ECONOMIC VALUE OF WATER IN THE RIO BRAVO BASIN (MEXICO): THE CASE OF BAJO SAN JUAN, JUAREZ AND SALTILLO

Final Report

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Economic Value of Water in the Rio Bravo Basin (Mexico): The Case of Bajo San Juan, Juarez and Saltillo

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3. Regional Output and Economic Value of Water (continues)

1. Water Requirements and Regional Output: A Methodology for Determining the Economic Value of Water

In the Rio Bravo Basin large urban settlements have thrived. In this region, manufacturing and services bear the overwhelming weight in the local output. Being water a scarce resource in this region, the present study addresses its role in the generation of value through three selected locations.

By means of official statistics, this paper estimates the level of economic output in terms of value added for the main economic activities. The purpose of this estimate is to relate the above mentioned generation of value to the quantity of water required with reference to specific economic sectors at a local level. The evaluation of water use provides elements of analysis to establish priorities in a quantitative fashion utilizing an aggregation approach, while resorting to macroeconomic concepts. A strategy for stimulating specific economic activities, while inhibiting others, including even the possibility of compensating affected parties, is to be a means to attain a better use of water to enhance the economic and demographic development in the basin.

The methodology used in this paper for assessing the economic value of water is made explicit from the outset. Here, water is dealt with exclusively as an *input*, in which case the value added by economic activity is related to the quantity of water required. This last amount can be established either by direct observation in the case of surface crop production, or else, by derived data.[1] After expounding this approach by sector of analysis, consideration is made for water as a non-produced input, with reference to water provision and distribution, as well as assimilative services. Further, water is considered as a final good, being the case for residential use and recreation activities. Finally, private and social values of water are detailed.

Regarding irrigated crop production, data is available regarding both gross and net water requirements in the case of irrigation districts, i.e. superficial water.[2] In the case of groundwater, no official statistics are collected. Therefore, benefit transfer is to be done from nearby districts. For mining, net water demand was estimated on the basis of

[1] A previous version of this methodology is found in Goicoechea (2005).
[2] CNA 2004b.

Canadian information.[3] As far as industrial activities are concerned, information from the United States was used.[4]

In-stream use has been dealt with through its specific acitivities, i.e. fisheries and aquaculture, hydro-power generation, navigation, assimilative services and recreation.

Due to data availability, no distinction is made regarding gross and net value added.[5]

1.1. Water as an Economic Input

Agriculture

Irrigated Crops

In order to estimate the value added per unit of water withdrawn, the following calculations have been made. Based on data by crop, which is specified indicating the source, the transformations to which data is subject, is further specified.

A. Data by crop

a) Harvested area, physical output and value of production by crop and location, by cycle (autumn-winter and spring-summer), and perennial. This information is obtained through CNA 2004a and SAGARPA 2003.
b) Hectare-centimeters of water, gross and net by crop and location, by cycle and perennial. In this case, direct observation for surface crops have been utilized (CNA 2004b) and transfer benefit for groundwater;
c) Costs or production, according to FIRA (on line), in order to deduce value added as share of gross output;
d) Price index by cicle and perennials, available on line at Banco de Mexico.

B. Transformations by crop

i) Value added coefficient:

(labor compensation+profits)/value of production

[3] Tate and Scharf, 1995.
[4] U.S. Geological Survey.
[5] That is to say, depreciation of fixed capital estimates in Mexico is done only at an aggregate basis for the economy as a whole, i.e. 72 economic activities. No data is available for industrial activities. Besides, since 1994, Banco de Mexico has interrupted the estimation of the stock of capital in the country.

ii) Value added:

value of production*value added coefficient/price index

iii) Water requirements:

meter-hectare of water*harvested area

iv) Economic value of water for crops:

value added/cubic meters of water

Rainfed Crops

In the present evaluation, water is considered as a natural resource previously stored, and extracted if it is the case, besides being conveyed and applied as an input by manpower. Not being the case with rainfed crops, the economic value attributed to water is nil. However, within an economic analysis by location, the value added generated in this activity is considered within the local product, contributing to the local economy and hence, to the performance of the region as a whole.

Livestock

In the case of livestock, data has been obtained through INEGI 2003a, 2003b, 2003c, with the exception of the price index, which is available on line at Banco de Mexico.

A. Data

a) Number of heads by specie;
b) Value of animals slaughtered by specie;
c) Value of livestock by-products by kind;
d) Derived water demand by head of specie;
e) Derived value added coefficient, as a share of the value of production;
f) Price index, by specie slaughtered and by-product.

B. Transformations

Value added (by specie and by-product):

value of production*coefficient of value added/price index

Livestock water demand:

water demand by head of specie*number of heads

Economic value of water for livestock

value added/water use

Forestry

As in rainfed crop production, in forestry water is a natural event. Therefore, no economic value is imputed to water. It contributes to the local generation of value, for which it is explicitly credited.

Official schemes oriented towards the payment for environmental services are an option, considering the relevance of this sector in the preservation of acuifers.

Fisheries and Aquaculture

In the production of any good or service an object of production as well as a means of production is required. Here, water ought to be considered as an economic input when these two –object and means- stand each on its own. In the case of fisheries and aquaculture, both elements constitute are bound together.[6] Therefore, no economic value is imputed to water. The generation of value for which fishing and aquaculture contribute, is duly accounted.

Mining, Manufacturing, Construction and Private Services

First, the data by sector is outlined, while the transformations to which is subject is detailed as follows:

A. Data by sector (two digits)

a) Value added, based on Censos Economicos 1999, available on line at INEGI;
b) Employees, from the same source as (a);
c) Derived water demand by employee, based on Tate and Sharf (1995) for mining, and U.S. Geological Service online for the rest;
d) Price index, by branch of industry, according to Banco de Mexico, on line.

B. Transformations

Value added:

[6] This is in so far as water, as a means, cannot be detached from the object of production, i.e. the fish before it is caught.

value added/producer price index

Water requirements:

water demand by employee*employees

Hydro-power Generation

In generating electricity, water becomes a means to produce this fluid, i.e. volume of water for a unit of electricity, as well as the scale of turbines. Being dams an edification upon an orographical facility, water efficiency to produce it derives in differential rents in the same manner as a fertile mine *vis a vis* a non-fertile one.

To estimate the value added generated locally, data from the electricity board at a national level could be used. Nevertheless, it would be advantageous to have access to information regarding the value of production and how is integrated according both to scale of production as well as the energy source.[7]

Navigation

Transport by this mode is included within the census data, in which case its contribution will be accounted for. As water is not applied as an input by man, no economic value is attributed.

Up to here, water has been considered as an economic input for the provision of goods and services, in which case its economic value has been estimated based on the value added obtained.

Tourism

Although there is no economic data for tourism broken down in locations, i.e. classified by municipality, the activity of lodgings and restaurants are taken, explicitly, as a proxy for this economic activity. In this case, both data variables and subsequent transformations are similar to private services.

[7] That is to say, steam, turbogas, internal combustion, geo-thermal, coal, nuclear, eolic etc.

