities suggest, that conditions in the Iowa-Cedar watershed were drier than expected in the past. Most notability, the probability of severe precipitation has increased substantially. More specifically, the Middle Basin exhibited a probability of 1.36% during the time period 1950 – 2004 that jumped to 5% during the time period of 2005 – 2014. These results are consistent with findings that precipitation extremes are increasing in the Midwest (Burch et al. 2010; Eisenack et al. 2014; Lehmann et al. 2015; Moser and Ekstrom 2010; and Runharr et al. 2012).

Table 4.6.1. Probability of Extreme and Severe Conditions

Basin	Severe drought	Extreme drought	Extreme Precipitation	Severe Precipitation
2005 - 2014				
Upper	1.25%	13.75%	16.25%	1.25%
Middle	1.25%	11.25%	16.25%	5%
Lower	1.25%	11.25%	17.5%	2.5%
1950 - 2004				
Upper	0.23%	15.45%	15.23%	0.45%
Middle	0.23%	16.82%	12.27%	1.36%
Lower	0.68%	15%	13.86%	2.05%

4.7 Summary

Overall, it appears that farmers are motivated to implement adaptation when climatic events threaten farm productivity. Furthermore, most farmers feel low to moderate risks and high self-efficacy. Most farmers reported multiple barriers to implementing adaptation. While significant relationships exist between perceived risks and adaptive support and perceived barriers and adaptive support there were more significant and in some cases stronger relationships for perceived barriers and adaptive support. Lastly, observed climate conditions shows some correspondence with farmers' perceptions. The finding from this section are further discussed in section 5.1.

CHAPTER 5

CONCLUSION

The following chapter summarizes key findings, study limitations and recommendations for future research, and revisits the purpose for this research. First, section 5.1 provides answers to the research questions. Next, section 5.2 discusses limitations to the study and provides recommendations for future research. Finally, section 5.3 concludes with a summary of key findings and implications.

5.1 Summary of the Findings

In order to better understand the role of farmer perceptions on their support for adaptation 4 questions were evaluated. First, what are farmers' perceived risks and how do they relate to support for adaptation? Farmers showed the greatest support for increasing organic material in the soil and the least support for irrigation. In general, farmers in the Iowa-cedar watershed prefer incremental adaptations to transformational adaptations. For example, the transformational adaptations of irrigation and planting perennial monocultures had the least support and the most reported barriers. Furthermore, farmer risks perceptions to drought, excess precipitation, and price crop volatility were poor predictors for farmer support for adaptation. Second, what are farmers' perceived barriers and how do they relate to support for adaptation? Farmers perceived the most to irrigation and the least barriers to increasing organic material in the soil. Finances was the most reported barrier and environmental concern was the least reported barrier. Lastly, farmer perceived barriers was a better predictor of support for adaptation their risks perceptions.

As for the question, do farmers in Iowa-Cedar watershed believe they have the ability to cope (self-efficacy) with increased precipitation, drought, and price crop volatility? Farmers generally have high self-efficacy for their ability to cope to future impacts on their farm. Farmers responded in similar ways for drought and excess precipitation, but had elevated significantly lower self-efficacy for crop price volatility. For the last question, do observed climate conditions help explain farmer risks perceptions to drought and increased precipitation, perceived self-efficacy, and perceived hazard experience? The Iowa-Cedar Watershed experienced more precipitation events than drought events during the time period from 2005 to 2014 compared to 1950 to 2004. Observed climate conditions best explained farmers' responses for current risks perceptions than any other factor More specifically, farmers perceived current drought risks to be lower than current excess precipitation risks. Based on the SPEI data for Iowa-Cedar watershed and climate change projections it was expected that farmers would indicate decreasing risks to drought from past to future and increasing risks from excess precipitation from past to future (Burch et al. 2010; Eisenack et al. 2014; Lehmann et al. 2015; Moser and Ekstrom 2010; and Runharr et al. 2012). However, the majority of farmers indicated sedentary risks perceptions. This further supports previous findings that show additional factors such as negative hazard experience and self-efficacy contribute to farmers' perceptions of risks alone (Arbuckle et al. 2014; Morton et al. 2015).

