TOWARD A SUSTAINABLE HEARTLAND: CONTRASTING FUTURE AGRICULTURAL SCENARIOS IN KANSAS

by

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Abstract

Agriculture is vital to the character of Kansas. It is threaded through the social, economic, and environmental systems that operate in Kansas and bring each system into interaction with one another. Loss of agriculture would mean drastic changes to traditional Kansas way of life due to the three pronged nature of agriculture in Kansas. Continuation of agricultural activity then is of great importance. Globalization, climate change, and environmental change pose threats to agricultural futures. This study is a meta-analysis of current literature in an attempt to assess the current state of sustainable agriculture in the state of Kansas. An emphasis was placed on climate as a driver of change and ways in which agricultural producers in Kansas may begin implementing sustainable adaptations. Barriers to implementing sustainable agricultural adaptations were also identified in the literature. Broadly speaking analysis focused on barriers created through policy and barriers created through gaps in knowledge and weak or missing connections, or cognitive barriers. Information gathered in the course of the literature analysis was used to generate two potential future agricultural scenarios for Kansas. Scenarios can be used to aid policy makers in assessing potential impacts of environmental change and interactions between different systems and scales. Two separate scenarios, Business-As-Usual and Sustainable-Adaptive, were developed with distinct characteristics. The Business-As-Usual scenario represents a future that is framed similar to the current situation. Changes built into the scenario stem from the projected changes to climate. The remainder of the narrative describes a future that has pursued developmental pathways driven by current policy and market forces. In contrast, the Sustainable-Adaptive scenario represents a Policy Reform scenario in which there is strong guidance through policy towards a developmental pathway that focuses on sustainable agricultural methods. This scenario describes a future in which environmental degradation is slowed or even reversed. Continued future work may focus on the role of water availability, community level impacts of sustainable adaptations, and the integration of stakeholder values as another layer of complexity in future scenarios.

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Dedication

To my wonderful husband, Gaelan McKillip - without you, there likely wouldn't be a thesis.

Chapter 1 - Beyond the Oxymoron: Sustainable Agriculture in Kansas

"The price of self-destiny is never cheap, and in certain situations it is unthinkable. But to achieve the marvelous, it is precisely the unthinkable that must be thought."
–Tom Robbins, Jitterbug Perfume

Agriculture is crucial to human activity and a key to continued survival. In 2011 population on the planet reached seven billion. It will continue to grow for some time. Concerns related to continuing to feed such a large population are a popular topic in contemporary discourse. The United States is a major agricultural producer globally. Agricultural practices produce food and contribute to the economy along with reinforcing human, social, and cultural systems. Depending on the nature of agricultural practice, the activity can have varying impacts on the environment. As global change (including climate change) continues it will be necessary for agricultural producers to make adjustments and adapt in order to feed the planet. Sustainability, a mindset oriented towards "maintaining or improving" (Harrington, L.M.B. 2009, 2011) the coupled human-environmental system, presents a different perspective for agriculture than the current mode of thought and opens new pathways for future development. Sustainable agriculture is one pathway of development that would seek to improve environmental and social conditions while continuing to significantly contribute to the economy. I work from the assumption that environmentally and socially sustainable agriculture is desirable, as opposed to agricultural practices that focus almost completely on economic concerns. Unfortunately, the present agricultural system existing in the United States has structures that serve as barriers to those interested in moving towards sustainable agriculture.

Prior to beginning of this study, I was involved in separate background research assessments on the topics of agricultural adaptation in Kansas, sustainable adaptation, and the impacts of subsidies on agriculture. This study represents an attempt to bring these separate projects together through a qualitative meta-analysis of relevant literature to assess current understanding of sustainable agriculture with an emphasis on application of that knowledge to possible transformations of the current system in the state of Kansas; as such this work fits within the realm of studies dealing with transformational adaptation (Kates *et al.* 2012). An emphasis was placed on drivers of change and ways in which agricultural producers in Kansas may begin implementing sustainable practices. Barriers to implementing sustainable agricultural adaptations are also identified through the meta-analysis. Broadly speaking, I focused analysis on obstacles created through policy and cognitive barriers. Information gathered in the course of the literature analysis was used to generate two potential future agricultural scenarios for Kansas. Scenarios can be used to aid policy makers in assessing potential impacts of human responses to change and interactions between different systems and at differing scales. A Business-as-Usual (BAU) scenario is presented depicting a possible future pathway that relies on market forces (Gallopin *et al.* 1997) and conventional forms of agriculture that tend to focus on free enterprise, the use of fossil fuel energy, and industrial agricultural production. A second scenario explores a future that focuses on sustainable agricultural production and includes significant changes to individual motives and related policy. These two scenarios represent two very different futures each situated near opposite ends of a continuum of plausible agricultural futures in Kansas.

It is becoming increasingly important to turn attention to the challenges of supporting such a large population on the limited planetary resources available (Wilson 2002). Equitable provision of the basic necessities for survival, such as adequate shelter, healthy natural and urban environments, and provision of nutritious food, should be a number one priority. The impacts of global climate change will serve as an added element of complexity when seeking to solve these problems (Foley *et al.* 2001). Perhaps one of the more daunting components of the challenge will be the equitable distribution of agricultural products across the global population. Rosen *et al.* (2010) found through the analysis of the commonly used Conventional Worlds, Barbarization, and Great Transitions scenarios that changes to the values and structures that underpin lifestyles of reduced consumption and energy demand will need to accompany transitions towards sustainable management of agriculture and other natural ecosystems.

Agriculture has a unique relationship to climate as a driver of change because aspects of agricultural production involve emission of greenhouse gases (GHG) whereas crops and soils provide a capacity to contribute to mitigation activities through carbon sequestration. Roughly 15% of global emission of greenhouse gases comes from agricultural sources (Minamikawa 2009). The double edged challenge will be to maintain agricultural production while reducing emissions and sequester already existing atmospheric carbon dioxide (CO_2) and other GHG such as nitrous oxide (N_2O) and methane (CH_4) (Smith *et al.* 2007). Any step taken to meet this challenge will inherently have impacts upon the soil, crop, and livestock management choices available to and made by agricultural producers. A similar double edged relationship may occur between agriculture and natural ecosystems. Agro-ecosystems under human agency can impact the ability of natural ecosystems to provide crucial ecosystems services (ES) such as the ability to provide habitat to non-agricultural species, cleanse water as it moves through the soil, or cycle nutrients and energy through the ecosystem. Changes in the character of ecosystems impact the services provided, the system adaptive capacity and system resilience to natural hazards and changing environmental conditions, and by extension these changes impact the ability of the agro-ecosystem to remain viable for provisioning service (agricultural production).

In Kansas, agriculture contributes significantly to social and cultural structures, the amount and character of the natural environment, and is also the largest economic industry within the state. Kansas agriculture generates products that are exported to over 100 countries around the world (Kansas Department of Agriculture 2011). This multifaceted role for agriculture highlights the importance of ensuring that viable and sustainable agricultural activities are practiced in the future. Based on major differences between sub-humid eastern Kansas and semi-arid western Kansas there are major differences in the character of agricultural activities across the state. In eastern Kansas, where there is more precipitation, crops such as winter wheat and corn dominate the landscape. In the drier western portion of the state, ranching and irrigated crop production are more common. In fact, ranching is so important that there are nearly twice as many cattle residing in the state than there are humans (KSDA 2012), and in some western regions cattle out number humans ten to one. Differences across the state may become more pronounced if variations in precipitation and increasing temperatures related to climate change continue to manifest themselves (Feddema *et al.* 2008). The complex nature of climate and agricultural interactions in Kansas underscores the need for location-based investigation and strategy in order to maintain viable agricultural production systems as transitioning to sustainable agriculture occurs.

Through this study, I explore potential agricultural futures in Kansas. Business-as-Usual (BAU) and sustainable-adaptive (SA) scenarios developed for both eastern and western Kansas allow for the examination of potential adaptive pathways and existing barriers to sustainable agriculture in the future. Research objectives for the study were informed by recurring themes throughout the meta-analysis of existing literature. Objectives were to:

1. Identify future climate projections for 2050 and 2100 for Kansas and the associated agricultural impacts,
2. Identify viable agricultural adaptations for Kansas that will be sustainable in the face of continued climate change,
3. Identify current barriers to sustainable agricultural adaptation with an emphasis on policy and cognitive barriers,
4. Create BAU and SA scenarios for future agriculture in Kansas,
5. Identify interactions among adaptations in different scenarios and how those adaptations are influenced by a change in spatial scale, and
6. Identify outcomes for future agriculture scenarios in both eastern and western Kansas.

In the remaining chapters of this thesis, I discuss the information gathered and used to address the research objectives. Kansas as the study area and the selected research methods are described and justified in Chapter 2. Chapter 3 provides a detailed review of the literature used to frame the study and develop the scenarios. Themes discussed in Chapter 3 include climate projections and their impacts on agriculture, foundational information on the concepts of vulnerability, adaptation, and sustainability, and the multiple forms of policy barriers. A detailed analysis of adaptation and sustainability as the concepts relate to the agricultural system in Kansas is provided in Chapter 4. Included in this chapter are the descriptions of selected sustainable agricultural adaptations for Kansas. Barriers created through current policy and cognitive hurdles are the topic of Chapter 5. Sources of barriers, such as governmental subsidies, environmental regulations, and missing knowledge and connections, are examined for their interactions with the current system and a possible sustainable future. In Chapter 6 the scenarios developed from the information described in the previous chapters are presented and used to identify potential adaptive pathways. A summary of the work provides the content for the seventh and final chapter of the study.

Chapter 2 - Study Area and Research Methods

"Though this be madness, yet there is method in't."
– Shakespeare, Hamlet

This chapter provides a discussion of the methods used to conduct the study and address the research questions associated with the identified objectives. In the first section, I discuss the state of Kansas as the study area. Section two of the chapter is a discussion of the research methods and approaches I used to conduct the study. An integrated quantitative and narrative research scenario method was chosen as the primary method of investigation for the study. Relevance and application of the study are discussed in the final section. On the whole, Chapter 3, a review of relevant literature, provides a grounded foundation from which to interpret the content of the study.

I. Study Area

Encompassed within the state of Kansas is the steep transition from the hillier topography and sub-humid climate of the east to the semi-arid, short grass steppe ecosystems of the west (Harrington, L.M.B. *et al.* 2009). Agriculture is not only a primary sector of the economy, it is also a part of the social fabric of Kansas and is, in most of the state, the dominant and most clearly apparent land use (Harrington, L.M.B. *et al.* 2010). This three pronged role for agriculture (*i.e.*, economic, social, and environmental) helped facilitate the examination of the sustainability of certain adaptations in regards to how they benefit each component of a complex and integrated system. In the east agricultural activity focuses on crop production and livestock production related activities are more common in the west (Harrington, L.M.B. *et al.* 2009). These variations allow for consideration of different agricultural practices, potential stresses, and adaptations (Harrington, J. *et al.* 2003).

The Homestead Act of 1862 provided land to settlers in exchange for agricultural cultivation and helped contribute to the settlement of Kansas by crop farmers in the late nineteenth century (Harrington, J. *et al.* 2003). Cattle ranching also began in the nineteenth century in Kansas and throughout the western Great Plains region (Harrington, L.M.B. *et* *al.*2010). Much of the livestock production occurs in southwestern Kansas and is primarily comprised of large scale feedlots (Harrington, J. *et al.* 2003). Recently dairying activities have moved into the region and may represent a way for local producers and communities to diversity economies and spread risk (Harrington, L.M.B. *et al.* 2010). "More than twenty very large dairies are, or were, in operation, some of them combined with beef operations," (Harrington, L.M.B. *et al.* 2010 p. 543). Water availability and the need for irrigation have been concerns for producers as long as the region has been in cultivation (Kromm and White 1992, Harrington 2011). Irrigated production, supported by the fossil groundwater in Ogallala Aquifer system, is the backbone of agricultural production and will continue to be necessary even as producers continue to transition to dryland techniques (Green 1993, Kettle *et al.* 2007, Harrington, J. *et al.* 2009).

> Irrigated agriculture…is central to an integrated agribusiness economy that demands seeds, fertilizers, pesticides, agricultural machinery, and credit. It supplies cotton to support gins and denim moils and feed grains to support cattle feedlots and meat-packing plants. Without irrigation, vast tracts of land now cultivated would be in pasture or extensively farmed with dryland techniques; the regional economy would be much smaller and far less active (Green 1993 p. 17).

Gains in irrigation efficiency and reductions in overall water consumption could allow producers continued access to water resources for several decades to come. However, these gains may be offset by increases in the amount of land brought into production (Harrington, J. *et al.* 2003).

Major agricultural vulnerabilities to environmental hazards are drought and wind (Leathers and Harrington 2000). Much of Kansas is characterized by variable precipitation; both in rate and intensity, and droughts occur frequently. Less intense droughts occur periodically while major droughts occur every few decades (Harrington, L.M.B. *et al.* 2009). Soil conservation practices are critical to maintaining soil resources in the face of drought and wind. "…The Dust Bowl also resulted from overuse of soil resources…Plowing and cultivation of large swaths of prairie left the soil open to extensive wind erosion and, when rain came again, water erosion," (Harrington, L.M.B. *et al.* 2009 p. 277). "While other hydroclimatic events, such as cold season blizzard conditions, hail, and flash flooding, produce vulnerability for the sparse population, drought is the system perturbation that seemingly has had the greatest socioeconomic impact," (Harrington and Harrington 2005 p. 48). Soils in Kansas are dominantly mollisols that generate "under prairie grasslands vegetation ranging from tall through midheight to short grass. Mollisols are utilized for food production wherever they are found in the world and are well known for their production of corn, wheat, sorghum, and other cereal grains," (Self 1978 p. 75). "Wind is a major cause of soil erosion in the region, contributing to nearly 81% of soil loss," (Leathers and Harrington 2000).

II. Research Methods

Before research began in earnest, I selected an appropriate perspective from which to conduct the study. Given the complex and interconnected natures of agriculture, climate change, adaptation, and sustainability it was important to select a method that allowed for consideration of the different themes of the study. A scenario-based approach, informed by systems theory, was chosen as most appropriate for investigation of climate change and sustainable agricultural options. In general, "complex systems theory is really a set of related theories grounded in the study of complex, hierarchically structured, non-equilibrium, and dynamic systems" (Straussfogel 1997 p. 119). Complex systems theory emerged from advances in physics and mathematics that allowed for a more extensive knowledge of nonlinear and complex systems. Coupled with these advances, complex systems theory also has roots in the disciplines of biology and psychology (Thelen 2007). These complex systems "are accepted as being open, indeterminate, and unpredictable" (Straussfogel 1997 p. 119). Perspectives more rooted in ecology and the human dimensions of global change also include components such as resiliency, uncertainty and vulnerability, hazards, and interactions between periods of gradual change and periods of rapid change and how these interactions occur over temporal and spatial scales (Folke 2006). Collins *et al.* (2008) also identified the idea of natural and human-induced pulses and presses within dynamic ecosystems that may control biotic processes.

Scenario development for use in strategic planning, similar to scenarios developed by the Intergovernmental Panel on Climate Change (IPCC), was chosen as the method of investigation. Scenarios are probable narratives developed to address systems dynamics in real life contexts. Scenario development as a research tool came into use after World War II (Biggs *et al.* 2007). Originally scenarios were mostly used by businesses trying to understand the array of uncertain business futures that lay ahead as the world began to globalize. A good example of using scenarios to plan for the future was done by the Royal Dutch/Shell Oil Company. Using scenario development, Shell was able to anticipate the conditions associated with the oil embargo of the 1970s, and to plan in advance for potential loss of profit (FKNMS 2010). In the late 1980s and 1990s scenario development saw resurgence in use by those attempting to understand the potential impacts of changing climates and global environments. Scenarios facilitate the examination of interactions between complex systems at different scales in an attempt to extrapolate potential future pathways of development, given a set of conditions, and the identification of possible adaptive strategy pathways for policy makers (Moss *et al.* 2010).