In brief, the evaluation of water in conducting economic acitivities has been made considering value added and the volume of water required. The standard alternative course of action to evaluate the value of water is the so called residual method. This approach assumes that water yields an economic rent, as a sort of economic surplus that the user or owner of the water receives.

Criticisms

The methodological approach laid out here, which at the same time is used throughout this paper, i.e. estimating the value aded per unit of water withdrawn, is strenously criticised by Young (2005). According to this author, this method at most has a useful descriptive meaning from a narrow regional stance, representing payments to the primary inputs processed by factor owners in the region. Three main objections are put forward by this author.[8]

a) It overstates the contribution of water by including the payments for all primary inputs, i.e. wages and salaries, interest, profits and rents, besides taxes and capital depreciation. Therefore, it clearly yields a large overstatement of its correct value;
b) Payments to factors of production, i.e. capital and labor are incorrectly treated as income or benefits. They should actually be understood as opportunity costs;
c) For intersectoral transfers and public investment in water supply, i.e., water policy issues of primary interest, value added is not a measure commensurate with benefits of transferring water from low to high value added uses, or the cost of supply of investments.

In the end, Young suggests even dropping the term value added, calling it instead “pricing factor incomes”, in so far as the first term is confusing for non economists. This author concedes that this method can be, at the most, an initial stage in the process of estimating the value of the marginal product of water in the long run, in the purpose of obtaining the residual return to water.

The first objection of Young is that water contributes to the value of the product but not as much as this measure claims. However, the “correct” value that this author upholds is a residual. That is to say, Young assumes that water yields or has to yield a rent (or quasi

[8] Young, 2005, p. 92

rent), in so far as it is mainly a fixed or limited input.[9] It is not clear why water should yield a rent because of its fixed nature, particularly in agriculture, where traditional irrigation technique do not treat it as a scarce resource, far less a fixed one, considering the widespread irrigation methods even in regions with serious droughts. While Young clarifies that it is in irrigated agriculture where water rents best reflect this situation (p.68), it would be interesting to know how relevant is this argument in the face of drip irrigation, plastic crop production and the myriad of water saving techniques in this field, not to mention technical possibilities and financial stimulus for water reuse in other sectors, i.e. industrial activity.[10]

The second objection according to Young, is of a normative nature, claiming that factor incomes should be regarded as opportunity costs, while through this approach, both are implicitly treated as income or benefits. In macroeconomics, whether it is regional or national, it would appear that both are dealt with as income or benefits, as any textbook in the subject can attest. However, Young appears to overlook that the fact that the value added, as an aggregate of goods and services produced by economic agents, is indepedent of being factor payments, i.e. rents or benefits to the factor of production owners. In the same normative venue, it could be stated that value added should be considered as aggregated output, besides opportunity costs of its elements and sources of revenue.

Regarding the third objection of Young, no doubt that the ratio of value added to unit of water withdrawn need not be a commensurate measure of the benefits derived from intersectoral transfers or supply investments. It attempts to expose the impact of aggregate value generation in terms of output, *vis a vis* water demands. More than an objection, this point of Young is a pertinent caveat to further analyze and substantiate impacts.

[9] P. 68. In an enlarged production function construed by the author (p. 60), output is a function of purchased materials and equipment (M), human input, e.g. labor (H), equity capital (K); other natural resources, such as land (L); and water (W), the residual claimant.

[10] There is a Neo-Malthusian flavor in Young´s analysis of water yielding a rent. If his analysis is static, of course water supply is unavoidably fixed or limited. Within this logic, he would be assuming what he attempts to prove.

1.2. Water as a Non-produced Output

Water Provision and Distribution

Water is not a produced good,[11] therefore there is no cost of production, strictly speaking. There could be a cost of abstraction, storage, transport, distribution, and even of restoration, i.e. it has to be moved from the source to the market. As a result, water is already a produced output. The value added of which water is subject, is part of the value of this good, as established in economic accounting.

Distinction ought to be made between its use and plausible replenishment, versus its abuse or overexploitation in terms of volume, for which a negative externalilty is implied. Quality deterioration conveys a deleterious effect, which has to be accounted for. Be it in terms of quantity or cualitatively speaking, the cost of restoration is to be estimated and established. This is not the case when a detrimental natural occurence appears in water, for instance, the presence of arsenic, or brackish aquifers. In this case, the cost of removal, if incurred, is part of .the process of making it drinkable.

Water is used for irrigation and urban water supply. In the last case, its contribution to value added is made explicit through water treatment costs. When used for irrigation, the pumping costs are incorporated in its value. No value as such is attributed to water as an output. However, a treatment for disinfection to make it drinkable, for instance of, becomes a value added to be accounted for as a component of its price.

Assimilative Services

Value of water is estimated here in terms of current costs for its treatment in order to fully restore it. That is to say, third party effects are estimated in terms of the difference between its full cost and expenses for current insufficient or incomplete water treatment, if this were the case

1.3. Water as a Final Good

In this last part of this appendix, water is considered as a final good. If it has been treated before to become drinkable, i.e. for residential uses and public services, its economic value of production has already been estimated. If, however, water is used for recreation,

[11] In the sense that forms a given stock, it cannot be multiplied. However, the quantity required can be reduced through efficiency, whether in production of goods and services, or in final consumption.

the importance of this activity is not subject to regional accounting, a common denominator of the valuation made in this work.

Residential Uses

When drinking water is being used as a final good through the physical network of a urban location, no value is generated. Its cost has already been considered when treated, and distributed. It is in this role that contributes to the value added by the branch of activity which provides it. Finally, it is consumed when demanded by households and public services, for which no extra value is imputed.[12]

Recreation

No economic value is attached to recreation uses of water. In this paper, water systematically enhances its own value or that of the products it helps to create when used as an input for production, but not in final consumption. Therefore, no value is attributed for water in this activity. Only its importance is to be briefly described in terms of heterogenous goods and facilities available for this service.

Summing up what has been outlined in this section, water is being considered as a non-produced output. In this sense, not bearing a cost of production, it is subject to modification by man in terms of location and eventually, treatment to insure it is safe for human consumption. In this manner, a value added has been incorporated, as a standard calculation of regional or national economic accounting.

In estimating the economic value of water, it must be an input, applied *ex-profeso* by manpower in producing a good or service. Being an input, as a means to produce it has to be independent of the object of production. With this proviso, its economic contribution is estimated as a ratio bewteen the value added and the quantity of water used.

As a final good, there is no further accounting for the value of water, in order to avoid double counting.

[12] As it is frequently reminded, double counting ought to be avoided.

1.4. Private and Social Values of Water

Water Allocation by Sector

A. Irrigated crops

At present, the private value of water in Mexico is nil. Implicitly, it is being assumed that being a renewable resource, both it terms of quantity and quality, whether it is derived from superficial or ground water, it is self-replenished. This approach does not take into account the excessive allocation of irrigated land in the case of surface water, or overexploitation of acuifers.

