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ECONOMIC IMPACT ANALYSIS OF REDUCED IRRIGATED ACREAGE IN FOUR RIVER BASINS IN COLORADO

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Overview

Water is an important natural resource that contributes to the Colorado's economic, cultural and social well-being. But, as recent events have shown, our limited water supply has many competing uses and is undergoing many rapid changes. Water rights are being voluntarily transferred from irrigated agriculture to municipal use, groundwater supplies are diminishing and wells without sufficient augmentation are being retired. Ultimately, this means fewer irrigated acres, and the economic impacts of this reduced activity are a key concern for rural communities (Pritchett, 2007).

A recent study seeks to correlate increasing water demand with reduced irrigated acres. With the approval of the 2003 General Assembly, the Colorado Water Conservation Board commissioned the Statewide Water Supply Initiative (SWSI), an 18-month study to explore, basin by basin, existing water plans, supplies, and existing and projected demands through the year 2030, as well as a range of potential options to meet that demand (Colorado Water Conservation Board, December 2004). As Colorado's population grows and urbanizes, water is expected to shift from agriculture to municipal and industrial (M&I) uses. In addition to the urbanization of agricultural lands, most water providers continue to acquire agricultural water rights, which are then allocated to other uses. Indeed, one of SWSI's major findings is that taking water from irrigated agricultural land and converting it to municipal use will be a primary source of water for cities. SWSI also estimates the number of acres of farmland that will be taken out of irrigation to meet future M&I water needs. Table 1 shows the projected water demand and acreage reductions in four of Colorado's river basins, as estimated by SWSI.

Table 1: Projected Growth in Municipal and Industrial Water

Basin	Projected Demand Increase (AFY)	% Increase in Water Demand	Projected Reduction In Irrigated Acres	Reduction as % of Currently Irrigated Cropland
Arkansas	98,000	38%	23,000-72,000	10-31%
South Platte	409,700	53%	133,000-226,000	29-49%
Republican	*	*	20,000	4%
Rio Grande	43,000	25%	60,000-100,000	20-32%

* SWSI did not analyze the Republican River Basin. Estimated acreage reductions for this basin were provided by the Republican River Conservation District, based on reductions required by Conservation Reserve Enhancement Program.

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If irrigated acres are reduced as is forecast in Figure 1, a significant reduction in a region's economic activity will result. Identifying and quantifying the economic impact of the reduction, disaggregating the impact among different industries in the region , and determining how government revenues might shrink is valuable information for many water stakeholders including farmers, businesses, water supply administrators, and regional leaders charged with economic development.

Four previous fact sheets described the economic, agricultural, and water use demographics of the East Arkansas, East South Platte, Republican, and Rio Grande Basins,[2] setting the foundation for discussing two overarching questions: what is irrigated agriculture's contribution to each regional economy and what economic activity will be lost if irrigated agriculture's reductions occur? Quantifying cash receipts is one way to measure the impact of irrigated agriculture to Colorado's economy, but the economic contribution of agriculture doesn't stop at the farm gate. Irrigated crop production supports agribusinesses. These primary industries encourage economic development through the purchase of inputs and the payment of wages and salaries to employees. Without other viable local base industries, a reduction in the revenue generated in the agricultural sector will have adverse economic impacts throughout the regional economy.

Recently, research from Colorado State University and the Colorado Water Resources Research Institute was undertaken to address these questions.[3] To quantify economic activity, the IMPLAN software program was used to create an input-output (I-O) model for each basin under study. The SWSI estimates of reduced irrigated acreage in each basin were then used to "shock" the I-O models in order to quantify the economic impacts associated with a reduction in irrigated acreage. The full report (see footnote 2) contains an introduction to I-O models and economic impact analysis. The study considers the four distinct agricultural areas separately in order to increase the accuracy and applicability of the estimates. Analysis of the Arkansas and South Platte Basins is restricted to the eastern portion of the basin where most irrigated crop revenues are found. The study then compares the impacts in each region in order to assist these stakeholders (and possibly others in similar situations) to prepare for, and minimize, the impacts.