Scenarios allow for the examination of both quantitative and qualitative conditions related to possible future conditions. Scenarios can be derived from mathematical models, such as those used in statistical analysis and computer climate models, or from a narrative approach (Figure 2.1). Inherent uncertainty within climate or economic modeling limits the accuracy of any model developed based on current projections. Scenarios based exclusively on mathematically derived models may also lack consideration of what can be thought of as the human element in building the future, such as shifting policy and social structures. Narrative approaches to scenario development attempt to anticipate aspects of the future with both empirical information and a story approach to describing potential future conditions. A lack of quantified and replicable projections is a potential weakness of narrative scenarios. As described by Raskin *et al.* (2005 p. 40), “Narrative offers texture, richness, and insight, while quantitative analysis offers structure, discipline, and rigor. The most relevant recent efforts are those that have sought to balance these.” One method for bringing narratives and models together is to develop scenarios using climate projections for baseline conditions and narrative components to provide insight on societal structure and values, and consideration of interacting policy, economic, and environmental systems.

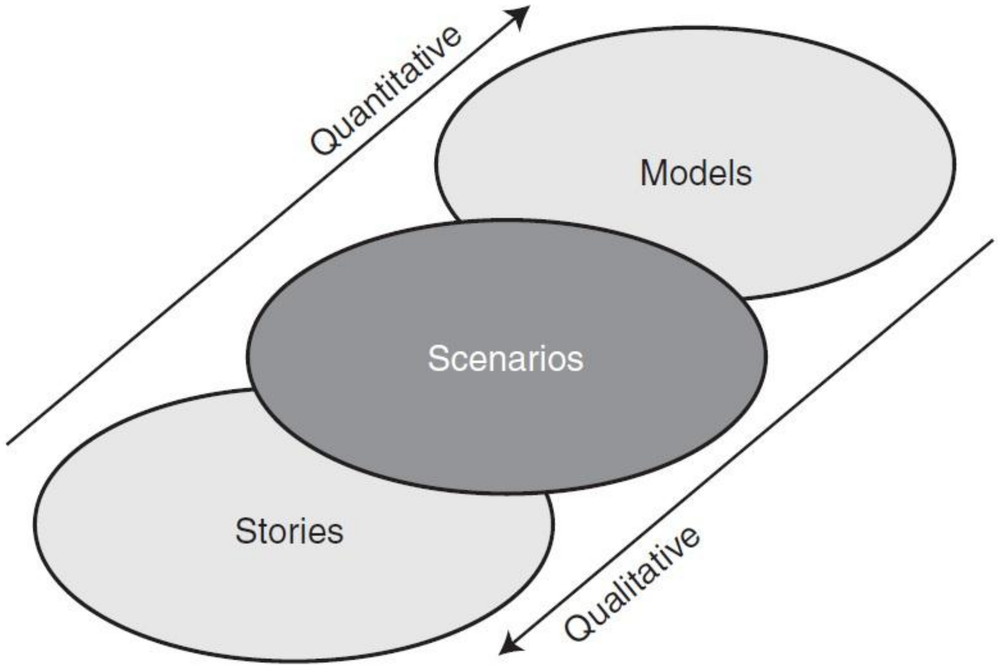

Figure 2.1 Conceptual diagram showing the unique position of scenarios along the quantitative to qualitative continuum (Raskin *et al.* 2005 p. 40)

The primary method for gathering information from which to develop the parallel scenarios of business-as-usual (BAU) and sustainable-adaptive (SA) policy reform was an extensive literature review. Works were selected and reviewed from across the quantitative - qualitative spectrum for their ability to contribute knowledge and enhance understanding of the systems being studied. Article content ranged from climate and sustainability model outputs to theory on systems dynamics and the adaptation process. Initially, articles were located and selected using keywords to search several databases. Keywords such as agriculture, climate change, Kansas, vulnerability, adaptation, and sustainability were used to find initial sources. Some articles were chosen because they occurred frequently in literature that had been reviewed. Over seventy journal articles, book chapters, and various forms of reports were chosen and used in the study. While literature was reviewed throughout the duration of the study, addition of new literature generally ended when saturation of ideas within the existing literature was reached. Literature was also selected to place emphasis on different scales of each system (e.g., individual producers, local communities and, state and national policy). Broadly speaking, the selected literature was placed into seven categories:

1. climate change projections, in a general sense and as specific to the study area as possible,
2. sustainability,
3. adaptation,
4. vulnerability,
5. potential barriers,
6. agricultural adaptation, and
7. agricultural character and adaptation within Kansas.

I used literature discussing climate projections and impacts to generate the baseline future climate conditions within the scenarios that would act as drivers within the other systems. Literature discussing agricultural adaptations and agriculture in Kansas was used to develop the narrative character of the scenarios while literature regarding adaptation, sustainability, and vulnerability was used to provide theoretical grounding for the scenarios.

Information gathered from the literature was analyzed and synthesized using several investigative steps (Table 2.1). The first step consisted of collection of data and the literature review. Common themes and major ideas, identified prior to the beginning of the literature review and found throughout the literature, were incorporated as components in the scenarios. Three fundamental components were used:

1. projections of future climate change within the study area,
2. sustainable agricultural adaptations, and
3. barriers to sustainable adaptation created by policy and cognitive barriers.

Research Steps	
Gathering of Knowledge (literature review)	Literature was collected, reviewed, and placed into 7 categories: 1) climate projections 2) sustainability 3) adaptation 4) vulnerability 5) policy 6) agricultural adaptation 7) agriculture in Kansas
Meta-Analysis (digging a little deeper)	Identification of common themes, barriers to adaptation, and characteristics and interactions between systems of study at different scales (i.e. producer, community, state/national)
Scenario Development	2 scenarios developed using UNDP framework

1) Business-As-Usual (BAU) 2) Sustainable-Adaptive (SA)

Table 2.1 General summary of research steps used to conduct study.

The second step of analysis and synthesis involved "digging deeper" into the literature and identifying further themes, such as the role of policy and cognitive barriers in sustainable agricultural adaptation. The final step was to bring together the themes and barriers identified in the literature into a cohesive manner that illustrated interactions between systems of study and the themes found within current literature. This was accomplished through the development of the two different future narrative scenarios for Kansas (BAU and sustainable-adaptive).

The Adaptation Policy Framework created by the United Nations Development Programme (UNDP) uses a similar approach for adaptation planning. The UNDP identified five components to the development of a research scenario (Raskin *et al.* 2005):

1. define the scope of the scenario,
2. assess current vulnerability to risk,
3. characterize future vulnerability,
4. develop adaptation strategies, and
5. continuation of the adaptation process.

I took each UNDP policy framework component into consideration and modified it for compatibility with the objectives of this study (Table 2.2). This was accomplished by focusing the framework upon climate variability as a driver of change and agriculture in Kansas as the system(s) of study. The scope was defined as identifying interactions between policy and cognitive barriers and sustainable agricultural adaptation and adoption in Kansas. Assessing current vulnerability of agriculture to climate-induced risk is the second component of the framework. In Kansas, current vulnerabilities may include sensitivity to drought and water shortages. The third component for the development of a scenario requires characterizing future risks associated with changing environmental (*e.g.*, climate) and social conditions. For example, extreme high summer temperatures and variable precipitation patterns within seasons may represent areas of vulnerability in Kansas as climate change impacts continue to manifest. Societal denial of the magnitude of risk associated with climate change may hinder adaptation. This study seeks to integrate climate change projections for Kansas over the next century with narrative contexts to assess potential vulnerabilities to climate change caused by interacting barriers.

	UNDP Framework	Study Framework
1	**Define the scope of the scenario**	Identify interaction between current policy and cognitive barriers and current agricultural practices and sustainable agriculture in Kansas
2	**Assess current vulnerability**	Evaluate vulnerability of agriculture in Kansas to climate change as identified in current literature Examples: drought, rising temperatures, soil loss, etc.
3	**Characterizing future risks**	Identified potential risks to agriculture in the future related to climate change Examples: increased precipitation variability, frequency and intensity of severe weather
4	**Develop adaptation strategy**	Identify potential adaptations based upon plausible outcomes of system interactions at varying scales and information gathered through literature review. Determine 'best' strategies for sustainable scenario and likely strategies under BAU.
5	**Continuation of adaptation process**	Development of the individual scenarios. Scenarios may be used as decision making tools for stakeholders and policy makers.

Table 2.2 Summary of UNDP framework for scenario development and how the framework was applied for use in the current study.

Adaptation strategies are developed based on the plausible outcomes of interactions between systems of study and barriers identified in the scenario, and can be used by policy makers to identify and implement a best development pathway(s). I reviewed existing literature related to a number of relevant topics such as vulnerability, federal subsidies, impacts of climate change, and sustainable agricultural adaptations to bring together a comprehensive sustainable agriculture adaptation strategy for policy makers in Kansas. The fifth and final component of the UNDP's research scenario process is a continuation of the adaptation process.

In order to assess vulnerabilities and impacts as accurately as possible, climate projections at the state level were needed. When documentation of impacts from climate change to agriculture was not available for Kansas directly, I used research on climate change impacts on neighboring/near by states (e.g., Iowa, Texas, Nebraska, Colorado) to help fill in gaps. Climate impacts to neighboring states serve as examples of what might be expected in Kansas based on physical and agricultural similarities.

III. Contributions

An integrated quantitative and narrative approach to scenario development allows for a multi-faceted examination of interactions between policy and knowledge barriers to sustainable agricultural adaptation to climate change in Kansas at different scales. The scenarios allow for the identification of viable sustainable agricultural adaptations for farmers in Kansas, as well as barriers created by policy and gaps in knowledge both at the state and national scale. Results from this approach may be used as decision support tools for producers and policy makers alike to aid in identification, selection, and implementation of sustainable agricultural development in Kansas. Results will also be publicly accessible in Kansas. Given the emphasis on scale inherent within the study, the study may also be used to help individual stakeholders gain a better understanding of concepts such as vulnerability, complex systems dynamics in Kansas, and ecosystem services. With better understanding hopefully comes enhanced decision making at each scale of the systems under study. In this way, the study attempts to contribute new knowledge to the general public and policy makers that leads to the implementation of a successful sustainable agricultural adaptation strategy.

Chapter 3 - Knowledge Follows the Literature

"If I have seen further it is by standing on ye shoulders of Giants"
- Sir Isaac Newton

This chapter consists of a review of literature and case studies relevant to the study of sustainable agricultural adaptations to climate and other drivers of change in Kansas. I begin by considering literature related to the broader concepts needed to provide a foundational context for the study. These topics include climate change, vulnerability, adaptation, sustainability, agricultural adaptation, policy related to agriculture, and a brief review of agricultural adaptation in Kansas.

I. Climate Change

Three impacts of climate change as a result of rising CO_2 concentrations that will affect agriculture will be the increased variability in precipitation, rising temperatures, and an increase in severe weather (Hay 2006, Karl *et al.*2009). In temperate wheat and corn producing regions such as Kansas climate change may actually be beneficial in the near term (Reilly *et al.* 2003). However, beyond an approximate 3°C increase in temperature this will no longer be true. In lower latitudes, moderate temperature changes are expected to result in reduced cereal yields (Easterling *et al.* 2007). Climate change will also impact the frequency and distribution of diseases both for crops and livestock (Belliveau 2006). Increased temperatures can directly influence production quality and quantity of livestock, especially dairy production, and other sectors sensitive to temperature (Hayhoe *et al.* 2004). Both daily maximum and minimum temperatures are expected to increase, with some scenarios suggesting a range of 5-14°C for Iowa (Moser *et al*. 2004). Temperature changes will also impact the amount of necessary heating and cooling days.

> Annual heating degree days in central Kansas would *decrease* from …5500 to about 3200 (base: 50 F) (sic), a 40% reduction, inferring a 40% reduction in annual heating demand and costs in central Kansas. Annual cooling degree days would *increase* from…1200 in central Kansas to 3200 (same basis), a 170 percent increase… (Wendland 1993 p. 164)

Extreme weather events and increased variability associated with climate will create systemic risk for farmers through more intense droughts and storms (discussed further under Policy). Severe winter storms in Kansas are likely to decrease as the result of warming temperatures, as liquid precipitation will become the dominant form of precipitation (Wendland 1993).

More recent studies indicate that by 2100 temperatures in Kansas will increase by about 8°F. Average temperatures will increase between 2-4°F with some areas warming more than others (Figure 3.1). IPCC climate change scenarios for precipitation suggest that averages will remain about the same throughout this century; however there will be increased variation in frequency and intensity of precipitation events (Figure 3.2) (Feddema *et al.* 2008).

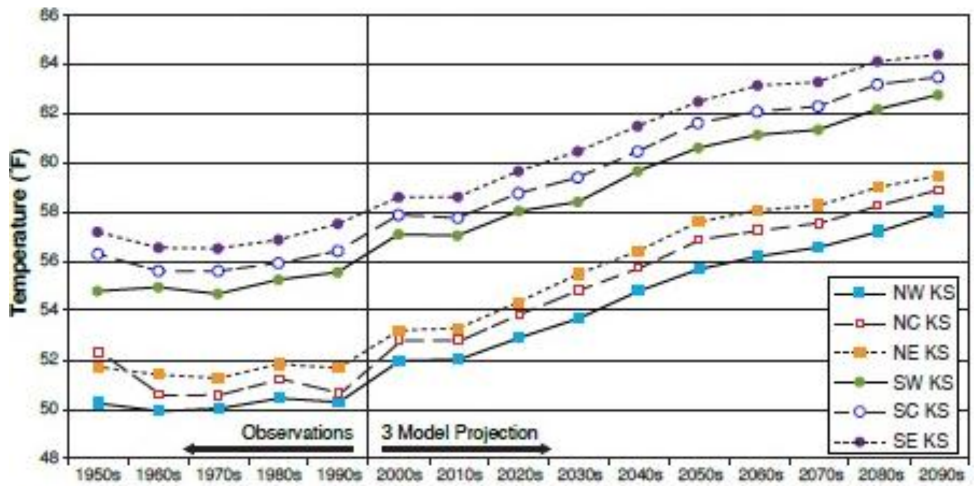

Figure 3.1 Annual average temperature projections for Kansas (Feddema *et al.* 2008).

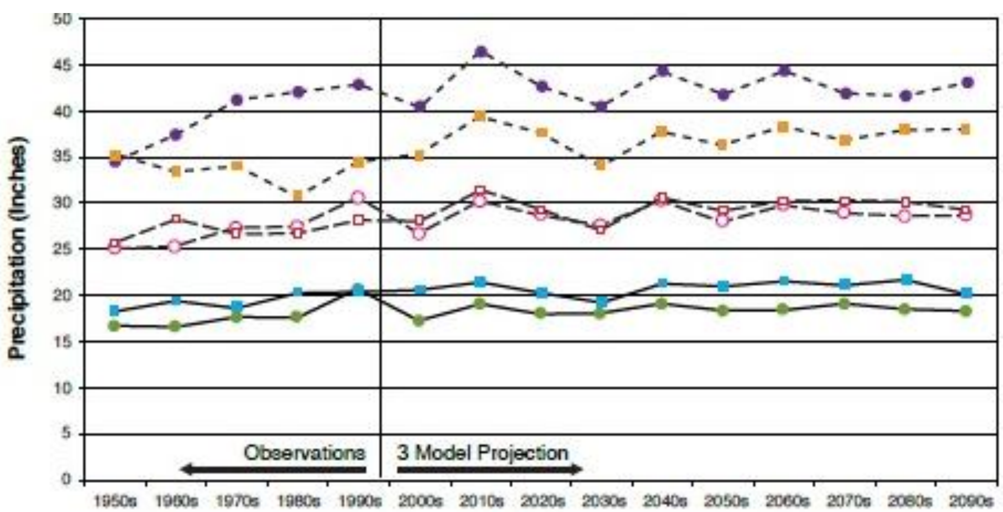

Figure 3.2 Average annual precipitation projections for Kansas (Feddema *et al.* 2008).

