ALTERNATIVE APPROACHES TO ESTIMATE THE IMPACT OF IRRIGATION WATER SHORTAGES ON RIO GRANDE VALLEY AGRICULTURE

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ALTERNATIVE APPROACHES IN ESTIMATE IMPACT OF IRRIGATION WATER SHORTAGES ON RIO GRANDE VALLEY AGRICULTURE[1]

Background. Irrigation water shortages in the Lower Rio Grande Valley (LRGV) region have occurred since the mid-1990s. These shortages followed the point in 1992 when Mexico began undersupplying the average minimum annual amount 350,000 acre-feet of water into the Rio Grande. The treaty of 1944 requires Mexico to deliver the 350,000 minimum average annual amount over defined five year cycles. The deficit for the 1992-97 cycle was 1,024,000 acre-feet. Without substantive repayment, the cumulative deficit has been projected to grow to 1,750,000 acre-feet by October, 2002 (the end of the current five year cycle). The impacts of these deficits on LRGV agriculture were not immediately felt as the remaining U.S. irrigation water supplies in Amistad and Falcon reservoirs were consumed. Irrigation supply shortages occurred when irrigation water demands exceeded the available supplies (after 1995), which had been drawn down during the deficit years since 1992.

Purpose. This paper compares alternate approaches to valuing the economic impact of irrigation water shortages from Mexican noncompliance with the 1994 treaty. The two methods compared are an average value-of-water approach, and an *ex post*, historical crop damages approach. The availability of historical and average water shortage amounts highlights the usefulness of the former method, while crop data limitations do not allow for a comprehensive treatment of the issue using the historical damages approach.

Value of Water Approach

The value-of-water approach estimates the economic impact associated with growing irrigated crops, and then divides this impact by the average water usage to produce those crops (see Appendix for more discussion of methodology). Using the 1992 cropping pattern and production levels as a baseline[2], this approach estimates economic values of $652 in business activity and 0.02 jobs per ac-ft of irrigation water applied at the farm gate. These figures form the basis for analyzing the economic impact of not having a given quantity of irrigation water at the farm gate. Table 1 shows the average annual economic impact of 2,000,000 acre-feet of irrigation water, compared to the 350,000 acre-feet average minimum annual release required from Mexico over a five-year cycle. Table 1 shows a range of reservoir amounts in between these extremes for illustration. For any given release amount, there is an assumed 41% loss through evaporation, diversion losses, and transportation losses to estimate the quantity available to LRGV growers for irrigation purposes (Column 2). The economic

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[1] This work is part of a larger irrigation cost/benefit study was supported by the CSREES Project "Efficient Irrigation for Water Conservation in the Rio Grande Basin, Task 1 "Irrigation District Studies – Economics"

[2] See Appendix for more discussion. The underlying assumption of the composite irrigated acre approach is that the 1992 cropping pattern reflects the near optimum that has evolved in the region to account for risk, soil productivity, crop rotation, prices, government programs, and capital infrastructure. This approach has been reviewed and approved by the U.S. Army Corps of Engineers for flood control projects in the LRGV for over twenty years. The approach has also been reviewed and published in scholarly journals, e.g.,
Robinson, John R. C., Ronald D. Lacewell, John R. Stoll, and R. Freeman. "Estimating Agricultural Benefits from Drainage Over A Relatively Level Terrain." *Agricultural Water Management* 21:79-91. 1992.

impacts in Columns 3 and 4 are based on the quantities in Column 2. Column 3 shows the annual dollars of gross business activity generated from production and sale of irrigated LRGV crops assuming application of the irrigation water amounts shown in Column 2. The gross business activity is a measure of the sales and billing receipts of all sectors of the LRGV regional economy. This measure incorporates the "farm gate" value of agricultural production as well as indirect, "up-stream" impacts on agricultural supply businesses sales.

