

Executive Summary

Water Economics in the Conchos River, Chihuahua, Irrigation Districts, 1990-2001

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by

Arturo Puente González*/

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Executive Summary

The National Hydraulic Program 2001-2006 enacted by the Federal Government sets forth actions to be carried out in order to maintain or to increase agricultural production and, at the same time, to reduce water use in agriculture, in such a way that the salvaged volume could be redirected to satisfy other users' demands, or to reestablish the hydrological equilibrium in basins or aquifers which currently are over exploited.

Also, this program points out that a water market is an instrument, which allows to reallocate this resource among different uses. This market should have an important role in setting off an effort to reduce water extraction from over exploited sources, by fixing an economic value to water, facilitating its allocation to activities of higher economic return.

In the context of a strategic priority to improve irrigation water efficiency and to value economically this resource, in particular for Irrigation District 005 Delicias, this paper was produced.

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The Conchos River Basin in the state of Chihuahua encompasses a 6.37 million hectares (63,709 square kilometers) area, stretching from the south-southeast to the center and northeast of the State. Three Irrigation Districts (IDs) can be found in this Basin, 005 Delicias (75,220 hectares), 090 Bajo Rio Bravo (10,153 hectares) and 103 Rio Florido (10,156 hectares). A low water conduction efficiency of 60% is one of the main problems of these IDs, which combined to a low application efficiency of around 50%, results in a global efficiency of only 30%.

The National Water Commission (CNA) estimated in 1999 that to increase the global efficiency rate to 55% in these three Irrigation Districts, investments of MX\$ 1,394 million (US\$139.4 million) are required, 88.6% of them for ID005 Delicias. An Increase in efficiency can salvage water, some 396 million cubic meters annually. This means that the marginal cost of salvaged water would be 23.5 cents (MX) per cubic meter, considering a 15-year useful life for investments in infrastructure and equipment.

Irrigation District 005 reports 9,069 users with water rights for 76,171 hectares. On average for the period 1990-2001, 60,448 hectares were irrigated annually in ID005 with a gross water volume of 961.8 million cubic meters, showing high variation coefficients, 53.7% and 53.1%, respectively. In 1990-2001, the average gross and net irrigation water volume applied were 15.9 and 9.4 thousand cubic meters per hectare, respectively, which resulted in an average conduction efficiency of 59.3%. On the other hand, average water productivity (in terms value of output) for the same period (in 2001 prices) was MX\$ 1,273/1,000 m³ (US \$127.3/1,000 m³).

The average irrigation rate (in 2001 pesos) was MX\$ 85/1,000 m³ (US \$8.5/1,000 m³) and its relation to value of output was 7%, which in general could be considered as adequate. Some 97% of the water volume was distributed to 17 crops: wheat, forage oats, rye grass, onions in the Fall-Winter Season; cotton, peanuts, onions, pepper, corn, sorghum and soybeans in the Spring-Summer Season; alfalfa and pecans throughout the year, and peanuts, corn, sorghum and soybeans as second crops. For the period 1990-2001 the average gross water volume applied to these crops was 932.4 million of cubic meters, with a 54% coefficient of variation.

To perform a financial and economic analysis of the agricultural production system, a representative model of Irrigation District 005 was developed. This model was based on the average harvested area and the average gross water volume observed for the 1990-2001 period. Applied water volume was 912.7 million cubic meters.

The harvested area and water volume used for the 19 crops (when forage corn and watermelon are added) under analysis represent 97.6% and 94.9% of their total. Outputs, inputs, factors and services prices are those observed in the 2001 agricultural year.

It can be estimated that this production system in 59,000 hectares generates each year a value of output of MX \$871.9 million (US \$87.2 million) and a value-added (remuneration to capital, land, labor, and net profit to producers) of MX\$ 449.5 million (US \$45 million). The main crops, in terms of their contribution to value-added, are peppers (22.1%), onions (13.7%) and pecans (14.2%).