Available growing times and rates for crop growth are also projected to change. Corn growing degree days are projected to increase by 50 percent in Kansas, suggesting a possible increase in growth rate, while winter wheat in Kansas is likely accumulate 2150 growing degree days by April (Wendland 1993). Emissions from agricultural activities are a driver of climate change but resource management practices can also mitigate climate impacts. Agriculture contributes an estimated 15 percent to overall greenhouse gas emissions (Minamikawa 2009). A commonly discussed mitigation activity is soil carbon sequestration. This can be achieved through using soil management techniques, such as no-till, or by planting appropriate cover crops (Smith 2010). Reduced embedded energy costs and greater efficiency leading to less overall use of fossil fuels have the potential to significantly contribute to greenhouse gas mitigation (Minamikawa 2009).

II. Impacts and Vulnerability

Vulnerability is commonly defined as a state of susceptibility to harm from exposure to stresses associated with environmental change and in the absence of strong (or a lack of) adaptive capacity. Vulnerability is normally discussed in the context of risk-hazard mitigation strategies (Eakin and Luers 2006). Vulnerability can also be understood as a "property of coupled, interacting social-environmental systems characterized by complex feedback relationships and trajectories of change," (Turner *et al*. 2003). Vulnerability is a dynamic process that changes in response to variations that occur within the overarching system of study (Cutter 2003). The IPCC's Working Group II (2007) defines vulnerability as a function of the exposure (magnitude, rate of change, variation) to a particular risk, the sensitivity of the community or activity to that risk, and the adaptive capacity of the social group. Vulnerability is difficult to measure and assess for two primary reasons. The first is that equity in vulnerability is usually a function of not only availability of resources, but also of access to the resources (Smit 2003). The second reason is because concepts such as equity, social justice, and what constitutes a resource are dependent on the values placed on them by society (Eakin and Luers 2006).

Agricultural vulnerabilities include weather extremes, fluctuations in market prices, changes in social support services, and crop loss. Farmers can also be vulnerable to the mistake of believing that all adaptations are sustainable (Smit 2003). It is important to note that vulnerabilities for the producer and his/her family, animals, and plants may not always be the same and in some cases may actually be in conflict with one another (Berry 2006). Vulnerability can also be affected by policy decisions and available insurance policies. Farm insurance, generally is used for adaptation or mitigation of the effects of climate hazards. However, it may not cover crop failure due to use of new or unproven farming methods (Wall *et al.* 2005).

Some states in the US have begun to examine the impacts of climate change on agriculture. State and regional impact assessments are used to prepare for potential impacts. Examples of state assessments include those done by Hayhoe *et al.* 2004 and Moser *et al.* 2004. Hayhoe *et al.* (2004) examined impacts associated with climate change in the state of California and found that while climate impacts will vary and so too will adaptation measures and costs, they are dependent upon emissions from the preceding decades. Moser *et al.* (2004) examined the impacts to the state of Iowa and concluded that there will be significant impacts to all sectors, including agriculture but by reducing heat-trapping emissions, minimizing pressures placed on the environment, and preparing for impacts that may be unavoidable, potential impacts of climate change may be reduced. Assessment reports from other regions help establish key components to be studied and can help predict impacts to locations with similar climate and agricultural production activity. For example Iowa and Kansas are both considered members of the MINK (Missouri-Iowa-Nebraska-Kansas) production region (Easterling *et al.* 1993) in which conditions from the 1930s drought were used as an analog of potential future conditions to model impacts for regions characterized by similar agricultural activities.

The rise of globalization has created new vulnerabilities for farmers and agriculture. Adger *et al.* (2007) points out that "the vulnerability of specific individuals and communities is not geographically bounded, but rather, is connected at different scales, so that the drivers of their exposure and sensitivity are inseparable from large-scale processes of sociocultural change and market integration." For example, coffee famers in Mexico are vulnerable to drought which can lead to a temporary increase in profits for coffee farmers in Vietnam and create a false sense of market and price stability. Adaptations taken at relatively small (*i.e.* local) scales can have unintended impacts on larger scales or globally. Climate change may increase the vulnerability of farmers to poverty, transmitted diseases from ordered products, and social inequity (Adger *et al.* 2007).

III. Adaptation

Adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2007). Adaptations may occur for any number of reasons in response to various drivers; however in the current context I am considering adaptation in relation to climate change as the primary driver. There are two forms of adaptation: autonomous and planned adaptations (Berry *et al.* 2006). Autonomous adaptations do not represent conscious response to climatic stimuli. They are triggered by ecological changes in the larger natural systems and by market or welfare changes in human systems in which one operates. Planned adaptations are the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state. Autonomous adaptations occur on a shorter timescale usually ranging from weeks to seasonal or annual. Actions taken that occur on an even shorter time scale may be thought of as minor adjustments rather than an adaptation. Planned adaptations range from five years to decades. Enrollment of land into the Conservation Reserve Program represents a planned adaptation to unstable markets made by a farmer by interacting with political structures and implementing an adaptation that occurs over the course of multiple years (Leathers and Harrington 2000). Moser and Ekstrom (2012) present another way of looking at adaptation in the context of climate change:

> Adaptation involves changes in social-ecological systems in response to actual and expected impacts of climate change in the context of interacting nonclimatic changes. Adaptation strategies and actions can range from short-term coping to longer-term, deeper transformations, aim to meet more than climate change goals alone, and may or may not succeed in moderating harm or exploiting beneficial opportunities, (p. 22026).

In some cases planned and autonomous adaptations may not be enough and transformational adaptations are needed (Kates *et al.* 2012). Transformational adaptations are

> …collective adaptations that would be explicitly planned and implemented, but they also include autonomous adaptations by individuals and organizations that can cumulate in transformative adaptations or actions intended to address other problems that can become transformative climate change adaptations… (Kates *et al.* 2012 p. 7156)

There are three categories of transformational adaptation:

1. enlarged scale or intensity,
2. new adaptation,
3. different places and locations.

Transformational adaptations will necessitate a great deal of effort and long-term commitment to initiate and sustain. Barriers to transformational adaptations exist, the same as they do for planned and autonomous adaptations. Kates *et al.* (2012) recommend integrating transformational adaptation into frameworks guiding risk and vulnerability and "expanding the menu of innovative transformational adaptations" to help overcome barriers. High vulnerability of specific places, peoples, and resources, and severe impacts from climate change that may create tipping points of change in human-environment systems are two reasons that transformational adaptations are needed.

Adger *et al*. (2005) discuss the importance of considering different scales when judging the success or failure of sustainable adaptations. Consideration of different scales is crucial in order to understand both up and down stream impacts of adaptations. Adger *et al.* (2005) define successful adaptations as those that depend upon both the spatial and the temporal scales to which they are applied. Elements of success vary from location to location and can be dependent upon local cultural context. Adaptations become "legitimate" when they have been validated by incorporation into policy, government, or institutional structures (Smit 2006). Mal-adaptation is a potential risk of adaptation (Moser and Ekstrom 2010). If potential impacts to down and up scale systems are not investigated prior to adaptation, new adaptations may create a need for more or bigger adaptations in the future. "Some incremental adaptation in the short run may prove maladaptive in the long run, setting up the need for system transformations," (Kates *et al.* 2012 p. 7158).

Sustainable adaptations in agriculture can not only mean adjustment to climate change impacts, but also help mitigate the drivers of climate change. Multiple categories of agricultural adaptation with mitigation potential have been identified; including adaptations designed to reduce soil erosion, increase crop rotation and biodiversity, modify microclimates by building more shelter and increasing ventilation, and change in land use patterns (Smith 2010).

IV. Sustainability

Broadly defined, sustainability is the ability of a system to self-sustain through time. However there are many conceptions of sustainability. Some notions of sustainability view it as a pathway to the future whereas others think of it from a normative perspective as an all-encompassing vision of future developments. Three general components of sustainability relevant to this study that are identified in the literature that I reviewed include: sustainable development, environmental sustainability, and sustainable agriculture. Sustainable development aims to improve social, economic, and environmental conditions among different populations and create equality. Environmental sustainability occurs through actions designed to improve current and future environmental quality. This applies to the ways in which humans consume, manage, and protect natural resources. Some notions of sustainability have been co-opted from their original context and distorted to fit the self-promotional needs of individuals, organizations, and businesses; and farmers and ranchers should be careful of such co-opted definitions (Cashman 2006).

Sustainable agriculture seeks to provide good stewardship for the land as well as improve living conditions for the individual and the family entity, conditions within the local/regional/national interacting social and economic systems, and meet the nutritional needs of the global population without reducing our future ability to do so.

> Today, concerns about sustainability center on the need to develop agricultural technologies and practices that: (i) do not have adverse effects on the environment (partly because the environment is an important asset for farming), (ii) are accessible to and effective for farmers, and (iii) lead to both improvements in food productivity and have positive side effects on environmental good and services. Sustainability in agricultural systems incorporates concepts of both resilience…and persistence…and addresses many wider economic, social and environmental outcomes. (Pretty 2007 p. 447)

Some sustainable agriculture strategies utilize adaptations to severe weather and to climate variations as pathways to sustainability. Management strategies include: crop diversification; diversify of enterprises within one farming operation, land resource management, water resource management including irrigation, and livestock management (Wall *et al*. 2005). These diverse management strategies are important because sustainable agriculture can contribute to each component in beneficial ways and strengthen ecosystem services (Pretty

2007). A major challenge to sustainability is the inherent uncertainty associated with the natural variations and magnitude of global climate change and local rates of climatic change (Shimmelpfennig1996, Minamikawa 2009). Sustainability should be a goal for future development with or without the need to adapt to climate change (Hay 2006).

V. Agricultural Adaptations

When adapting to climate change, species diversity in both plants and animals will be important. Diversity can help reduce risk of loss by spreading the impacts of disease and pests across multiple ecosystems lessening the overall impact (Tilman 1999). "A major protection against these possibilities is diversity-the diversity of crops deployed in a region, the diversity of substitute crops, and the diversity of genetic resistances within crops," (Tilman 1999 p. 5999). Crop diversification may occur through the selection of crops for their ability to fix nitrogen and carbon to the soil, as well as their natural resiliencies to future climate conditions and environmental hazards. Other benefits of naturally fixing nitrogen and carbon to soil include: improved soil quality, reduced vulnerability to drought through increased water storage, and increased crop yield (Smith 2010).

One form of livestock management is pastured livestock. Pasture based livestock systems involve the raising and production of cattle for consumption in open pastures rather than in intensive feeding systems or confined animal feeding operations (Bernues 2011). Pasture-based livestock, when numbers are carefully managed, can be a sustainable option because the practice encourages biodiversity in both plants and animals, and may lower embedded energy costs of production (Bernues 2011). Barry (2006) suggests that native grasses be used as pasturage so that habitat can be created for forage species migrating northward with warming temperatures. Production of livestock can also provide an on-farm source of organic matter to be put back into the soil (*i.e.* manure). Soil is a natural resource and should be managed properly in order to prevent significant loss of the soil resource. As climate change progresses, soil will become one of the most valuable resources and is already beginning to disappear at alarming rates (Montgomery 2007, Pimentel 2003). The Conservation Reserve Program (CRP) represents an attempt to conserve soil through planned adaptation and policy intervention.

VI. Policy

Governmental decisions and policy have the potential to greatly influence agricultural production and environmental protection. Federally subsidized crop insurance and subsidies provided to the fossil fuel and ethanol industries as well as subsidies provided for corn and ethanol have significant implications for agricultural production. Lobbying within the federal government, as well as at state levels, exerts influence over the policies created to influence agricultural production.

In general, governmental subsidies represent the transfer of financial and economic resources to those actively participating within the economy. These subsidies influence prices and production costs (Koplow and Dernbach 2001). Subsidies can include direct and indirect monetary transfers aimed to benefit one specific sector, such as energy. This is accomplished through tax breaks and benefits or agency outlays. Benefits to other sectors from subsidies for the energy sector are considered indirect transfers. Secondary subsidies can be identified in externalities and subsidies to close complements. Externalities are usually defined as benefits of cost transferred onto surrounding populations without compensation. Goods and services that encourage the use of a sector's products or services are considered subsidies to close complements. (Koplow and Dernbach 2001) For example, subsidies to fossil fuels which keep gasoline prices lower than they would be otherwise encourage automobile use and purchase, thus supporting the automobile manufacturing and sales industries.

An often over looked form of government subsidy related to agriculture is crop insurance. The "U.S. crop insurance program is first and foremost a government program intended to convey economic benefits to a particular segment of the economy – the U.S. farm sector," (Goodwin 2001 p. 643). Though intended to reduce risk and provide benefits to the agricultural sector, crop insurance may actually be hindering the development and implementation of sustainable agriculture. A key characteristic of government crop insurance is that it covers *multiple perils*, which means that all potential risks of loss are covered and can be indemnifiable (Goodwin, 2001) making a private market unviable. Two primary potential concerns within crop insurance have been identified: *moral hazard* and *systemic risk* (Goodwin 2001, Miranda and Glauber 1997).

In short, moral hazard is the possibility that farmers who have purchased crop insurance may take fewer precautions against harm (Horowitz and Lichtenberg 1993). Research has shown that farmers who have purchased crop insurance are more likely to use increased amounts of nitrogen, pesticides, as well as insecticides and herbicides. A farmer who gains crop insurances "will increase nitrogen application per acre by 18.4 pounds, roughly 19 percent; pesticide expenditures per acre by $3.70, roughly 21 percent; herbicide per acre-treatments by 0.06, or 7 percent; and insecticide per acre-treatments by 0.17, or 63 percent," (Horowitz and Lichtenberg 1993). Increased chemical use "could affect the environmental quality both through direct changes in input use decisions on existing cropland and indirectly through changes in cropping patterns," (Horowitz and Lichtenberg 1993) as well as through increased leaching or runoff of chemicals into water systems.

The second identified hazard, systemic risk occurs in agriculture "primarily from the impact of geographically extensive unfavorable weather events, such as droughts or extreme temperatures, which induce significant spatial autocorrelation among individual farm-level yields," (Miranda and Glauber 1997, p. 205). Systemic risk from large area hazards can decrease farm and farmer sustainability by encroaching on a farmer's ability to make crop diversity and management decisions, as well as the farmer's ability to distribute risk across multiple farms, crops, or aggregates of farms and crops. Widespread constraints on production viability prevent a primary function of crop insurance to take effect: the combining and distribution of risk across individuals (Miranda and Glauber 1997). Since increasing the financial stability of and decreasing risk to both the farm and the farmer is a goal of sustainable agriculture, systemic risk coverage in crop insurance can be seen as a hindrance to adopting a pathway toward sustainable agriculture. Such concerns in crop insurance practices may cause indemnity payments to increase relative to the amount paid in by premiums, corroding the financial strength and viability of insurers (Miranda and Glauber 1997). Smit *et al*. (2002) found that while insured farmers implemented risk mitigating strategies around the same time as their uninsured counter parts, insured farmers are generally associated with lower on farm species diversity and higher rates of mono-cropping.

Subsidies provided by the government to both the fossil fuel and the corn-based ethanol industries exert influence over current agriculture practices and can hinder the implementation of sustainable agriculture by reinforcing the use of chemical inputs and use of fossil fuel energy to meet energy needs. Corn is heavily subsidized not just as a food and feed crop, but also for the manufacture of ethanol fuels. The US began subsidizing the manufacturing of corn based ethanol fuel in the 1970s as a response to the oil and gas shortage crisis in the early part of that decade (Gardner 2007). Ethanol subsidies take the form of tax credits for energy companies rather than direct payments to producers, and research indicates that subsidies may not be benefiting farmers who choose to grow corn for ethanol production (Pimentel 2003). Government subsidies provided to the fossil fuel industry account for approximately 80 percent of all subsidy monies distributed by the government for the production of energy (Goldemberg 2003).

