Concerns over the continual reduction of available groundwater in southwest Kansas have been increasing. This concern is compounded by the high dependence on irrigated agriculture and the related agribusiness industry, which is a staple to the regional economy and employs a large labor force. Future climate variation may enhance the sensitivity of the region to limited water availability. Through archival research and interviews, this study examines the impact of both structural forces (such as policy makers and legal bodies) and individual agents (local farmers, ranchers, and other citizens) on the capacity of southwest Kansas to adapt to climate variation. Although structure does have an impact, agency components far exceed structure in overall impact on the adaptive capacity of the region.

Key Words: southwest Kansas, adaptive capacity, climate variation, structure, agency, irrigation

Introduction and Background

Southwest Kansas is a region characterized by significant agriculture, little topographic relief, and considerable seasonal climatic variation throughout four distinct seasons. The semi-arid region has an economy that is strongly tied to crop agriculture and livestock (Hart 2003). These activities rely heavily on the pumping of fossil groundwater reserves from the High Plains Aquifer system, specifically the unconfined Ogallala Aquifer and the confined Dakota Aquifer (Kromm and White 1992). In addition, the area has a history of drought with major events in the 1890s, 1930s, and 1950s (Worster 1979). This extensive withdrawal from the aquifer system, along with the substantial risk for drought, has increased the vulnerability of the region to climate variation.

This study focuses on a nineteen-county region in southwest Kansas (Fig. 1). It seeks to determine the degree to which compo-
nents of structure and agency influence the capacity of the area to adapt to climate variation. In particular, we focus on the ability of the region to react to potential increases in drought. On average, the region receives 15 to 25 inches of precipitation annually. Average temperatures range from 30°F in January to 80°F in July. Humidity fluctuates based on influences from the American Southwest and the Gulf of Mexico, and the resulting contrasts often lead to intense thunderstorms in the spring and summer.

Water resources in southwest Kansas are heavily dependent on the Ogallala Aquifer. Covering portions of eight states (Colorado, Wyoming, South Dakota, Nebraska, Oklahoma, New Mexico, Texas, and Kansas), this groundwater accumulated slowly over tens of thousands of years as fluvial deposits from the then-forming Rocky Mountains (Weeks et al. 1988). The High Plains Aquifer, which includes the Ogallala formation, lies beneath approximately 174,000 square miles, including 33,000 square miles in Kansas (Dennehy 2000). Within Kansas, aquifer thickness varies greatly from place to place but is greatest in southwest Kansas. While large-scale irrigation began in southwest Kansas in the late 1800s with the use of surface water, the implementation of large-capacity pumps allowed for flood and center pivot irrigation drawing on groundwater by the middle of the 20th century. As a result, water used for agricultural irrigation encompasses 90 percent of aquifer withdrawals (Buchanan and Buddemeier 2001).

The demographics of the region have changed significantly in the past 20 to 30 years due to an increased need for low-wage labor. Immigrants from Mexico and southeast Asia have moved into the area to work in meat packing plants and other livestock-related industries. In Ford County (Dodge City), Hispanic populations rose from 16 percent of total population in 1990 to 38 percent in 2000, while in Seward County (Liberal) the percent jumped from 20 to 42 percent, and Finney County (Garden City) experienced an increase from 25 to 43 percent in Hispanic population (Vandenack 2004). This consid-

![Southwest Kansas Study Area](image)

Figure 1: Study area. Source: Kansas Geospatial Community Commons.
erable demographic change is but a single example of the impacts intensive agricultural irrigation and agribusiness development have had on the region.

The Great Plains has been prone to boom and bust cycles since the first agricultural settlers came in the early-to-mid 1800s. In an effort to attract settlers to the region, local booster groups often advertised the area as an agricultural promised land, without disclosing the region’s many climatic risks (Riebsame 1994). This promotion attracted farmers from moisture-abundant areas who had established farming methods, many of which were not appropriate in the semi-arid climate of southwest Kansas (Baltensperger 1979; Riebsame 1994). A major drought occurred in the 1890s, only a few years after the area was widely settled. This resulted in significant population losses for many counties in southwest Kansas (Warrick and Bowden 1981).

