CENTER FOR WATER POLICY
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Climate Change Impacts on Agriculture in the Rio Grande River Basin

KEY MESSAGE: Agriculture consumes more than 85 percent of the surface water and groundwater withdrawals in the Rio Grande Basin. Droughts are already a serious threat to agriculture in the region, and climate change combined with population growth will stress irrigation supply even further. Higher temperatures due to climate change are expected to increase evapotranspiration rates, while concurrent new patterns of lower precipitation are projected to reduce surface flows and aquifer recharge rates. The exploitation of groundwater resources is also expected to increase, which suggests a basin-wide approach encompassing both surface water and groundwater governance may be preferable to today's fragmented and overlapping methods. The current governance regime, which parses surface water regulation at the sub-basin level, is not equipped to sustainably regulate groundwater withdrawals.

The Rio Grande is an essential freshwater source for over 13 million people living in northern Mexico and the southwestern U.S. (USCB 2013, CONAPO 2013). At 1,896 mi (3,051 km) long, the Rio Grande is the fifth longest river in North America and the twentieth longest river in the world. Starting at the headwaters in the San Juan Mountains of southern Colorado, the Rio Grande flows southward through New Mexico, Texas, and Mexico, where it empties into the Gulf of Mexico (Figure 1). Traditionally, the Rio Grande is divided into the Upper Rio Grande, which runs through Colorado and New Mexico, and the Lower Rio Grande, which runs through parts of Texas and the Mexican states of Chihuahua, Durango, Coahuila, Nuevo Leon, and Tamasulipas. The Rio Grande flows 1,255 mi (2,019 km) along the U.S.-Mexico border, splitting the river's 182,000 mi^2 (471,000 km^2) drainage basin nearly equally between the two countries (IBWC 2014).

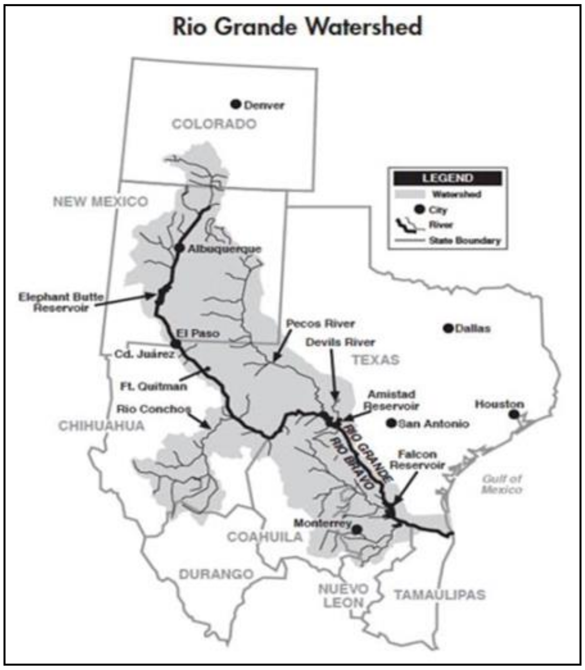

Figure 1. The Rio Grande Basin. Source: TCEQ 2010.

Agriculture in the Rio Grande River Basin

Irrigation, for cotton, alfalfa, sugar cane, pecans, and pasture, is by far the largest water use in the basin. In the Upper Rio Grande Basin alone, from its headwaters in Colorado to Fort Quitman in Texas, over 300,000 acres (120,000 hectares) are irrigated, including 25,000 acres (10,000 hectares) on the Mexican side of this section of the basin (SECURE Water Act 2011). Agriculture, including livestock production, accounts for over 85 percent of the surface water withdrawals in the basin (TWRI 2012). Irrigation supports a $1 billion agricultural sector in the transboundary region of the system alone (TWRI 2012). In the Rio Grande Basin, production is critically dependent on surface water irrigation from the river and its tributaries, especially in times of drought. Texas is the third largest agricultural state by annual production value in the U.S. after California and Iowa**.** An extended drought in 2006 caused an estimated $50 million in production losses for dryland, or non-irrigated, farms in Texas' lower Rio Grande Valley (Santa Ana 2013). In 2009, drought losses amounted to $19 million, and drought conditions in 2013 led to an estimated $100 million loss for all crops and an average 50 percent loss of planted acreage. The increased dollar loss in 2013 compared to 2006 was primarily due to higher commodity prices, not increased acreage (Santa Ana 2013). According to Dr. Luis Ribera, an agricultural economist at Texas A&M AgriLife Extension,"Of the $19 million in losses [in 2009], irrigated crops only accounted for less than $1.4 million of that. This just reemphasizes our dependency on Rio Grande irrigation water" (Santa Ana 2013).