Average net profit (excluding land rent and including government direct support to grains) for this production system can be estimated at MX\$ 3,798/ha (US\$ 379.8/ha) and a real return on capital (adjusted to inflation) of 25.9% can be estimated. An outstanding net profit is obtained in peppers, onions, watermelons and pecans (net profits higher than MX\$ 10,000/ha, and real return on capital of more than 50%). An average MX \$ 1,238/ha (US \$123.8/ha) estimated water cost represents 10.9% of production costs for the whole system.

A linear optimization model was developed for the agricultural production system. This model maximizes total net profit (including direct support payments) to MX\$ 279.6 million (US\$ 28.0 million) and a value-added of MX\$ 525.5 million (US\$ 52.6 million), for 49,982 hectares. These both net profits and value-added, are 25% and 17% higher than the respective values of the agricultural production system benchmark.

The model to optimize the use of water and to maximize net profits of the agricultural production system, shows an increase in the area planted to vegetables and permanent crops, while the peanuts and forage corn area remains being important, and a reduction in the wheat area. It is important to highlight that grain corn grain sorghum and soybeans should be excluded from the cropping pattern.

For an available water volume of 912,749 thousand cubic meters (long-term volume), distributed on 49,982 hectares, a shadow price of surface water of MX\$ 63/1,000 m³ (US\$ 6.3/1,000 m³) is estimated.

While for a 445,029 thousand cubic meters volume (2001 volume) distributed on 25,149 hectares, a shadow price of surface water of MX\$ 122/1,000 m³ (US\$ 12.2/1,000 m³) can be estimated. In the 2001 agricultural year, which showed a critical water shortage, surface water price paid by producers was MX\$ 80/1,000 m³ (US\$ 8.0/1,000 m³).

This suggests that for a condition of relative water availability a shadow price lower than the market price could be expected, while for a condition of water scarcity, a shadow price higher (52.5%) than the market price would be anticipated. With high water availability, a higher area is sown with grains, which show a low net profit, diminishing, therefore, the water shadow price.

Conclusions

- A considerable potential exists in ID005 for salvaging water through technical improvement,
- High variability in irrigation water availability causes high fluctuations in producers net profit,
- Under conditions of relative water availability, water rates in ID005 are, in general, adequate in relation to value of output and to the shadow price,
- Both high value-added and net profits are obtained owing to vegetables and permanent crops,
- High value-added and net profits generated through the agricultural production system set favorable conditions for technical improvement in ID005, and,
- ID005 could significantly increase water productivity through investments in new and innovative technology.

Recommendations

- Water rates should be kept in the neighborhood of 7-10% of value of output,
- Sorghum and grain corn should be excluded from the cropping pattern,
- It is important to carry out a detailed analysis of the financial and economic feasibility of an investment project for technical improvement of ID005, especially to assess its execution,
- This evaluation clearly should establish the amount of water salvaged, and the estimated volume or share to be released both to the Río Conchos for ecological renewal, and to the Rio Grande in accordance with the Treaty on Distribution of International Waters between Mexico and the United States,
- Water salvaged in agriculture should not be used to enlarge the irrigated area, and legal and institutional mechanisms should be set down to make this regulation effective, and,
- Water allocated to agriculture should be enough for a cropping pattern which generates net profits to producers similar to that obtained in years showing average water availability, in order to guarantee the feasibility of an investment project designed to save water.



Table 1. Summary of Irrigation Plan Results 1990-2001

Year	AGRICULTURAL YEAR					
	Physical Irrigated Area Ha	Double Crop Index */	Physical Irrigated Area Ha-Irrigation	Irrigations	Net Volume 1,000 m ³	Gross Volume 1,000 m ³
1990	83,370.0	1.11	305,096.9	3.7	795,657.1	1,307,208.0
1991	96,378.0	1.28	314,973.0	3.3	790,280.8	1,275,752.8
1992	100,992.0	1.34	419,224.0	4.2	933,278.7	1,489,214.4
1993	92,223.0	1.23	372,773.0	4.0	948,850.2	1,722,528.0
1994	86,957.0	1.16	347,709.0	4.0	859,761.7	1,410,831.5
1995	11,468.0	0.15	28,396.0	2.5	82,716.9	135,686.1
1996	20,625.0	0.27	70,258.0	3.4	191,393.0	319,690.7
1997	85,492.0	1.14	342,400.0	4.0	823,420.6	1,329,466.1
1998	53,911.0	0.72	212,460.0	3.9	496,482.3	904,551.8
1999	23,884.0	0.32	63,246.0	2.6	232,350.4	386,931.0
2000	44,910.0	0.60	167,054.0	3.7	467,338.0	814,226.0
2001	25,160.0	0.33	94,777.0	3.8	244,097.8	445,028.7
Average	60,447.5	0.80	228,197.2	3.6	572,135.6	961,759.6
S.D.	32,469.2	0.43	132,923.4	0.5	308,224.0	510,629.1
C.V. (%)	53.7	53.7	58.2	14.6	53.9	53.1

