WHEN WINNING IS LOSING: ARKANSAS RIVER INTERSTATE WATER MANAGEMENT ISSUES

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1. INTRODUCTION

The NSF-funded Human-Environment Regional Observatory (HERO) project is addressing local vulnerability to hydroclimatic variability at four sites across the United States. To-date, the research emphasis has been on naturally-occurring extremes, primarily floods or droughts, as influenced by structure (e.g., government policies) and agency (i.e., individual decision making). The HERO team of researchers at Kansas State University is studying human dimensions of global change in a nineteen county study area in the southwest corner of Kansas. In examining important hydroclimatic iterations that impact local vulnerability in southwestern Kansas, our emphasis has been on multi-year droughts. Significant hydroclimatic perturbations marked the 1950s, as well as the 1930s; these droughts and others during the late 1800s have had a tremendous influence on human adjustment and settlement (Worster, 1979) in an area that has been referred to as 'the heart of the Dust Bowl.'

Residents of semi-arid southwestern Kansas developed surface irrigation in the late 1880s, based on the flows of the Arkansas River, in order to establish a reliable source of water for agricultural crops. With its headwaters high in the Rockies near Leadville, Colorado, the Arkansas becomes an exotic stream, with volume losses to both infiltration and evaporation, as it crosses the High Plains. Throughout the 20th century, water availability was a significant determinant of community viability in southwest Kansas (Bloomquist et al., 2002). The local hardships of the "dirty thirties" provide a sharp contrast to a vibrant economy tied to utilization of groundwater resources. In the period after World War II, relatively low cost energy and the widespread availability of high quality groundwater from the High Plains/Ogallala aquifer led to the development of a vertically integrated agricultural system involving irrigated feed grains, livestock feeding, and meat packing plants (Harrington et al., 2003).

As the accessibility of local groundwater reserves declines, the quality of Arkansas River water flowing into southwestern Kansas is becoming a major concern. The Arkansas is a regulated river with significant diversions for irrigation occurring in eastern Colorado. Irrigation return flows have impaired the quality of water entering western Kansas. Salinity levels have the potential to impact both the alluvial aquifer and High Plains/Ogallala aquifer waters. In this paper, we document the significant changes in the nature of local water resource utilization based on archival research. We then present results from stakeholder interviews designed to obtain local knowledge regarding sensitivity and adaptive capacity to hydroclimatic variability.

2. SURFACE IRRIGATION AND JOHN MARTIN RESERVOIR

Irrigation, first using surface waters and more recently water pumped from the Ogallala/High Plains Aquifer system, has been a way for local agricultural producers to adjust to uncertainty in rainfall delivery to southwestern Kansas (Sherow, 1990; Kromm and White, 1992). Diversion of surface waters from the Arkansas River began in the Garden City, Kansas, area in the late 1800s as local entrepreneurs developed infrastructure to tap river flow (Sherow, 1990). Similar efforts to access the freshwater resources of the Arkansas River system were occurring upstream in Colorado portions of the watershed, as the Rocky Ford, Fort Lyon, and Amity canal systems were developed. A 1907 Supreme Court ruling in the case of Kansas v. Colorado (206 U.S. 46, 114-117; see Olson et al. 2004) established the concept of equity in interstate water resource rulings (Sherow, 1990). As pressures on the water resources available from the Arkansas River increased, so too did pressure to build infrastructure to manage the water supply.

Water conflicts frequently occur in arid and semi-arid regions where water availability is critical to many economic activities. In an attempt to deal with the highly variable local hydroclimatic conditions, the Caddoa Reservoir Project was proposed at a site in Bent County, Colorado, approximately 100 km west of the Kansas state line. The Flood Control Act of 1936 authorized the project for both flood control and irrigation, and provided funding for the 4.2 km long and 47 m high dam. Construction of the concrete and earthfill structure by the Army Corps of Engineers, which was slowed during World War II, was completed in 1948. The lake extends upstream for 19 km and covers 71.2 sq. km.

Based on an established history of interstate disagreement on access to Arkansas River waters, the building of John Martin Dam and Reservoir (originally authorized as Caddoa Reservoir) added a new factor to the discussions. Initial optimism about an end to litigation over "the American Nile" was shortsighted (Sherow, 1990). Almost a decade of negotiations was needed to work out the Arkansas River Compact in 1948. The Compact between Colorado and Kansas, which was developed to regulate regional water use for irrigation, conservation and other beneficial purposes, was approved by both state legislatures in 1949. President Truman signed the federal bill to ratify the Compact on 31 May 1949, after it moved quickly through Congress (63 Stat. 145).