The importance of the Rio Grande for irrigation is not confined to the lower portion of the basin; farmers at the river's headwaters in lower Colorado withdraw a substantial portion of its flow before it completes its brief journey into New Mexico. In 2014, for example, at the start of the irrigation season in late April, flows were reduced from 1,330 ft^3 (38 m^3) per second to just 209 ft^3 (5.9 m^3) per second by the time the Rio Grande reached the New Mexico state line, a reduction of 84 percent (Logan 2014).

The Rio Grande is also an important international source of irrigation water. The Mexican state of Chihuahua, located mostly in the Rio Grande Basin, is a major dairy center, producing over 200 million gallons (760 megaliters) of milk in 2002 (Garcia *et al.* 2004). Dairy production in the region is water intensive; each cow requires an estimated 713 gallons (2700 megaliters) per day, including the water needed to grow the alfalfa and water for cooling the herds (Garcia *et al.* 2004).

Alfalfa requires 86 percent more irrigation water than more water-use efficient crops, such as sorghum. Irrigation methods in the watershed are far from efficient, with water applications based on schedules rather than crop needs, accompanied by high evapotranspiration (ET) and percolation losses (Garcia *et al.* 2004). Pecans are another water-intensive crop grown in Chihuahua; 96 percent of production is irrigated, with an estimated 69-75 percent from groundwater sources. On an annual basis, over 300,000 acre-feet (0.37 km^3) of water is utilized to irrigate pecans in Chihuahua, accounting for 9-15 percent of the production costs for this profitable commodity (Garcia *et al.* 2004). The cost for water is due primarily to the electricity used for pumping.

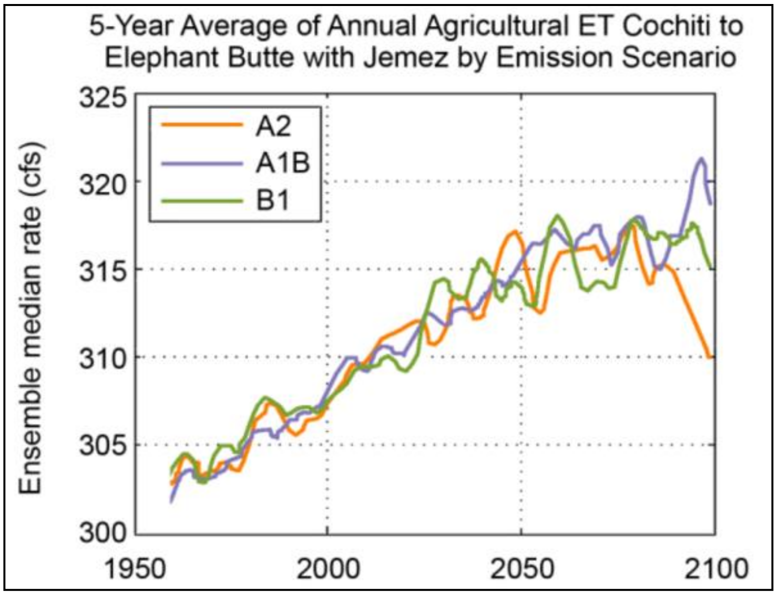

Figure 2. Agricultural ET demands under three emissions scenarios for the upper portion of the Rio Grand basin. Source: Llewellyn & Vaddey 2013.

Climate Change Impacts

A 2011 climate change study by the U.S. Bureau of Reclamation quantifies temperature and precipitation projections for the western U.S., including the Rio Grande Basin. Utilizing data from spatially downscaled CMIP 3 averages of 112 climate simulations, the study projects increased temperatures of 5–6° F (2.8-3.3° C) during the 21st century in the Upper Rio Grande Basin, compared to average temperatures from the period 1950-1979 (SECURE Water Act 2011). Precipitation is projected to remain at historic levels or decrease slightly, up to 2.5 percent in the New Mexico and Colorado portions of the basin (SECURE Water Act 2011). Overall, the study predicts that changes in precipitation due to climate change will be minor compared to current inter-annual variability.