5.2 Limitations and Recommendations

While this research is representative of the U.S. farm population in rain fed areas, applying findings from this study should be done with caution. Differences in local or regional agricultural practices, climate conditions, and crop type may produce responses contradictory to the ones presented here. Furthermore, findings of from this study may not be applicable to future farming populations which may have different experiences and beliefs. A major limitation to this work is that that it cannot distinguish whether or not farmers are actually prepared for future threats to their crop, or if they just feel prepared. At this time, there is no way to make the distinction between perceived resilience and actual resilience. However, a longitudinal study could be produced to document farmers' perceptions to hazard and actual conditions that transpired overtime. In addition to the specific adaptations, risks, and barriers evaluated in this study, future research should also include general questions typically found in other studies. The benefit of adding questions such as "I would use adaptation to reduce the impact of climate change on my yields" is twofold. First, this question removes the assumption that increased climate impacts influence adaptation. Second, it allows for greater comparisons to be made with other studies. This study contradicted several findings produced by an earlier survey in the same region. It is unclear if the is a result of human error or stark differences in sample population. Therefore, there should be follow-up surveys to see if and how farmer's responses have changed over time. Furthermore, this study fails to account for the interconnectedness of perceived barriers. Barriers are believed to be interdependent, sometimes weakening or reinforcing one another (Burch et al. 2010; Eisenack et al. 2014; Lehmann et al. 2015; Moser and Ekstrom 2010; and Runharr et al. 2012). For example, do farmer state a form of adaptation is difficult to integrate because they lack the time or finances to implement the adaptation? Similarly, if farmers lack the finances, is that why they report having a lack of equipment? Failure to account for interrelationships could result in ineffective planning and policy (Eisenack et al. 2014; Moser and Ekstrom 2010). While the literature suggests a connection between adaptation barriers, this relationship has not been statically tested. Since, perceived barriers was found to be a significant predictor of adaptation, future research should explore the interconnectedness between barriers.

One potential approach to exploring this gap in knowledge is running a correlation analysis. While this method does not fully disclose the interrelationships between adaptation, it can provide some information regarding how similar farmers perceive barriers in relation to one another. Another approach, may be to evaluate the conditional probability of the barriers. More specifically, what is the probability of farmers reporting an adaptation is “hard to integrate” given that they perceive “finances” as a barrier. Insights produced from these suggestions can provide more information regarding gaps in farmer knowledge in order to maintain resilience through education and outreach programs.

5.3 Conclusion

Climate change projections suggest that the rate and intensity at which change can occur might overwhelm farmers’ ability to mentally or financially cope with climate change. Therefore, extending hazard mitigating support beyond traditional reactive rather than proactive responses is critical to insuring the continued productivity of the U.S. agricultural sector. Adaptation has been identified as one approach that can be used to improve agricultural resilience. Despite the potential to increase the resilience of agriculture to climate change, application of adaptive measures has been slow. Concerns for the increased vulnerability of the agricultural sector and finite funding for programs aimed at reducing the consequences of agricultural vulnerability have heightened the need for understanding the complex relationship between farmer perceptions and support for adaptation in order to provide targeted policy and outreach that would produce the most agricultural resilience. Therefore, the purpose of this two phase study was to examine the relationship between farmer perceptions and farmer support for climate change adaptation practices. Ultimately, failure to understand factors that influence and impede support for adaptation may result in a less desirable agricultural production system, reduced human health, and diminished environmental quality.

Overall, findings from this study suggest that farmers are more concerned with financial risks and barriers than any other factor. For example, farmers perceived the highest risks to be associated with crop price volatility and not drought risks and increased precipitation risks. Furthermore, while other risks types were believed to be the same in the past and the future, perceived crop price volatility was the only evaluated risks to increase from past to future. Similarly, the majority of farmers believed they had the ability to cope with future drought and excess precipitation extremes, however the opposite was true for crop price volatility. Farmers also reported “finances” as a barrier to implementing adaptation more frequently than any other barrier.

