A Preliminary Assessment of Crop Production and Estimated Irrigation Water Use for Chihuahua, Mexico

C. Parr Rosson, III
Aaron Hobbs
Flynn Adcock

Department of Agricultural Economics
Center for North American Studies
Texas A&M University

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1The authors are Professor and Director, Research Assistant, and Research Associate and Assistant Director, respectively, Dept. of Agricultural Economics, Center for North American Studies, Texas A&M University. For additional information call 979-845-3070 or e-mail prosson@tamu.edu. The authors acknowledge Frank Daniello and Jose Peña for their contributions to this project.
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Executive Summary

In May 2002, Mexico’s accumulated water debt with the United States had reached 1.5 million acre feet. Prolonged drought in South Texas and northern Mexico, trade growth and increased agricultural production spurred by NAFTA, and an increasing population and industrial base on both sides of the U.S.-Mexico border, have placed greater pressure on the Rio Conchos/Rio Grande water system. During this time, 1994-99, crop irrigation and production have continued in Chihuahua, which contains the Rio Conchos basin, a major Mexican water source of the Rio Grande River.

Irrigated production of the crops grown in the Mexican state of Chihuahua and analyzed in this study increased 200 percent between 1980 and 1999, going from 1.0 million metric tons (mmt) to 3.0 mmt. Irrigated harvested area increased 35 percent over the same period from 554,613 acres to 750,430 acres. From 1995 and 1999, irrigated production was up 11.2 percent while irrigated harvested area increased 3.3 percent. Average irrigated crop yields increased nearly eight percent over this same period, ranging from 0.4 percent for barley to 83 percent for cantaloupe.

Although the total acreage under irrigation has increased only marginally, producers in Chihuahua have reduced harvested area for the grains, soybean, and cotton crop category by 30,000 acres and forages by 3,000 acres. Vegetables, melons, fruits, and nuts, however, account for an increase of 55,700 irrigated acres, leading to a net gain of 22,700 acres under irrigation, an increase of 3.13 percent. This change in irrigated crop mix was most likely profit driven as producers switched from crops with relatively low prices, such as grain sorghum, barley, rye and soybeans, to those with higher prices, such as alfalfa, cantaloupe, peanuts, peppers, potatoes, and watermelon. It should be noted that many of these alternative crops are more water-intensive than crops previously produced in Chihuahua.

Irrigation water use, while down from its peak of 2.3 million acre feet (maf) in 1997, increased five percent from 1995-99, with the largest increase, 47 percent, between 1996 and 1997. Increased irrigation water use was due to larger acreage of water-intensive crops such as alfalfa, apples, pecans, melons, vegetables, and corn. It is estimated that irrigated alfalfa acreage increased 11 percent from 1999-2001, while production tripled, due mostly to higher yields.

Despite prolonged drought, producers in Chihuahua have continued to grow irrigated crops. Although total irrigated acreage has increased only marginally, producers have switched from crops that use less water to crops that use more water, causing total water use to rise by more than the increase in total irrigated acreage. While Mexico claims that surface water use has fallen, it appears that the use of wells for irrigation has increased. Continued groundwater irrigation in the region will likely reduce stream runoff and limit the flow of water from the Rio Conchos basin into the Rio Grande, though the precise amount is not measurable with existing data.
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Drought in the Lower Rio Grande Valley of Texas (LRGV) and northern Mexico has focused recent attention on the importance of the Rio Conchos watershed as a major source of shared water between the two countries. Trade growth and increased agricultural production spurred by NAFTA, along with an increasing population and industrial base on both sides of the U.S.-Mexico border, have placed greater pressure on the Rio Conchos/Rio Grande water system. In the Rio Conchos basin, agricultural irrigation represented 92.7 percent of total water use in 1995 (Kelly, p. 16). In the LRGV of Texas, irrigation accounts for 85 percent of water use.

Mexican authorities claim that the drought (1994-99) has reduced available water so that they cannot deliver the 350,000 acre feet (af)/year agreed to in the Water Treaty of 1944. Mexico’s accumulated water debt has reached 1.5 million acre feet (maf). Recent articles in the Austin-American Statesman document the growing water shortages in Chihuahua, where many of the tributaries draining into the Rio Conchos originate. Some authorities in Texas and the United States claim that Mexico is in violation of the treaty and are calling for a resolution of the issue. These views are documented in the Brownsville Herald and the McAllen Monitor, and most recently in major news reports by the Associated Press and Washington Post.