3. THE HIGH PLAINS OGALLALA ALTERNATIVE

Technological developments and growing knowledge of the extensive nature of local groundwater and energy resources were important factors in a regional/local switch to use of "underground rain" (Green, 1973). Windmills and hand-dug wells were available to residents of southwestern Kansas as they tried to establish family farms in the late 1800s. Developments in pump design, availability of fossil fuel-based energy sources, and water delivery systems evolved during the first-half of the 20th Century. With Frank Zybach's invention of the center pivot system (1st patented in 1949) and the availability of low-cost natural gas from the Hugoton Field, southwestern Kansas was transformed during the 1960s and 1970s into an area with a seemingly endless and reliable groundwater supply that could be used for crop production (Green, 1973; Kromm and White, 1992). Irrigation systems based on surface water, which were small in areal extent, became nearly insignificant as the groundwater-based economy expanded.

4. A FINITE RESOURCE, AN INTEGRATED AGRIBUSINESS ECONOMY, AND CHANGING REALITIES

A vertically integrated agribusiness economy developed in southwestern Kansas around a historic cattle culture, the availability of extensive groundwater resources, and local progress in

animal feeding. Brookover Feed Yard in Garden City, Kansas, was the first commercial feedlot and advertises itself as 'the yard that started it all.' An integrated system of irrigated feed grains (primarily corn and sorghum), confined animal feeding operations (growing in both number and in the size of individual feed yards), and establishment of large beef packing plants transformed the economy (Harrington et al., 2003).

Initial ideas about an unlimited and well-connected western mountain-based supply of recharge waters for the Ogallala system were incorrect (Green, 1973). It took several decades, but by the mid-1970s, concerns about depletion of the High Plains/Ogallala aquifer began to take center stage (Kromm and White, 1992). As groundwater geologists and others in the scientific community became increasingly concerned about the future of the groundwater supply, some went so far as to propose a metaphor (a 'Buffalo Commons') for a significant transformation of the entire Great Plains region (Popper and Popper, 1987). By the late 20th Century in some areas of western Kansas (Kettle, 2003), declines in saturated thickness have led to a transformation back to dryland (as opposed to irrigated) agriculture.

In the half century following the construction of John Martin Reservoir, stream flows in the Arkansas in southwestern Kansas declined significantly (Angelo 1994). What was once a highly variable hydrologic system became considerably more predictable, as a lack of flow became the most common condition in southwestern Kansas. Until recent legally mandated changes, the Arkansas River typically had a dry streambed throughout much of southwestern Kansas during most of the second half of the 20th Century. Beginning with a 1980 challenge by the State of Kansas, legal battles between Kansas and Colorado over the volume of flow in the Arkansas River eventually advanced to the Supreme Court (514 U.S. 673; see Olson et al. 2004). In, the Supreme Court ruled that Colorado had violated the 1949 Compact. As a result, surface waters are now once again flowing with greater regularity in the Arkansas River in southwest Kansas. The poor quality of the river waters that are flowing into western Kansas, largely due to salt accumulations as water is repeatedly diverted for agriculture and then returned to the Arkansas river system, are likely to produce new vulnerabilities for some residents of southwest Kansas.

5. HYDROCLIMATIC VULNERABILITY

Since Euroamerican settlement in southwestern Kansas well over a century ago, recurring droughts have exposed the residents to a major form of hydroclimatic vulnerability. 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 socio-economic impact. As a part of the HERO project, undergraduate students in the Research Experience for Undergraduates (REU) program worked under faculty guidance to identify and interview community water supply managers in 2003, and important stakeholders—largely scientists and resource managers—in 2004. The overarching theme for these interviews was hydroclimatic variability and how it impacts southwestern Kansas. In each year, over a dozen interviews were conducted. Synthesis of local sensitivities and adaptive capacity based on these discussions stresses the overarching importance of water availability (the quantity of water) to southwest Kansas residents.

The 2004 interviews brought out a number of adaptive activities on the part of water resource users in southwestern Kansas. Activities that were mentioned frequently by respondents included changes of crops based on water availability, shifts to dryland farming, diversification of activities, enrollment in federal agricultural programs (e.g., CRP, EQIP), and irrigation technology improvements. Most adaptive and mitigative programs and activities mentioned related more to water availability, particularly groundwater. However, a few respondents did bring up water quality issues, a topic that most likely would not have been mentioned in the early 1990s. Quality concerns appeared to be split between surface and groundwater resources,

but most of these respondents were in positions to have good recognition of the linkage between stream quality and alluvial aquifers.