Higher temperatures combined with stable or reduced precipitation may lead to increased ET for agriculture in the region, resulting in increased irrigation needs in an already water stressed system (Figure 2). Additionally, higher winter temperatures may reduce the amount of snowpack, as more precipitation falls as rain rather than snow, while higher spring temperatures can reduce runoff by increasing the amount lost to evaporation. Since the system is largely snow-fed, the effects of climate change on flows may be significant. In 2014, the Natural Resources Conservation Service estimates that spring runoff in central New Mexico will be just 31 percent of historical average levels, due largely to evaporative losses as the state enters its fourth consecutive “very dry” year (Fleck 2014). One study also estimates that climate change could reduce Rio Grande flows by 4–14 percent by 2030 and 8-28 percent by 2080 (Hurd & Coonrod 2008).

By 2030, agricultural losses in New Mexico due to water shortages could range from \$7-34 million, and by 2080, agricultural losses may be in the range of \$13-83 million, which represent losses of 2-9 percent and 4-22 percent, respectively (Hurd & Coonrod 2008, Figure 3). In Texas, the state water plan forecasts the annual irrigation deficit in the Rio Grande Basin to be 260,000 acre-feet (0.32 km^3) of water by 2060, causing \$48 million in losses and the loss of 655 jobs (Satija 2014). Another estimate places economic losses at \$134 million annually, with job losses of 4,130 (RGRWPG 2011).

In the Lower Rio Grande Region M, which comprises eight border counties in Texas, up to \$250 million of agri-

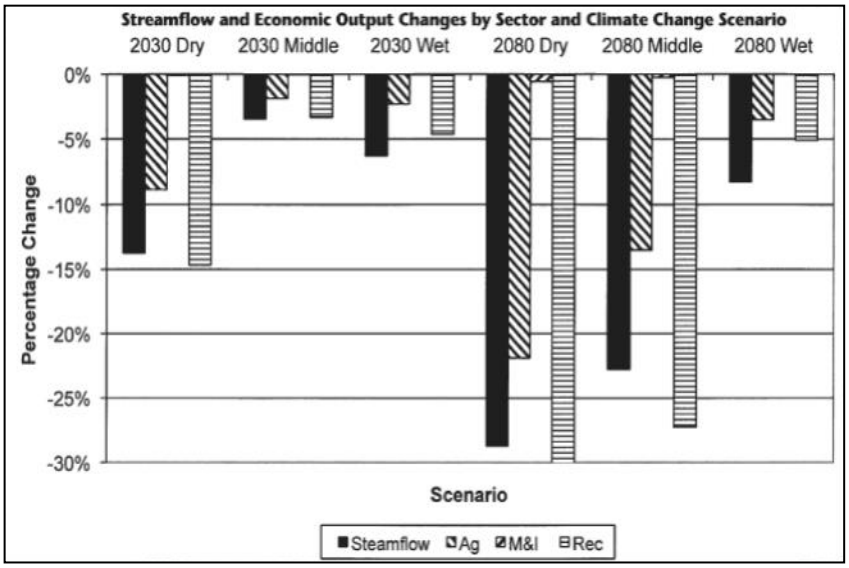

Figure 3. Streamflow and economic output changes for agricultural, municipal & industrial, and recreational sectors in New Mexico under three climate change scenarios. Source: Hurd & Coonrod 2008.

culture is at risk from inadequate supplies of irrigation water, and costs include losses of $135 million and 4,130 jobs annually (USBR 2013). By 2060, an additional 86,000 acre-feet (0.11 km^3) will be needed for all uses due to climate change, on top of the additional 592,000 acre-feet (0.73 km^3) due to population growth in the region (USBR 2013).