The social cost of water used in crop production could be considered two-fold. First, by estimating the differential between the value added per unit of water of a specific group of crops, with the group of highest value added per unit of water. This method would bring into evidence the high oppportunity costs of producing cereals and other low income crops. This first procedure would underline the disparity of water use, as cereals and grains often tend to draw a substantial amount of water with resulting in modest amount of value added. This approach would also imply the convenience of introducing high value added crops, in order to make better use of the water. Unfortunately, this is not of an enticement, despite the convincing rationality involved, assuming a higher value of the crop and an increase in profits. In this case, a compelling force would imply the competitivenes of the crops under cultivation with imports, taking into account tariff barriers, or even if they are fully abolished.[13]

A second approach to estimite the opportunity costs of water in crop production would be by comparing specific group of crops with the average value added per cubic meter obtained in the location. This might suggest curtailing irrigated crop production altogether, particularly with a well developed manufacturing and service sectors competing for water, let alone the urban population and its water requirment for human development.

[13] According to NAFTA rules, by 2008 trade barriers for agricultural products will be abolished (OECD 1997). The price gap between Mexico on the one hand, and Canada and the US on the other, would place serious hindrances for the remaining production of basic crops in Mexico, both due to the chronic overvaluation of the Mexican currency and a gap in physical yields. This legal decision on trade barrier removals, could be the single most important element in reducing water demands in Mexican crop production, as imports would increase considerably, assuming there are enough loans for Mexico, facing recurrent trade and current account deficits.

B. Rest of economic activities

In the case of Mexico, the availability price and quantity per cubic meter by location is provided on an aggregate basis,[14] i.e. without detailed information by kind of user.[15] The private cost of water, taken as the average price charged by the water board, implies a considerable bias.

An alternative course of action would be to estimate the difference between the average price paid for a cubic meter obtained by the specific economic activity, and the weighted average in the location, to be taken as the opportunity cost for every unit of water used. This comparison is considered equitable, in so far as it takes into account the performance of a location, on average. If opportunity costs were to be calculated on the basis of the highest economic value added yielded by water, it would reflect the most efficient use of water. However, it would be highly unequitable for the rest of activities, i.e. non-manufacturing.

Residential consumption is not subject to this comparison, in so far it is not oriented towards production. However, its price currently paid will be given as a terms of reference to compare it with other uses.

Wastewater by Source

A. Irrigated crops

Elimination of residuals of fertilizers and pesticides in in water which has been used for irrigation, is not binding in Mexico. As these residuals are being poured into the Río Bravo, it conveys an externality to be coped with. The cost of treatment for urban supply water becomes a proxy for this negative externality.

B. Rest of economic acitivities

The rest of activities, besides crop production, require a primary assimilative service for wastewater. Considering that wastewater might be subject to a partial treatment, the difference between what is spent at present and its primary assimilative service is to be considered as an external cost. In the case of Mexico, it is estimated a primary wastewater

[14] Annual physical output (cubic meters), invoicing and gross revenue by the local water board.
[15] CNA 2004d.

treatment of US$0.64 per cubic meter. The treatment currently provided (activated sludges and stabilization lagoons), is estimated at US$0.09 per cubic meter.[16]

Full pricing cost of treated water, while it is efficient, might not be equitable. Therefore, a progressive rate structure could avoid the regressive nature of a flat water rate. The differential among various uses is to be considered, subject to the accesibility of data.

1.5. Location Selection

In selecting the locations for the Rio Bravo basin, two basic considerations were made.

a. Crop production demands a disproportionate amount of water, while it has a meagre contribution in terms of value added.

b. Alongside, non-crop production economic activities are substantial, basically manufacturing and private services, besides a large population, all of which compete with crop production due to water scarcity.

c. Intersectoral transfers of water within the location are plausible, besides economically grounded, in order to improve its effect in the generation of value.

If a specific location does not have room for water sectorial transfers, it implies that no activities with low value added are present. For instance, if irrigated crop production takes place, it should rely on sewage. However, consideration should be made, in particular, to alternative sources of water supplies, outside the location.

[16] According to local experts, a primary treatment at present costs seven pesos, while the basic ones currently applied cost one Mexican peso.

2. Introduction

This paper evaluates the economic value of water in three representative locations located in the Rio Bravo Basin. Formally known as the Bravo-Conchos, this basin overlaps across five Mexican states,[17] beneath the Rio Bravo in northeastern Mexico.

The economic value of water is estimated as the ratio between the value added in each economic activity, and the amount of water required. Both components of such regoinal evaluation are outlined beforehand, in order to place in context the importance of the natural resource under consideration.

The first location selected is Bajo San Juan, in the northern part of the state of Tamaulipas, 100 kilometers away from the Gulf of Mexico, where the Rio San Juan, from where it takes its name, joins the Rio Bravo. This location spreads over six municipalities.[18] The most important one is Reynosa, whose capital, bearing the same name, is a leading population center.[19] Besides, this town is a foremost maquiladora location,[20] along with two other towns in the state of Tamaulipas.[21] This location depends form the El Azucar dam whose main purpose is the irrigation of low value crops,[22] besides urban water supply. In this last respect, the Rio San Juan also contributes to the urban water supply of Monterrey, political capital of the neighbouring Nuevo Leon state, through El Cuchillo dam, with three quarters (74.8%) of its water requirements. Local acquifers in the location are subject to brackish groundwater. In so far as Monterrey has no room for intersectoral transfers,[23] increases in its supply are to be arranged exogenously through the Bajo San Juan location.

[17]That is to say, Chihuahua, Durango, Coahuila, Nuevo Leon and Tamaulipas.
[18]Camargo, Gustavo Diaz Ordaz, Mier, Miguel Aleman, Reynosa and Rio Bravo.
[19]Populated with 435 thousand inhabitants. It has a similar population to Matamoros (425 thousand), a border town across Brownsville, Texas.
[20]Temporary in-bond import of intermediate goods free of duty, undergoing a labor-intensive assembly process to be further exported.
[21] Matamoros and Nuevo Laredo (across Laredo, Texas), are the other two key centers for offshore assembly production in Tamaulipas.
[22] Irrigation district No. 26, with a strong presence of feed grains.
[23] While 5,000 Hectares of irrigated crops -mainly low value added pastures- took place in the metropolitan area of Monterrey (3.3 million inhabitants in 2003), using the residual water generated by this metropolis, estimated at 183 Mm3 per year.

A second location for this study is Juarez, in the state of Chihuahua, located at the inception of the Rio Bravo in Mexican territory.[24] It is composed of three municipalities, i.e. Guadalupe, Juarez and Praxedis G. Guerrero. Ciudad Juarez, capital of the municipality of the same name and the largest city in the state.[25] It is the most important maquiladora center along the Mexico-U.S. border. Four fifths of its water supply comes from in-stream Rio Bravo derivation, The remaining is supplied from the local acquifer, jointly exploited with El Paso, Texas, as both cities are located across each other, with the river in between, being a permanent source of strain as far as water supplies are concerned.

Both locations, Bajo San Juan and Juarez, are directly affected by the water treaty whereby Mexico is to deliver to the United States 431.7 cubic hectometers annualy, computable on a five year cycle basis. Considering water availabilities and local consumption, Mexico has not fulfilled this committment. As a result, this is an additional impending difficulty for the economic and demographic feasibility of the location. One of the objectives of the present paper is to evaluate the economic use of this resource in the above mentioned locations, putting forward alternatives to increase the generation of value, alongside the possibility of reducing the level of water consumed in the basin.