Subsidies and other environmental regulations that interact with agriculture such as the Conservation Reserve Program may have good intentions but may fail to meet their goals (Koplow and Dernbach 2001, Leathers and Harrington 2000). The CRP is run by the USDA and is the major provider of funding for buffer strips at the edge of cropped areas. Between 2001 and 2002 over $1.6 billion was spent to fund the CRP (Lovell and Sullivan 2006). Such programs can influence land use decisions and may significantly change the rates at which sustainable agricultural practices are adopted (Lant *et al.* 2002). Lovell and Sullivan (2006) suggest that in order to derive the full benefits of conservation and buffer incentive programs, such as the CRP, buffers need to be better understood for their impacts so that they may achieve maximum efficiency in design and placement. Environmental regulations can dictate land use patterns by creating financial incentives for producers to engage in certain activities like irrigation of crops in the face of water supply depletion. In Kansas regulations such as the Irrigation Initiative and the approved conservation measures laid out in the Conservation Districts Law are examples of environmental regulations that dictate land use patterns (Kettle *et al.* 2007). "Government policies, including…agricultural subsidies, and environmental programs, have played important roles in the settlement and use of the land of the Great Plains," (Harrington 2009 p. 2).

Though mostly thought about at the national scale, lobbyists are present at all governmental scales and play a crucial behind the scenes role in the creation of agricultural policy. In the book, *Farming in the Dark,* the role of lobbyists in Kansas is discussed (Janke 2008).

VII. Agriculture in Kansas

Historically the biggest threats to agriculture in Kansas have been drought and wind (Hewes 1965). In 1923, Kincer wrote that irrigation would be needed in order to continue to viably grow crops on the Great Plains. However, Baltensperger (1979) found that for the time period of 1870-1900, farmers did not believe that irrigation or adaptation was necessary in order to grow the same crops as had been lucrative in traditional Mid-west states such as Iowa and Illinois. Prior to the Dust Bowl, conventional wisdom held that "the rain follows the plow," (Baltensperger 1979). More recently, studies (Harrington 2009, p. 7) have shown that

> although irrigation has helped mitigate agricultural sensitivity to climate variability…it may actually increase vulnerability in the long term. As the groundwater resource upon which the region has become reliant is depleted, agriculture will be forced to change again in response to this stress.

There is also indication that market forces influence farmers' decisions to transition from beef to bison production (Popper and Popper 1999). Traditionally, Kansas farmers switch from corn to wheat production during periods of drought, at least once a drought becomes apparent.

Future adaptation in Kansas may occur along three themes: use of technology, changes in social conditions, and changes in land use. The first theme holds that new technologies and management practices such as soil conservations practices and/or subsurface drip irrigation will reduce the impacts of drought. Changes in social conditions would occur through increased or strengthening of governmental aid programs, price protection, farmer knowledge of sustainable practices, and local investments in the economy. The final theme advocates for a return to native grass regimes, a transition away from crop production, and a move towards ranching (Riebsame1983). Different adaptations will be necessary for eastern and western Kansas due to the different climate regimes and potential impacts of climate change (Brunsell *et al.* 2010). Another future, perhaps metaphorical, was described by Popper and Popper (1987) with their suggestion of a "Buffalo Commons" for the Great Plains. The main idea behind the concept was "that a new path lay about a generation ahead: large-scale land-restoration project," (Popper and Popper 1999 p. 1). Kansas is located within the region designated as the Buffalo Commons (Kettle *et al.* 2007). This idea draws on similar themes discussed as "the tragedy of the commons" (Hardin 1968). A transition to bison production and more traditional grazing-based ecosystems are part of the idea of a future "Buffalo Commons" (Popper and Popper 1987).

VIII. Summary

The above literature review discussed material related to seven general categories: climate change, vulnerability, adaptation, sustainability, agricultural adaptation, policy, and agriculture in Kansas. Information gathered through the course of the literature review serves as foundational knowledge to provide a context of the remainder of the study. Future climate will be characterized by increased variability in precipitation and increasing temperatures impacting both crop and livestock production. Adaptation to impacts associated with climate change can occur through at least two methods: planned and autonomous adaptation. Adaptations may increase vulnerability to interacting up and downscale systems and should be thoroughly investigated before implemented. Vulnerability is a state of susceptibility to harm and is defined by three components: exposure, sensitivity, and adaptive capacity. Sustainability is a developmental pathway with a vision to reduce vulnerability in all systems and create equitable production processes that are beneficial to social, economic, and environmental systems alike. Agricultural adaptation occurs through changes made to crop, livestock, and soil management decisions and on-site enterprises. Diversity in multiple forms is crucial for agricultural adaptation. Policy related to energy and agricultural subsidies, environmental regulations, and lobbyists/interest groups associated with agriculture in Kansas could present potential barriers to adaptation. Policy has significantly shaped the land use and settlement patterns of Kansas. Irrigation is a traditional adaptation undertaken in Kansas in response to drought and precipitation variability. A return to bison production and native grasses is commonly discussed as a future adaptation for Kansas.

Chapter 4 - Moving Forward and Getting Back (to Nature): Adaptation and Sustainability

*The great flow that maintains the universe, call it the cycle of life, the course of nature each one of us is just a small part of that part; one in the all. Yet without all the individual ones, the all can't exist. This world flows by following grander laws that we can't even imagine. To recognize that flow, to work in it, to decompose, and recreate, that is alchemy***.**

-Full Metal Alchemist

The previous chapters provided background information and context for the study. My focus here is on a meta-analysis of the concepts of adaptation and sustainability. Adaptation and sustainability often go hand-in-hand in discussion, especially with respect to climate change. Despite the frequent linking, adaptation and sustainability are two separate concepts and should be understood as such before bringing them together. After discussing the individual merits of adaptation and sustainability, as well as their relationship with each other, I will describe common sustainable agricultural adaptations with an emphasis on Kansas.

I. Adaptation

Autonomous adaptations (also called spontaneous adaptations) are those that do not constitute a conscious response to climatic stimuli but are triggered by ecological changes in natural systems or by market or welfare changes in human systems. These adaptations occur over short time scales that can range from weeks to seasonal shifts (Berry *et al.* 2006, Bryant *et al.* 2000). Autonomous adaptations are almost exclusively made on the individual or farm level. An example of autonomous adaptation would be the use of water harvesting strategies in advance of what is expected to be a dry summer.

On the other hand, adaptations that are the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state are called planned adaptations. Planned adaptations, by their very nature, occur on a longer time scale ranging from five years to decades. Planned adaptations are most often made by institutions, governments, and organizations rather than at the individual level. These adaptations have the greatest potential to impact social, economic, and environmental systems, and manifest as changes to existing policy or the creation of new policies, establishment of new organizations, institutions, and regulations designed to mitigate the future impacts of climate change. (Risbey *et al.* 1999, Berry *et al.* 2006) Enrollment in the Irrigation Initiative provided by the state of Kansas is an example of a planned adaptation (Kettle *et al.*2007).

Adaptation does not always imply that improvements have been made or that the system is operating more efficiently or in a more self-reliant manner. Mal-adaptation can occur when adjustments or adaptations result in more negative than beneficial impacts. Adger *et al.* (2003) highlights mal-adaptation by discussing the importance of interactions between scales as well as up and down scale impacts when considering which adaptations to make. Teleconnections between systems can lead to vulnerabilities in one location caused by events, such as drought or energy shortages, in another location. According to Adger *et al.* (2008, p. 151):

> By framing vulnerability in terms of nested relationships, we emphasize not only the synergistic and interdependent nature of social-ecological relationships at different scales, but also illustrate how the forces of globalization are making such interdependencies critical determinants of local vulnerability.

Thus, producers in Kansas may find themselves vulnerable to market fluctuations associated with events in other countries. For example, an increase in production in one location may lead to lower market prices in Kansas and less income for producers.

According to Moser and Ekstrom (2010) there are three distinct phases that occur during the adaptation process:

1. understanding,
2. planning,
3. and managing.

Each of these phases is comprised of embedded sub-processes (Figure 4.1). Understanding involves basic components of adaptation such as detecting a problem, collection of information about the problem, and potentially redefining the problem in a way that does not require adaptive measures. During the second phase of adaptation, planning, options for adapting are developed, the options are then assessed, and a final option is selected. The third and final phase of adaptation is managing. In this phase, options selected in phase two are implemented, monitored, and then evaluated. Depending on the results of subsequent evaluations, the adaptation process may begin again with the identification of a new problem within the system. "Monitoring and evaluation stages are critical to an adaptive management approach because they help support institutional and social learning, which is commonly considered necessary to deal with complex and uncertain problems," (Moser and Ekstrom 2010, 22027). Each of the phases of adaptation have potential barriers of adaptation that can potentially derail the process. In order to move on to the next phases, these potential barriers must be properly dealt with in order to avoid creating more barriers farther along the adaptation process.

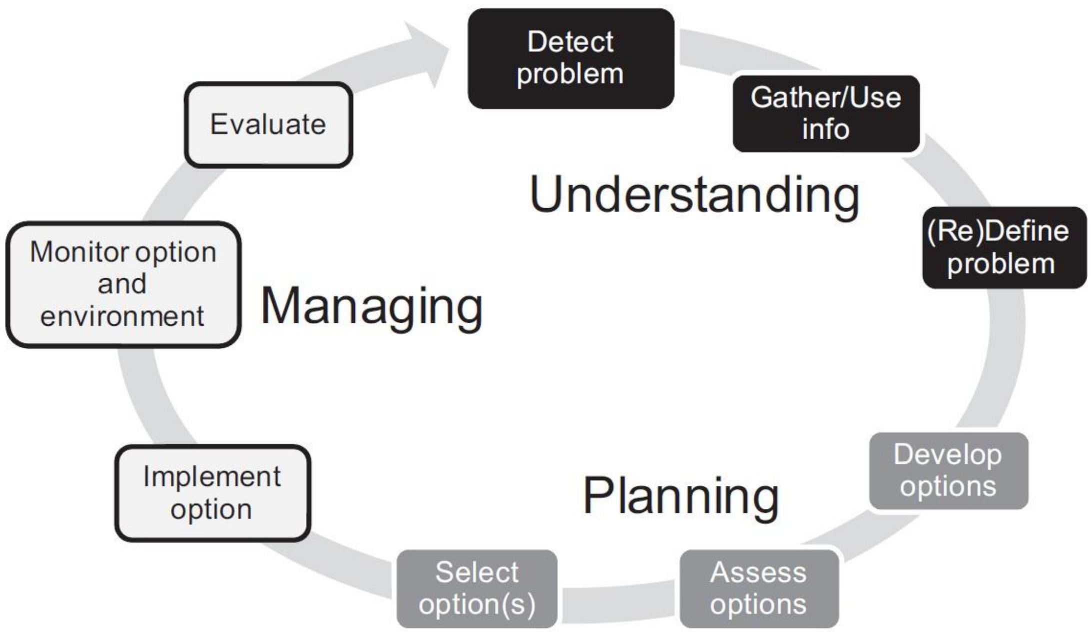

Figure 4.1 Phases and sub-processes of the adaptation cycle (Moser and Ekstrom 2010, 22027).

Successful adaptations are dependent on both the spatial and temporal scales to which they are applied (Adger 2003). This means that adaptations should be evaluated for their impacts on systems in other locations and also for their impacts further in time. Adaptations that do not provide benefits in the future such as continued soil replenishment are not considered to be beneficial or sustainable in the long term. An example of a historical adaptation to drought in Kansas that was not successful was the idea that rain follows the plow (Baltensperger 1979). This adaptation required farmers to continue to plow their dry soils in order to bring the rain. An example of an adaption in Kansas that facilitates current agricultural production but may be unsustainable in the longer term is irrigation from the Ogallala Aquifer (Peterson *et al*. 2003, Green 1993) According to Harrington (2009) recent research has shown that while irrigation may allow for the continued production of crops in the present, irrigation may actually increase long term vulnerability to drought by depleting local groundwater supplies. Wilbanks and Kates (1999) highlight the need for consideration of local conditions when adapting to environmental variability. The scale and scope of adaptations can have significant impacts on the number and types of barriers encountered during the adaptation process (Moser and Ekstrom 2010). In Kansas it is particularly important to take differences between the eastern and western portions of the state into account when assessing the long-term viability and up and downscale impacts of adaptation.

II. Sustainability

In the broadest sense sustainability is the ability of a system to self-sustain across time and in some cases space. Sustainability has been conceptualized as a pathway for future development and as an all-encompassing process of thought that seeks to integrate all systems together and make decisions and actions whose benefits are distributed across each system and through time (Harrington 2009). In some ways sustainability is as much a vision of the future and future pathways to development as it is a developmental strategy. Unfortunately, some notions of sustainability have been co-opted from their original context and distorted to fit the self-promotional needs of individuals, organizations, and businesses (Cashman 2006). Sustainability can be broken down into three overlapping primary components (Swart *et al.* 2004):

1. economic sustainability,
2. environmental sustainability, and
3. social or cultural sustainability.

Sustainable economic development pertains to the economic performance of a system. Associated with economic sustainability are built environments that focus on creating a method of advancement that encourages equity among populations that can be sustained in a forward thinking, dynamic process driven manner. Economic sustainability contributes to increasing the resilience and adaptive capacity of a system while decreasing vulnerability. Environmental sustainability occurs through management actions involving natural ecosystems designed to improve current environmental quality and help ensure long term maintenance of that quality. Social or cultural sustainability seeks to improve conditions through the building of social capital and services that support local communities and cultures (Swart *et al.* 2004).

Sustainability in agriculture brings the goals of environmental and social sustainability together to create a production system that is kind to the environment and also builds capital in the social structures associated with agriculture (Pretty 2007, p. 451):

> As a more sustainable agriculture seeks to make the best use of nature's good and services, technologies and practices must be locally adapted and fitted to place. These are most likely to emerge from new configurations of social capital, comprising relations of trust embodied in new social organizations, new horizontal and vertical partnerships between institutions, and human capital comprising leadership, ingenuity, management skills and capacity to innovate.

Sustainable agriculture generally refers to the ability to continue production without degrading the environmental and natural resource base while at the same time taking into consideration economic and social conditions for the producer (Pretty 2007). In Kansas, sustainable agriculture would seek to be beneficial to each of the three roles agriculture plays (economic, environmental, and social/cultural). These three roles are closely aligned with the three components of sustainability. This may help facilitate the implementation of sustainable agricultural practices. As the largest user of land in Kansas (KSDA 2012), it is important that agricultural land is managed in a manner that allows for improved quality of soils, water, surrounding flora and fauna, in the future for both crop and livestock operations (Pretty 2007). Four key principals should guide sustainable agriculture (Table 4.1).

	Principles for Sustainable Agriculture
I	Integration of biological and ecological processes such as nutrient cycling, nitrogen fixation, soil regeneration, allelopathy, competition, predation and parasitism into food production processes
II	Minimize the use of those non-renewable inputs that cause harm to the environment or to the health of producers and consumers
III	Make productive use of the knowledge and skills of producers, thus improving their self-reliance and substituting human capital for costly external inputs
IV	Make productive use of people's collective capacities to work together to solve common agricultural and natural resource problems, such as for pest, watershed, irrigation, forest and credit management

Table 4.1 Four principles for sustainable agriculture (Pretty 2007, p. 451).

Implementation of sustainable agricultural practices in Kansas would lead to improvements in the economic, environmental, and social systems that interact with agriculture. Environmental benefits to Kansas could include a decrease in soil loss associated with wind and runoff events, increased support for naturally provided ecosystem services, and an overall improvement to environmental quality that will extend beyond the limits of individual centers of production. Economic benefits will result from a decrease in the need for costly technological inputs, such as chemical fertilizers and general energy costs. Other economic benefits may result from a stabilization of individual producer finances and the economies of local communities. Engagement in community wide activities such as Community Supported Agriculture (CSA or CSAs) and local energy cooperatives can contribute to the stabilization and growth of local economies (Carolan 2011). Continuation of this most traditional Kansas way of life will help sustain local communities and build social capital. Social conditions may also improve as non-producing members of local communities begin to establish personal connections with agriculture and food production.