High winds and blowing topsoil characterized the “dirty thirties,” a period of major drought in the area. High winds blew the dry topsoil, resulting in a large amount of erosion (Worster 1979). Some counties lost between 30 and 50 percent of their population as a result of the economic depression and drought (Warrick and Bowden 1981). Drought during the 1930s forced many farmers, along with the federal government, to rethink their approach to land management, specifically conservation techniques and agricultural land management. President Franklin D. Roosevelt’s New Deal started a number of programs to promote a change in land management techniques. Soil conservation districts and shelterbelts to reduce wind erosion were introduced, and farmers with sandy soil were encouraged to graze animals on this land instead of growing crops (Worster 1979).

When the 1952-1957 drought struck southwest Kansas, groundwater-based irrigation had become widely available. A massive increase in the use of groundwater had occurred with the widespread use of center pivot irrigation. The first center pivot irrigation system was patented in 1949, allowing farmers to use cheap or even free natural gas to pump underground aquifer water to the surface (Green 1992). The Palmer Drought Severity Index (Fig. 2 next page) reached its lowest point in recorded history in southwest Kansas in September 1956. In southwest Kansas, farmers have a long history of relying on irrigation to provide a steady supply of water for their crops, initially with ditch irrigation systems (Sherow 1990), and later with center pivot systems that became popular in the 1970s. Irrigation reached its peak of water withdrawal in 1978 (Kromm and White 1992).

Despite the prominence of irrigation, the most recent drought in 2001 and 2002 still greatly impaired producers in southwest Kansas. The Garden City Daily Telegram estimated that this minor drought cost the rural High Plains economy over $6 billion (Hanson 2002). The federal government provided hundreds of millions of dollars in aid to farmers, low interest loans, and opened Conservation Reserve Program (CRP) land for grazing use (Garden City Daily Telegram 2002a & b, Hanks 2002). Overall, the drought had a devastating impact on dryland farmers’ total operations. Irrigators were forced to increase pumping, which, due to rising energy prices, increased economic costs.

Technological changes in production agriculture, specifically the invention and widespread use of center pivot irrigation, have resulted in considerable use of the water reserves in the High Plains Aquifer (Green 1992; Kromm and White 1992). This innovation was triumphed as a major adaptive measure. Recently, however, there has been increased concern over the aquifer’s depletion and the related impacts on the future economy of the region (Kromm and White 1992).

With 30 percent of irrigated land in the United States being in the Great Plains (Kromm and White 1990), depletion of the aquifer is significant in Kansas. Seventy percent of all water used in Kansas is withdrawn from the High Plains Aquifer. The estimated economic impact of High Plains Aquifer irrigation in southwest Kansas totals $188
millon per year (Buchanan and Buddemeier 2001). While the amount of available water fluctuates throughout the aquifer due to varying saturated thickness, large areas of the region are predicted to be dry within the next 25 years, while other areas could sustain pumping at current rates for up to 300 years (Kromm and White 1992).

**TERMINOLOGY AND METHODS**

A greater understanding of past and current adaptive capacity in southwest Kansas is needed, and given the importance of local decision making in adjustments to management and operational practices, a focus at the local scale is a highlight of this study. A key component in understanding adaptive capacity is the interaction between structure and agency (Sorrensen et al. 2006).

Structure is defined here as the governing policies and organizations that regulate or influence the manner in which people use natural resources (Benton and Redclift 1994; Sorrensen et al. 2005). Structural organizations, such as the Kansas Water Office and Groundwater Management Districts (GMDs), regulate water use by monitoring the amount of water that is pumped from the aquifer. Other organizations, such as the U.S. Environmental Protection Agency (EPA) and the Kansas Department of Health and the Environment (KDHE), address environmental concerns by monitoring runoff from cattle feedlots and agricultural chemicals applied to crops.