Contrary to expectations, farmers perceived risks were generally not predictive of farmers support for adaptation. The few relationships between farmer responses for perceived risks and support for adaptation could be a result of farmers’ stationary perception of risks. More specifically, the majority of farmers in the Iowa-Cedar basin reported low to moderate risks to drought, excess perception, and price volatility risks for the past, present, and future. Despite these responses to risks, when given the scenario of 50% crop loss at various frequency of occurrence, farmers’ responses did not correspond to their perceived willingness to implement adaptation. This is likely because the farmers were responding to a hypothetical situation which may or may not occur. Therefore, a farmer can indicate that they would be willing to implement adaptation if crop losses of 50% occurred annually and feel no risks if they do not believe the scenario will occur. Similarly, a farmer can indicate that they would be willing to implement adaptation if crop losses of 50% occurred annually and feel no risks because they have a high ability to cope. Hence, perceived risks may only be a strong predictor of support for adaptation if the farmer believes their crops would be negatively impacted and they would not be equipped to manage those impacts. In contrast, perceived barriers are a strong predictor of adaptive support. This may be because perceived barriers have less mediating factors then risks perception. Lastly, climate conditions are consistent with farmers' perceptions regarding drought and precipitation events.

When advocating for hazard relief, adaptations cost should be emphasized. Since there is little concern for future impacts, compounded saving may not motivate farmers to implement adaptation. Therefore, proposed adaptations must have short term and long terms financial returns. In this case, short-term returns would incentivize farmers to implement adaptation and long-term returns would safe-guard the future productivity of agriculture. As indicated in this study, farmers are generally more supportive of incremental rather than transformational adaptations. Policy makers face the difficult task of identifying a cultivating adaptations that meet human and environmental needs.

REFERENCES

Arbuckle, J. G., J. Hobbs, A. Loy, L. W. Morton, L. S. Prokopy and J. Tyndall. 2014. "Understanding Corn Belt Farmer Perspectives on Climate Change to Inform Engagement Strategies for Adaptation and Mitigation." *Journal of Soil and Water Conservation* 69(6):505-516.

Arbuckle, J., L. Morton and J. Hobbs. 2013. "Farmer Beliefs and Concerns about Climate Change and Attitudes toward Adaptation and Mitigation: Evidence from Iowa." *Climatic Change* 118(3/4):551-563.

Arbuckle, J. G., L. W. Morton and J. Hobbs. 2015. "Understanding Farmer Perspectives on Climate Change Adaptation and Mitigation: The Roles of Trust in Sources of Climate Information, Climate Change Beliefs, and Perceived Risk." *Environment and Behavior* 47(2):205-234.

Arbuckle, J., L. Prokopy, T. Haigh, J. Hobbs, T. Knoot, C. Knutson, A. Loy, A. Mase, J. McGuire, L. Morton, J. Tyndall and M. Widhalm. 2013. "Climate Change Beliefs, Concerns, and Attitudes toward Adaptation and Mitigation among Farmers in the Midwestern United States." *Climatic Change* 117(4):943-950.

Archie, K. M., L. Dilling, J. B. Milford, and F. C. Pampel. 2014. “Unpacking the Information Barrier: Comparing Perspectives on Information as a Barrier to Climate Change Adaptation in the Interior.” *Journal of Environmental Management* 133:397-410.

Barnett, J., L. S. Evans, C. Gross, A. S. Kiem, R. T. Kingsford, J. P. Palutikof, C. M. Pickering, and S. G. Smithers. 2015. “From Barriers to Limits to Climate Change Adaptation: Path Dependency and the Speed of Change.” *Ecology and Society* 20(3), 11p.

Begueria, S., S. M. Vicente-Serrano, F. Reig, and B. Latorre. 2014. “Standardized Precipitation Evapotranspiration Index (SPEI) Revisited: Parameter Fitting, Evapotranspiration Models, Tools, Datasets, and Drought Monitoring.” *International Journal of Climatology* 34:3001-3023.

Biesbroek, G., R. J. Swart, W. G. M. Van der Knaap. 2009. “The Mitigation-Adaptation Dichotomy and the Role of Spatial Planning.” *Habitat International* 33(3):230-237.

Biesbroek, R., J. Klostermann, C. Termeer, and P. Kabat. 2011. “Barriers to Climate Change Adaptation in the Netherlands.” *Climate Law* 2:181-199.