III. Synergies between adaptation and sustainability

An important distinction between adaptation and sustainability is that adaptations for the most part are one-time decisions or actions such as the decision to plant a new crop in response to prolonged drought or the decision to modify existing policy for the future based on perceived impacts. Sustainability is largely a dynamic process that continues infinitely as society continues to progress (Adger 2005). Sustainability can be a series of individual adaptations, both autonomous and planned, across multiple spatial and temporal scales (Table 4.2). That being the case, not all adaptations are sustainable. The two are not mutually inclusive and in fact some adaptations can be entirely unsustainable, even when the intention was to be sustainable. It is therefore necessary to investigate the up and down scale and long term impacts of each adaptation in order to ascertain its contribution towards sustainable agriculture.

	Autonomous Adaptation	**Planned Adaptation**
Characteristics	Does not constitute a conscious response to climatic stimuli; is triggered by ecological changes in natural systems and	Deliberate policy decision; awareness of changed conditions or impending changes; may require development of

	changes in *human systems (IPCC)*	new infrastructure
Time Scale	Short term Weeks, seasonal, annual	Long term 5 – 10 years
Impact Scale	Individual producer/family Individual production system	Institutions Social, economic, and environmental systems
Example In Agriculture	Use of new technology to harvest new sources of water and conservation of soil moisture	Policies regulating soil management practices to reduce loss of soil nutrients. E.g. Conservation Reserve Program and subsurface drip irrigation

Table 4.2 Summary of adaptation forms, time scales, systems impacted, and examples from agriculture.

IV. Sustainable Agricultural Adaptations

Sustainable adaptions in agriculture have the potential to create benefits on temporal and spatial scales. Adaptations made on an individual farm may create benefits that extend beyond the boundaries of the farm because of interactions with other systems such as the local social community or the state political system (Wall *et al.* 2005). It is critical that potential up and down scale impacts of a particular adaptation are considered (Adger *et al.* 2005, Swart *et al.* 2004). Adaptations may also interact with other systems at the same scale. For example, an adaptation designed to increase yield such as the application of chemical fertilizers may adversely impact soil quality over time. Common sustainable agricultural adaptations can be divided into three general categories (Wall *et al.* 2005):

1. soil management,
2. crop and livestock management,
3. on-site enterprises.

These categories were selected because they each represent a different component of agriculture. While the adaptations are broken down into these components, each adaptation also interacts in its own way with the other components.

Soil management occurs through the actions that farmers take to keep their soils viable for agriculture. As climate change progresses, soil will become one of the most valuable resources. Soils are eroding at alarming rates (Montgomery 2007, Pimentel 2003), highlighting the need to continue to make sustainable adaptations to soil management strategies. Within soil management, there are two prevalent forms of sustainable adaptations: the use of organic matter to replenish soil nutrients and changes in tillage practices.

The first form of soil management adaptation is nutrient replenishing and cycling. Conventional practice is to use chemical fertilizers to replace lost nutrients (Tilman 1999). In the long run however this is unsustainable because it does nothing to restore long-term soil quality, can also cost the farmer significant amounts of money, and increases greenhouse gas emissions from the agricultural sector (Moser 2012, Tilman 1999). Those input costs may be offset by increased yields but concerns exist about off-site consequences, externalities, and honest pricing (Pretty 2007). Organic matter can be gathered from animal manure, cover crops, and composting activities. When applied to soils, organic matter can be used to replenish nutrients (Moser 2012). Using organic matter as fertilizer also increases the cycling of energy through the farm system so that the manure from livestock fertilizes the crops that in turn may feed the livestock. Financial benefits for the producer's also may occur if the farmer is purchasing fewer chemical fertilizers from a third party supplier. It may be difficult for large farm operations to successfully implement an organic matter dominated fertilization regime due to initial overhead costs or loss of production levels. Another adaptation to increase nutrient cycling utilizes grasses native to the region for grazing animals. Native grasses have been shown to be more efficient at cycling and fixing nutrients to the soil than invasive or monoculture plants (Jackson 1990). "Recovery of soil carbon and nitrogen should be more rapid if fields are planted with a high-diversity mixture of appropriate plant species," (Tilman 1999, p. 5999).

"Conventional" tillage practices are damaging to the soil quality because tillage breaks up soil structures and allows for the release of moisture into the air as the soil is turned over. This reduces the soil moisture available to crops over time, and can also increase a location's vulnerability to hazards, causes a loss of biodiversity, a weakening of ecosystem services, and soil erosion. Carbon is also released into the atmosphere through conventional tillage as the soil is overturned and soil microbial processes are brought closer to the soil-atmosphere exchange interface. Carbon sequestration in agricultural soils is seen as one of the significant contributions agriculture can make when it comes to reducing greenhouse gas emissions (Minamikawa 2009, Moser 2012). Storing carbon in soils may present an economic opportunity for farmers in the future should a viable carbon exchange be implemented at either a national scale or within

Kansas. Reduced or no till practices, which have already been adopted in certain locations, allow for the storage of moisture and carbon in the soil and also encourage the formation of organic material such as bacteria and microorganisms that provide essential crop nutrients and enhances crop production (Smith 2010, Pretty 2007). Disturbing the soil through tillage causes organic matter to be broken up before it can accrue to beneficial levels (Brussaard 2007). It is for these reasons that employing reduced tillage practices constitutes a sustainable agricultural adaptation.

Crop and livestock management refers to the actions farmers take to manage their combined total of various crops and livestock in their farm system (Wall *et al*. 2005). The prevalent form of farming in Kansas is large scale monoculture cropping, with the size of the endeavor increasing from east to west. However in the west, ranching and crop production for feed are the primary agricultural activities (Harrington *et al.* 2010, Harrington *et al.* 2009). Adaptations to cropping systems generally occur through changes to the diversity of on farm species and a rotation of crops. Livestock adaptations occur through changes to species diversity like cropping adaptations, and also through adjustments to production methods, such as a transition to pasture-based livestock.

One impact of climate change will be the northward movement of species habitat zones for both plants and animals as a result of rising temperatures (Berry 2008). Varying crop selection to include plants naturally well suited to the changing climate would be a sustainable adaptation (Wall *et al.* 2005). Climate related hazards such as drought should also be considered and plants chosen for their natural resilience to a changing frequency of such hazards (Bryant *et al.* 2000). This helps to reduce vulnerability because when crop choice adaptation is implemented, plants selected should have a more natural tolerance to small temporal scale variation in daily weather patterns and climate conditions (Wall *et al.* 2005, p. 121):

> A diversity of crop types and varieties are grown in rotation and in different areas of farm properties. This spreads the risk of losing an entire year's production since conditions can vary across fairly small areas and different crops vary in how they respond to those conditions.

This adaptation may contribute to the overall resiliency of the farm system by providing habitat for local animals and encourage "pests" that may be beneficial in managing an efficient nutrient cycling when native plants are uses (Berry 2008). Varying spatial extent and magnitude of hazards may also influence selection decisions (Adger 2008).

Producers may choose to vary species diversity by selecting crops based on their ability to fix nitrogen and sequester carbon dioxide in the soil. This is known as greenhouse gas sequestration (Smith 2010). Nitrogen in the soil is a natural fertilizer for plants and is imitated by nitrogen based chemical fertilizers (Tilman 1999, Bryant *et al.* 2000). Farmers may become less dependent on chemical fertilizers if there is a natural source of soil nitrogen helping to lessen the financial burden. If implemented on a large scale, use of natural sources for soil nitrogen may cause a reduction in the production levels of chemical fertilizers, which could help reduce overall GHG emissions from agriculture (Pretty 2010). This may occur because manufacture of nitrogen based chemical fertilizers is fairly energy intensive so a reduction in the need for nitrogen fertilizers may also create a decrease in energy consumption.

For some the addition of livestock to the farm system simply for the use of manure as fertilizer may represent an adaptation in itself (Wall *et al.* 2005). For systems that already include livestock, a transition to pasture based livestock management is another sustainable adaptation that can be made (Bernues *et al.* 2011). Pasture based livestock management involves the raising and production of cattle in open pastures rather than intensive feed lots (Bernues *et al.* 2011). Raising livestock in this manner contributes to sustainable agriculture because pasture management has the potential to provide habitat for native fauna, reduce the energy and water consumption, provide open areas of native grasses, and produce healthier livestock. Increases in biodiversity and native plant growth combined with decreases in the use of corn-based feed and related embedded energy can significantly reduce a system's vulnerability to hazards. For example, livestock are likely to be more resistant to the negative health impacts associated with rising temperatures when they are able to move about and find shade as opposed to the limited conditions available in high intensity, industrial feedlots (ten Napel 2011). Transitioning to pasture based livestock production methods in Kansas may help restore the natural prairies that no longer dominate the landscape.

On-site enterprises are those activities that may not be directly agricultural such as plowing or planting, but still occur within the production system that contribute to the overall agricultural operations. An example would be local energy generation using a wind turbine. Adaptations to on-site activities can be especially beneficial because they can easily be expanded to include not just the individual production systems but also the local community. Diversifying income sources can also help spread the risk of financial loss across an entire production system (Wall *et al.* 2005). Berman (2004) found that the ability to access goods from other communities and that a means of diversifying local economies are critical to the ability to absorb the impacts of climate change. Adaptation to climate change does not just mean reducing or eliminating the potential impacts of climate change. Communities should seek to find ways to economically capitalize on potential opportunities created by any type of future risk. For example, a small community vulnerable to population and wage loss should investigate the advantages of eco and agrotourism and other potential sources of income. The ability to spread the impacts across a community and thereby mitigate individual impacts increases the community's over all resilience to both economic and environmental changes (Berman 2004).

A commonly discussed form of sustainable on site enterprise is the production of renewable alternative energy. Alternative energy production can occur through the use of solar panels, wind turbines, or bio energy production (Brunsell *et al.* 2008). One way to expand alternative energy production beyond the individual farm system is to create a community based alternative energy cooperative. Similar cooperative endeavors can be applied to the production of bio energy and wind power. In some states, excess energy unused by the community can be sold back into the power grid for financial gain. While solar and wind energy are the generally the most discussed forms of alternative energy they may not be appropriate for each producer depending on their specific location, resources, and vulnerabilities. Pretty (2007) discusses how the production and use of biomass-based fuels can reduce carbon emissions lowering on-site energy costs and also spread risk of financial loss across multiple activities. Participation in available markets such as carbon cap and trade programs may also represent an on-site enterprise that "may offer new opportunities for income generation," (Pretty 2007, p. 459).

Small- scale on site enterprises have the potential to benefit the individual farm system but are less easily expanded to the community scale, unless the community works together to create a critical mass of a desired product. For example, on-site composting allows farmers to cycle energy and nutrients back into the system and may also save resources if the material was previously shipped off the farm. Small efforts like these can contribute to soil conservation practices (Smith 2010). Another small-scale enterprise that may be an option is Community Supported Agriculture (Carolan 2011). Carolan suggests that where viable, CSAs represent a small-scale on-site enterprise because the can generate an alternative source of revenue for producers and can also help to bring consumers into more contact with food production.

V. Summary

Adaptations occur as a response to observed impacts or perceived impacts of future events. In the context of this study of Kansas agriculture and sustainability, adaptations can occur as a response to the observed, perceived, or expected impacts of climate change (Table 4.3). Adaptations interact with multiple systems and on different spatial and temporal scales. Two forms of adaptation have been discussed: autonomous and planned adaptation. Autonomous adaptations are made by individuals and occur on a short temporal scale while planned adaptations address regional issues and occur on a longer temporal scale, ranging from years to decades.

	Soil Adaptations		Crop Adaptations		Livestock Adaptation
	Tillage Practices	Organic Matter Use	Crop Diversity	Crop Selection	Livestock
Adaptation/ Replaced activity:	Reduced or No till / Conventional till	Application of composted and animal manure Material / Chemical fertilizer use	Selection and planting of multiple crops / Mono-cropping	Selection of crops for suitability to new climate regimes, potential to fix nitrogen & sequester carbon	Raising & production of cattle for consumption in open pastures
Sustainable impacts:	Storage of moisture & carbon in the soil; encourages formation of organic material, bacteria, micro-organisms	Reduces energy use within the farm system and increases on-farm nutrient cycling.	Creates biodiversity, additional income , and habitat for native fauna	Improved soil quality, increased crop yield	Provide habitat for native fauna, reduce the energy and water consumption, provide open areas of native grasses, and produce healthier livestock
Reduction of vulnerability	Increased soil moisture reduces vulnerability to drought and wildfires	Decreased vulnerability to variations in price of chemical	Distributes risk of loss across multiple crops	Less dependent on chemical fertilizers; Natural resiliencies to	Livestock less vulnerable to health impacts of rising temperatures

	fertilizers;	variations in weather /climate conditions & natural hazards

Table 4.3 Summary of sustainable agricultural adaptations.

Sustainability is an all-encompassing dynamic process that serves as a pathway towards improved environmental, social, and economic conditions. Sustainability can be conceptualized as a series of adaptations designed and undertaken to create benefits to the individual that expand beyond to the community, state, and national scales. In agriculture, sustainable adaptations will occur as a result of human responses to continued global changes, including climate change. Sustainable agricultural adaptations should seek to improve the quality of the environmental, social, and economic systems within which farms and farmers operate. These adaptations should also seek to improve the larger scale systems that interact with individual systems to create benefits that are all encompassing and self-perpetuating. Sustainable adaptations to climate change will be crucial for agriculture in Kansas order to continue to provide quality, nutritious food to a growing population. However, there are barriers that must be overcome before sustainable agriculture can be effectively implemented. These barriers can present themselves in any number of ways and vary depending on the specific characteristics of each location.

Chapter 5 - Jumping the Hurdle: Policy and Cognitive Barriers to Sustainable Agricultural Adaptation

"There is no such thing as a weird human being. It's just that some people require more understanding than other people…Whether a man is a criminal or a public servant is purely a matter of perspective,"
-Tom Robbins, Another Roadside Attraction

In this chapter, I continue by discussing certain forms of policy and how they interact with sustainable agriculture at different scales. The primary focus of the discussion will be on the ways in which policy interacts with agriculture to create barriers to sustainable agricultural adaptation. Barriers to agricultural sustainability are policies or activities that prevent a farmer from implementing a sustainable adaptation on their farm or ranch. Some barriers are created by place characteristics. Barriers can be overcome with changes to management and thinking, genuine effort, and shifts in land uses, available resources, and institutions (Moser and Ekstrom 2010). For example, a farmer may choose not to install a solar panel on his/her farm because the area does not consistently receive enough sunlight. Differences in climate, environment, and culture among regions, and consideration of all potential best practices should be taken into account when creating policy so as not to accidentally create new barriers through maladaptation (Moser and Ekstrom 2010).

The remainder of this chapter discusses barriers in one of two broad categories, policy and/or cognitive. Policy barriers come in three general categories: federal subsidies, environmental regulations, and special interest group lobbyists/actors. Cognitive barriers informed by cultural and traditional structures, as well as policy, form the second category. Gaps in knowledge or understanding and weak or missing connections are the basis for cognitive barriers. The chapter concludes with a discussion of reasons it is important to understand the interactions of barriers with sustainable agriculture and with a brief summary of the types of barriers to sustainable agriculture and the scales on which they operate.

I. Policy Barriers

Policy barriers manifest themselves within the legislative and institutional structures that relate to agriculture; these structures may be difficult to overcome. Policy barriers may be particularly difficult to overcome because they are the results of the political structures that help shape society and culture (Smit and Pilifosova 2003). I suggest that relevant policy barriers fit into three general categories:

1. federal subsidies,
2. environmental regulations, and
3. lobbyists and outside actors/interest groups.

Federal subsidies relate to energy subsidies, agricultural subsidies such as the Conservation Reserve Program, and the federal crop insurance program. Insurance coverage policies can restrict sustainable agricultural adaptations by limiting the activities for which a farmer can receive insurance coverage. Environmental regulations can significantly influence land use and production patterns and therefore should be discussed as a policy barrier, when those rules limit flexibility related to sustainability. Conservation, irrigation, and emissions regulations can all act as obstacles (Moser and Ekstrom 2010). Lobbyists and outside players associated with certain interest groups or corporations (*i.e*. bankers/the financial industry) can exert an influence over management decisions that can create policy barriers to sustainable agricultural adaptation for both producers and communities. It is important to note that a lack of policy/regulation can be equally as detrimental to the adoption of sustainable practices (Cashman 2006).