Agency is defined as the local decision makers’ or stakeholders’ involvement in processes influencing adjustment and change (Benton and Redclift, 1994; Sorrensen et al. 2006). Farmers, ranchers and community leaders are important stakeholders in southwest Kansas. Organizations such as the Kansas Livestock Association are also considered to be examples of agency. These associations are comprised of local stakeholders that interact with structure. They are independent of public funding or control, and are a method for stakeholders to unite under a common name and purpose.

Despite the importance of structure and
agency in adaptation to climate variation, the roles of each in the adaptive capacity of the region and the interactions between the two are poorly understood. This study seeks to gain a greater understanding of these roles and interactions in the context of southwest Kansas.

The adaptive capacity of southwest Kansas appears to hinge on several important aspects of potential alteration of methods and practices and adjustment to a changing climate. The modification of farming practices, including improvements in irrigation technology and procedure, as well as crop selection and differentiation, improve the efficiency of water usage and extend the usable life of the aquifer. In addition, the continuing role of agribusiness expansion and diversification can improve the adaptive capacity of the region by providing alternative sources of income for the region.

A complete description of the HERO methodology is provided by Sorrensen et al. elsewhere in this issue (2005). In order to develop an understanding of the problems and adaptive capacity of southwest Kansas, we conducted and recorded 19 interviews. Our conversations about southwest Kansas involved academic professionals in the fields of history, geography, and agricultural engineering, along with geologists, water systems managers, community leaders, housing developers, feedlot operators, extension agents, and county-level government agents. Experts and academics with the University of Kansas in Lawrence, Kansas State University in Manhattan, and state government officials in Topeka were interviewed between June 30 and July 5, 2004. On July 7 and July 8, 2004, we interviewed water resource experts, extension agents, housing developers, and feedlot operators in Garden City, Dodge City, and surrounding communities. Interviews ranged in length from twenty minutes to one and one-half hours. In total, we interviewed academic researchers (4), government and extension agents (7), water systems managers (2), water specialists and geologists (6), feedlot operators (2), and developers and community leaders (2). In some cases, one interviewee was placed into more than one category, and is thus counted twice.

In addition to the interview process, we conducted archival research to gain an understanding of past droughts. Specific adaptation methods – through both structure and agency – were noted. Because the drought of the 1930s has been a subject of numerous studies, our archival research focused on two other specific drought events: the 1950s drought and the minor event of 2001-2002. In addition, particular technological advancements and benefits to farmers existed within these time periods that were not available previously. For example, the 1950s period represented the first drought in which center pivot irrigation methods were a potential factor in adaptation to dry conditions. Much of the information that we obtained came from articles in newspapers from the three largest cities in the study area: The Southwest Daily Times (Liberal, KS), The Garden City Telegram, and The Dodge City Daily Globe.

THE ROLES OF STRUCTURE

Our interviews indicated that the roles of structure in southwest Kansas are not as prevalent or influential on the overall adaptive capacity as the roles of agency. There are numerous structural forces that must be considered, however. The state government enforces regulations in place on water rights, which are essential to the ability of irrigators to provide water to crops. These rights have historically applied to both surface and groundwater, though today the use of groundwater far exceeds the use of surface in southwest Kansas, as surface water is very limited. The conflicts between senior and junior water rights holders must be resolved in some manner to continue irrigation while satisfying the needs of everyone as much as possible. As the terms imply, senior water rights are those that have been held longer than junior water rights. Groundwater Management Districts (GMDs) enforce such regulations developed at the state and local level. GMDs, along with the Kansas Geological Survey (KGS), also study the stability of the aquifer and recommend and enforce
regulations derived from such studies. These studies are also critical in developing efficient water withdrawal procedures and plans in the region.