Bradshaw, B., H. Dolan, and B. Smit. 2004. “Farm-level Adaptation to Climatic Variability and Change: Crop Diversification in the Canadian Prairies.” *Climatic Change* 67:119-141.

Brody, S. D., B. M. Peck, and W. E. Highfield. 2004. “Examining Localized Patterns of Air Quality Perception in Texas: A Spatial and Statistical Analysis.” *Risks Analysis* 24(6):1561-1573.

Brown, P. R., K. L. Bridle, S. J. Crimp. 2016. “Assessing the Capacity of Australian Broadacre Mixed Farmers to Adapt to Climate Change: Identifying Constraints and Opportunities.” *Agricultural Systems* 146:129-141.

Burch, S. 2010. “In Pursuit of Resilient, Low Carbon Communities: An Examination of Barriers to Action in Three Canadian Cities.” *Energy Policy* 12:7575-7585.

Burton, R. J. 2014. "The Influence of Farmer Demographic Characteristics on Environmental Behaviour: A Review." *Journal of Environmental Management* 135:19-26.

Chite, R. 2014. "The 2014 Farm Bill (PL 113-79): Summary and Side-by-side." Congressional Research Service:1-234. http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R43076.pdf.

Dai, S., M. D. Shulski, K. G. Hubbard, and E. S. Takle. 2016. “Short Communication a Spatiotemporal Analysis of Midwest US Temperature and Precipitation Trends During the Growing Season from 1980 to 2013.” *International Journal of Climatology* 36:517-525.

Eakin, H., A. York, R. Aggarwal, S. Waters, J. Welch, C. Rubinos, S. Skaidra-Heisters, C. Bausch, and J. M. Anderies. 2016. “Cognitive and Institutional Influences on Farmers’ Adaptive Capacity: Insights into Barriers and Opportunities for Transformative Change in Central Arizona” *Regional Environmental Change* 16:801-814.

Eisenack, K., S. C. Moser, E. Hoffmann, R. J. Klein, C. Oberlack, A. Pechan, M. Rotter, and C. Termeer. 2014. “Explaining and Overcoming Barriers to Climate Change Adaptation.” *Nature Climate Change* 4:867-872.

FEMA (Federal Emergency Management Agency). 2016. Hazard Mitigation Grant Program. September 28. Accessed on October 30, 2016. https://www.fema.gov/hazard-mitigation-grant-program.

Grothmann, T. and A. Pratt. 2003. “Adaptive Capacity and Human Cognition.” Paper presented at the open meeting of the Global Environmental Change Research Community, Montreal, Canada, October 16-18.

Haden, V., M. T. Niles, M. Lubell, J. Perlman and L. E. Jackson. 2012. "Global and Local Concerns: What Attitudes and Beliefs Motivate Farmers to Mitigate and Adapt to Climate Change?" *Plos One* 7(12): 1-7.

Head, L., J. Atchison, A. Gates, and P. Muir. 2011. “A Fine-grained Study of the Experience of Drought, Risk and Climate Change among Australian Wheat Farming Households.” *Annals of the Association of American Geographers* 101(5):1089-1108.

Hernandez, E. A. and V. Uddameri. 2014. “Standardized Precipitation Evapotranspiration Index (SPEI)-based Drought Assessment in Semi-arid South Texas.” *Environmental Earth Science* 71”2491-2501.

ICWICT (Iowa-Cedar Watershed Interagency Coordination Team). 2016. “Welcome to the Iowa-Cedar River Basin.” Last modified February 1. Accessed October 24, 2016. http://www.iihr.uiowa.edu/iowacedarbasin/.

ICWICT (Iowa-Cedar Watershed Interagency Coordination Team). 2014. “Iowa-Cedar Watershed.” Last modified March 27. Accessed October 24, 2016. http://www.iihr.uiowa.edu/iowacedarbasin/watersheds/.

IPCC (Intergovernmental Panel on Climate Change). 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. The Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.), (pp. 151). Geneva, Switzerland. http://epic.awi.de/37530/1/IPCC_AR5_SYR_Final.pdf.