In general, subsidies have tended to favor unsustainable practices, such as subsidization of corn that lead to large scale, monocropping systems and industrial production. Subsidies are designed to help regulate or stabilize sectors of the economy, such as the growth of biofuel crops for ethanol production. In agriculture, subsidies are intended to help insure that producers make a profit even if market prices dip below the cost of production or as an incentive for the production of specific crops (Koplow and Dernbach 2001, Goodwin 2001). An agricultural subsidy linked to soil conservation is the CRP, which allows producers to receive payments for land taken out of production. A critique of the CRP and similar conservation buffers is that they may not take local conditions into consideration or even the varying conditions at a specific production site (Lovell and Sullivan 2006). In Kansas, “slippage” has been identified as a negative impact of the CRP (Leathers and Harrington 2000). Slippage occurs when a farmer brings new land into crop production and the numbers of acres enrolled in the CRP are not matched by an equal number of acres being taken out of production. While rates of slippage varied from county to county, Leathers and Harrington 2000 found that “it appears that the CRP fell far short of its intended goals,” (p. 90).

Though not often thought of as a government subsidy program “...the U. S. crop insurance program is first and foremost a government program intended to convey economic benefits to a particular segment of the economy - the U.S. farm sector,” (Goodwin 2001 p. 643). The federal crop insurance program is intended to address multiple perils and designed to protect producers from numerous forms of loss (Goodwin 2001). Local insurance programs are unable to compete with the federal program because this sort of insurance program is financially unfeasible for small scale operations. Systemic risk and moral hazard have been identified as issues within the program itself (Miranda and Glauber 1997). Systemic risk prevents crop insurance from performing its primary duty of combing and distributing risk across individual farmers. Systemic risk represents a barrier created by the interaction of policy on a national scale with the specific hazards of each farm system. This impairs a farmer’s ability to efficiently manage their farm systems and spread their own risk of loss across their farm. As climate changes, hazards may shift compounding the impacts of systemic risk. For example, as temperatures rise in some regions and not in others, farmers may experience rising temperatures and new invasive pests as a hazard to which producers in other regions are not exposed. Moral hazard is the idea that insured farmers may take fewer precautions against loss and may actually engage in practices that are known to be risky (Horowitz and Lichtenberg 1993).

Smit *et al.* (2002) found that while insured farmers implemented risk mitigating strategies around the same time as their uninsured counter parts, they are generally associated with lower on farm species diversity, a sustainable adaptation discussed previously. Insurance providers may be reluctant to cover sustainable practices that are seen as untested or unreliable (Wall et al. 2005). Producers enrolled in the federal crop insurance program have also been connected to higher usage rates for chemical inputs such as nitrogen fertilizers and pesticides (Horowitz and Lichtenberg 1993).

Companies involved in the production of ethanol fuel, and not just producers who grow corn for ethanol use, are beneficiaries of subsidies as well. This linkage is known as close components (Koplow and Dernbach 2001). Another sector of the economy that is heavily subsidized is the fossil fuel industry. In fact, subsidies of fossil fuels constitute over 75 percent of total energy subsidies in the United States. Subsidies may seem somewhat straightforward, but they can extend a significant reach when external variables and players are taken into account. In some cases subsidies seem to be granted more out of tradition and as a service to the status quo rather than out of need and fair and equal distribution of financial and economic resources. Research indicates that subsidy monies do not always benefit the intended target or the overall economy (Pimentel 2003). Economic inefficiencies aside, agricultural and fossil fuels subsidies also contribute to the environmental degradation associated with industrial agriculture. These subsidies exerting a significant influence over the economic and political systems within which farmers can operate and make decisions, and thus represent a significant policy barrier to the effective implementation of sustainable agriculture as an adaptation to climate change.

Fossil fuels comprise approximately 80 percent of the global energy supply (Figure 5.1). As a result oil, coal, and natural gas, when combined with ethanol and the fossil fuel needed for production, are subsidized within the United States almost to the exclusion of other forms of energy (Combs 2008) (Figure 5.2). Fossil fuel based sources of energy account for roughly 80 percent of the US subsidies for energy. This is only half a percent different than the portion of the energy market fossil fuels control. It is beyond the scope of this paper to discuss whether or not there is a direct relationship between amount of government subsidy allocated and the amount of control of the market, but it is certainly an interesting avenue for future research.

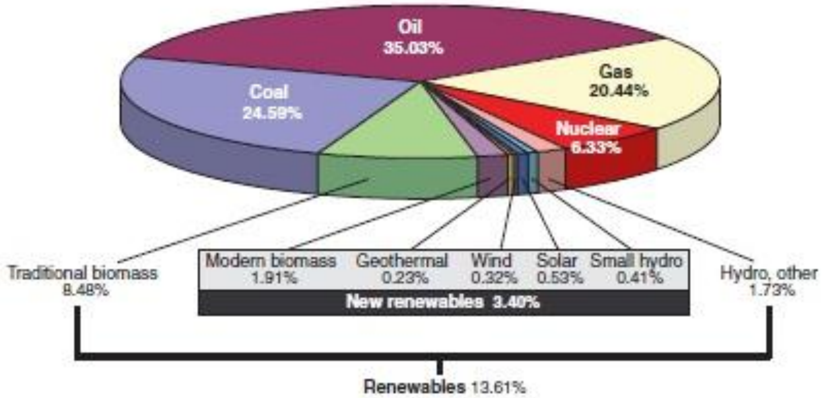

Figure 5.1 Breakdown of the global energy supply (Goldemberg 2003).

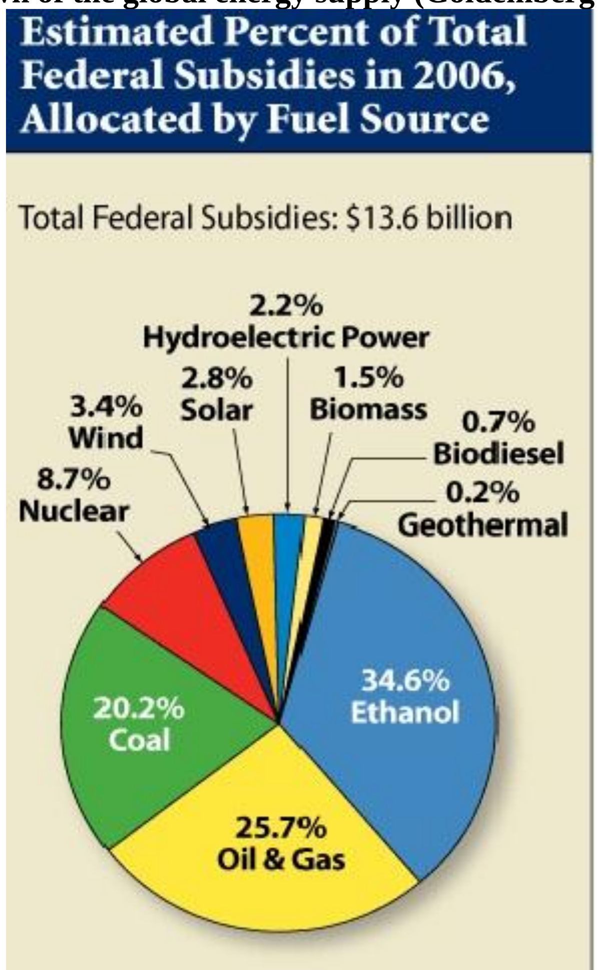

Figure 5.2 Percent of federal fuel subsidies by source. Here ethanol is considered a fossil fuel based source due to the inefficiencies in production. (Combs 2008)

These subsidies to the fossil fuel industries, primarily oil, coal, and natural gas, have kept energy prices in the United States speciously low. Low prices reinforce farmers' decisions, conscious or unconscious, to rely on the fossil fuels as the dominant source of on farm energy. "Total energy costs of $28.8 billion in 2003 represented 14.4 percent of annual production expenses...As a result, unexpected changes in energy prices or availability can substantially alter farm net revenues, particularly for major field crops," (Schnepf 2004, p. 2). Fossil fuels energize everything from tractors that work the land, to the lights in the barn, all the way up.to the freight trucks that ship and transport goods. However, not all uses of fossil fuels are so easily observable. Embedded energy exists at nearly every level of agriculture that can be studied. Perhaps the most common source of embedded energy is chemical based fertilizers and pesticides. These artificial sources of nutrients and protection are energy intensive in their production (Schnepf 2004). Indeed, natural gas is a principle component of nitrogen based fertilizers, which are commonly used by industrial farmers.

Currently, ethanol subsidies take the form of tax credits for energy companies rather than direct payments to producers. Ethanol is also a relatively inefficient fuel source, requiring 29 percent more energy to produce a gallon of ethanol than the ethanol itself contains (Pimentel 2003). In contrast, certain biodiesel fuels can return upwards of 90 percent of the energy input required for production (Hill *et al.* 2006). Increased demand for corn has helped create the ingrained custom of monocultural cropping. Monocultures lead to soil degradation due to heavy use of agrochemicals (manufactured fertilizers and pesticides) and a lack of nutrient recycling and replenishment. Dry soils, soils low in organic matter, and nutrient deficient soils are vulnerable to loss from erosion, run off, and as the Dust Bowl demonstrated, wind (Harrington 2009, Leathers and Harrington 2000). A focus on high intensity monoculture additionally means that the farmers are not raising livestock on the same land. Livestock manure is an essentially free and renewable on farm resource that can be highly useful as a fertilizer and is fairly efficient at replenishing soil nutrients. Without locally available livestock manure, dependence on nitrogen based chemical fertilizers is reinforced. Monoculture systems leave crops vulnerable to pests and diseases as one outbreak can destroy an entire field or season (Pretty 2007).

Subsidies keep the price of corn low making it an easy and affordable staple food for livestock produced in feedlots. By extension this keeps the price of meat in supermarkets artificially low and un-reflective of the true cost of production. Low prices lead to lofty levels of consumption creating a consistent demand. Combined, the low cost of corn for feed and consumption rates of livestock meat form a feedback system that is both detrimental to the environment and not sustainable.

Environmental regulations can help dictate land use patterns and the activities producers engage in during production. Some regulations may impose a financial burden by requiring producers to pay for permits (Moser and Ekstrom 2010) like those required by the Clean Air and Water Acts. State level regulations can control the flow of and access to resources. An example in Kansas is the Irrigation Initiative which encourages the use of irrigation even with decreased precipitation and depletion of the Ogallala Aquifer (Kettle *et al.* 2007). Other state level regulations can limit the adaptive capacity of individual producers. The Conservation Districts Law lays out in the Conservations Measures statute the state approved conservation activities producers may undertake. Conversely, a lack of environmental regulations can also create barriers to sustainable adaptation. According to Moser and Ekstrom (2010) "a lack of high-level leadership and guidance (governance) can undermine the capacity and willingness to make adaptation decisions," (p. 22028). Failure of state and national level policies to coordinate the impacts of environmental regulation differences across scales can create barriers to adaptation as well.

Other components of the policy making process can present barriers, such as competing policy goals between actors involved in the policy-making process (Moser 2012). Lobbyists paid by major corporations or special interest groups can influence those in charge of policy creation and decision making to continue with the status quo or even create new policies that are detrimental. This is usually done to ensure that policy conditions continue to be favorable to a certain method of agricultural production that generates profits for corporations. "Particularly powerful actors might stand to benefit from carrying out an action and thus may be inclined to dismiss uncertainties and unknowns about potential negative consequences or ignore legal or ethical constraints," (Moser 2012 p.167). High intensity feed lots and monocropping systems are examples of methods of production that generate profits for corporations or interest groups but could potentially lose policy protection if sustainable adaptions were enabled with new policy language.

In Kansas, the Kansas Livestock Association (KLA) is an organization that influences local agriculture related policies. In an interview for the book, Farming in the Dark (Janke 2008), Donn Teske stated:

> KLA—they are so well indoctrinated into Kansas politics, it's like a god out there, and it's an entity. I asked one of the Farm Bureau presidents, "How did they get so much power?" He said, "I'd like to know too!" The KLA membership numbers aren't as large as Farm Bureau, but they have big money behind them. They throw socials at least once a week for the legislators in Topeka. They don't legally get check off dollars, but the check off dollars go into the same building, and then you've have these firewalls to keep the money separate. Maybe it can't go for lobbying, but it goes for other things to free up the funds for lobbying. Those check off dollars really mess up agriculture, really mess things up. Now all of a sudden these commodity organizations have all this money. It isn't doing the best for farming overall or for farmers overall, it is just for this specific commodity.

Table 5.1 provides a summary of the key points presented.

		Examples	**Possible Implications**
Policy Barriers	**Subsidies**	Energy Subsidies - Crop Insurance – Agricultural Subsidies	- can keep cost of production artificially low - reinforce unsustainable practices e.g., application of nitrogen based chemical fertilizers produced cheaply with subsidized natural gas - engage in riskier behavior (no or mal adaptation) due to moral hazard - lowers amount of financial resources available for new development and incentives
	Lobbyists/ Interest Groups	KLA - Ag. Corporations – Kansas Farm Bureau – No Till on the Plains	- influence policy and decision makers through monetary contributions - influence policy and decision makers through supporting a specific mindset - create disconnect between communities and policy makers - restrict available resources such as seed

			varieties
	Environmental Regulations	Clean Air/Clean Water Acts - Conservation Reserve - KS Regulations	- influence land use patterns and changes - permitting and restrictions may create financial barriers - limited incentives may impact scope of on-site enterprises

Table 5.1 Summary of barriers to sustainable agricultural adaptation in Kansas.

II. Cognitive Barriers

Cognitive barriers are those created due to some form of missing information or knowledge about a topic, event, or activity. Information-based barriers are not a new phenomenon and can accompany nearly any scenario that requires change. Cognitive barriers generally do not imply that nothing is known about the topic, event or activity. In fact, it is usually the case that just a few pieces of knowledge are missing and those unavailable components prevent full understanding. This may be especially true about knowledge surrounding climate and environmental change, sustainability, complex system dynamics, and the nature of agricultural production in Kansas. Another form of cognitive barrier stems from weak or sometimes completely missing connections or linkages related to the agricultural production system.

One of the more daunting challenges to adoption of sustainable agriculture is misinformation among the general public regarding the nature of climate change (Moser 2012). Much of this misinformation can be traced back to a misunderstanding about the nature of science and uncertainty within climate change science. Shimmelpfennig *et al.* (1996) highlight three uncertainties within climate change projections that can initiate cognitive barriers:

1. the global time path and local rate of global change,
2. changes to the daily and seasonal patterns of climate change, and
3. changes in the intensity of extreme weather events.

Decision makers would like to have salient and credible information to consider. With climate science producing future projections with inherent uncertainties, it is not hard for special interests to foster concern about inaccurate information, to create political mindsets against a proactive response to climate change, and to create suspicions about the nature of sustainable agriculture. A common example of misinformation is the belief that "everywhere is just going to get warmer."

Missing knowledge or misunderstanding of complex system dynamics can present cognitive barriers as well. Systems can range in size from an individual household to a complex network of international players. Systems often combine and interact in complex ways. Connected and nested systems and scales refer to the complex and interconnected nature of coupled social-environmental systems that can lead to unintended consequences both up and down scale. As Adger *et al.* (2007, p.1) note:

> …the vulnerability of specific individuals and communities is not geographically bounded, but rather, is connected at different scales, so that the drivers of their exposure and sensitivity are inseparable from large-scale processes of sociocultural change and market integration.