Various federal programs also have impacts. CRP has provided farmers with incentives to idle portions of their land that are considered susceptible to erosion and degradation. The idling of this land takes marginal land out of production and ends aquifer use in those areas. Additional structures are also important in the adaptive capacity of the region. The extensive and well-maintained road network (consisting of U.S. and Kansas highways and local county roads) provides support for the large trucks needed to ship goods to and from local business. The power network (electrical and natural gas) provides energy to local farmers and local business alike. It also allows for locally produced energy (from mined natural gas to electricity produced by imported coal to naturally-occurring wind) to be transported elsewhere. Federal crop subsidies provide payments to crop producers. A recent, voluntary program operating under the Natural Resource Conservation Service (NRCS) of the United States Department of Agriculture (USDA) is the Conservation Security Program (CSP). Not to be confused with CRP, CSP involves providing financial support to individuals who take land out of use for strictly environmental preservation.

THE ROLES OF AGENCY

The agency-based forces that influence adaptive capacity in the region are substantially more influential, and these are plentiful. The significance of the agency-based forces is enhanced by the existence of a “cattle culture” in the region that enables a sort of agriculture that perhaps would not be feasible elsewhere in the nation. Interviews across the region suggested that residents and officials were not only accustomed to the presence of extensive agriculture, but were indeed proud of and pleased with its presence. Said one local city official, “people who live in Garden City don’t find the feedlots offensive because they recognize that’s the centerpiece of their economy.”

The abundance of options available to local decision makers (ranging from alterations of farm practices to implementations of new technology) suggests that agency plays a primary role in the adaptive capacity in southwest Kansas. A possible reason why this population utilizes agency-based forms of adaptation by and large is the dependence farmers (and the local economy overall) have on the land for their livelihoods. Interviews suggested that local residents seek local solutions for the problems and challenges they face.

Technological advancements, which are implemented by individual farmers, have a considerable impact on the adaptive capacity of the region. Of particular note is the impact of irrigation in southwest Kansas, especially the pumping of groundwater and the implementation of center pivot irrigation systems. Center pivot irrigation systems dramatically changed the landscape and farming practices of southwest Kansas. While structural components (including government subsidies and funded research) facilitated the implementation of center pivot irrigation (and similar technological advancements), the actual implementation was carried out by individual farmers.

The efficiency of this irrigation method has come into question, since the strong summer sun, dry air, and prevalent winds cause very high evaporation rates. The goal of farmers using irrigation is to get the appropriate amount of water to the roots of the plant while using as little water as possible. Thus, instead of spraying water into the air (as was the case with early systems), drop-down nozzles were fitted to center pivot irrigation systems in the late 1980s, allowing for more direct application. Recently, research and development of subsurface drip irrigation (SDI) has provided a new frontier in irrigation technology. SDI involves the installation of underground piping that applies irrigated water directly to the roots of the plant by a method known as low energy precision application (LEPA). Such systems have proven expensive, however, and the investment in all irrigation technology is a considerable strain.
on regional producers. SDI systems have a life expectancy of 10 to 15 years, requiring the system to be replaced regularly at considerable expense.

Fertigation is another method of water application that has made some inroads in the region. This process involves the application of agricultural and city wastewater to crops. The application of a water and nutrient mix (contained in the waste material) to the crops provides beneficial nutrients to the plants and serves as a disposal for wastewater. However, both ground and surface water quality becomes a major concern with this method. Interviews were conducted with individuals who utilize wastewater application. Those who practice this method argue that the storage of effluent in ponds increases its evaporation, and that application to crops does not hamper water quality because most of the nutrients are absorbed and used by the crops. However, environmental regulation agencies have expressed concern over potential runoff and seepage into water supplies. Parts of the water table are at risk for pollutant contamination, especially in the eastern parts of the study area, where the water table is shallow. A handful of interviews of government and local officials indicated that nitrate contamination has become an issue, particularly in the alluvial aquifers of the Arkansas and Cimarron Rivers, which traverse the central and southwest portions of the region. Nitrates from applied crop chemicals have the potential to seep into water supplies.