*/ Considering an irrigated area (ha) per season of

75,220

Table 2. Resources and Impacts of the Agricultural Production System

ITEMS	Fall/Winter Season			
	Wheat 1	Oat F. 2	Rye Grass 3	Onions 4
Harvested Area				
Total hectares	11,105	756	473	660
Share (%)	18.4%	1.3%	0.8%	1.1%
Applied Nitrogen				
Total nitrogen (ton)	2,799	121	139	214
Share (%)	31.9%	1.4%	1.6%	2.4%
Labor				
Work-days (no.)	38,869	1,890	2,600	79,890
Share (%)	3.8%	0.2%	0.3%	7.9%
Applied Water (Gross)				
Total 1,000 m ³	164,438	8,590	6,154	13,972
Share (%)	17.1%	0.9%	0.6%	1.5%
1,000 m ³ /ha	14.81	11.37	13.02	21.16
Value of Output (VO)				
Millions of Pesos	97.3	6.3	4.2	31.2
Proportion (%)	11.2%	0.7%	0.5%	3.6%
Value-Added (VA)				
Millions of Pesos	37.6	2.5	2.3	23.2
Proportion (%)	8.4%	0.6%	0.5%	5.2%
VA/VO Ratio (%)	38.7	39.8	55.4	74.3
Water Productivity				
VO per 1,000 m ³	592	729	681	2,236
VA per 1,000 m ³	229	290	377	1,662
Man-days per 1,000 m ³	0.24	0.22	0.42	5.72

ITEMS	Spring/Summer Season								
	Cotton 5	Peanuts 6	Onions 7	Peppers 8	Watermelon 9	Maize G. 10	Maize F. 11	Sorghum 12	Soybeans 13
Harvested Area									
Total hectares	3,360	4,478	619	3,340	1,300	2,630	2,630	466	837
Share (%)	5.6%	7.4%	1.0%	5.5%	2.2%	4.4%	4.4%	0.8%	1.4%
Applied Nitrogen									
Total nitrogen (ton)	430	187	201	932	91	388	364	75	42
Share (%)	4.9%	2.1%	2.3%	10.6%	1.0%	4.4%	4.1%	0.9%	0.5%
Labor									
Work-days (no.)	52,077	87,328	74,909	292,235	53,300	24,986	15,781	3,961	7,114
Share (%)	5.1%	8.6%	7.4%	28.9%	5.3%	2.5%	1.6%	0.4%	0.7%
Applied Water (Gross)									
Total 1,000 m ³	48,067	62,484	13,505	84,212	28,358	35,807	35,807	6,724	10,651
Share (%)	5.0%	6.5%	1.4%	8.8%	2.9%	3.7%	3.7%	0.7%	1.1%
1,000 m ³ /ha	14.31	13.95	21.81	25.21	21.81	13.61	13.61	14.43	12.73
Value of Output (VO)									
Millions of Pesos	60.5	59.2	29.3	155.1	36.4	23.9	19.6	3.0	5.4
Proportion (%)	6.9%	6.8%	3.4%	17.8%	4.2%	2.7%	2.2%	0.3%	0.6%
Value-Added (VA)									
Millions of Pesos	25.4	28.2	21.8	99.3	28.6	8.5	8.4	1.2	2.5
Proportion (%)	5.7%	6.3%	4.8%	22.1%	6.4%	1.9%	1.9%	0.3%	0.5%
VA/VO Ratio (%)	42.1	47.5	74.3	64.0	78.6	35.7	42.7	40.6	45.2
Water Productivity									
VO per 1,000 m ³	1,258	948	2,169	1,842	1,284	668	546	442	511
VA per 1,000 m ³	529	451	1,612	1,179	1,008	238	233	179	231
Man-days per 1,000 m ³	1.08	1.40	5.55	3.47	1.88	0.70	0.44	0.59	0.67