A third location is located in the south-east portion of the state of Coahuila, comprising the municipality of Saltillo, the political capital of the state, as well as the adjacent Ramos Arizpe. Besides its administrative importance, Saltillo is a leading demographic center,[26] with a well developed non-maquiladora industrial activity. It is 241 kilometers away from the nearest US border.[27] For its water supply, this location is wholly dependent on the overexploited Saltillo-Ramos Arizpe acquifer.

[24]That is to say, where the Rio Grande, as it is known in the United States, divides the states of New Mexico and Texas, prior of being the watershed between Mexico and its northern neighbour.
[25]1.3 million inhabitants.
[26]Being the largest city in the state, it has 608 thousand inhabitants, along with 33 thousand in Ramos Arizpe.
[27] Roma, Texas.

3. Regional Output and Economic Value of Water

Key economic patterns of irrigated agriculture are set forth, through the value added for irrigated agriculture classified by crop groups, i.e. cyclical (autumn-winter and spring-summer), as well as perennials. Afterwards, the same exercise is undertaken for different livestock species and its products. Fisheries, mining, manufacturing, building and private services, undergo a similar analysis. The data is presented for each of the three locations, each one being an aggregation on the basis of its municipal activiity.

3.1. Crop Production

3.1.1. Irrigated Crops

3.1.1.1. Crop Groups

Area Harvested

During the crop year of 2003,[28] Bajo San Juan harvested 66.8 thousand hectares. In terms of harvested area, crop production was conducted overwhelmingly during the autumn-winter cycle (97.9%). Perennials covered only 2.1% of the area.[29] Out of the 10.5 thousand hectares harvested in Juarez, more than half (51.9%), was ploughed during the spring-summer cycle, while 31.3% of the area was cultivated with perennials. The remaining 16.8% refers to the area harvested during the autumn-winter cycle. Saltillo is the smallest of the three locations in terms of area harvested, with 6.1 thousand hectares during the 2003. In this location, 54.8% was devoted to perennials. The spring-summer cycle covered 31.1% of the area, while the remaining 14.1% corresponds to the autumn-winter cycle.

Table 1. Irrigated Crop Groups. Area Harvested. 2003 (Hectares and percentage)

	Juárez		Saltillo		Bajo San Juan	
TOTAL	10,523	100.0%	6,070	100.0%	66,826	100.0%
	7,228	68.7%	2,744	45.2%	65,417	97.9%
Autumn-winter	1,769	16.8%	856	14.1%	-	-
Spring-summer	5,459	51.9%	1,888	31.1%	65,417	97.9%
Perennials	3,295	31.3%	3,326	54.8%	1,409	2.1%

Source: Based on CNA 2004a and SAGARPA 2004

[28]Comprising form October 2002 to September 2003 for cyclical crops, and the calendar year, i.e. 2003 for perennials.
[29]No crop was cultivated in Bajo San Juan during the spring-summer cycle.

In terms of area harvested, the difference among the three locations is considerable. For instance, in 2003 Bajo San Juan ploughed 11 times more than Juarez. While the last one mentioned and Saltillo expose a more even distribution of crop groups with perennials and within cyclical crops, the Bajo San Juan is heavily concentrated in the autumn-winter cyclical, suggesting scant heterogeneity in its crop mix.

Water Consumption

Distinction is made between gross water consumption, i.e. considerig the total water use for irrigation on the one hand, and net water consumption, once its return flow has been taken into account. These estimates are the result of an aggregation of gross and net water demands for each one of the crops cultivated in the three locations under study, through official data (CNA 2004b).

Table 2. Irrigated Crop Groups. Water Consumption. 2003
(000 cubic meters and percentage)

	Juárez		Saltillo		Bajo San Juan	
Gross Water Consumption						
TOTAL	131,019	100.0%	65,904	100.0%	387,223	100.0%
Cycle	75,647	57.7%	22,747	34.5%	378,623	97.8%
Autumn-winter	17,518	13.4%	6,061	9.2%	-	-
Spring-summer	58,129	44.4%	16,686	25.3%	378,623	97.8%
Perennials	55,372	42.3%	43,157	65.5%	8,600	2.2%
Net Water Consumption						
TOTAL	75,027	100.0%	33,374	100.0%	210,123	100.0%
Cycle	43,632	58.2%	11,065	33.2%	207,498	98.8%
Autumn-Winter	10,423	13.9%	2,932	8.8%	-	-
Spring-Summer	33,209	44.3%	8,133	24.4%	207,498	98.8%
Perennials	31,395	41.8%	22,309	66.8%	2,625	1.2%

Source: Based on CAN 2004a, CNA 2004c and SAGARPA 2004

Gross Water Consumption

Water consumption in the Bajo San Juan was 387,223 thousand cubic meters in 2003. Most of it (97.8%) went for the autumn-winter crops, while only 2.2% was used in perennials. In Juarez, water demands were 131,019 m^3. Over two fifhts (44.4%) went to spring-summer crops, while an almost equivalent portion (42.3%), was used for perennial crops.[30] Irrigated crops in Saltillo consumed 65,904 thousand m^3, of which almost two thirds (65.5%) was required by perennials, and 25.3% for spring-summer cycle crops.

Bajo San Juan consumed almost six times more water than Juarez, both located alongside the Río Bravo. Irrigated crop production in the first one is supplied by surface water in its entirety, while in the second case, fourth fifths are provided by the river itself. The remaining one fifth in Juarez is groundwater (CNA 2004a).

Net Water Consumption

Taking into account ground returns, water consumption represents 54.3% of the total amount irrigated in the Bajo San Juan. That is to say, 210,123 thousand cubic meters. In Juarez, net consumption of water was 75,027 thousand m^3, averaging 57.3% of gross water irrigated. In the case of Saltillo, net consumption was 33,374 thousand cubic meters, i.e. 50.6% of the total amount irrigated.

Table 3. Irrigated Crop Groups. Net Water Consumption. 2003 (Meter-Ha)

	Juárez	**Saltillo**	**Bajo San Juan**
TOTAL	0.71	0.55	0.31
Cyclical	0.60	0.40	0.32
Autumn-Winter	0.59	0.34	0.00
Spring-Summer	0.61	0.43	0.32
Perennials	0.95	0.67	0.19

Source: Based on CNA 2004a, CNA 2004b and SAGARPA 2004

Regarding net water consumption by area, Juarez uses 0.71 meters-hectare, followed by 0.55 m by hectare in the case of Saltillo. The requirments of Bajo San Juan are a scant, i.e. 0.31 meters-hectare. In this last location, during the spring-summer cycle, the demand

[30] The remaining 13.4% of the water was consumed by autumn-winter crops.

for water remains at the same level for this location as a whole, being reduced to 0.19 m in the case of perennials.

The largest heterogeneity of water consumption by area is evinced in Juarez. In this location, perennials required 0.95 meters-hectare, and 0.59 meters-Ha. for the autumn-winter cycle. For the spring-summer crops, consumption reaches 0.61 meters-Ha. In the case of Saltillo, perennials averaged 0.67 m per hectare, while it was 0.34 m per hectare for the autumn-winter cycle, and in between, the spring-summer cycle crops with a net consumption of 0.43 m per hectare.