Scales may also range in size for extremely local to international and from the short term to decadal or longer. How systems and scales interact with each other is a function of specific vulnerabilities, resources, and form of the connections. This is highlighted by Wilbanks and Kates (1999 p.602):

> For instance, it is clear that some of the driving forces for global change operate at a global scale, such as the green-house gas composition of the atmosphere and the reach of global financial systems. But it seems just as clear that many of the individual phenomena that underlie microenvironmental processes, economic activities, resource use, and population dynamics are at a local scale.

Increased globalization presents an example of a how systems can interact not only with other systems on the same scale but with various systems at multiple scales. Globalization demonstrates how impacts of adaptation now have a global reach highlighting the vast range of spatial scales at which systems can now operate. Some systems, such as government structures and policy operate on a much slower time scale than other systems like households. This disconnect between operational temporal scales can create barriers when agricultural needs are not being met in on a reasonable timeline.

> …temporal origins of the barrier relative to the location of the actor are important. The temporal dimension includes contemporary versus legacy barriers, and along the spatial/ jurisdictional dimensions (which sometimes coincide, other times differ in scale), proximate versus remote barriers. (Moser and Ekstrom 2010 p.22030)

Systems require inputs to function and should produce outputs as a return. In agriculture this concept is as simple as inputting a seed and receiving the grain harvest from a plant. Common inputs into agricultural systems include environmental, financial, energy, and technological. Inputs into each system come from outputs of other systems, perhaps operating at different spatial and temporal scales.

Barriers to adaptation can be created because of values and social constructs that operate at the scales of producer, community, and the state or national level (Wilbanks and Kates 1999). These construct help shape the way producers and community members perceive the status quo and value new information and events (Moser and Ekstrom 2010). Political systems and institutions are also influential:

> ...deeply held values and beliefs that influence how people perceive, interpret, and think about risks and their management, what information and knowledge they value, what concerns have standing, and so on-in short, a foundational influence on the decisions and choices made during the adaptation process, (p. 22029).

In this way ingrained beliefs, ideologies, social norms, political rhetoric, and personal perceptions of events, adaptation, and perceived outcomes can generate barriers to adaptation (Moser 2012). Such cognitive barriers may be the hardest to overcome because they require a shift in the way one thinks and a societal paradigm to overcome (Kates *et al.* 2012).

Challenges to implementing sustainable agriculture in Kansas can also arise due to missing or weak connections between agricultural production/producers and those who consume the finished product, or food. These weak connections may be the result of an industrial system of food production and the associated policies, corporations, and values. Carolan (2011) suggests that a lack of embodied experiences with agriculture and food production among the general public is responsible for some of this barrier. It is not uncommon to hear that children think milk/food comes from the grocery store, with no recognition of additional links to the production agricultural system. Carolan further suggests that without crucial embodied experiences agriculture will not be seen as an act, something the one *does*, but rather an impersonal production system purely designed to put food in the grocery stores. In an increasingly technological and industrial society, agricultural producers have been successfully removed from the daily activities of the general public. This separation may lead to apathy towards the needs of producers and natural and agroecosystems. Table 5.2 provides a summary of important points regarding cognitive barriers.

		Example	**Possible Implications**
Cognitive Barriers	**Lack of Knowledge**	**Magnitude of Climate Change** - **Timescale of policy making** - **Rate of environmental change**	- unable to understand full impacts of climate change - dissatisfaction with policy not meeting current needs - assumption that changes happen "in the future" - belief that current practices are taking good care of the environment
	Lack of Connection	Policy Makers and Process - Agriculture and Environment	- low rates of involvement or apathy - lack of concern over environmental degradation -lack of connection to realities of agricultural production

Table 5.2 Summary of cognitive barriers to sustainable agricultural adaptation.

III. Summary

Barriers inherently exist within every system and at every scale. One of the most significant barriers may be the scale at which an individual thinks. It may be hard for an individual to understand the impacts of climate change or the need for sustainability if they are unable to think beyond the local and regional systems they are already acquainted with. Barriers to sustainable agricultural adaptation associated with climate change fall into two major categories, policy and cognitive barriers. Subsidies to the energy industry and environmental regulations, interest groups and lobbyists, and crop insurance are all examples of policy barriers. Cognitive barriers occur due to lack of information or misunderstanding of the magnitude and temporal scale of climate and environmental change and the complex nature of existing agricultural production systems. An inability to 'see' how a transition to sustainable production might happen also represents a cognitive barrier. Missing or weak understanding of the connections between producers, general citizens, and production and natural ecosystems can help form the second type of cognitive obstacles. Policy and cognitive barriers may interact to reinforce one another. Missing knowledge can lead to unsatisfactory policy. In addition, policy may reinforce social and cultural structures that foster the development of cognitive barriers. An example of this feedback loop may be seen in situations where current educational standards for K-12 students have not been updated (a result of the longer temporal scale of policy change/reform). Advances in scholarly understanding typically moves forward more rapidly and this may lead to incomplete or inadequate policy developed by those with gaps in their knowledge. While these barriers present significant challenges to meaningful sustainable adaptation to climate change in the agricultural sector they can be overcome by a transition to policies that take system and scalar interactions into account will be crucial to successful adaptation.

Chapter 6 - Looking into the Crystal Ball: Future Agricultural Scenarios for Kansas

"Conceptual paths wide open, I'm scared to death
Existential weight no longer holds you back
Conceptual paths wide open, I'm scared to death
I'm ready for the future; I'm ready for what happens next"
-Tom Gabel, Conceptual Paths

Previous chapters have provided background information that served as the building material for the development of two scenarios. The current chapter discusses scenarios more in depth and discusses the two scenarios developed in this study: a Business-As-Usual (BAU) and a Sustainable-Adaptive (SA) scenario.

I. Scenarios

Scenarios are useful because they allow investigation of nearly any possible future condition and are especially useful for analyzing interactions between different systems at different scales. These characteristics are important because extrapolating the up and down scale impacts of adaptations and barriers are necessary for adaptions to become "mainstreamed" or to be successful (Smit 2006). When policy makers and individual producers are more easily able to examine possible interactions and related outcomes, it may become easier for them to identify best possible decisions and make better management decisions as well. A scenario narrative can put impacts and barriers into a real-life context and make them seem more human, less abstract, and make it easier for decision makers to place themselves in a particular situation allowing them to better understand management and policy pathways. In this way a scenario narrative may also help overcome cognitive barriers created by weak or missing connections. In the absence of the ability to actually experience possible future scenarios, description of the existing system along with future scenarios may serve as a sort of proxy embodied experience to create or strengthen connections.

Since the new wave of scenario development focused on environmental and climate change began in the 1990's, several different scenarios have commonly been used to guide researchers. Conventional Worlds, Barbarization, and Great Transitions scenarios developed by the Global Scenarios Group in 1997 encompass possible futures, all with distinct characteristics (Gallopin *et al.* 1997). In the Conventional Worlds scenario pathways tend to follow “many of the dominate forces driving development and globalization in recent decades,” (Rosen *et al.* 2010). In contrast, Barbarization worlds present “the grim possibility that the social, economic, and moral underpinnings of civilization deteriorate as emerging problems overwhelm the coping capacity of both markets and policy reform,” (Gallopin *et al.* 1997 p. 7). Great Transition scenarios illustrate futures where a “new suite of values – human solidarity, quality-of-life, and respect for nature – revises the very meaning of development and the ‘good life’” (Raskin 2008 p. 464), a future in which sustainability is a fundamental value rather than a debatable option. One Conventional Worlds scenario is a Policy Reform scenario in which there are

> no major changes in the international order rooted in the nation-state, institutional structures, and the continuity of dominant consumerist cultural values. However…governments intervene to redirect economic growth to achieve key internationally recognized goals for poverty reduction, climate change, ecosystem preservation, water supply adequacy, and pollution control (Rosen *et al.* 2010 p. 2-3)

The following scenarios represent two possible agricultural futures in Kansas, integrating climate projections and their impacts on agriculture, policy and cognitive barriers. Viable sustainable adaptations were identified within the existing literature and discussed in the previous chapters. Each scenario takes into account climatic, environmental, and agricultural difference between the eastern and western regions of Kansas and address diverging pathways when necessary. Key themes discussed such as subsidies, special actors like lobbyists, environmental regulations, and sustainable benefits within interacting systems guide the narratives. The first scenario, Business-As-Usual (BAU), may be considered as a Conventional Worlds scenario and is typified by an approach to agriculture in Kansas that follows current tendencies. The second scenario may also fall under a Conventional Worlds heading but in contrast to the BAU mindset, sustainable adaptive management is dominant and guides a Policy Reform future. My perspective is that a Policy Reform future that supports sustainable agriculture in Kansas can help lay the foundation for a Great Transition scenario farther along the developmental pathway by addressing policy and cognitive barriers and contributing to a socio-cultural paradigm shift. Kates *et al.* (2012) describe this as a transformational adaptation.

II. Business-As-Usual

In the BAU future, current mindsets and policy structures continue to function much the same as they presently do. Both policy and cognitive barriers continue to affect sustainable agricultural adaptation as a result of an economy-first and short term profit mindset. Very little long term environmental guidance is provided for policy makers, institutions, and others who may be in a decision making positions that impact agricultural production in Kansas (Wilson 2002). In both eastern and western Kansas agricultural production carries on with a make money and "feed the globe" mentality. This mentality relies on the continuation of corporate agri-businesses and an industrial form of production and distribution. Crops and livestock raised in Kansas are primarily to be exported to other areas within the US as well as to over 100 countries (KSDA 2012). In order to maintain or increase extant levels of agricultural output, current agricultural practices will continue largely unchanged with innovations in technology and genetics designed to maximize yields per acre or per drop of water. These choices reinforce the use of unsustainable practices, such as irrigation with fossil ground water, to meet demand. While a conversion to dryland techniques has been observed in parts of Kansas and greater efficiency in irrigation techniques are to be expected, there is evidence that this will be accompanied by an increase in the amount of land brought into cultivation (Harrington *et al.* 2009). Conservation practices may push the need to adapt into the future by several decades.

Other practices such as chemical inputs, fossil fuel dependent machinery and distribution systems, and monocropping which are unsustainable when used for an extended period of time (over the course of multiple decades) persist with reinforcing policy driven subsidies and support. In the east this may translate to increased or maintained use of chemical fertilizers, pesticides, and herbicides to support agro-ecosystems dominated by intensive monocropping. Crop producers in western Kansas are likely to continue to use chemical inputs, produce crops for animal feed, and reinforce water intensive livestock production. In the west this could translate to a continuation of high rates of monocropping, irrigation, and water drawn from the Ogallala Aquifer for feed grain production, and the use of feedlots for livestock production. In some locations a reduction in the use of water drawn from the Ogallala Aquifer has already been seen; this change is accompanied by a shift towards dryland agriculture and increased efficiency in methods (Kettle *et al.* 2007).

Monocropping and feedlots both contribute to a decrease in local biodiversity and other ecosystem services (Foley *et al.* 2005). In different ways each method of production interacts with natural ecosystems and the services they provide. Use of human inputs to the agroecosystem weakens many ecosystem services and the natural environment's resilience while increasing vulnerability to hazards such as disease that has the potential to wipe out entire yields and/or feedlots. Hazards associated with climate change will continue to threaten agriculture (SRES 2000) with the impacts becoming more severe as resilience declines in the absence of policy guidance to implement sustainable adaptations and reduce vulnerability.

The use of unsustainable methods of agricultural production will continue to be reinforced by policy structures that generally block sustainable adaptation in Kansas. Copious subsidies to the energy sector, pro-agribusiness environmental regulations, and lobbyists/outside interest groups forge ahead with a policy making process that is largely disembodied from natural systems, producers, and the cultural systems impacted. Producers seeking to transition to a locally sustainable method of production, citizens hoping to establish a healthy agroscape (Lal *et al.*1999), and communities looking for new ways to build social capital are likely to not be favored with a BAU mindset. Structures will continue to reinforce cognitive barriers which are devoid of ways in which communities and consumers learn about, experience, and subsequently relate to agriculture linked with natural ecosystems.

Costs will remain low and unreflective of embedded energy consumption and environmental degradation costs associated with production due to subsidies provided by the government to producers of fossil fuels. Subsidies to the fossil fuel industry keep energy costs unrealistically low thereby contributing to the low price of chemical inputs such as nitrogen based fertilizer or the use of fossil fuels to power on site machinery and meet general energy demands. Financial resources spent subsidizing fossil fuels will limit the amount of financial resources available to invest in alternative energy production, local infrastructure, and other forms of local social capital enhancement like community based educational and outreach services. Rising fuel costs create rising costs of production and distribution for producers and are already beginning to become a burden (Harrington 2009). Further price hikes and a rapidly depleting resource base could mean energy shortages that could have a significant impact on agricultural production costs.

Crop and flood insurance provided by the federal government will continue to impact issues related to moral hazard and systemic risk. Moral hazard allows producers to continue to engage in risky on site behaviors and investments. Available insurance may influence producers to not adapt to changing conditions in meaningful ways. Variations in precipitation patterns and rising temperatures related to climate change will influence planting and chemical application schedules however producers may be slow to adapt due to a false sense of security created by the multi-peril nature of federal crop insurance. Increased periods of drought and flash flooding also associated with climate change (Karl *et al.* 2009) will exacerbate problems stemming from systemic risk. Given the spatial variability in climate and environmental change producers may be increasingly on the hook for teleconnected hazards in other locations. Insurance premium rates may rise in response to more frequent hazards also adding to the financial burden placed on producer and an increase in costs passed along to consumers.

Environmental regulations while generally intended to serve as a safe guard against environmental degradation may become troublesome simply because they generally are created and function on the larger state/national scales and also on a longer temporal scale. Because of a combination of a minimize harm ethos and a view towards a longer temporal scale, environmental regulations may place producers in a precarious situation of realizing adjustment needs to be taken but they are unable to do so because out of date regulations limit viable options. In the absence of significant policy reform, lobbyists and significant actors within special interest groups will continue to exert influence over decision makers and even the policy making process itself. Due to the power of BAU actors, environmental regulations that are adjusted to accommodate changing climate and environmental conditions will likely fall into the category of too little and too late or fit within the 'no regrets' mindset (*e.g.*, adjustments that make economic sense anyway). For example, the Irrigation Initiative begun in Kansas in 1990 provides cost sharing programs for producers to invest in water-efficient technology (Kettle *et al.* 2007). While such initiatives serve a purpose, producers who use such programs as sources of financial stability rather than see them as environmental restoration projects may be unwilling to transition to dryland agriculture. From an economic perspective losing financial income may be a key to decision-making even as droughts increase and water resources become scarce.

As policy and producer interactions continue to play out in BAU in a manner similar to the present, cognitive barriers will continue to persist in the absence of any significant modifications to the structures that currently exist. The educational system will continue to emphasize and reinforce the methods and values associated with production agriculture. A continued focus on feeding the globe and industrial production methods will mean that large portions of society will continue to be disconnected from the process and act of getting their hands dirty and growing the food. Information regarding the magnitude and variability of climate change impacts will continue to be questioned, downplayed, and debated by politicians and swept under the rug by lobbyists aiming for policy benefits creating gaps between the science community and the general population. Without improved climate science literacy and overcoming these cognitive issues, policy barriers will persist and the trend of environmental degradation will continue unabated. Soil will continue to be a growth medium rather than a living system and there will be an on-going need to add artificially produced nutrients. Other ecosystem services provided by healthy soils will be low and perhaps continue to decline. Soil erosion is likely to increase as a result of drought and wind or large runoff events. Biodiversity, which is crucial to the resilience of ecosystems, will continue to drop off as species unable to migrate begin to die off due to habitat losses associated with intensive monocropping, feedlot production methods, or increased stress created from climate change. On site biodiversity is likely to decline as natural inputs from ecosystem services are increasingly replaced by technological inputs.