The purpose of this study is two-fold:

1. To document recent trends in irrigated production of major crops grown in the Mexican state of Chihuahua, focusing on the drought period 1994-99, and

2. To estimate the amount of irrigation water used in Chihuahua to sustain crop production under semi-arid conditions in the region.

All results reported in this study are preliminary and may change as additional data become available and are incorporated into the analysis.

Chihuahua and the Rio Conchos

Chihuahua is a diverse agricultural production region. Although historically known for production of apples, peaches, and pecans, more recently there has been increased production of peanuts, alfalfa, cantaloupe, and watermelon. Crops are grown under semi-arid conditions. Rainfall averages from 13.8-16.7 inches per year, with two-thirds occurring from May-October, and peak rainfall from July to September (CROPOWAT 7.0). October-January is relatively dry with less than 1.0 inch falling in most months. Since 1960, temperatures at the Chihuahua, Chihuahua weather station have averaged from a low of 50 degrees Fahrenheit in late November through January to a high 80.6 degrees in early June (USDA, FAS, PECAD).

It has been documented that annual inflows to La Boquilla, Chihuahua’s largest reservoir, were 33 percent lower during the period 1994-99, 699,000 af, compared to the long-term historical average, 1.043 maf (Kelly and Comision Nacional del Agua-CNA). The major
irrigation districts in the Rio Conchos basin reduced water use between 42 percent to 15 percent during the drought period (1994-99, Kelly). The Texas Center for Policy Studies report noted that as surface water availability has declined, the use of wells for irrigation has increased. This led to high extraction rates for some of Chihuahua’s major aquifers, with use exceeding recharge by 19 to 127 percent. It is not clear that overuse of these aquifers has reduced water flows into the Rio Conchos and its tributaries, but concerns have been raised about this possibility. Some analysts believe that drought in Mexico and Texas, coupled with increased water use from wells in Chihuahua, likely exacerbated the water problem, leading to reduced water availability for irrigation in the LRGV of Texas and in the Mexican state of Tamaulipas. It was estimated that annual average rainfall in the Rio Conchos basin was 47 percent of normal in 1994 and 69 percent of normal in 1995. For 1993, 1996, and 1997 rainfall was estimated at about 80 percent of normal levels (Kelly from the Brandes Report).

Surface water represents about 20 percent of the available irrigation water supply in the Delicias irrigation district, with the major sources being the La Boquilla and Francisco Madero reservoirs (Kelly). Together, these two reservoirs account for 77 percent of storage capacity in the Rio Conchos basin (Center for North American Studies-CNAS estimate). The San Gabriel and Pico de Aguila supply the Rio Florido irrigation district, which uses primarily surface water for irrigation. The Bajo Rio Conchos district relies primarily on the Luis L. Leon reservoir. CNA estimates indicate that water use efficiency in the Rio Conchos basin is about 40 percent (Kelly). It is likely that these high rates of water loss represent system delivery inefficiencies due to seepage and evaporation in canals as well as irrigation losses due to runoff, wind, evaporation, and improper irrigation water application. It is uncertain exactly what proportion of total irrigation water is represented by surface sources and groundwater throughout the Rio Conchos basin.

**Crop Production Trends**

Irrigated crop production in the Mexican state of Chihuahua has increased 200 percent since 1980, from 1.0 million metric tons (mmt) to 3.0 mmt in 1999 (table 1). Irrigated harvested area increased 35 percent over the same period from 554,613 acres to 750,430 acres. Yields for all irrigated crops increased 114 percent to 4.03 mt/acre. For 1999, grains, soybeans, and cotton accounted for 41 percent of irrigated production in Chihuahua, followed by forages (22 percent), tree nuts, fruits, and peanuts (20 percent), and vegetables (17 percent). It is estimated that irrigated production represents about 82 percent of total agricultural production in the state, but this varies widely by crop.

The peak in irrigated acreage and production in Chihuahua was 1997 when 1,106,341 acres were harvested to produce 4.274 mmt of output (table 1). Since then, irrigated acreage has fallen 32 percent, production is down 29 percent, but irrigated crop yields have declined only four percent. Irrigated corn, alfalfa, cotton, pecans, apples, dry beans, and green peppers represented 73 percent of total irrigated crop acreage in Chihuahua for 1999.
Irrigated corn acreage was 38 percent of total corn acreage in 1999, but accounted for 85 percent of corn production. Since 1995 irrigated corn acreage has increased 23.2 percent, from 123,861 acres to 152,414 acres (table 1). Production of irrigated corn increased 63 percent, while yields were up by 33 percent. Peak irrigated corn production occurred in 1992 at 725,000 mt. Irrigated corn acreage, however, peaked in 1993 at 327,845, with yields peaking in 1999 at 2.784 mt/acre or about 110 bushels/acre.