Table 1. Economic Impact of Benchmark Water Shortage Levels

Water Shortages		**Average Regional Losses Associated with Water Shortages at Farm Gate**	
Reservoir Quantity *(acre-feet)*	Farm gate Quantity [1/] *(acre-feet)*	Business Activity [2/] *(dollars per year)*	FTE Jobs [2/] *(jobs per year)*
2,000,000	1,180,000	$769,360,000	23,600
1,900,000	1,121,500	$730,892,000	22,420
1,800,000	1,062,000	$692,424,000	21,240
1,700,000	1,003,500	$653,956,000	20,060
1,600,000	994,000	$615,488,000	18,880
1,500,000	1,147,500	$577,020,000	17,700
1,400,000	885,000	$538,552,000	16,520
1,300,000	826,000	$500,084,000	15,340
1,200,000	708,000	$461,616,000	14,160
1,100,000	649,000	$423,148,000	12,980
1,000,000	590,000	$384,680,000	11,800
—	**563,826** [3/]	**$367,614,552**	**11,277**
900,000	531,000	$346,212,000	10,620
800,000	472,000	$307,744,000	9,440
700,000	413,000	$269,276,000	8,260
600,000	354,000	$230,808,000	7,080
500,000	295,000	$192,340,000	5,900
400,000	236,000	$153,872,000	4,720
350,000 [4/]	**206,500**	**$134,638,000**	**4,130**

[1/] Assumes 41% losses from reservoir to the farm gate.

[2/] Calculated using per acre foot impact estimates of $652 and 0.02 jobs.

[3/] Benchmark TNRCC value showing average decrease in annual agricultural water diversions from the baseline period of 1992.

[4/] Benchmark average annual minimum amount of delivery from Mexico under the 1944 treaty.

Cumulative Loss. The estimates in Table 1 can be used to estimate either average annual economic losses or the total cumulative economic loss from water shortages due to Mexican noncompliance with the 1944 treaty. For example, the economic loss from the cumulative water debt is estimated by applying the per ac-ft values to the total water debt accumulated since 1992[3]. The underlying assumptions are a) that all of the annual deficits which resulted in the debt accumulation would have been used for irrigation, and b) the use of this water would have resulted in the approximate irrigated crop mix, productivity and average gross value of the 1992 baseline pattern.

Annual Losses. Annual economic impacts using the value-of-water approach can be calculated in several ways. First, a cumulative 10-year estimate could be divided by ten to derive an average annual value of either the loss in business activity or precluded employment. Annual economic impacts can also be derived by applying the dollar (or employment) per ac-ft values to benchmark average annual water quantities. Two examples, both highlighted in Table 1, are the 350,000 ac-ft average annual minimal quantity stipulated by the 1944 treaty, or the average decline in annual agricultural water diversions since 1992 (563,826 ac-ft) estimated by TNRCC. (Note that the 350,000 ac-ft benchmark would be subject to the full 24.5% transportation loss, while the downriver diversions would not.) For example, the Texas Governor's Office White Paper[4] used the 563,826 ac-ft benchmark to highlight estimated annual losses[5] for 1998 through 2001 of $367.6 million each year (from Table 1).

Historical Crop Damages Approach

An alternative *ex post* approach to estimating economic impacts is by measuring the change in farm gate or regional gross value of affected crops. This approach requires annual county level crop production data. The available sources (USDA-NASS) unfortunately do not track all of the relevant crops. The U.S. Census of Agriculture data do have the necessary detail, but are only collected every five years. For example, Table 2 shows the decline in selected crop acres in 1997 using 1992 as a baseline.

A comprehensive and current damage assessment using the historical damages approach is not possible without statistical extrapolation from Ag Census data, which is beyond the scope of this paper and was not attempted by a recent USDA study[6]. The USDA study estimated an average annual decrease in gross value (of major row crops only) of $34 million per year for the 1996-1999 period compared to 1990-1995. These only reflect "farm-gate" losses and do not capture the broader economic impacts in the regional economy.

Another complicating factor is that farmers of certain crops are partially compensated by crop insurance policies. The USDA calculations did not take into account for any insurance

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[3] Note: this is the basis for estimates of nearly $1 billion in lost business activity and 30,000 precluded jobs.

[4] "An Issue of Non-compliance between Mexico and the United States of American in accordance with the 1944 Treaty Between Mexico and the United States of America." From a March 18, 2002 letter March 18, 2002 letter from Texas Gov. Rick Perry to U.S. Secretary of State Colin Powell.

