The Future of Water in the Middle Rio Grande Basin

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The Middle Rio Grande (MRG), defined here as the portion of the basin from Elephant Butte Reservoir (EB) in New Mexico to the confluence with the Rio Conchos in Far West Texas and Northern Chihuahua (Fig. 1), faces profound water supply and demand challenges stemming from a changing climate, agricultural intensification, growing urban populations, and a segmented governance system in a transboundary setting. A core question for this basin is: how can water be managed so that competing agricultural, urban, and environmental sectors can all realize a sustainable future? A consortium of universities led by UTEP recently completed a 6-yr research project to address this question. We summarize results here from our interdisciplinary research, conducted in a stakeholder participatory mode, aimed at defining "water futures", considering possible, probable, and preferable outcomes from known drivers of change. Our conclusions are drawn from a combination of experimental field research plus developing and evaluating scenarios of the future, using a suite of scientifically rigorous computer models.

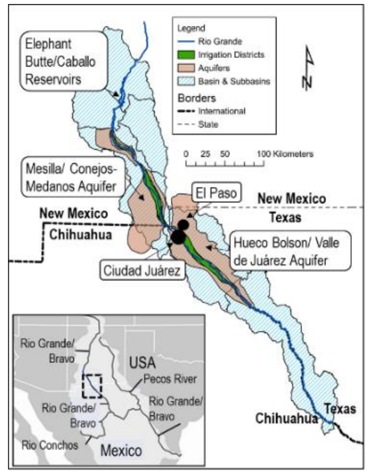

Fig. 1. Location of MRG, freshwater aquifers, Ciudad Juarez and El Paso, and irrigation districts

Our results show that there is a high probability of declining surface water inflows due to climate change in the Rio Grande headwaters. Flow into EB are shown in Fig. 2 for three climate scenarios: wet, moderately dry, and very dry. Results show that there is increased risk of prolonged surface water shortages, since EB Reservoir will frequently be below 50% full under current water release protocols and will meet irrigation demands only 20% of the time under a likely drier climate scenario. Nevertheless, relatively low volumes of water could provide environmental pulse flows in some years and would result in relatively small reductions in the total economic value of water in the region while meeting important environmental goals.

Increased groundwater extraction is now, and will continue to be, the likely response to decreasing water supply. Our results for the future of groundwater under three climate scenarios are shown in Fig. 3. There is very little aquifer recharge under any scenario; much more water is pumped (about 230 MCM/yr, primarily by cities) than is replaced (about 40 MCM/yr, from a combination of natural and agricultural recharge). Flood irrigation using surface water provides some recharge to groundwater, but flood irrigation using groundwater provides only return flow, not true recharge. The result is that total fresh groundwater depletion is likely to occur well before the end of the century (in about 40-50 years) without changes in management, technologies, and/or policies (Fig. 4). This result would be catastrophic to the economic health of the region.

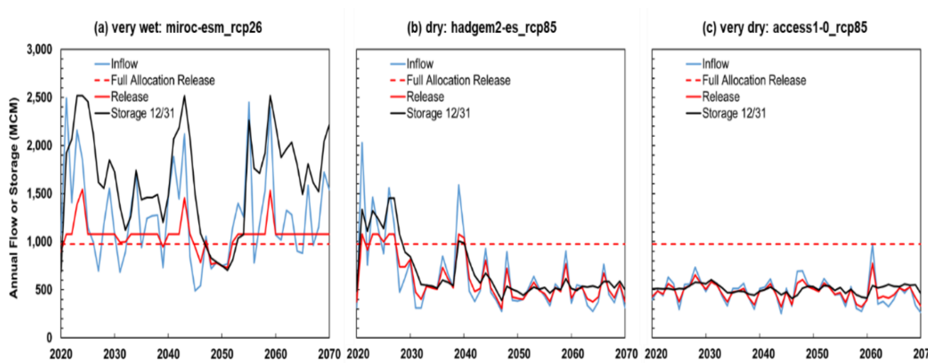

Fig. 2. Projected annual EB inflow at San Marcial (blue line), surface water in storage (dark gray), and EB releases (solid red), under three different climate projections.

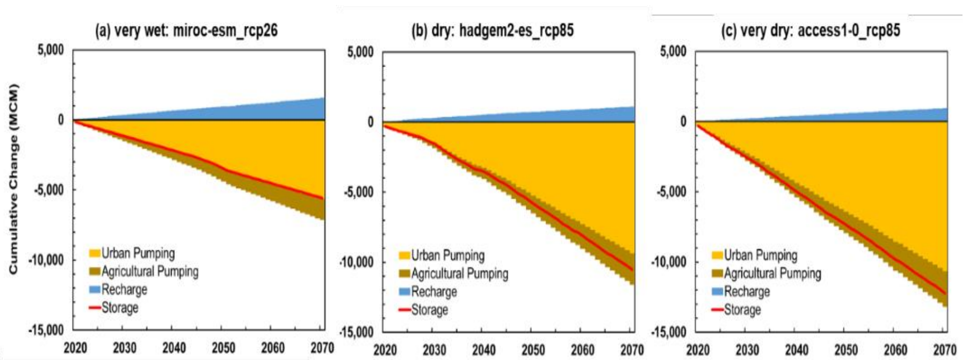

Fig. 3. Projected impacts of three climate scenarios on cumulative urban pumping, pumping for agriculture, recharge + return flows, and groundwater storage in the Hueco Bolson (see Fig. 1), 2020-2070. Pumping shown as negative values and recharge as positive values.