Producers in some areas have reverted back to dryland agriculture, particularly where aquifer saturated thickness and depth have made pumping either too expensive or impossible. In dryland agriculture, only crops such as wheat and milo that can survive on a limited water supply are grown. However, dryland agriculture has a much lower yield and return on investment. Reverting to dryland agriculture has impacts on the economic stability of the region. Many counties in southwest Kansas were among the poorest counties in the nation before and during the Great Depression. However, the introduction of intense irrigation and agriculture drastically changed the economic state of the county. Today, many southwest Kansas counties are relatively prosperous (Bloomquist 2002). Dryland agriculture isn’t nearly as economically lucrative as irrigated agriculture, and many local residents, farmers, and officials believe that dryland agriculture cannot support the economy and the population of southwest Kansas today. “I don’t know how many farmers it takes to support one grocery store, one car dealer, and whatnot,” said one local producer [but] if there’s only 70 farmers in a dryland county, which is a typical number now, versus 400 or 500 in an irrigated county, you can see what the population differential will do to the county.” One government agent said, “The idea of cutting back water might be ethically desirable but it’s not financially possible because of the debt load and constraints that [farmers are] under.”

An alternative land use process is to fallow land by rotating crops and leaving land unplanted for a year or several years at a time to protect the nutrient base and soil integrity. Thus, twice the amount of land will be required to match the level of production that was existent prior to fallowing the land. Twice the land means twice the property taxes and costs of land ownership. If irrigation continues, it also means overall that there are twice the irrigated acres, and while the fallowed land may not be actively irrigated during the process, the land remains open to irrigation. However, interviewed government officials indicated that a clear goal at the local and state level is to take land entirely out of irrigation. One program geared at this is an irrigation transition program, where “if [producers in a high priority area where new wells cannot be installed] would be willing to go to dryland, [the state] would provide a grant to help them make that transition…and once they transition to dryland as part of that grant agreement, they would agree to dismiss the water right.”

Crop selection and rotation also play a significant role in the adaptive capacity of the region. Producers want to grow a crop
variety that is designed for the area while also raising a crop that is economically rewarding. The ratio between applied water and crop production appears very concrete for many crops. Corn (currently the prevalent crop in the region) will grow in accordance to how much water is applied – the more water, the more corn (up to a point).

Wheat, however, has limited a response to water received. Wheat also responds somewhat to an increased level of irrigated water. However, a surplus of rainfall has no positive impact on wheat like it does on corn, and thus, irrigation becomes less important for wheat. “Wheat is drought-tolerant. It will grow a little bit of grain in the worst conditions so you’ll always have something, but it won’t respond when you get good conditions. If you get a lot of rain, or whatnot, guess what? You get the same amount of wheat.” Excess rain doesn’t necessarily have a negative impact unless the precipitation comes at a time of harvest.

Agribusiness and industry also impact the adaptive capacity of southwest Kansas. Broadening and diversifying the commercial and industrial presence in the region is seen by farmers and local officials as particularly important, any many believe that agribusiness and industry serve to do just that. New forms of financial profit are welcomed in a region where the current economic backbone may be at risk. The rationale behind placing agribusiness and industry in the “agency” category hinges on the roles these entities play. Structure as we interpreted it here is reserved for policymaking entities; despite their considerable influence locally and regionally, agribusinesses remain under the influence of policy and decision makers.

The clearest example of the role industry has played is the beef packing and feedlot industry. Feedlots and beef packing plants came to southwest Kansas largely due to the high cattle population of the region, and also because environmental standards were somewhat lower than other regions. Wages are also lower, and the labor force is not unionized. The local production of feed, as well as relatively mild winters and cool summer nights (that limit cold and heat stress on animals) were attractive to the feedlot industry. As one local official put it, “We have more cows than people. Cows rule.” The beef packing and feedlot industry has served as a staple to the economy of the region. Agribusiness is by far the largest employer in the region.