[5] Note: these are losses to the broader economy of the region, not just at the farm gate.

[6] USDA Office of the Chief Economist. "Assessment of Drought and Water Availability for Crop Production in the Rio Grande Basin." April 2002.

indemnities already collected by farmers as partial compensation in a particular year. The crops that tend not to be insured (e.g., vegetables) happen to be the same crops for which there is no annual, county-level data. The situation is further complicated since formerly irrigated crops only qualify for dryland crop insurance coverage in the absence of *a priori* expectations of adequate water supplies. The following example (Table 3) calculates per acre compensation for three insured row crops for which there is also annual, county-level NASS data in 2001. The total amount needed to equate the region's farmers to irrigated insurance levels is about $14 million. The "compensation" relates to lost gross value, thus the disaster assistance referred to in Table 3 would only compensate for losses at the farm gate, as opposed to the broader economic losses captured by the value-of-water approach.

Table 2. Comparison of 1992 and 1997 Ag Census Data for Border Counties Downriver from Amistad Reservoir.

	Irrigated Farms		Harvested Irr. Cropland		Irrigated Vege. Acres		Irrigated Orchard Acres	
	1992	1997	1992	1997	1992	1997	1992	1997
Cameron	609	615	119,744	104,969	6,063	2,678	--	--
Hidalgo	1,009	844	218,423	179,657	49,048	26,762	28,520	25,505
Maverick	126	111	10,404	8,320	1,559	849	3,410	3,142
Starr	28	40	7,968	--	4,900	3,372	--	--
Webb	41	35	3,405	1,908	--	--	408	177
Willacy	78	67	15,773	17,075	2,182	2,195	--	--
Zapata	10	8	21,257	17,244	--	--	--	--
TOTAL	1,901	1,720	396,974	329,173	63,752	35,856	32,338	28,824
% decline from '92		-9.5%		-17.1%		-43.8%		-10.9%

Table 3. Estimated Disaster Assistance to Compensate Rio Grande Valley Crop Producers Bey Non-Irrigated Insured Levels in 2001.

	Cotton (lb)	Sorghum (cwt)	Corn (bu)
1996-2001 Avg. Irrigated Harvested Acres[1/]	72,134	88,896	58,100
1996-2001 Weighted Avg. Irrigated NASS Yield[1/]	727.5	34.8	60.2
Avg. 2001 Dryland t-yield[1/]	335.0	26.2	48.2
Difference	392.5	8.6	12.1
Percent Acres Covered	100%	100%	100%
2001 Insurance Price Level ($/unit)	$0.63	$3.13	$2.00
Insurance Price Election (%)	100%	100%	100%
Level of Coverage (%)	65%	65%	65%
Per acre assistance required to compensate irrigated crops insured as dryland due to water shortages	$160.71 per acre	$17.47 per acre	$15.67 per acre
Total regional assistance to compensate irrigated crops insured as dryland from water shortages created my treaty non-compliance	**$14,056,346 for all three crops**		

[1/] averages for Cameron, Hidalgo, Maverick, Starr, Webb, Willacy & Zapata Counties, USDA-NASS

APPENDIX: Value of Water Approach

Assumptions, Methodology, and Limitations

Concepts. The approach to estimating the regional economic value of lost crop production, in this report, is termed *opportunity cost* analysis by economists. The “costs” of not producing are expressed as foregone regional economic activity that could have otherwise enhanced the region’s gross regional product (value added), income and employment. A major underpinning of this analysis is that the loss of confidence that there will be any future Mexico inflows up to the minimum required by the treaty 350,000 acre-feet causes growers to curtail production. This is evidenced by recent trends in irrigated production. Even though some production was occurring during the deficit period, it was at lower and lower levels due both to a prolonged drought and the lack of expected inflows in the river. The initial task at evaluating the opportunity cost from this curtailment is to value the use of the water in a normal production year.