Linkages between Irrigation Water and Area

The Bajo San Juan and Juarez irrigation districts overwhelmingly depend on the supply of water by the Rio Bravo. Being a renewable resource, the supply of water for these two irrigation districts expose a considerable degree of variation, while they bear the bulk of fluctuations, considering its availability. That is to say, due to water shortages water demand has fallen to 110.1 Mm^3 in 2000, while reaching a maximum of 739 Mm^3 in 1989. In the case of Juarez, a minimum of 94.5 Mm^3 was available in 1998, while a maximum of 255.6 was experienced in 1995. In the case of Saltillo, there are no time series available to evaluate its performance.

Table 4. Bajo San Juan and Juarez Irrigation Districts. Water and Area. 1986-2003 (000 m^3, hectares and meter-hectare)

	Bajo San Juan			Juarez		
	Water (000 m^3) (1)	Area (Has) (2)	Meter-hectare (3) = (1)/(2)	Water (000 m^3) (4)	Area (Has) (5)	Meter-hectare (6) = (4)/(5)
Mean	338,290	62,754	0.54	191,852	14,926	1.29
Maximum	739,010	83,332	0.89	255,620	20,452	1.25
Minimum	110,100	37,191	0.30	94,506	6,845	1.38
log(std dev)	4.69	3.62	-0.72	4.16	5.22	-0.77
Trend*	-5.7%	-2.7%	-3.0%	-4.4%	-2.5%	1.9%

* Estimates are reported in Appendix 3.
Source: Based on CNA 2004f.

When examining the pattern of water available for agriculture and the area under cultivation, there are various elements which must be made explicit. For the period 1986-2003, there is a long term trend of water reduction in both districts. At the Bajo San Juan, water constraints have resulted in a reduction rate (-5.7% on a yearly basis), more than twice compared to Juarez (-2.5%). In contrast, the Juarez district reduced its area under cultivation at a rate of 4.4% yearly, while Bajo San Juan diminished its acreage by -2.7%. As a result, this last location reduced its hectare-meter requirements by 3% yearly, while Juarez was even able to increase it by 1.9% per year, on average, during the above mentioned period.

The heterogeneity both of water requirements and area under cultivation, as well as the ratio derived thereof, is measured by the logarithm of the standard deviation. While Juarez bears a higher heterogeneity than Bajo San Juan, it also exposes a larger variance in terms of area, and as a consequence, of the rate of both. The aggregate response of Juarez has been to reduce the area under cultivation at a higher pace than Bajo San Juan (-2.7%), despite a lower rate of water abatements. At the same time, Juarez even increased water volumes by area at a rate of 1.9%, while Bajo San Juan constrainted such relative volumes at 3% on average. In this respect, Juarez exposes an example of successful adjustment in terms of water constraints.

The above results are confirmed when the area under cultivation becomes a function of the water supplies. For instance in the Juarez district, the acreage with respect to water exposes nearly a unit elasticity (0.86), while it is ostensibly inelastic in the case of Bajo San Juan (0.24).[31] While in both cases water and area are reduced, Bajo San Juan shows considerable resistance to abate its area under cultivation when water supplies are curtailed. In the same fashion, as a district, Bajo San Juan would seem to be far less adept to react increasing the crop acreage when more water were to become available.[32]

Value Added

In what follows, the value added by irrigated crop groups is considered first. Afterwards, the ratio between value added and the area harvested is obtained.

[31] The statistical results are reported in Appendix 3.

Table 5. Irrigated Crop Groups. Value Added. 2003 (US$ 000)

	Juárez		Saltillo		Bajo San Juan	
TOTAL	9,976	100.0%	14,087	100.0%	24,317	100.0%
Cyclical	5,599	56.1%	4,471	31.7%	24,132	99.2%
Autumn-Winter	1,025	10.3%	670	4.8%	-	-
Spring-Summer	4,574	45.8%	3,802	27.0%	24,132	99.2%
Perennials	4,377	43.9%	9,616	68.3%	185	0.8%

Source: Based on Banco de Mexico, 2005, FIRA 2005 and SAGARPA 2004

Bajo San Juan produced 24,317 thousand dollars of irrigated crop output in 2003.[33] Allmost all of it (99.2%) came belongs to the autumn-winter cycle. The participation of perennials in value generation was close to nil (0.8%). Saltillo contributed with 14.1 million dollars, while Juarez almost reached 10 million dollars. In the case of Juarez, more than two fifths of the total output is due to spring-summer cycle (45.8%) and to perennials (43.9%).[34] In Saltillo, almost two thirds of the value added comes from perennials (68.3%), while more than one fourth (27%) belongs to the spring-summer crops.[35]

Considering the amount of value added in irrigated crops among the three locations, Bajo San Juan produces almost as much as the joint output of the other two. That is to say, Bajo San Juan produced 24.3 million dollars of irrigated crops, while Saltillo reached 14.1 and Juarez 10 million dollars in 2003, respectively.

The extent at which Saltillo generates value per hectare in comparison to Juarez, suggests a high value crop mix of the former, by local standards. Saltillo is an undisputed leader, with 2.3 thousand pesos by hectare on average, ahead of Juarez (US$ 948 per hectare), and a modest amount (US$ 364 per hectare) at the Bajo San Juan.

When output is considered by group of crops, a similar pattern appears. In particular, Saltillo reached 782 dollars by hectare in 2004 during the autumn-winter cycle, as well as US$ 2,014 per hectare for spring-summer crops, and US$ 2,891 for perennials by hectare.

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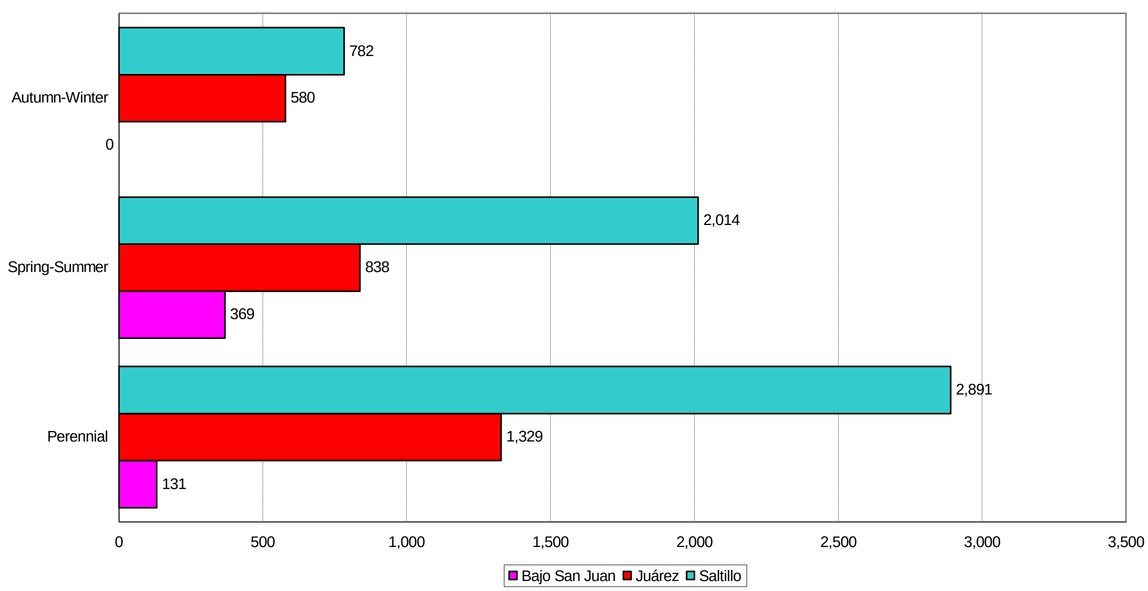
[32] Abstraction is made of other factors like prices and the crop mix, which necessarily affect this outcome.
[33]In oder to express values in terms of 2004 US currency, local economic output is being converted to 2004 prices using local deflators, after which its conversion to US currency is made.
[34]The generation of value added by autumn-winter crops is represented by the remaining 10.3%.