A few details about the modeling assumptions are pertinent. Historically, most water transfers have been conducted on a wholesale basis, with the formerly irrigated lands being fallowed (i.e., converted to grassland) or converted entirely to dryland agriculture. However, the unfavorable economic outlook for dryland cropping and rangeland restoration has often led to land abandonment after water transfers, supporting the belief that all acres taken out of irrigation will be fallowed (Smith, 2005). Thus, the results presented here are based on the assumption that all acres taken out of irrigation will be subsequently fallowed.

Also, the economic impacts derived in this analysis represent what is likely to occur in the short run, when there is limited ability to react to the reduction in agricultural output. Over time, human resources and substitutable capital will migrate to other employment, although there will be less migration out of agriculture than would be the case with other sectors because of the culture of an agricultural way of life, the older average ages of farmers, and their more isolated locations (Howe and Goemans, 2003). In a prosperous region like the South Platte, displaced labor, capital, and land are likely to be reemployed in other productive activities within a relatively short period. The losses in the other basins are likely to persist over a longer period.

Results

The study results provide several insights. First, irrigated agriculture's contribution to economic activity varies by region, as can be seen in the second column of Table 2. Measured at the farm gate, production agriculture makes a significant portion of sales for the Rio Grande basin (48 percent of total output). In contrast, production agriculture is significant in the East South Platte basin but it makes a smaller proportion *relative* to total economic activity in the basin due to the sheer size of the economy. Simply put, the South Platte basin economy has more sources of economic activity when compared to the Rio Grande region.

[2] All four fact sheets can be found at http://dare.agsci.colostate.edu/csuagecon/extension/pubstools.htm

[3] J. Thorvaldson and J. Pritchett. "Economic Impact Analysis of Irrigated Acreage in Four River Basins in Colorado." *Colorado Water Resources Research Institute Completion Report No. 207*, 2006. Located at http://www.cwrri.colostate.edu/pubs/series/completionreport/crlist.htm

The economic activity generated per acre of irrigated cropland also varies by region, as can be seen in the third column of Table 2. Total economic activity can be represented by the sum of the following three components (Anderson, Wengert, and Heil, 1976):

- **Direct Activity:** Revenue flows from the sale of crops
- **Indirect activities:** The revenue generated by irrigated agriculture's demand for inputs from other industries (e.g., fertilizer, machinery, etc.)
- **Induced activity:** The revenue generated as employees spends their wages in the regional economy (e.g., at restaurants, supermarkets, pharmacies, banks, etc.)

In the third column of Table 2, the direct, indirect and induced activity has been summed and then averaged for each acre of the regions' cropland. The lowest value is found in the Arkansas at $428 per acre and the highest is in the Rio Grande at $1,127 per acre. The prevailing crop mix describes, in part, the difference. The primary crop in the Rio Grand (in terms of its value) is potatoes, a high value crop that requires significant inputs to be grown and is exported almost exclusively out of the region. Forage crops are typical in the Arkansas, and these perennial crops require relatively fewer inputs. In addition, much of the forages grown in the Arkansas Valley are used locally. So when is economic activity high within a regional economy? When high value crops are sold outside the region, when revenues from the crop sales are spent on locally produced inputs and when local support industries use local labor and inputs.

Table 2. Irrigated Agriculture and Economic Activity for Colorado Regions

Region	Farm Gate Receipts Relative to Regional Sales[a]	Economic Activity Generated per Acre of Irrigated Cropland	Representative Cropping Pattern
Arkansas	31%	$428	Forage Crops
Republican	37%	$678	Continuous Corn, Alfalfa
Rio Grande	48%	$1,127	Potatoes, Barley, Alfalfa
East South Platte	2%	$690	Corn, Alfalfa, Sugar Beets

[a]All receipts from production agriculture

Output Impacts

Table 2 is a snapshot of economic activity, but does not indicate how this activity changes as irrigated acres are lost. To do this, the midpoints of reduced irrigated acreage from Table 1, valued according to 2004 prices and cropping patterns are used to shock that basin's I-O model, thus generating the direct, indirect and induced impacts. In Table 3, the total impact is broken down into its component parts, with the first column listing the region and the second column stating the acreage reduction. The total effect is the sum of the direct, indirect and induced effects, and is shown in the third column of the table. The direct effects represent the lost irrigated crop sales, and are shown in the fourth column of the table. The indirect and induced effects are an important part of an industry's contribution to the regional economy, and are shown in the fifth and sixth columns of the table, respectively. The indirect effects are the decreases in inter-industry purchases (fertilizer, seeds, etc.) in response to the decreased demands of irrigated agriculture. The induced effects reflect changes in household spending as household income decreases due to the decrease in production. From Table 3, The East South Platte region experiences the largest economic impact followed by the Rio Grande Basin.