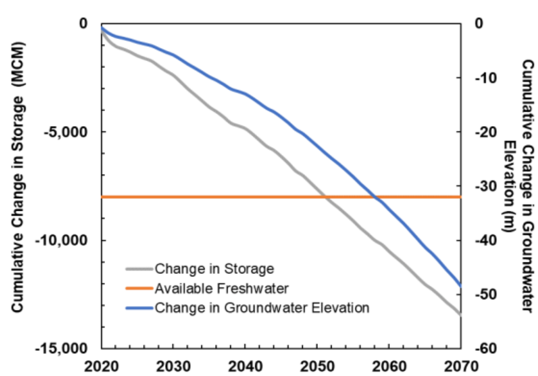

Fig. 4. The future under "business as usual:" Projected change in aquifer storage and groundwater elevation,

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Extreme interventions will be needed to sustain agricultural intensification under continuing climate change. Examples of feasible technologies that hold promise include desalination of brackish groundwater for irrigation, developing water markets to increase flexibility in water use, and transitioning to high-value crops that are relatively drought- and salt-tolerant. These measures need to be combined with improvements in agricultural irrigation methods, such as drip irrigation, and improved management, such as ET-based irrigation scheduling. In addition, policies to limit water use are needed, since farmers tend to use saved water to expand production. In urban settings, most of the water used indoors is recycled through the wastewater system; thus, the greatest savings at a household level is through outdoor water conservation. Promising outdoor conservation measures include xeriscaping, improved landscape irrigation, and reduced reliance on water cooler-based air conditioning.

Stakeholders throughout the basin agree that interventions to prevent the depletion of fresh groundwater are called for, but they do not agree on which interventions are preferable. Agreeing on solutions is further complicated by fragmentation of water governance, water rights, and responsibilities in the basin (across nations, states, and other jurisdictions; urban/agricultural conflicts; and surface vs. subsurface management). Much joint work is needed to build knowledge, rapport, and trust for future shared decisions. Policy, management, and/or conservation changes could extend the useable life of aquifers, but not indefinitely, and will come at a high cost. There is much more brackish groundwater compared to fresh groundwater, but it is not useable as is and is expensive to treat.

Our results show that greater systemic efforts at conservation, use of brackish water (via desalination), increased reuse through water treatment, artificial aquifer recharge, and possibly water importation will all be necessary to meet growing demands of urban centers in the MRG. The net result is not that the region will "run out" of water, but that water will be much more costly in the future. Within the next 3-4 decades, the relatively cheap water that has supplied the MRG historically will be consumed. A significant social justice question, needing serious research and policy debate, is "how will water demands be prioritized as supplies dwindle, and who will bear the cost of developing and using new water sources to meet the needs?"

In summary, "business as usual" in the MRG is not sustainable. Climate is becoming warmer and drier, and this trend is expected to continue. The situation will become perilous as it continues, and if change accelerates, can even become catastrophic. The probable outcomes for the future include: 1) a warmer, drier climate in the Rio Grande headwaters that will result in less reliable surface water supplies and increasing reliance on groundwater by agriculture, exacerbated further by agricultural intensification and the shift to high demand perennial crops; 2) growing urban populations that will increase overall demand, forcing cities to use more expensive sources of water; 3) increasing inadequacy of the current governance structure that does not allow flexibility in water allocations; more flexibility could result in more efficiency as supplies become less reliable; and 4) growing tension across political jurisdictions since governance of groundwater is fractured between three states in two countries, though stakeholders are interested in seeing voluntary binational cooperation on groundwater management going forward.

We evaluated possible interventions (technologically possible, but not necessarily economically viable) that could address these challenges. For agriculture, possible interventions center around: 1) alternative sources of water, especially desalination of brackish water; 2) alternative methods of irrigation, especially drip irrigation; 3) improved water management, especially ET-based irrigation management; 4) improved salinity management, especially gypsum application or use of sulfur burner technologies; and 5) alternative crops, none of which are as profitable as pecans, so their adoption would have to be subsidized. We evaluated possible interventions that rely on alternative water sources for urban water use as well. These include: 1) more desalination, 2) direct potable re-use, and 3) imported water. All of these would make water much more expensive for urban consumers, many of whom in our region are low-income. Conservation, especially related to outdoor water use, also could be efficacious to a degree, at much less cost. The question of which of these is preferable in terms of efficacy, cost, and social justice is a question to be answered by stakeholders, informed by policy-oriented scientific research, and would require much more public engagement and civic discourse than is now practiced typically. However, water management across all sectors and jurisdictions must be improved to realize a more sustainable future.

The challenges to achieving a more sustainable water future are many but among the greatest threats is aquifer depletion since groundwater is the most important source for urban uses and a growing source for agricultural uses. Because the aquifers are shared between the US and MX, the problem of depletion is also shared; thus, the responsibility for solutions also must be shared. Adaptive cooperation could provide a useful framework for meeting this challenge. Adaptive cooperation is needed across four important themes (plus additional research and outreach in support of these themes): 1) information sharing, especially regarding groundwater pumping, trends in total water demand, use of alternative sources, and conservation measures; 2) conservation, especially regarding outdoor water use in urban settings and improved irrigation management in agricultural settings; 3) greater development and use of alternative water sources, especially desalination, wastewater reuse, and imported water; and 4) new limits to water allocation and withdrawals coupled with more flexibility in transferring water among uses. A major policy question is how will the cost of these actions be borne?

For more detail, see: W.L. Hargrove et al. 2023. The future of water in a desert river basin facing climate change and competing demands: A holistic approach to water sustainability in arid and semi-arid regions. Journal of Hydrology: Regional Studies, Vol. 46. https://doi.org/10.1016/j.ejrh.2023.101336

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