That is to say, Saltillo has the highest high value crop mix in terms of value generated for the three groups of crops. In a second place, Juarez obtained US$ 580 per hectare for the autumn-winter cycle, US$ 838 per hectare for the spring-summer cycle and US $ 1,329 per hectare for perennials. A lagging position in terms of crop value is exposed by the Bajo San Juan. Here, the largest value is reached for the spirng-summer cycle, with US$ 369 per hectare, while no harvest took place in the autumn-winter cycle. The lowest value appears in perennials, with US$ 131 per hectare.

There is a consistent pattern among the three locations when irrigated crop groups are considered. That is to say, Saltillo is a leader in the various crop groups, while Bajo San Juan is particularly lagging. This performance exposes the ample possibilities for this last location to improve the level of economic output without increasing the area under cultivation.

Graph 1. Irrigated Crop Groups. Value Added by Area. 2003 (US$/Hectare)



Source: Based on Banco de México, FIRA, INEGI and SAGARPA

Economic Value of Water

In order to estimate the economic value of water for each group of crops, its value added is being related both to the net and the gross consumption of water. In other words, it is

[35]The autumn-spring cycle represents the remaining 7.1% of the total value added in the region.

being shown how much value is generated while taking into the acount the extent of water consumed.

Net Economic Value

In an aggregate fashion, Saltillo averages the equivalent of US 0.42 per cubic meter, while Juarez and Bajo San Juan are less than one third of the former, i.e. 0.13 and 0.12 dollars per cubic meter, respectively, during the crop year of 2003. Taking into account the various crop groups, the range for net economic value of water goes from US$ 0.47 per cubic meter for the Saltillo during the spring-summer cycle, to US $0.10 dollars, for the autumn-winter cycle in Juarez. In evey single group, Saltillo reaches the highest economic value of water. For the autumn-winter cycle, the leader is also Saltillo, with US$ 0.23 per cubic meter consumed, ahead of Juarez (US 0.10/m^3).[36]

In the case of perennial crops, Saltillo reached US$ 0.43. Behind this mark, Juarez shows a coefficient of US$ 0.14 per cubic meter, while Bajo San Juan is lagging with US 0.07/m^3.

Table 6. Irrigated Crop Groups. Net and Gross Economic Value of Water. Crop Groups. 2003 (US $/$m^3$)

	Juárez	Saltillo	Bajo San Juan
Net Value			
TOTAL	0.13	0.42	0.12
Cycle	0.13	0.4	0.12
Autumn-Winter	0.1	0.23	-
Spring-Summer	0.14	0.47	0.12
Perennials	0.14	0.43	0.07
Gross Value			
TOTAL	0.08	0.21	0.06
Cycle	0.07	0.2	0.06
Autumn-Winter	0.06	0.11	-
Spring-Summer	0.08	0.23	0.06
Perennials	0.08	0.22	0.02

Source: Based on Banco de México, CNA 2004a and 2004c, FIRA and SAGARPA 2004

Gross Economic Value

Taking into consideration that the net demand for water corresponds roughly to one half of the total amount of water irrigated,[37] the gross value of water is basically twice in the case of the three locations. The corresponding coefficients are found in the preceding table, keeping for each crop group the implicit proportion.

The economic value of water in irrigated crops is placed in context in section three, when considering the rest of economic activities in the locations. Besides, in a section underneath, valuation comparisons with other locations are discussed.

3.1.1.2. Individual Crops

In the previous section, crop production has been analyzed by groups, regarding the cycle in which they are cultivated, as well as whether they are perennials. In what follows, each crop group is considered on the basis of each of individual product by location.

Juarez

In the case of Juarez, production is concentrated in a handful of crops. Out of the 9.984 million dollars of value added produced in 2003, cotton and alfalfa together accounted for 75.7% of the total.[38] A second group of four crops, contributing with a value added ranging between 4.6% and 5.6%, contributed with 19.7% of the total. This is the case for oats for silage and wheat during the autumn-winter cycle, with 5.6% and 4.6% of the total value added, respectively. Regarding perennials, pasture and fruit trees contributed with 4.9% and 4.6%, respectively.

The rest of the crops participate with one percent of the total value added, at the most. For instance, during the spring-summer cycle, sorghum for silage during the spring summer cycle as a second crop represented 1.8%.[39] Additionally, a contingent of sorghum for

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[36] As mentioned before,there was no output during the autumn-winter cycle in Bajo San Juan.

[37]As specified previously, 49% in the case of Bajo San Juan region, 56% for Juarez and 54% for Saltillo, as an aggregation of individual flows, on the basis or official data (CNA 2004c).

[38] That is to say, cotton (41.4%) and alfalfa (34.3%).

[39] Second crops are referred to the output being harvested during the spring-summer cycle, using reminding water allocations from the current cycle. That is to say, if a crop producer manages to save a specific amount of water, he (or she) is entitled to use that water, normally resorting to a short cycle crop. Therefore, it is plausible to harvest two crops during spring-summer.

silage reached 1%. A modest amount of value added was derived by pastures during the same cycle, with 0.9% as a second crop, and 0.5% for the first one.