Although the focal concern regarding water resources in southwestern Kansas historically has been water availability, there have been signs of increasing concern with water quality over the last decade (Table 1). During 2003-4 HERO interviews with key informants, declining water quality in the Arkansas River alluvial aquifer generally did not appear "on the radar screen" of major issues for the region. Only in interviews with knowledgeable hydrogeologists at the Kansas Geological Survey did ongoing change in the salinity of the alluvial aquifer become a topic of discussion. Environmental analysts with the Kansas Geological Survey and with state agencies like the Department of Health and Environment (KDHE) and the Kansas Water Office (KWO) are continuing to gather data regarding both surface water and groundwater conditions across the state. They are perhaps painfully aware of water resource concerns, in terms of both quantity and quality, and a number are involved in facilitating communication of conditions and potential responses to farmers, feedlot operators, and ranchers, as well as county and municipal governments. Unfortunately, state agencies often lack credibility with local landowners (Harrington 2001).

TABLE 1
DRIVERS OF WATER MANAGEMENT AND ENVIRONMENTAL ADJUSTMENTS IN SOUTHWESTERN KANSAS

Condition/Driver	Time frame	Responses
Semi-arid climate and Unreliable precipitation	Ongoing; Beginning 1880s	Search for dependable water supplies; Irrigation (using surface water)
Major droughts	Repeated; e.g., 1930s, 1950s	Outmigration; Establish more reliable water supplies: reservoir construction
Technological change	Ongoing; 1950s-1970s; 1970s-present	Improved ability to adjust Growing groundwater utilization Increasing irrigation efficiency
Reservoir management (Colorado): Loss of surface flows in western Kansas	1940s-1990s	Shift to use of almost entirely groundwater based irrigation; Changing nature of agriculture-based economy (e.g., crop changes)
Growing knowledge of finite nature of Ogallala aquifer	1970s – present	Increasing diversification into comparatively low water use agricultural activities
1995 court ruling: Poor quality (high salinity) stream return flows in Colorado reduce Kansas water quality	1995-present	Initial concerns expressed by scientific community about a water quality issue

6. NEW VULNERABILITIES

Throughout much of Euro-American settlement and utilization of southwest Kansas, the primary water-related concern was finding additional resource capacity. Fortunately for the residents of the "land of the underground rain" (Green, 1973), the waters of the High-Plains/Ogallala aquifer system are of excellent quality. However, as the supply of 'fossil water' becomes less available, either through utilization or increasing cost for pumping the water to the surface, a new form of hydroclimatic vulnerability will need to be addressed by the residents of southwest Kansas (see Harrington 2005).

Although larger volumes of water originating in Colorado are now flowing into western Kansas based on the legal negotiations in the 1990s, the quality of that water is a concern. Recent EPA records (305b, under the Clean Water Act) and data collected by the Kansas Geological Survey indicate that Arkansas River waters flowing into western Kansas are impaired, exhibiting a high dissolved salt content (see, e.g., Whittemore, 2000). Because of connections between surface water and alluvial groundwater, groundwater resources are becoming degraded. Further legal negotiations between the two states will likely be necessary to address the changing interstate resource issues and the related implications for sustainable resource use.

Southwestern Kansas residents have demonstrated their ability to adapt to environmental conditions, and display a belief in themselves regarding their resiliency. While a 'Buffalo Commons' may be one future scenario, the form, or forms, of adjustment could follow a variety of paths, related to water use, water quality management, and/or population and land use shifts. Adaptation in the form of land abandonment, as happened during the Dustbowl, is one possibility. Not everyone abandoned the land even in the 1930s, however, and continuing adjustments in water management, crop choice, and diversification of activities are evident at the current time. Successful adaptation to changing natural resource conditions like hydroclimatic variability, groundwater declines, and surface water salinization will require consideration of a variety of actions. Mitigation of some problems, including surface water flows and water quality, will require careful negotiations toward wise management of interstate resources.

The interstate water agreement between Colorado and Kansas was meant to alleviate some of the water needs in southwestern Kansas. In this instance, as in so many others, human action intended to fix an environmental problem led to a generally unanticipated negative attendant condition. Continued attention to improving natural resource conditions will need to take into consideration potential side-effects. Cross-boundary water issues will continue to be important both within countries like the United States, and between countries, as may be found in the Middle East. The conditions found here have implications for negotiations between a variety of political entities, which will need to have awareness of both current problems and the variety of potential effects of actions taken to address known problems.

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