Regarding the presence of beef packing in southwest Kansas, however, there are two sides to the issue. Beef packing remains as a potential adaptation to future climate changes that limit intense crop production. However, the future impacts of this industry are highly dependent on a variety of factors. First, feedlots utilize both imported feed grains and those grown locally. The Wind River Rail Terminal north of Liberal exists to receive and store grain shipments. Should a (greatly) higher percentage of feed need to be imported due to a reduction of crop production in southwest Kansas, it is unclear whether the feedlot and beef packing industry would remain in the region. Some locals and officials believe a continued beef packing presence is likely. Others believe that such a situation could cause these industries to leave. “If groundwater depletion occurs or drought occurs, many people out there have a feeling that we’d still be able to import feed grains from other parts of the country. It takes a lot of faith to believe that…I wouldn’t look at it as being crazy, but [the feedlots and beefpacking plants] could be in Minnesota tomorrow…in a very short period of time, maybe eight or ten years, you have all these beef packing plants moving into the Great Plains, and some people feel they could they could [leave] just as fast.”

The overall vulnerability of the industry to financial hardship also leads to concern. The presence of a livestock-based disease that could possibly be transferred to humans, such as BSE (Mad Cow Disease), or any other disease that would be crippling to the industry, such as Foot and Mouth Disease, could severely damage the industry. The job loss in southwest Kansas could be devastating, and a massive out-migration of people could result. As one official commented, “If anything happened to that (beef packing)
industry, this town would blow away, I think. It supports everything.”

Other forms of agribusiness diversity have proven viable in the region. Dairy development has increased in the region. In 1990 there were no dairies in western Kansas. By 2000, there were 21 dairies with approximately 60,000 cattle. Like beef packing, the dairy industry serves as a source of income to the region and could supplement losses from a decline in crop production.

High land values in California have prompted dairies to sell land to urban developers. The dairies are able to purchase far cheaper land in southwest Kansas. While water is needed, dairies require nowhere near the amount of water that would be needed for intensive crop farming and irrigation.

A July 2004 meeting of a local dairy association in Garden City included discussion of some concerns over dairy production – not necessarily about the impacts of dairy on the region, but the attractiveness of southwest Kansas to dairy producers. Many explicitly noted that regulations over water (quantity and quality) are stricter in Kansas than they are in some other states, and that dairies were locating elsewhere (Texas was specifically mentioned) where regulations are more lax. Despite these concerns, there are a healthy number of dairies already present in southwest Kansas.

STRUCTURE-AGENCY INTERACTIONS

It is also apparent that the interactions between the various structure and agency forces are critical to understanding the true nature of adaptive capacity in southwest Kansas. Although structure does not have the greatest influence on adaptive capacity, it serves to constrain or enhance the ability of agency to act. The role of structure is to “provide incentives, both positive and negative, that help the local leadership.” Thus, the adaptive capacity of the region is clearly contingent upon stakeholder involvement in the formulation of policy and cooperation between organizations. As one local government official stated, “Nobody likes to have the big stick waved in front of them, and the more you have [adaptation] on a voluntary basis, you get a lot more public participation.”

There are specific examples of this interaction. Kansas State University Cooperative Extension Service specialists in the area serve to educate not just farmers, ranchers, local businesspeople and entrepreneurs, and residents, but also those who formulate public policy at the local, state, and federal levels of government about farming, ranching, and other agricultural practices. The extension service focuses on effective communication and education as key facilitators to adaptation. Thus, the interaction between structure and agency is greatly supported by the local specialists in the extension service.

The participation of agents -- citizens and producers -- in the formulation of public policy is also another interaction between structure and agency. They involve themselves in a plethora of ways – picketing, petitioning, contacting their representatives, voting, and even running for public office. In many cases, structure is important in encouraging and facilitating agency involvement. For example, the local groundwater board solicits stakeholder involvement in the formulation and enforcement of regulations. This interaction enables education of the general populace by requiring structural parties to provide access to stakeholders and the general populace to important summary and locally specific information. Structure and agency interaction also requires local decision makers to show an interest and actively participate in the processes of the structure.