Kates, R.W. 1997. “Climate Change 1995: Impacts, Adaptations, and Mitigation.” *Environment: Science and Policy for Sustainable Development* 39(9):29-33.

Kates, W., W. R. Travis, and T. J. Wilbanks. 2012. “Transformational Adaptation When Incremental Adaptations to Climate Change are Insufficient.” *PNAS* 109(19):7156-7161.

Klein, R. J. T., E. L. F. Schipper, and S. Dessai. 2005. “Integrating Mitigation and Adaptation into Climate Development Policy: Three Research Questions.” *Environmental Science and Policy* 8:579-588.

Knowler, D. and B. Bradshaw. 2007. "Farmers’ Adoption of Conservation Agriculture: A review and Synthesis of Recent Research." *Food policy* 32(1): 25-48.

Knutson, C. L., T. Haigh, M. J. Hayes, M. Widhalm, J. Nothwehr, M. Kleinschmidt and L. Graf. 2011. "Farmer Perceptions of Sustainable Agriculture Practices and Drought Risk Reduction in Nebraska, USA." *Renewable Agriculture and Food Systems* 26(3):255-266.

Kok, M T. J., and H. C. de Coninck. 2007. “Widening the Scope of Policies to Address Climate Change: Directions for Mainstreaming.” *Environmental Science and Policy* 10:587-599.

Langer, E. J. 1975. “The Illusion of Control” *Journal of Personality and Social Psychology* 32(2):311-328.

Lambert, D. M., P. Sullivan, R. Claassen and L. Foreman. 2007. "Profiles of US Farm Households Adopting Conservation-compatible Practices." *Land Use Policy* 24(1):72-88.

Leggett, J. A., and R. K. Lattanzio. 2016. Climate Change: Frequently Asked Questions about the 2015 Paris Agreement. Congressional Research Service. https://fas.org/sgp/crs/misc/R44609.pdf.

Leggett, J. A., R.K. Lattanzio, and E. Bruner. 2013. Federal Climate Change Funding FY2008 to FY2014. Congressional Research Service. https://www.hsdl.org/?view&did=745047.

Lehmann, P., M. Brenck, O. Gebhardt, S. Schaller, and E. Subbauer. 2015. "Barriers and Oppertunities for Urban Adaptation Plannig: Analytical Framework and Evidence from Citites in Latin American and Germany." *Mitigation Adaptation Strategies Global Change* 20:75-97.

Liu, X. A. Vedlitz, and L. Alston. 2008. "Regional News Portrayals of Global Warming and Climate Change." Environmental Science and Policy 11:379-393.

Locatelli, B., C. Pavageau, E. Pramova, and M. Di Gregorio. 2015. "Integrating Climate Change Mitigation and Adaptation in Agriculture and Forestry: Opportunities and Trade-offs". W*IREs Climate Change* 6:585-598.

McFadden, J. R., and J. A. Miranowski. 2016. "Climate change: Challenge and Opportunity to Maintain Sustainable Productivity Growth and Environment in a Corn-Soybean Bioeconomy." *AgBioForum* 19(2):92-111.

Melillo, J., T. C. Richmond, and G. Yohe. 2014. Highlights of Climate Change Impacts in the United States: The Third National Assessment. US Gove. Print. Office, Washington, DC.

Menapace, L., G. Colson, and R. Raffaelli. 2015. "Climate Change Beliefs and Perceptions of Agricultural Risk: An Application of the Exchangeability Method." *Global Environmental Change* 35:70-81.

Mohanty, B. and S. Misra. 2016. "Non-parametric Statistics" In *Statistics for Behavioural and Social Sciences*, 708-719. Thousand Oaks: SAGE Publications Ltd.

Morton, L. W., J. Hobbs, J. G. Arbuckle and A. Loy. 2015. "Upper Midwest Climate Variations: Farmer Responses to Excess Water Risks." *Journal of Environmental Quality* 44(3): 810-822.

Moser, S. C. and J. A. Ekstrom. 2010. "A Framework to Diagnose Barriers to Climate Change Adaptation" *PSAS* 107(51):22026-22031.