ITEMS	Permanent and Second Crops						Cropping Pattern Model	System Total
	Alfalfa 14	Pecans 15	Peanuts 16	Maize G. 17	Sorghum 18	Soybeans 19		
Harvested Area								
Total hectares	9,883	3,653	1,071	6,726	2,261	2,754	59,002	60,448
Share (%)	16.4%	6.0%	1.8%	11.1%	3.7%	4.6%	97.6%	100.0%
Applied Nitrogen								
Total nitrogen (ton)	682	580	45	992	365	138	8,785	
Share (%)	7.8%	6.6%	0.5%	11.3%	4.2%	1.6%	100.0%	
Labor								
Work-days (no.)	54,359	109,598	14,987	60,533	16,955	20,656	1,012,026	
Share (%)	5.4%	10.8%	1.5%	6.0%	1.7%	2.0%	100.0%	
Applied Water (Gross)								
Total 1,000 m ³	229,184	67,030	7,462	54,981	14,547	20,775	912,749	961,760
Share (%)	23.8%	7.0%	0.8%	5.7%	1.5%	2.2%	94.9%	100.0%
1,000 m ³ /ha	23.19	18.35	6.97	8.17	6.43	7.54	15.47	15.91
Value of Output (VO)								
Millions of Pesos	142.5	98.3	13.6	56.5	13.2	16.5	871.9	
Proportion (%)	16.3%	11.3%	1.6%	6.5%	1.5%	1.9%	100.0%	
Value-Added (VA)								
Millions of Pesos	61.4	64.0	6.2	17.1	4.6	6.7	449.5	
Proportion (%)	13.7%	14.2%	1.4%	3.8%	1.0%	1.5%	100.0%	
VA/VO Ratio (%)	43.1	65.2	45.5	30.3	34.9	40.4	51.6	
Water Productivity								
VO per 1,000 m ³	622	1,466	1,828	1,028	906	793	955	
VA per 1,000 m ³	268	955	832	312	317	320	492	
Man-days per 1,000 m ³	0.24	1.64	2.01	1.10	1.17	0.99	1.11	

Table 3. Summary of Financial Results, 2001 (excluding land rent)

Indicators	Average Cropping Pattern	Fall/Winter Season			
		Wheat 1	Oat F. 2	Rye Grass 3	Onion 4
Prices (2001)					
Domestic Financial Price (pesos/ton)	2,929	1,460	812	200	1,300
Financial Profitability to Producer (2001)					
Gross Income (pesos/ha/season)	14,778	8,760	8,282	8,860	47,320
Total Production Cost (pesos/ha/season)	11,347	7,888	7,304	6,141	29,174
Net Profit (pesos/ha/season)	3,431	872	978	2,719	18,146
Nominal return to Capital (%/season)	30.2%	11.1%	13.4%	44.3%	62.2%
Real return to Capital (%/season) 1/	22.9%	4.8%	7.0%	36.1%	53.0%
Government Direct Support (pesos/ha/season)	367	778	0	0	0
Net Profit+GDS (pesos/ha/season)	3,798	1,650	978	2,719	18,146
Nominal return to Capital (%/season)	33.5%	20.9%	13.4%	44.3%	62.2%
Real return to Capital (%/season) 1/	25.9%	14.1%	7.0%	36.1%	53.0%
Financial Indicators - Water (2001)					
Average Price of Water (pesos/000 m ³) 2/	80	80.0	80.0	80.0	80.0
Cost of Water (pesos/ha/season)	1,238	1,184.6	909.2	1,041.5	1,692.9
Cost of Water/Total Production Cost (%)	10.9%	15.0%	12.4%	17.0%	5.8%
Regional Financial Competitiveness (2001)					
Domestic Factors Cost (pesos/ha/season) 3/	5,331	3,360	2,908	3,192	18,913
Net Value-Added (pesos/ha/season) 3/	7,619	3,389	3,294	4,912	35,170
Nominal Private Cost Ratio (season) 3/	0.89	0.99	0.88	0.65	0.54
Average Yield 1990-2001 (ton/ha)					
Average Harvested Area 1990-2001 (ha) 4/	59,002	11,105	756	473	660
Average Applied Water 1990-2001 (000 m ³) 5/	912,749	164,438	8,590	6,154	13,972

1/ Nominal return to capital deflated by the 2001 inflation rate, 6%.