Data Development. The direct impact of irrigation water on the regional economy is based on an estimate of the total value of production per acre-foot of water, assuming that acreage is allocated among crops as if producers made cropping decisions anticipating no shortages of irrigation water. Crop yields per acre and crop prices are based on annual county or regional estimates published by Texas Agricultural Statistics Service. The value of output per acre for each crop is multiplied by the percentage of crop land assumed to be devoted to that crop, and these values are then summed across all crops to find the value of irrigated output for a "composite" acre of land. This typical acreage represents a conservative estimate of the value of using the irrigation water because in the likelihood that farmers have a more plentiful supply of water they would irrigate more valuable crops than, say, cotton or grain sorghum. The intent here is to show that the historical water deficits could have been used at least in the crop mix that was actually irrigated. The composite acre uses cotton (34.3%), sorghum (23.8%), citrus (8.8%), sugar cane (8.6%), corn (5.6 %), forages (4.5%), and vegetables and other crops (14.4%). The gross values per acre, per crop were first divided by their respective water use (acre-feet), to obtain gross value per acre-foot for each crop. This set of values was then multiplied by the acreage proportions and summed to obtain the weighted (by acreage) gross value per acre foot for the composite acre. The results are an estimate of the average direct economic impact on crop sales of an acre-foot of water used for irrigation in the region.

Another key assumption in this analysis was the relationship between water quantities in the reservoir system and irrigation supplies delivered at the LRGV farm gate. For this analysis, it was assumed that reservoir evaporation losses were 3%, river transportation losses were 8%, and 30% conveyance losses within Districts, for a total estimated loss of 31%.

Macroeconomic Analysis. All region-wide impacts on business activity, employment and income are derived from the estimates of direct production losses from the irrigated agriculture sector in the region. In its Senate Bill 1 work, the TWDB Planning Division has developed models of the water planning regions of Texas, using the IMPLAN software. These regional input-output models provide data showing the buying and selling linkages among all sectors in the economies, ultimately producing “multipliers” that allow calculations of the indirect changes on the regional economy caused by changes in individual sectors of the economy. These multipliers estimate the effect of increases or decreases in demand for goods and services on all the region’s sectors.

Limitations. The procedure for calculating direct impacts (lost potential crop production) results in average, not marginal, value of water estimates. In practice, at the margin, producers notified of a reduction in anticipated water availability *after planting decisions have been made* would first reduce or eliminate irrigation of crops returning a lower value, and would eliminate irrigation of higher valued crops only in the event of larger water restrictions. Thus, the estimate of the average value of water may be higher than the marginal value, particularly in the instance of a relatively small shortage. Alternatively, if an anticipated shortage were announced *in advance of planting decisions*, producers would be more likely to first reduce acreage of crops requiring more intensive irrigation and producing higher values. In this case, the average value could be considerably less than the marginal value.

The regional economic impact of a water shortage on all businesses may be understated two reasons. First, the analysis assumes that farmers would have used the water that they did not receive in the same pattern as the water that they actually used in each year of the historical period. More likely, farmers assured of adequate water supplies would have expanded irrigated acreage of the higher valued crops (sugarcane and vegetables) and not the lower valued crops of cotton and grain sorghum. The value of sales from acreage of sugarcane and vegetables is significantly higher than the average of all crops as shown in the historical composite acre. Hence, the direct impacts of water shortage are likely understated. The second reason is that the analysis does not take into account any "forward linkages", the value of economic activity generated by the local processing of local farm products. Rather, the indirect impacts presented in this report account only for the interactions of farmers and their suppliers those to whom they pay for goods and services. Some level of impact exists if local food or feed processors lose local raw materials, but data are not sufficient for the analysts to estimate this phenomenon in this region. Most processing of raw farm products is thought to occur outside of the Rio Grande Valley region. However, the processing does take place throughout Texas and the United States and lost processing would cause impacts in those locations.

The farm impacts represent the best estimate of a typical irrigation crop mix in the region and can not be used to determine specific local farm damages as would be done in an analysis of disaster loss. This analysis should only be used only to provide a macroeconomic (regional) view of economic development that was prevented from benefitting the region because of the deficits. More extensive research and resources are needed to provide interested parties with data that could show actual, detailed damages done, either on-farm or area wide.