Increased runoff during the winter may lead to greater threats of flooding, while also reducing the availability of irrigation water from the Rio Grande during the spring and summer irrigation season (Paskus 2013). While reservoir storage can mitigate some of the effects of variable flow regimes on agriculture, the reservoirs themselves are vulnerable to increased evaporation with higher temperatures, although lower reservoir levels may counteract this effect somewhat because less surface area is typically exposed to evaporation (Llewellyn & Vaddey 2013).

Furthermore, higher temperatures may increase the length of growing seasons up to two weeks longer by the end of the 21st century compared with averages for the late 20th century (Gutowski *et al.* 2008). Longer growing seasons increase demand for agricultural irrigation water, and water availability is expected to be the limiting factor in agricultural productivity under climate change. Overall, climate change is predicted to increase temperature and decrease precipitation, resulting in a loss of productivity for the agriculture sector in the Rio Grande Basin.

Policy Implications

Policies regarding irrigation for agriculture will need to be updated and addressed based on the predicted effects of climate change. Improved irrigation efficiency could address much of the agricultural water shortage in the region. A 2013 study of the Rio Grande Basin in New Mexico found average on-farm water-use efficiency for alfalfa, pecan, and cotton crops to be 64 percent, with a range of 10-95 percent, yet conveyance losses reduced average efficiency to just 35 percent (Ahadi *et al*. 2013). This implies substantial room for improvement. However, producers, especially in Mexico, may need financial and technical assistance to adopt such measures as laser field leveling and more precise control of water applications to meet plant needs without water waste (Garcia *et al*. 2004). In the U.S., the USDA's Conservation Reserve Enhancement Program (CREP) for the Colorado portion of the Rio Grande Basin illustrates the level of improvement considered achievable. The CREP specifies a goal of 12 percent lower water use for irrigation over 40,000 acres (16,000 hectares), for a total savings of 60,000 acre-feet (0.07 km^3) per year (FSA 2013). It remains to be seen whether this modest goal will be achieved, but it is clearly insufficient to have a significant effect on the overall low rates of irrigation efficiency in the basin.

In addition, conveyance losses are often an important source of basin recharge contributing to basin stability. For example, the Mesilla Bolson aquifer in New Mexico might become depleted if conveyance losses were reduced or eliminated (Ahadi *et al.* 2013). Given the complex nature of water allocations and deliveries specified in both the U.S.-Mexico Water Treaty of 1944 and the Rio Grande Interstate Compact among Colorado, New Mexico, and Texas, localized effects may be more important than overall systemic efficiencies for some parts of the basin. Perhaps since Region M is the most downstream region, and thus insulated from most allocation requirements, the 2010 Region M plan proposes aggressive irrigation efficiency measures to address future needs resulting from population growth. Together, increased on-farm and conveyance efficiencies are projected to cover over half of the shortfall (USBR 2013). Addressing conveyance losses also reduces losses in the many municipal systems, such as El Paso's, which rely on agricultural conveyance infrastructure.

The next largest means of closing the gap due to population growth and climate change is the purchase of existing water rights, which typically indicates a transfer from agricultural to municipal users. Many farmers are selling their water rights to municipalities, in large part to avoid the significant risks of irrigation-dependent agriculture in the Rio Grande Basin (Satija 2014). From 1996 to 2008, individuals, primarily farmers, and irrigation districts in Texas' Falcon-Amistad Water Market in the Lower Rio Grande sold rights to 42,301 acre-feet (0.052 km^3) of water, while municipalities purchased 37,560 of those acre-feet (0.046 km^3) and government agencies purchased most of the remainder (Leidner *et al.* 2011). On average, the price of water rights in that market tripled between 1996 and 2005, while the general consumer price index rose just 37 percent, reflecting the higher values placed on water for municipal uses (Leidner *et al.* 2011).