2/ Financial price of water corresponds to the operation and maintenance costs.

3/ Includes rent of land and excludes Government Direct Support.

4/ Equivalent to 97.6% of the total harvested area, which includes other crops.

5/ Equivalent to 94.9% of the total applied water, which also irrigates other crops.

Indicators	Spring/Summer Season									
	Cotton 5	Peanuts 6	Onions 7	Peppers 8	Watermelon 9	Maize G. 10	Maize F. 11	Sorghum 12	Soybeans 13	
Prices (2001)										
Domestic Financial Price (pesos/ton)	4,500	4,900	1,400	1,800	800	1,400	300	1,100	2,600	
Financial Profitability to Producer (2001)										
Gross Income (pesos/ha/season)	18,000	13,230	47,320	46,440	28,000	9,100	7,440	6,380	6,500	
Total Production Cost (pesos/ha/season)	15,208	11,366	28,123	30,607	13,099	8,849	6,322	6,498	5,972	
Net Profit (pesos/ha/season)	2,792	1,864	19,197	15,833	14,901	251	1,118	-118	528	
Nominal return to Capital (%/season)	18.4%	16.4%	68.3%	51.7%	113.8%	2.8%	17.7%	-1.8%	8.8%	
Real return to Capital (%/season) 1/	11.7%	9.8%	58.7%	43.1%	101.7%	-3.0%	11.0%	-7.4%	2.7%	
Government Direct Support (pesos/ha/season)	0	0	0	0	0	829	0	829	829	
Net Profit+GDS (pesos/ha/season)	2,792	1,864	19,197	15,833	14,901	1,080	1,118	711	1,357	
Nominal return to Capital (%/season)	18.4%	16.4%	68.3%	51.7%	113.8%	12.2%	17.7%	10.9%	22.7%	
Real return to Capital (%/season) 1/	11.7%	9.8%	58.7%	43.1%	101.7%	5.9%	11.0%	4.7%	15.8%	
Financial Indicators - Water (2001)										
Average Price of Water (pesos/000 m ³) 2/	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	
Cost of Water (pesos/ha/season)	1,144.5	1,116.2	1,745.1	2,017.2	1,745	1,089	1,089	1,154	1,018.1	
Cost of Water/Total Production Cost (%)	7.5%	9.8%	6.2%	6.6%	13.3%	12.3%	17.2%	17.8%	17.0%	
Regional Financial Competitiveness (2001)										
Domestic Factors Cost (pesos/ha/season) 3/	5,676	5,021	17,858	15,752	9,704	3,495	3,058	3,306	3,139	
Net Value-Added (pesos/ha/season) 3/	7,570	6,289	35,169	29,723	21,995	3,247	3,176	2,588	2,936	
Nominal Private Cost Ratio (season) 3/	0.75	0.80	0.51	0.53	0.44	1.08	0.96	1.28	1.07	
Average Yield 1990-2001 (ton/ha)										
Average Harvested Area 1990-2001 (ha) 4/	3,360	4,478	619	3,340	1,300	2,630	2,630	466	837	
Average Applied Water 1990-2001 (000 m ³) 5/	48,067	62,484	13,505	84,212	28,358	35,807	35,807	6,724	10,651	

1/ Nominal return to capital deflated by the 2001 inflation rate, 6%.

2/ Financial price of water corresponds to the operation and maintenance costs.

3/ Includes rent of land and excludes Government Direct Support.

4/ Equivalent to 97.6% of the total harvested area, which includes other crops.

5/ Equivalent to 94.9% of the total applied water, which also irrigates other crops.