Economic multipliers measure secondary economic impacts (indirect and induced) by quantifying the relationship between an initial change in an industry's final demand and the total effect that this has on the sales of goods and services of all sectors within the region, as well as its effect on regional household spending. The greater the indirect and induced effects are, the greater the multiplier will be. Each basin's output multiplier for irrigated agriculture is displayed in the final column of the table.

The output multiplier indicates the economic inter-connectedness that irrigated agriculture has with the region, and the degree to which a decrease in activity in the irrigated agriculture sector results in a decrease in purchases from other local industries and local resource providers. A large multiplier indicates that that industry has many ties to the local economy (it does not necessarily indicate high output). For instance, the East South Platte multiplier of 1.78 means that for every $1 we take out of the production of irrigated agriculture, the total impact on the entire East South Platte Basin will be a loss of $1.78 of economic activity. The output multiplier is thus a good indicator of the size and extent of the ripple effects and is intimately related to the proportion of inputs to irrigated

Table 3: Impact Components and Multipliers

Basin	Estimated Acres Lost	Total Economic Impact (mill $)	Direct Effect (mill $)	Indirect Effects (mill $)	Induced Effects (mill $)	Output Multiplier
East South	159,500	-$110.07	-$61.98	-$36.96	-$11.12	1.78
Arkansas East	47,500	-$20.33	-$13.80	-$5.46	-$1.07	1.43
Republican	20,000	-$13.60	-$10.75	-$2.11	-$0.69	1.25
Rio Grande	80,000	-$98.78	-$80.98	-$9.10	-$8.71	1.22

agriculture that are purchased locally (i.e., within the study region). There are likely many factors that influence the variations in output multipliers across basins seen here. Three of the most important factors include:

1. Size and of the economy

Typically, the larger the size of the economy, the more economic activity is internalized. Conversely, the smaller the economy is, the more dependent the it is on economic activity from other functional economies, and hence the more income tends to leak outside the area as goods and services necessary for day-to-day commerce are imported (purchased from outside the area). Given the limited number of linkages that exist in these smaller economies, multipliers tend to be smaller, resulting in a smaller total effect for a given impact, since more of the ripple effects occur outside of the region. However, because there are fewer businesses among which the losses can be spread, the losses could actually be more concentrated and severe in these areas.

One way to measure the size of an economy is by the number of unique industries in that economy. For instance, the economy in the East South Platte Basin consists of roughly twice as many unique industries as the other three basins. This may suggest that farmers in the East South Platte Basin are able to purchase a larger proportion of their factors of production from within the basin, as compared to the other three basins. If indeed crop farmers can buy more of their inputs locally, then a reduction in the crop farmers' output will have a larger effect on the local economy, as the providers of those inputs to crop farming face reduced demand. Thus, the ripple effect within the region will be larger, resulting in a higher multiplier.

2. Diversity of the economy

An indicator of the diversity of an economy is the Shannon-Weaver diversity index, which is provided by IMPLAN. The Shannon-Weaver diversity index is determined by the number of industries there are in the region and how well-distributed employment is throughout all of those industries. Its values range from zero to one, with one being perfect diversity. Conversely, as employment and output become concentrated in fewer industries, the Shannon-Weaver index approaches zero. The Shannon-Weaver diversity indices for each basin are displayed in Table 4. As might be expected, the Shannon-Weaver diversity index corresponds positively to the size of the multipliers in all four basins. For comparison purposes, the Shannon-Weaver diversity index for Colorado's economy as a whole is 0.77.

Table 4: Relationship between Shannon-Weaver Diversity Indices

Basin	S-W Index
East Arkansas	0.6095
East South Platte	0.7219
Republican	0.6228
Rio Grande	0.5776

3. Use of locally-provided inputs

When a sector relies heavily on local industries for inputs, it will have a relatively large multiplier. Large multipliers indicate that there are many ties to the local economy, such that money is used more times before it escapes from the economy. The use of locally-provided inputs depends on the land characteristics and crop-mix of the area, as these will affect the type and amount of inputs required. The use of locally-provided inputs also depends on the local availability of these inputs, which is determined to some extent by the size and diversity of the economy.