Nasher N. M. R. and M. N. Uddin. 2014. "Analyzing Wetness and Dryness Severity in Bangladesh: Using Standardized Precipitation Index (SPI) in GIS Environment." *Journal of Environment Science and Natural Resources* 7(2):127-131.

NASS (National Agricultural Statistics Service). 2013. “Statistics by Subject—National Statistics for Corn.” Accessed on October 28, 2016. http://www.nass.usda.gov/Statistics_by_Subject/result.php?8D643273-366F-3C5C-A47DD4F8F1A01894&sector=CROPS&group=FIELD%20CROPS&comm=CORN.

Niemeyer, S., J. Petts, and K. Hobson. 2005. “Rapid Climate Change and Society: Assessing Responses and Thresholds.” *Risk Analysis* 25(6):1443-1456.

Niles, M. T., M. Lubell, and M. Brown. 2015. “How Limiting Factors Drive Agricultural Adaptation to Climate Change.” *Agriculture, Ecosystems and Environment* 200:178-185.

NOAA (National Oceanic and Atmospheric Administration). 2013. An Interpretation of the Origins of the 2012 Central Great Plains Drought. ftp://ftp.oar.noaa.gov/CPO/pdf/mapp/reports/2012-Drought-Interpretation-final.web-041113.pdf.

NSF (National Science Foundation). 2016. “NSF at a Glance.” October 24. https://www.nsf.gov/about/glance.jsp.

NWS (National Weather Service). 2009. Central United States flooding of June 2008: Service Assessment: Silver Spring, Md., National Oceanic and Atmospheric Administration, National Weather Service, 50 p. http://www.nws.noaa.gov/om/assessments/pdfs/central_flooding09.pdf.

O’Connor, C. 2013. “Soil Matters: How the Federal Crop Insurance Program Should be Reformed to Encourage Low-risk Farming Methods with High-reward Environmental Outcomes.” Paper presented at the 2013 AAEA: Crop Insurance and the Farm Bill Symposium, Louisville, Kentucky, October 8-9.

OMB (Office of Management and Budget). 2016. *Budget of the U.S. Government: Fiscal Year 2017*. Washington, DC: GPO 2016. Accessed on October 28, 2016. https://www.whitehouse.gov/sites/default/files/omb/budget/fy2017/assets/budget.pdf.

Pannell, D. J., G. R. Marshall, N. Barr, A. Curtis, F. Vanclay and R. Wilkinson. 2006. "Understanding and Promoting Adoption of Conservation Practices by Rural Landholders." *Animal Production Science* 46(11): 1407-1424.

Pielke, R. A. 1998. “Rethinking the Role of Adaptation in Climate Policy.*” Global Environmental Change* 8(2):159-170.

Pryor, S. C., D. Scavia, C. Dower, M. Garden, L. Iverson, R. Nordstrom, J. Patz, and G. P. Robertson. 2014. *Climate Change Impacts in the Unites States: The Third National Climate Assessment*. U.S> Global Change Research Program 418-440.

Reimer, A., B. Gramig and L. Prokopy. 2013. "Farmers and Conservation Programs: Explaining Differences in Environmental Quality Incentives Program Applications between States." *Journal of Soil and Water Conservation* 68(2): 110-119.

Runharr, H. H. Mees, A. Wardekker, J. Sluijs, and P. J. Driessen. 2012. “Adaptation to Climate Change-related Risks in Dutch Urban Areas: Stimuli and Barriers.” *Regional Environmental Change* 12:777-790.

Safi, A. S., W. J. Smith, and Z. W. Liu. 2012. "Rural Nevada and Climate Change: Vulnerability, Beliefs, and Risk Perception." *Risk Analysis* 32(6):1041-1059.

Schipper, E. L. F. 2006. “Conceptual History of Adaptation in the UNFCCC Process.” *RECIEL* 15(1): 82-92.

Shields, D. A. 2014. Crop Insurance Provisions in the 2014 Farm Bill. Congressional Research Service http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R43494.pdf.

Shields, D. A. 2015. "Federal Crop Insurance: Background." Congressional Research Service. https://www.fas.org/sgp/crs/misc/R40532.pdf.