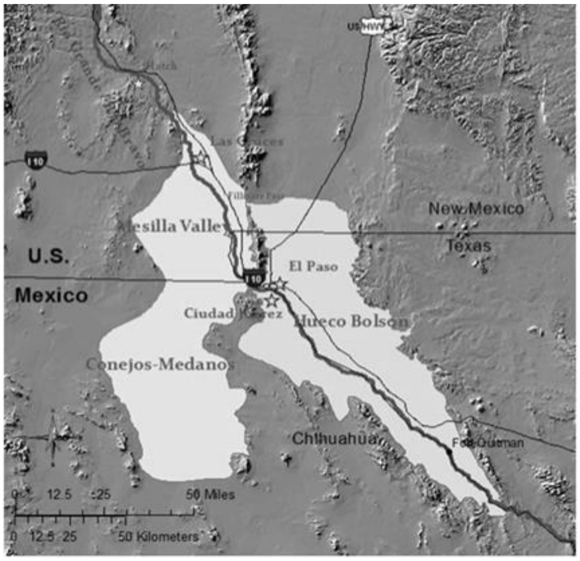

Figure 4. Significant transboundary aquifers in the Rio Grande Basin, spanning more than 150 miles of the international border. Source: Alley 2013.

On the U.S. side of the border, farmers have also responded to reduced water availability by switching from cotton to more profitable sugarcane, a commodity heavily subsidized in the U.S. through import controls under the mechanism of tariff rate quotas (Garcia *et al*. 2004). In addition, water availability and projected water availability for the annual growing season have a large effect on the amount of acreage planted, which varies greatly from year to year (Santa Ana 2013).

Sales of water rights, switching to alternative crops, and reducing planted acreage are seemingly successful adaptations to existing water stress. However, many of the market-based means employed to address current water scarcity will no longer suffice under the increased water stress wrought by climate change. The sale of water rights to municipalities, for example, may simply reflect their greater ability to pay for access to water today, and does not guarantee cities a supply under the restricted flow regimes under climate change. While agricultural uses can be adapted and curtailed relatively easily, adequate supplies of drinking water are critical to human survival. Similarly, the switch to higher value crops such as sugarcane reflects a purely economic value assessment distorted by federal subsidies. Allocation policies reflecting the carrying capacity of the Rio Grande system in physical terms, rather than purely economic terms, will be needed as climate change reduces capacity. Reductions in agricultural production in the basin may be in the best long-term interests of the region, but they must be in response to long term sustainable policy rather than relatively short term economic considerations like spot commodity prices.

Rio Grande governance regimes also do not address groundwater resources in an effective way, even though groundwater aquifers are important water sources, especially for many municipalities and growers (Figure 4). The significance of groundwater to the overall hydrology of the Rio Grande system was formally recognized by the International Boundary and Water Commission (IBWC) as far back as 1973, but as of 2008, no groundwater allocation mechanism had been developed (Umoff 2008). In 2006, the U.S. passed an aquifer assessment act for the Rio Grande Basin (U.S.-Mexico Transboundary Aquifer Assessment Act 2006), which may eventually result in the incorporation of groundwater components in the treaty's governance provisions (Umoff 2008). However, of $50 million authorized over its 10-year life, projects associated with the act received just $500,000 in funding in fiscal years 2008 and 2009, $1 million in 2010, and nothing in 2011 or 2012 (Alley 2013). While some progress has been made, further progress is dependent on funding in future years (Alley 2013).

The states recognize the importance of groundwater. Texas, for example, is currently suing New Mexico, as it did in 1974, over groundwater withdrawals from more than 3,000 wells, contending that the withdrawals deplete Texas' share of the basin's water (Paskus 2013). The current and historical disagreements over groundwater, along with the professed interest at the IBWC in addressing the groundwater gap, suggest that this area is ripe for policy formulation in the dominant governance regimes in the basin. Policies should be developed with a focus on integrating groundwater aquifers into basin governance. Integration of groundwater supplies will become especially important when Texas implements plans to meet future shortages in part through brackish groundwater desalination.

Finally, the existence of two significant agreements, the Treaty and the Compact, and many smaller governance agreements in the Rio Grande Basin and portions thereof, along with the institutional complexities of daily water allocations, point out a fundamental weakness of the current governance regime. Since the current governance regime is not watershed-based, it cannot holistically address the basin's long-term water issues. This is especially true for agriculture, by far the largest water-using sector in the region, and one coming under increasing pressure from growing municipal demands. As the value of watershed-based governance is becoming more widely recognized, perhaps it is time for the region to consider a game-changing interstate and international agreement, similar to the Great Lakes Compact. That the issues of water scarcity under climate change are perhaps more significant in the Rio Grande region than in the Great Lakes only highlights the urgency of a new approach.

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