Table 5 shows the total output impact in each basin and compares the total impact to each basin's total output and agricultural output. The rows display the impacts by basin. The first column displays the value of total output in each basin, while the second column shows the total impact as a proportion of this output. The third column shows the total impact as a proportion of *all* agricultural output, while the fourth column shows the total impact as a proportion of *irrigated* agricultural output. The last column shows the

Table 5: Output Impacts Relative to Total Output and Agricultural Output

Basin	Total Output (million $)	Total Economic Impact (million $)	Impact as % of Total Output	Impact as % of Agriculture	Direct Impact as % of Irrigated Crop Sales	Lost Economic Activity per Acre
East Arkansas	$2,001.26	-$20.33	1.02%	3.20%	13.87%	$428
East South Platte	$95,827.04	-$110.07	0.12%	5.64%	52.28%	$690
Republican	$3,116.60	-$13.55	0.43%	0.82%	2.08%	$678
Rio Grande	$2,499.35	-$98.78	3.95%	8.16%	8.72%	$1,235

impact per acre lost, which can also be interpreted as the economic activity generated by one acre of irrigated crops in that basin.

The total impact is greatest in the East South Platte Basin, which is expected due to the fact that this basin is projected to experience the greatest loss of irrigated acreage. In this region, the total reduction in economic activity is $110 million (about 0.12% of the region's total economic activity). The lost economic activity *per acre* is greatest in the Rio Grande Basin, where a high-value crop (potatoes) is largely exported out of the region. As stated previously, economic activity per acre tends to be higher when high value crops are sold outside the region and when local support industries use local labor and inputs.

Impacts per Capita

Even if the *total* impact in a particular basin is smaller than in others, if the population density in the first basin is much lower than in the others, the impact will be spread out over fewer people and thus the impact *per person* will be higher. Support for this idea can be seen in Table 6. Due to the much lower population densities in the East Arkansas, Republican, and Rio Grande basins, the per capita losses are much greater in these basins. In contrast, the South Platte Basin, which has the highest population density of all basins under study, has the lowest per capita impact.

Table 6: Per Capita Impacts

	Total Impact (mill $)	Population	Per Capita Impact
East Arkansas	-$20.33	53,245	-$382
East South Platte	-$110.07	1,136,568	-$97
Republican	-$13.55	56,768	-$239
Rio Grande	-$98.783	46,726	-$1,929

Other Impacts

The previous results examine the impact to the regional economy as a whole, but do not disaggregate the impact among different sectors or crops. The impacts are distributed unevenly among sectors and crops, a distribution which is sure to be important to stakeholders. A table of the top 5 most-affected sectors and crops in each basin can be found in CWRRI Completion Report No. 207 (see Footnote 3). Employment and tax impacts can also be found in the Completion Report.

Conclusions

Substantial differences between the regions exist, both in terms of impacts and multipliers, and further analysis suggests that differences in multipliers has much to do with differences in the diversity of each region's economic base, as is expected.

In terms of total impact, the South Platte Basin experiences the largest total impact, which is not surprising considering that this basin is projected to experience the largest decrease in irrigated acreage. The South Platte Basin also has the largest multiplier, meaning that the initial impact will generate more ripple effects within this basin. This can be explained by the greater size and diversity of the East South Platte Basin's economy. At first glance, these results may seem to suggest that the East South Platte Basin will be the area worst-hit by the acreage reductions. However, upon further analysis, it becomes apparent

that the East South Platte Basin experiences the lowest per capita impacts due to this basin's relatively high population density. Also, because of the greater diversity of the East South Platte Basin's economy, it may be better equipped to weather such an economic impact than the other economies under consideration.

Although the Rio Grande basin did not experience the greatest loss of acres, it did experience the largest employment loss, both in terms of total jobs lost and proportion of total workforce lost. This can be partially explained by the high labor requirements for producing hay, the main crop grown in this region. This outcome provides further evidence that it is important to look at more than just the raw numbers of acres that will be lost to predict the impact—the true impact depends on which crops are lost and in what region.

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