Smith, J. A., M. L. Baeck, G. Villarini. D. B. Wright, and W. Krajewski. 2013. “Extreme Flood Response: The June 2008 Flooding in Iowa.” *Journal of Hydrometeorology* 14:1810-1825.

SPEIbase. 2016. SPEI Global Drought Monitor. Accessed on November 2016. http://sac.csic.es/spei/map/maps.html.

Ford, T. W. 2014. “Precipitation Anomalies in Eastern-Central Iowa from 1640 – Present.” *Journal of Hydrology* 519:918-924.

Ummenhofer, C. C., H. Xu, T. E. Twine, E. H. Girvetz, H. R. McCarthy, N. Chhetri, and K. A. Nicholas. 2015. “How Climate Change Affects Extreme in Maize and Wheat Yield in Two Cropping Regions.” *American Meteorological Society* 28:4653-4687.

UNEP (United Nations Environment Programme). 2016. The Emissions Gap Report 2016. United Nations Environment Programme, Nairobi.

Urban, D. W., J. Sheffield, D. B. Lobell. 2015. “The Impacts of Future Climate and Carbon Dioxide Changes on the Average and Variability of US Maize Yields Under Two Emission Scenarios.” *Environmental Resource Letters* 10.

USDA (United States Department of Agriculture). 2016. Agriculture and Food Research Initiative (AFRI). Accessed on October 30. https://nifa.usda.gov/program/agriculture-and-food-research-initiative-afri.

USDA (United States Department of Agriculture). 2012. “Rapid Watershed Assessments.” Accessed October 24, 2016. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ia/technical/dma/rwa/?cid=nrcs142p2_008192.

USDA (United States Department of Agriculture). 2016. “Agency Overview.” October 19. Accessed on October 24, 2016. https://www.nass.usda.gov/About_NASS/index.php.

USDA (United States Department of Agriculture). 2012. *Census of Agriculture*. https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_US/usv1.pdf.

Varble, S. 2014. “The Role of Adaptation and Information in Agricultural Sustainability and Resilience.” PhD diss., Southern Illinois University Carbondale.

van Dijl, E. A., K. A. Grogan, and T. Borisova. 2015. “Determinants of Adoption of Drought Adaptations among Vegetable Growers in Florida.” *Journal of Soil and Water Conservation* 70(4):218-231.

Vicente-Serrano, S. M., S. Begueria, and J. I. Lopez-Moreno. 2010. “A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index.” *Journal of climate* 23:1696-1718.

Vicente-Serrano, S. M., S. Begueria, and J. I. Lopez-Moreno, M. Angulo, and A. El Kenawy. 2010. “A New Global 0.5° Gridded Dataset (1901-2006) of Multiscalar Drought Index: Comparison with Current Drought Index Datasets Based on the Palmer Drought Severity Index.” *Journal of Climate Notes and Correspondence* 103-1043.

Villarini, G., J. A. Smith, and G. A. Vecchi. 2013. “Changing Frequency of Heavy Rainfall over the Central United States.” *American Meteorological Society* 26:351-357.

Wilhelmi, O. V. and D. A. Wilhite. 2002. “Assessing Vulnerability to Agricultural Drought: A Nebraska Case Study.” *Natural Hazards* 25:37-58.

Wilson, R. S., G. Howard, and E. A. Burnett. 2014. “Improving Nutrient Management Practices in Agriculture: The Role of Risked-based Beliefs in Understanding Farmer’s Attitudes toward Taking Additional Action.” *Water Resources Research* 50(8):6735-6746.

Wright, B. D. 2014. “Multiple Peril Crop Insurance.” *The magazine of goof, farm, and resource issues* 29(3):1-5.

Xu, H., T. E. Twine, and E. Girvetz. 2016. “Climate Change and Maize Yield in Iowa.” *PLOS ONE* 20.

Yang, M., D. Yan, Y. Yu, Z. Yang. 2016. “SPEI-Based Spatiotemporal Analysis of Drought in Haihe River Basin from 1961 to 2010.” *Advances in Meteorology*.

Zipper, S. C. , J. Qiu, and C. J. Kucharik. 2016. "Drought Effects on US Maize and Soybean Production: Spatiotemporal Patterns and Historical Change." *Environmental Resource letters* 10.

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