A business-as-usual scenario paints an image of agriculture in Kansas that is remarkably similar to the one seen today. Producers will generally become increasingly dependent on links to corporate agriculture and federal subsidies to stabilize their financial income and keep production costs low. As the pace of environmental degradation continues, natural ecosystems will be unable to provide services to and support agricultural for activities. These trends will leave producers dependent upon energy and technological inputs. Programs such as the federal crop insurance, the CRP, and state level initiatives that provide further financial assistance may lead to producer policy dependency and reluctance to engage in new adjustments, unaccompanied by federal subsidies that will help them adapt to a changing environment. Climate change, use of fossil ground water, soil erosion, and other changes could lead to a future in which agriculture is no longer able to perform its duty as the primary driver of the economy in Kansas.

III. Sustainable - Adaptive Scenario

In contrast to the BAU scenario a sustainable adaptive-scenario is characterized by strong policy reform to guide response to climate and environmental change and move forward along a sustainable pathway (Ruttan 1999). This will involve a paradigm shift such as that described by a Great Transition scenario (Raskin 2008). Harrington *et al.* (2009) notes a "'can-do' attitude that promotes adaptation and resiliency" (p. 288) in Kansas that may be drawn upon to help initiate sustainable adaptation. Policy changes in this scenario focus on sustainable development and the equitable distribution of resources to increase overall quality of life. State level policy reforms lead a transition away from a "feed the globe" mindset to one that prize supporting the local community, building social capital, or "feeding the community." A mindset such as this will lead to a transition away from industrial and corporate methods of production which in turn leads to an effort to reduce energy and technological inputs into the agro-ecosystems of Kansas. Meaningful policy reform in this scenario is facilitated and reinforced by a stakeholder involvement strategy establishing local values, changing management practices, and related policy making.

Stakeholder involvement as an active participant will help overcome several of the existing cognitive barriers to sustainable agriculture (Pretty 2007). Integrating stakeholders such as individual producers, community representatives, business owners, and policy actors together in a deliberative process that leads to the articulation of values and subsequent policy making will allow the concerns and needs at the local scale to be brought to the attention of those helping make policy at the larger state scale. This should help the state level policy development process to better incorporate local characteristics and variability. By integrating local stakeholders into the state policy and resource management process, the stakeholders become enmeshed in the development of systems that guide their onsite activities. As Ostrom *et al.* (1999) have discussed, local control helps build systems that can avoid the tragedy of the commons (Hardin 1968). This should lead to a greater sense of community involvement and satisfaction benefitting the local social capital. Including stakeholders in the policy making process also decreases the influence of lobbyists and other special interest players. Avoiding this significant interference, policy makers will be able to create rules and regulations that are genuinely beneficial to local stakeholders and the environment. Local citizens will benefit from involvement and networking as they begin to experience the process of policy making as a personal experience. These changes will remove cognitive barriers created by a lack of connection to and/or an understanding of the process and the spatial/temporal scale at which various policies operate.

With the concerns and needs of individual producers and communities given greater voice, sustainable adjustments and adaptations will be more easily implemented. Existing subsidy programs and monies are restructured and reallocated into incentive programs that benefit local biodiversity and economic diversity within on-site enterprises (Pretty 2007). Reallocated financial resources can be used to revamp existing subsidy programs with aims to improve the environment such as the Conservation Reserve Program and reduce vulnerability by spreading financial resources across multiple sectors of the economy. Biodiversity incentive programs should seek to increase crop and livestock diversity within the agricultural system and also within species that are natural residents of the local ecosystem but are not related to agricultural production. To encourage crop diversity, programs meant to alleviate the risks and costs of initial sustainability transitions are developed and followed. These adaptive pathway programs provide assistance for establishment and initial production of fruits, vegetables, and grains that are geared towards local consumption. Livestock biodiversity can increase through policy that encourages crop producers to being raising small numbers of livestock to help efficiently use non-crop biomass and cycle nutrients through the system. Those involved in livestock production may move away from intensive feedlots for finishing and instead rely on native grasses for animal weight gains. Without the need for standardization related to intensive feeding operations, ranchers are likely to begin raising multiple varieties/species of livestock.

State level initiatives to restore the native prairie ecosystems especially geared toward the western portion of the state, could lead to an increase in nonagricultural biodiversity by increasing areas of natural habitat. Improvements in environmental quality as a result of sustainability policy reform will increase system resilience as a result of improvements in soil quality. The character of biodiversity may also change as some species migrate away from the state but are replaced by species migrating to the area from even warmer and drier states such as Oklahoma, Texas, and New Mexico. On-site enterprises may contribute to maintaining biodiversity as well when they include activities such as crops for biodiesel production or personal crop plots for the producers' family. Diversity within on-site enterprises reduces a producer's risk to individual hazards when production and income is spread across multiple endeavors. Future policy is likely to be cognizant of this and designed to support a wide array of on-site enterprises.

Policies developed to support a transition from business-as-usual to a sustainable adaptive scenario would largely be funded by restructured and reallocated priorities and related subsidy dollars. Financial resource redistribution would create the ability to develop new subsidies programs along with tax credits, incentive programs, and location based insurance programs that help mitigate moral hazard and systemic risk. Continued education programs for local stakeholders (including producers) and general community members could also be supported by reallocated financial resources. Continued educational opportunities allow communities to remain updated with regard to the monitoring of current activity surrounding recent policy initiatives and aware of new information regarding climate and environmental change. Advances in citizen science and K-12 programs may help alleviate cognitive barriers related to gaps in general knowledge.

Sustainable agricultural adaptions are likely to occur more rapidly in a future where policy reform supports and encourages sustainable development pathways. Crop and livestock management decisions could begin to change; thus altering the character of agricultural systems in Kansas. In the east this may manifest through a transition to polycropping systems which seek to select crops based on their production value as well as their ability to help restore lost ecosystem services. For example species may be chosen that can help sequester greenhouse gases in the soil along with building nitrogen stocks. An emphasis could be placed upon selecting a crop rotation that is naturally well suited to the new emerging new climate regimes and the associated environmental variability. Crop rotations that move from grain production to nutrient restocking will lead to a decrease in dependency upon chemical applications to maintain production.

Western Kansas would see a transition to pasture based livestock systems and recognition of some of the ideas associated with the "Buffalo Commons" as presented by Popper and Popper (1987). Native grasses supported by policy reforms serve as the forage material for livestock and habitat for nonagricultural species. This should also allow a decline in the amount of irrigation needed to raise feed grains that were important with intensive cattle feeding operations. Native grasses are generally more efficient cyclers of nutrients and will contribute to a restoration of soil quality. Some producers may choose to raise bison as a method for increasing biodiversity, a trend that is already being seen (Popper and Popper 1999). Bison production is a "healthy alternative to beef and the desirability of an animal that is well adapted to region environmental conditions also constitute reasons for shifts and hope for a reliable income source," (Harrington 2009 p. 5).

Fossil fuel energy demands and expenditures could decrease through the wide spread adoption of on-site alternative energy production. Restructured subsidies mean that there is financial support for producers to establish necessary infrastructure and make alternative energy production a viable adaptation. Energy produced on-site can be used to power individual systems, with excess energy being sold back into the general power grid. In Kansas wind energy production is has already been shown to provide a financial gain (Harrington 2009). Energy cooperatives formed within and between communities can stabilize local economies and reduce vulnerability to increasing fossil fuels costs or related energy shortages. Living with current solar generated power is likely to contribute to an overall increase in personal well-being. Other on-site enterprises such as composting and biofuel production have the capacity to contribute to a sustainable future in similar ways.

For producers that are located near larger communities and therefore markets, Community Supported Agriculture (CSA) may not only serve as an alternate source of income for producers, it may also make great strides in overcoming cognitive barriers for town residents centered around weak or missing connections to the food production system. Through buying into a CSA, community members create a direct connection between themselves and the processes and environment producing their food. This connection may generate a sense of responsibility and concern for the quality of food production and the environment that supports it. In this way more and more people may beginning having embodied experiences with agriculture and begin to come to a deeper understanding of the great need to protect and restore the natural ecosystems that support families agriculture in Kansas.

A sustainable adaptive scenario is a future in which governmental intervention has led to the creation of policy that encourages sustainable agricultural adaptation to climate change. A stakeholder involvement approach to governance spawns a reorganization of the existing policy structures that are acting as barriers to sustainable agricultural adaptations. A restructuring of the financial resources provided by the citizens through their government can create room to fund diversity incentives, new production and distribution infrastructure for local communities, and locally operated crop insurance programs to help combat the effects of moral hazard and systemic risk. Revised environmental regulations are driven by stakeholder concerns and prioritize conservation, restoration, equitable access to and distribution of natural resources. Overall community wellbeing increases as financial burdens decrease, education and outreach opportunities combat certain cognitive barriers, and environmental quality begins to regenerate. In this future, producers in Kansas are less vulnerable to the soil degradation and losses seen in the business-as-usual scenario and generally more resilient due to increase of biodiversity.

IV. Discussion

Each scenario provides a look into possible agricultural futures in Kansas at different ends of the sustainable development continuum. As such the scenarios present different normative views for the future of Kansas. The two scenarios explore differences related to variation in both climate and agricultural production in eastern and western Kansas. These differences illustrate the importance of understanding local conditions (Wilbanks and Kates 1999). Community based adaptive governance will be necessary for the sustainable adaptive scenario to come to fruition. However, the sustainable adaptive scenario provides a vision and perhaps motivation for Kansans who can begin working within current structures to transition to a pathway of sustainable agricultural production.

Chapter 7 - Farther Along the Pathway: Summary of Study and Avenues for Future Research

"Our greatest glory is not in never falling but rising every time we fall."
- Confucius

Agriculture is vital to the character of Kansas. It is threaded through the social, economic, and environmental systems that operate in Kansas and helps bring each system into interaction with one another. Agriculture is also globally critical for the support of the Earth's population of 7 billion-plus and growing. Continuation of agricultural activity then is of great importance. Globalization, climate change, and environmental change pose threats and create risks to agricultural futures. Sustainable agricultural practices offer producers multiple pathways along which they can continue to produce agricultural goods but also can begin to restore to the environment and reinvigorate their local community. If one thinks of alchemy as the transmutation of something ordinary into something extraordinary or precious; then sustainable agriculture can be thought of as a sort of alchemy. Kates *et al.* (2012) suggest that transformational adaptation may be needed to help the planet move toward sustainability. So in much the same way that early scientists attempted to turn lead into gold with alchemy, the idea of sustainability allows us to break down the existing interacting systems and scales associated with agricultural production and hopefully rearrange the parts into a manner that ideally is beneficial to each interacting component at each scale. Alchemy and sustainability require persistence, hard work, and an abundance of knowledge. While alchemy has yet to create the desired gold, sustainability is genuinely possible if it is committed to as a development pathway by producers, communities, and policy makers alike (Ruttan 1999).

This study addressed barriers to sustainable agricultural adaptation in Kansas. Development of two contrasting future scenarios facilitated consideration of multiple existing barriers and operating systems. Information used to build the scenarios was gathered and analyzed over the course of a broad literature review and qualitative meta- analysis. Both qualitative and quantitative data found in the course of the literature review were used to provide content for the scenarios developed. Through analysis of the literature two key themes were identified as barriers to sustainable agricultural adaptation. Current policy related to energy subsidies, agricultural subsidies such as the CRP and federal crop insurance and outside players like interest groups and lobbyists create obstacles termed policy barriers (Table 7.1). The other hurdles considered in the scenarios were those that are created through insufficient or missing knowledge and an inability to make logical connections, or cognitive barriers (Table 7.1). Quantitative climate projections for the 21st century drawn from climate model ensemble output for 2050 and 2100 provided the change in climate conditions built into the scenarios. Two separate scenarios, Business-As-Usual and Sustainable-Adaptive, were developed with distinct characteristics (Table 7.2).

The Business-As-Usual scenario represents a future that is framed similar to the current situation. Changes built into the scenario stem from the projected changes to climate. The remainder of the narrative describes a future that has pursued developmental pathways driven by current policy and market forces. Little long term environmental guidance for stakeholders and policy makers leads to the continuation of practices and policies that contribute to ongoing environmental degradation. A focus on industrial production methods and the growth of large corporate agri-businesses characterizes agricultural output in Kansas. Western Kansas maintains a vertically integrated system of cattle production and irrigated feed crop production. In eastern Kansas intense monocropping activities persist or increase along with associated rates of chemical inputs application.

Barrier Type	Form of Barrier	Examples in Kansas
Policy	Subsidies Environmental Regulations Special actors/ Interest groups	Energy subsidies Crop Insurance C.R.P. Irrigation Initiative Kansas Livestock Association No Till on the Plains Kansas Farm Bureau
Cognitive	Missing Knowledge Missing Connections	Rate and magnitude of climate and environmental change Agriculture and Environment Policy makers and the policy setting process

Table 7.1 Summary of policy and cognitive barriers identified and discussed throughout the study.

In contrast, the Sustainable-Adaptive scenario represents a Policy Reform scenario in which there is strong guidance through policy towards a developmental pathway that focuses on sustainable agricultural methods. This scenario describes a future in which environmental degradation is slowed or even reversed. A transition to stakeholder involvement based management and decision making in policy facilitates sustainable adaption. Policy and cognitive barriers are addressed through reform to policy including restructuring of subsidy programs to encourage diversity and on-site alternative energy production. Cognitive barriers are addressed through community activities centered on local agriculture such as Community Supported Agriculture and outreach programs that help build connections between communities and the agricultural products they consume. Increased involvement of stakeholders in the political process reduces the influence of lobbyists and creates connections between stakeholders and policy makers that did not previously exist.

	Western Kansas	Eastern Kansas
Business-as-Usual	-ranching & intensive cattle feeding -high rates of irrigation and chemical inputs on feed grain -focus on industrial/corporate production / vertically integrated -designed to "feed the world" -continuation of environmental degradation -loss of biodiversity -soil nutrients and storage capacity - weakening of ecosystem services	-intensive mono-cropping -high rates chemical inputs -nitrogen fertilizers, pesticides, herbicides -focus on industrial/corporate production -designed to "feed the world" -limited on-site biodiversity -continuation of environmental degradation -loss of biodiversity/ soil nutrients - weakening ecosystem services

Sustainable-Adaptive	-pasture based livestock systems -dry-land agriculture production -use of native grasses to restore ESS and biodiversity -organic matter primary source of inputs -emphasis on feeding location -on-site enterprises -CSA to build connection -alternative energy co-ops -investment in local resources -local production/distribution infrastructure -community engagement in policy making -community education programs -riparian irrigation -restructured subsidies programs -replenish -soil nutrients and storage capacity -plant and animal biodiversity - support natural ecosystem services	-poly-culture cropping systems -low chemical input and high organic matter use -dry-land agriculture techniques -native vegetation buffers to increase off-site biodiversity -varied species selection based on suitability to new climate regimes -emphasis on "feeding the location" -on-site enterprises -CSA to build connection -alternative energy co-ops -investment in local resources -local production/distribution infrastructure -community engagement in policy making -community education programs -replenish -soil nutrients and storage capacity -plant and animal biodiversity -support natural ecosystem services

Table 7.2 Summary of themes discussed within the developed scenarios. Differences are highlighted between eastern and western Kansas.

I. Avenues for Future Research

The complex natures of the multiple themes integrated in this study provide ample pathways for future investigation. One potential future study of particular interest is investigation of other barriers created through policy not discussed in this study. The role water availability plays in policy and the agricultural enterprise would add another layer of complexity to scenario development. How does water availability influence agricultural related policy and create barriers to adaptation? What preconceived ideas about and associations with water might be creating cognitive barriers? How will the BAU and Sustainable-Adaptive scenarios change with the addition of water related policy and cognitive barriers? Addressing these questions may be important in the future as the weather extremes and climate variations associated with climate change continue to manifest. At a more local scale, future research could also examine the impacts and acceptance of implemented sustainable adaptations such as CSAs and alternative energy production cooperatives on community economies and social conditions. Information from such a study would only add to a more robust scenario that considers local components as well as state and national scale components. Others may tackle bringing local stakeholders and their needs and visions for the future into the discussion. This way deep underlying values and beliefs can be addressed and built into varying future scenarios. Connections with local actors enable the maintenance of strongly held values with pathways toward a sustainable future.

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