Mexico’s Servicio de Informacion Y Estadistica Agroalimentaria Y Pesquera (SIAP) reports that for the 2001 crop year Chihuahua’s total corn for grain production was 657,120 mt while total acreage was 560,455. Center for North America Studies estimates of irrigated corn production and acreage are 523,987 mt and 191,115 acres, respectively. The irrigated corn yield for 2001 was calculated to be 2.74 mt/acre or 108 bushels. These estimates assume that irrigated corn acreage was 34.1 percent of total in 2001 which was the average from 1995-99 and that irrigated corn production was 79.74 percent of total corn production, reflective of the same five year average. These estimates would indicate that between 1999 and 2001 irrigated corn acreage in Chihuahua increased by 25 percent and that irrigated corn production was up 23 percent.

Irrigated cotton acreage has declined nearly 10 percent since 1995 and peaked at 158,000 acres in 1997. Irrigated production was off by the same amount, but yields held steady at about 1.43 bales per acre.

Irrigated acreage of soybeans, grain sorghum, rye grass, wheat and barley have all declined over the periods 1990-99 and 1995-99. In 1999 there were only 1,600 acres of barley for grain and 300 acres of soybeans harvested in the state.

Alfalfa is the number one irrigated forage crop produced in Chihuahua accounting for 69 percent of acreage and 64 percent of irrigated forage production in 1999 (table 1). Oats, corn, sorghum, and wheat account for a majority of the remaining output. Alfalfa acreage has increased 14 percent since 1995, but 110 percent since 1990 and was not reported in any significant amount before 1987. Alfalfa production has expanded 64 percent since 1995, while yields have increased 44 percent over the same period. For 2001, SIAP estimates indicate that alfalfa acreage was up by 11 percent in 2001 over 1999, while production nearly tripled to 2.0 mmt with yields up 159 percent to 15.51 mt/acre. Corn, sorghum, and oats forages have all declined in acreage since 1995, but oats forage production has increased by 26 percent due to higher yields.

Tree Nuts, Tree Fruits and Peanuts
Irrigated apples and pecans accounted for 84 percent of tree fruit, tree nut, and peanut acreage in 1999 (table 1). Apple acreage was up nine percent since 1995 and 31 percent since 1990, while pecan acreage increased by 21 and 53 percent, respectively, over the same period. Irrigated apple output increased 17 percent, while pecan production was up 54 percent. Peanuts, the next most important irrigated crop of this category with 20,119 harvested acres in 1999, were up 303 percent in acreage and 313 percent in production since 1995. Peanut acreage also increased 20 percent from 1990-99, while output was up 71 percent over the same period.

**Melons and Vegetables**

Irrigated vegetable and melon acreage has increased 23 percent since 1995 and 177 percent since 1990, while production is up 41 and 255 percent for the same periods (table 1). Peak acreage and production occurred in 1997, with total acreage falling 30 percent and production off 18 percent since then. Irrigated dry beans, green peppers, and onions accounted for 73 percent of total irrigated reported vegetable acreage and 64 percent of irrigated vegetable production. Potatoes, dry peppers, watermelon, cantaloupe, and tomatoes represent the other major vegetable crops grown in the region. All other vegetable crops reported declines in acreage and production, but accounted for only 1,600 harvested acres.

The largest proportional increases in vegetable and melon acreage were for watermelon, dry peppers, potatoes, cantaloupe and onions. Acreage increases for 1995-99 ranged from eight percent for tomatoes to 116 percent for watermelon. Increases in irrigated production (1995-99) ranged from 230 percent for watermelon and 110 percent for cantaloupe to 96 percent for potatoes and 43 percent for onions. Irrigated production of tomatoes and dry peppers experienced declines of 31 and 11 percent, respectively.

Over the 1990-99 period irrigated watermelon acreage was up 600 percent, followed by tomatoes (517 percent), dry beans (151 percent), cantaloupe (132 percent), green peppers (120 percent), and onions (61 percent). Production increases over the same period were 891 percent for watermelon, 702 percent for tomatoes, 452 percent for cantaloupe, 180 percent for green peppers, 160 percent for dry beans, and 83 percent for potatoes.