Table 7. Irrigated Individual Crops. Juarez. Area, Value Added and Water Productivity 2003

	Area		Value Added		Value Added/Area	Water Productivity Gross	Net
	Ha	%	$ 000	%	$ 000/Ha	US$/m³	
TOTAL	**10,523**	**100.0%**	**9,984**	**100.0%**	**0.949**	**0.08**	**0.13**
Cycle	**7,228**	**68.7%**	**5,606**	**56.2%**	**0.776**	**0.07**	**0.13**
Autumn-Winter	*1,769*	*16.8%*	*1,025*	*10.3%*	*0.580*	*0.06*	*0.10*
Oats for silage	468	4.4%	563	5.6%	1.202	0.17	0.28
Wheat	1,297	12.3%	456	4.6%	0.351	0.03	0.05
Pasture	4	0.0%	7	0.1%	1.722	0.13	0.22
Spring-Summer	*5,459*	*51.9%*	*4,581*	*45.9%*	*0.839*	*0.08*	*0.14*
Cotton	3,870	36.8%	4,132	41.4%	1.068	0.10	0.17
Sorghum for silage 2nd	893	8.5%	181	1.8%	0.202	0.02	0.03
Sorghum for silage	461	4.4%	102	1.0%	0.220	0.02	0.04
Pasture 2nd	126	1.2%	88	0.9%	0.698	0.08	0.14
Pasture	91	0.9%	54	0.5%	0.591	0.07	0.12
Vegetables	18	0.2%	25	0.2%	1.379	0.11	0.20
Perennials	**3,295**	**31.3%**	**4,377**	**43.8%**	**1.329**	**0.08**	**0.14**
Alfalfa	2,491	23.7%	3,429	34.3%	1.377	0.07	0.13
Fruit trees	225	2.1%	487	4.9%	2.163	0.17	0.30
Pastures	579	5.5%	462	4.6%	0.797	0.09	0.16

Source: Based on Banco de México, CNA 2004a, CNA 2004b and CNA 2004c, FIRA and SAGARPA 2004

As far as the area harvested is concerned, cotton represents 36.8%, while alfalfa reaches 23.7%, amounting 60.5% of the total. A second group of four crops,[40] comprised 24.3% of the total area.

Net water productivity was US$ 0.17 per cubic meter in the case of cotton, while it is reduced to US$ 0.07 in the case of alfalfa. Bearing in mind that the average in this location for all crops was US$ 0.13/m^3, these two products are within this range. Fruit trees (perennials) and oats for silage (autumn-winter) are at the upper scale of net water productivity in Juarez, i.e., 0.17 dollars per cubic meter in both cases. On the lower end, sorghum for silage, both the ordinary one and the second crop, expose US$ 0.03 per

[40] Oats of silage and wheat for the autumn-winter cycle; and pasture and fruit trees for perennials.

cubic meter, while wheat reaches a slightly higher value (US$ 0.05). Unspecified vegetables show a value of US$ 0.20/m^3, just around the average performance in the district. A similar result is observed in the case of pastures in autumn-winter (US$ 0.22/m^3) and perennials (US$ 0.16/m^3).

Saltillo

Regarding Saltillo, out of the 14.1 million dollars of value added, most of it (68.3%) arises from perennial crops.

Table 8. Irrigated Individual Crops. Saltillo. Area, Value Added & Water Productivity 2003

	Area		Value Added		Value Added/Area	Water Productivity	
						Gross	Net
	Ha	%	$ 000	%	$ 000/Ha	US$/m^3	
TOTAL	**6,070**	**100.0%**	**14,087**	**100.0%**	**2.321**	**0.21**	**0.42**
Cycle	**2,744**	**45.2%**	**4,471**	**31.7%**	**1.629**	**0.13**	**0.20**
Autumn-Winter	*856*	*14.1%*	*670*	*4.8%*	*0.782*	*0.11*	*0.23*
Oats for silage	477	7.9%	364	2.6%	0.763	0.11	0.22
Barley for silage	371	6.1%	292	2.1%	0.787	0.11	0.23
Garlic	2	0.0%	13	0.1%	6.467	1.60	4.09
Wheat	6	0.1%	1	0.0%	0.145	0.03	0.07
Spring-Summer	*1,888*	*31.1%*	*3,802*	*27.0%*	*2.014*	*0.23*	*0.47*
Potatoes	266	4.4%	2,543	18.1%	9.561	0.73	1.45
Sorghum for silage	880	14.5%	245	1.7%	0.279	0.04	0.08
Serrano chilies	62	1.0%	237	1.7%	3.827	0.32	0.56
Tomatoes	18	0.3%	193	1.4%	10.749	0.89	1.56
Tomatillo	25	0.4%	150	1.1%	6.016	0.50	0.87
Courgettes	48	0.8%	144	1.0%	3.010	0.25	0.44
Sorghum for brooms	180	3.0%	102	0.7%	0.566	0.04	0.09
Corn	385	6.3%	88	0.6%	0.228	0.04	0.08
Poblano chilies	10	0.2%	52	0.4%	5.166	0.43	0.75
Coriander	9	0.1%	22	0.2%	2.459	0.20	0.36
Cauliflower	4	0.1%	22	0.2%	5.438	0.45	0.79
Corn on the cob	1	0.0%	2	0.0%	2.013	0.32	0.71
Perennials	*3,326*	*54.8%*	*9,616*	*68.3%*	*2.891*	*0.22*	*0.43*
Pasture	1,275	21.0%	3,749	26.6%	2.940	0.34	0.93
Nuts	953	15.7%	3,378	24.0%	3.544	0.28	0.49
Alfalfa	980	16.1%	2,077	14.7%	2.119	0.11	0.20
Fruit trees	48	0.8%	205	1.5%	4.281	0.35	0.62
Peaches	23	0.4%	97	0.7%	4.199	0.33	0.58
Asparragus	40	0.7%	92	0.7%	2.295	0.19	0.33
Plums	6	0.1%	18	0.1%	2.969	0.23	0.41
Pistachioes	1	0.0%	1	0.0%	1.308	0.10	0.18

Source: Based on Banco de México, CNA 2004a, CNA 2004c, FIRA and SAGARPA 2004

Within perennials, production is concentrated on pasture (26.6%), nuts (24%) and alfalfa (14.7%). For spring-summer crops, representing 27% of the total value added in this location, most of it belonging to potatoes (18.1%). Production in the autumn winter cycle is reduced to 4.8% of the total value added, where oats and barley, both for silage, represent 4.8% and 2.6% of it. For the spring-summer cycle, representing 27% of the total, potatoes has an overwhelming weight (18.1%).

There are eight crops weighting each between one and five percent of the total value added. In the case of autum-winter crops, oats and barley, both for silage, contribute with 4.8% and and 2.6%, each respectively. For the spring-summer cycle with the exception of sorghum for silage, the rest are vegetables.[41] In the case of perennials, an array of unspecified fruit tress represents 1.5%. The rest of products represent less than one percent of value added.

Regarding water productivity, garlic has a net productivity of 4.08 dollars/m^3, contrasting with a minimal area harvested (two hectares in the autumn-winter cycle). Tomatoes and potatoes follow with US$ 1.56 and US$ 1.45 per cubic meter, being the crops which contribute most to the value added for the spring-summer cycle, despite using 4.4% of the total area.

The rest of crops are below a one dollar mark of water productivity per cubic meter. While the average is 0.42 dollars per cubic meter for this location, vegetables are above this average. Typically cereals are at the lower end, with 8 cents per dollar for corn and sorghum for silage, for instance.

Bajo San Juan

Considering the 24.3 million dollars produced by this district in 2003, an overwhelming portion (99.2%) comes from the spring-summer cycle. Two crops represent the bulk of the value added, i.e. sorghum (77.2%) and corn (16.3%), which happened to have been harvested in the above mentioned cycle. Besides a modest contribution by cotton and water melon, with 3.5% and 1.5%, the rest of crops contributes with less than one percent

[41] With respect to value added, this group is comprised by serrano chilies (1.7%), tomatoes (1.4%), tomatillo (1.1%) and courgettes (1%).

of the value added. While there is no output during the autum-winter cycle, perennials account for less than one percent (0.8%) of the total value added.