Indicators	Permanent Crops		Seconds Crops			
	Alfalfa 14	Pecans 15	Peanuts 16	Maize G. 17	Sorghum 18	Soybeans 19
Prices (2001)						
Domestic Financial Price (pesos/ton)	848	19,210	4,900	1,400	1,100	2,600
Financial Profitability to Producer (2001)						
Gross Income (pesos/ha/season)	14,416	26,894	12,740	8,400	5,830	5,980
Total Production Cost (pesos/ha/season)	11,964	15,218	10,114	8,242	5,626	5,370
Net Profit (pesos/ha/season)	2,452	11,676	2,626	158	204	610
Nominal return to Capital (%/season)	20.5%	76.7%	26.0%	1.9%	3.6%	11.4%
Real return to Capital (%/season) 1/	13.7%	66.7%	18.8%	-3.9%	-2.2%	5.1%
Government Direct Support (pesos/ha/season)	0	0	0	829	829	829
Net Profit+GDS (pesos/ha/season)	2,452	11,676	2,626	987	1,033	1,439
Nominal return to Capital (%/season)	20.5%	76.7%	26.0%	12.0%	18.4%	26.8%
Real return to Capital (%/season) 1/	13.7%	66.7%	18.8%	5.6%	11.7%	19.6%
Financial Indicators - Water (2001)						
Average Price of Water (pesos/000 m ³) 2/	80.0	80.0	80.0	80.0	80.0	80.0
Cost of Water (pesos/ha/season)	1,855.1	1,467.9	557.7	654.0	514.8	603.5
Cost of Water/Total Production Cost (%)	15.5%	9.6%	5.5%	7.9%	9.2%	11.2%
Regional Financial Competitiveness (2001)						
Domestic Factors Cost (pesos/ha/season) 3/	5,263	8,855	4,810	2,919	2,485	2,563
Net Value-Added (pesos/ha/season) 3/	6,215	17,530	5,799	2,547	2,038	2,416
Nominal Private Cost Ratio (season) 3/	0.85	0.51	0.83	1.15	1.22	1.06
Average Yield 1990-2001 (ton/ha)	17.00	1.40	2.60	6.00	5.30	2.30
Average Harvested Area 1990-2001 (ha) 4/	9,883	3,653	1,071	6,726	2,261	2,754
Average Applied Water 1990-2001 (000 m³) 5/	229,184	67,030	7,462	54,981	14,547	20,775

1/ Nominal return to capital deflated by the 2001 inflation rate, 6%.

2/ Financial price of water corresponds to the operation and maintenance costs.

3/ Includes rent of land and excludes Government Direct Support .

4/ Equivalent to 97.6% of the total harvested area, which includes other crops.

5/ Equivalent to 94.9% of the total applied water, which also irrigates other crops.

Table 4. Results of the Optimization Model

Maximization	\$ Total	\$/Ha
Net Profit	279,584,928	5,594
Value-Added	525,483,698	10,513

*7 Includes direct support.

	Wheat 1	Oat 2	Rye Grass 3	Onion 4
Harvested area (ha)	6,000	0	2,000	1,640
Net Profit (pesos/ha)	1,650	978	2,719	18,146
Value-Added (pesos/ha)	3,389	3,294	4,912	35,170

	Cotton 5	Peanut 6	Onion 7	Pepper 8	Watermelon 9	Maize G. 10	Maize F. */ 11	Sorghum 12	Soybeans 13
Harvested area (ha)	2,867	0	355	3,408	3,000	0	2,887	0	0
Net Profit (pesos/ha)	2,792	1,864	19,197	15,833	14,901	1,080	1,947	711	1,357
Value-Added (pesos/ha)	7,570	6,289	35,170	29,723	21,995	3,247	3,176	2,588	2,936

	Alfalfa 14	Pecan 15	Peanut 16	Maize G. 17	Sorghum 18	Soybeans 19
Harvested area (ha)	16,826	5,000	6,000	0	0	0
Net Profit (pesos/ha)	2,452	11,676	2,626	987	1,033	1,439
Value-Added (pesos/ha)	6,215	17,530	5,799	2,547	2,038	2,416