**Summary**

From 1995-99, producers in Chihuahua have reduced harvested area for the grains, soybean, and cotton crop category by 30,000 acres and forages by 3,000 acres. Vegetables, melons, fruits, and nuts account for an increase of 55,700 irrigated acres, leading to a net gain of 22,700 acres under irrigation, an increase of 3.13 percent. This change in irrigated crop mix was likely profit driven as producers switched from crops with relatively low prices, such as grain sorghum and soybeans, to those with higher prices, such as alfalfa, cantaloupe, peanuts, peppers, potatoes, and watermelon. It should be noted that many of these alternative crops are more water-intensive than crops previously produced in Chihuahua.
Estimated Irrigation Water Use

Irrigation water use estimates were derived using irrigated acreage numbers from the above analysis and applying them to the CROPWAT model version 7 developed by the Food and Agriculture Organization of the United Nations. CROPWAT 7 calculates irrigation water use for various crops after accounting for local evapo-transpiration rates, water use efficiency, rainfall, soil type, and optimum yields for each crop. To estimate water use in Chihuahua, CROPWAT was adjusted to reflect actual evapo-transpiration rates for Chihuahua based upon semi-arid climactic conditions, local rainfall amounts, a medium soil, 50 percent water use efficiency, and optimum yields for each crop analyzed. Data were lacking for four crops, potatoes, cucumbers, other fruits, and other vegetables, so the estimates in this report reflect a lower bound for the actual irrigation water used in the state. It should be emphasized that these estimates are preliminary and may change as this analysis is refined.

Total estimated irrigation water use in Chihuahua has nearly doubled since 1980 from 1.2 maf to a peak usage of 2.3 maf in 1997 (table 2). Since 1980, average annual irrigation water use increased by five percent each year up to the peak usage. The single largest year-to-year increase in the use of water for irrigation occurred from 1995 to 1996 when usage expanded by 47 percent, likely due to worsening drought conditions in the Rio Conchos basin. Since 1997, irrigation water use has fallen to 1.58 maf in 1999, a drop of 31 percent. Between 1995-99 irrigation water use increased five percent, indicating that while reservoirs in the Chihuahua may have fallen due to drought, producers switched to underground water sources for irrigation.

Five crops used 1.173 maf of irrigation water in 1999 and accounted for 74 percent of irrigation water use. In order of importance, these were: corn (293.6 thousand acre feet-taf), alfalfa (261 taf), cotton (224.2 taf), apples (193.9 maf), and pecans (174.8 taf) (table 2). Among these top five crops, water use per acre ranged from a low of 1.92 af for corn to a high of 3.38 af for apples. Due to relatively low water delivery efficiency in most of the region and to low water use efficiency on farm, these per acre usage figures could increase as this analysis is refined to more accurately reflect the actual efficiency of water use in the region. It has been estimated that 90 percent of the alfalfa and most of the pecan orchards in the region are flood irrigated, leading to relatively high rates of water loss due to runoff and evaporation (Kelly and Personal interview, Julie Watson Associated Press 5/1/02).

Green peppers, grain sorghum, and wheat together used 197.3 taf of irrigation water in 1999 (table 2). Other major crops using irrigation water were oats, dry beans, onions, peanuts, and watermelon, which together used an estimated 159.3 taf of irrigation water in 1999. Dry peppers, tomatoes, peaches, rye grass, and cantaloupe accounted for most of the remaining irrigation water use. Among these crops, peaches is the most water intensive on a per acre basis.
(3.38 af), followed by tomatoes (2.91 af), cantaloupe (2.03 af), dry peppers (1.76 af), and rye grass (1.03 af).

**Conclusions**

Despite prolonged drought, irrigation and agricultural production have continued in Chihuahua, Mexico. While total irrigated acreage has declined 32 percent from the peak in 1997, it has increased over the period 1995-99 by three percent, while irrigated production rose 11 percent. Producers have switched from relatively low profitability crops to alternatives that are more profitable and more water-intensive. As a result, irrigation water use, while down from its peak of 2.3 maf in 1997, increased five percent from 1995-99, with the largest increase, 47 percent, between 1996 and 1997. It is estimated that irrigated alfalfa acreage has increased 11 percent from 1999-2001, but production tripled due to higher yields. It is uncertain what proportion of total irrigation water is from surface and groundwater sources. Increased use of aquifers in the Rio Conchos basin, however, will most likely lower the water table in the region, leading to reduced runoff and less surface water availability downstream in the Rio Grande River.
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