Communicating research results from both academia and private parties to both government officials and stakeholders also serves as a form of interaction and furthers the education process. It can be suggested that research at a land-grant university, especially one with an agricultural experiment station network, would fall under structure (or, perhaps, guided by structure) while privately conducted research would likely fall under agency. At any rate, the research process ties in both structure and
agency through the research process as well as the presentation of information to the general populace and government agencies. The interaction involves not only providing information, but also garnering feedback and input from both structural entities and agents, and sparking interest, discussion, and perhaps even debate and controversy among and between the two.

Such research also enables adaptation through the development of new technology and practices. Demonstration projects for the local producers by the researchers and/or by structural institutions facilitate interaction by bringing innovation to the farmers. Such communication of ideas strengthens the local ability to adapt by facilitating not only a better understanding of the technology and practices, but also the reasoning behind their development.

**CONCLUSION**

The primary concern for a much of the economic production in southwest Kansas is water availability. One academic professional stated, “We no longer believe that it’s a sustainable system…and at this point we are just trying to implement activities to extend and conserve [the water supply].” Parts of our High Plains Aquifer study area have already been forced to make a transition to dryland agriculture. Most irrigators have, in some way or another, reduced their water dependence out of economic necessity. However, since the High Plains Aquifer is a heterogeneous formation, some regions that are dependent on the aquifer will be able to pump at current rates for decades to come. Understanding the issues at the local level is important to policymakers, researchers, and all local residents. One local official stated, “I think lots of people [have] a genuine interest in preserving water supplies because that’s part of their lifestyle and they want to leave something to their heirs, to their children.” Future conditions will tell how accurate this supposition is. While we do not believe that local stakeholders maliciously abuse their water resources, we believe some local stakeholders and some government officials lack the total appreciation of the real possibility of climate variation and the associated negative impacts.

Adaptation appears possible given several different characteristics of the region. Large industry and agribusiness have become potential sources of adaptation through the diversification of the economic base and the provision of employment for citizens and immigrant laborers, though its reliance on declining groundwater supplies makes its long-term stability suspect. Technological improvements to irrigation procedures and enhancements and alterations of farming practices also serve as enhancements of adaptive capacity by maximizing efficiency of the usage of existent water resources and extending the usable life of the aquifer.

People certainly possess the ability to adapt, but the region’s level of adaptive capacity is still unknown. Economic diversification (potentially including alternative energy, less water-intensive agriculture, ecotourism, or other forms of tourism) will need to continue. Future economic success will require education of both local residents and producers by researchers and extension agents about sustaining properly managing the region’s resources, especially water. Groundwater is a finite, nonrenewable resource in most of southwest Kansas, and therefore the local economy needs to plan and adapt to this situation. New conservation techniques for irrigation (including subsurface drip irrigation) must be used widely to reduce aquifer depletion. The region will not be able to sustain widespread large-scale irrigation operations, though localized use of groundwater in areas with abundant supply will no doubt continue. More land will need to convert to dryland farming and pasture. People may need to accept the fact that a shift to dryland agriculture would not support the current production and populations levels in the region.

And of course, simple cooperation between organizations at a structure and agency level has some impact on adaptation. Our inclination is to believe such an interaction would be positive, regardless of its specifics, for communication between parties is vital for
adaptation to even be possible. Communication allows stakeholders to express concerns and hopefully have those concerns addressed, but there are no guarantees. For cooperation and adaptation to occur, each party is going to need to feel as if their concerns are, at the very least, heard.

Future research is needed to formulate a better picture of adaptive capacity in southwest Kansas. A larger individual perspective encompassing a broader span of the study area would be beneficial to future study. Interviews with dairy, hog, and/or cotton producers, for example, would provide further information. In addition, speaking with farmers forced to convert to dryland production and reviewing interviews of water systems managers conducted by the 2003 HERO-REU group, in order to obtain further knowledge on the perspectives of these individuals, is recommended. Since one cannot predict all future events and trends, successors to this study will need to monitor new technologies, future economic trends, the overall stability of the region, and future water availability issues.

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