Table 9. Irrigated Individual Crops. Bajo San Juan. Area, Value Added and Water Productivity. 2003

	Area		Value Added		Value Added/Area	Water Productivity	
						Gross	Net
	Ha	%	$ 000	%	$ 000/Ha	US$/m³	
TOTAL	**66,826**	**100.0%**	**24,317**	**100.0%**	**0.364**	**0.06**	**0.12**
Cycle	**65,417**	**97.9%**	**24,132**	**99.2%**	**0.369**	**0.06**	**0.12**
Autumn-Winter	-	-	-	-	-	-	-
				-			
Spring-Summer	*65,417*	*97.9%*	*24,132*	*99.2%*	*0.369*	*0.06*	*0.12*
Sorghum	54,343	81.3%	18,765	77.2%	0.345	0.06	0.11
Corn	8,329	12.5%	3,953	16.3%	0.475	0.07	0.12
Cotton	1,080	1.6%	843	3.5%	0.781	0.14	0.41
Pop corn	990	1.5%	364	1.5%	0.368	0.06	0.10
Water melon	97	0.1%	58	0.2%	0.593	0.10	0.16
Melon	47	0.1%	38	0.2%	0.810	0.17	0.25
Onion	28	0.0%	31	0.1%	1.125	0.24	0.34
Green chilies	11	0.0%	24	0.1%	2.205	0.46	0.67
Sorghum for brooms	139	0.2%	18	0.1%	0.132	0.02	0.04
Sorghum for silage	313	0.5%	14	0.1%	0.044	0.01	0.01
Tomatillo	7	0.0%	10	0.0%	1.491	0.31	0.45
Garlic	2	0.0%	7	0.0%	3.371	0.71	1.02
Beans	19	0.0%	4	0.0%	0.214	0.05	0.07
Nopal (cactus)	12	0.0%	3	0.0%	0.214	0.04	0.06
Perennials	**1,409**	**2.1%**	**185**	**0.8%**	**0.131**	**0.02**	**0.07**
Pasture	1,193	1.8%	128	0.5%	0.107	0.04	0.08
Other citric	216	0.3%	57	0.2%	0.266	0.01	0.06

Source: Based on Banco de México, CNA 2004a and 2004c, FIRA and SAGARPA 2004

Regarding, net water productivity for 2003, the average for the district is US$ 0.12/m^3, coincident with the two most important crops. Due to the low weight of vegetables in the total value added geenerated, its higher productivity hardly increases the district average.

3.1.1.3. Valuation Comparisons

Using the residual method, Lindgren (1999) found a value of water equivalent to US$ 0.51/m^3 for commercial for commercial crops in the Stampriet aquifer, Naimibia, while using the residual method.

In another study for Namibia, MacGregor *et al.* (2000), reports an economic value of water for commercial agriculture equivalent to US$ 0.49 for 1996 agriculture, as a ratio between value added and water used. For susbsistence agriculture, the value was US$ 0.57/m^3, being US$ 0.52 for agriculture on average, being irrigated crop production the leading activity in terms of income.

Using the residual procedure, water productivity in Haryana, India, was US$ 0.02/m^3 for crop production, according to an official survey.[42]

Typically, willingness to pay for a farmer is within the range of US$ 0.01-0.25 per cubic meter, according to Wu, Whittington and Sadoff (undated). Crop cultivated, amont of rainfall, prices of outputs and key inputs, are responsible for this wide range. These authors observe that cereals are at the lower end, while fruits and veggetables are at the opposite, subject to market conditions and transportation costs for the latter. In well-run irrigation schemes, Wu, Whittington and Sadoff, assume an economic value of US$ 0.05/m^3 (p. 16).

In the above mentioned literature, no reference is made as to whether the calculations are referred to gross or net water demands. It is being assumed that the value estimates are implicitly gross requirements. Therefore, the comparisons with the results of the present work are likewise. Considering the results for gross water productiivity obtained here, they fit within Wu, Whittington and Sadoff ranges. Juarez and Bajo San Juan are slightly above the mark for an adroit irrigation scheme, with US $ 0.06/m^3. At the same time, in these two locations, individual crops with a minimium productivity are at the bottom range, with US $0.01 and US $0.02 in both cases regarding sorghum for silage in Juarez and Bajo San Juan. Saltillo has an average productivity of US$ 0.21, already at the upper limits

[42]Government of India: Cost of Cultivation of Major Crops, Ministry of Agriculture, 1993 (quoted in Rogers *et al.* 1998).

established by Wu, Whittington and Sadot. In terms of individual crops, garlic is responsible for the high value attained, with US $1.60 in Saltillo and US$0.71 in Bajo San Juan. In general, the three locations fit whithin the parameters of the three authors mentioned.

Table 10. Individual Crops. All locations. Gross Water Productivity 2003 (US $/m³)

	Average	Maximum	Minimum
Juarez	0.08	0.17 Other fruits perennials	0.02 Sorghum for silage autumn-winter
Saltillo	0.21	1.60 Garlic autumn-winter	0.04 Corn spring-summer
Bajo San Juan	0.06	0.71 Garlic spring-summer	0.01 Sorghum for silage autumn-winter

Source: Based on Banco de México 2005, CNA 2004a, CNA 2004b, FIRA 2005 and SAGARPA 2004

Regarding local experiences in measuring value as a ratio between value added and water unit of input, in Caborca, an irrigation district located in the state of Sonora,[43] a similar estimate was made.[44] For the 2002 agricultural year, perennials reached a mean of 0.23 dollars of value added per cubic meter. For the autumn-winter crops, it averaged 0.09 cents per cubic meter, while the spring-summer showed a slightly higher value (0.13). Therefore, Caborca shows a value as high as Saltillo in perennials, where it stands out both in terms of area and value added. This confirms the relative backwardness of Bajo San Juan and Juarez in this group of crops. For autumn-winter crops, Caborca is as low as the worst performer of the three locations, i.e. Bajo San Juan. For the spring-summer cycle, except Juarez, the other two locations perform better than Caborca.

[43] That is to say, nortwest part of Mexico.
[44] Goicoechea, 2004.

In a recent study for the Lerma-Chapala region,[45] surface irrigation for crops exposed an equivalent of 0.13 dollars per cubic meter was obtained for the period 1997-2003 at prices of 2004.[46] Considering the five states over which this region spreads, it reached 0.17 dollars as the highest value in the region of the state of Michoacan. The lowest value was found in the state of Mexico, with 0.12 dollars per cubic meter. Therefore, Saltillo outperforms Lerma-Chapala, while the other two regions of this study remain below it.

3.1.2. Rainfed Crops

For the three locations under consideration, rainfed crop production is considered in what follows. In the case of Juarez, no output is obtained in this type of agriculture. Saltillo harvested 23.6 thousand hectares, most of it (88%) during the spring-summer cycle. In the case of Bajo San Juan, the rainfall area harvested reached 84.8 thousand hectareas, with an overwhelming weight for the autumn-winter crop (98.1%). The rest are spring-summer crops.

Table 11. Rainfed Crop Groups. Area Harvested. 2003 (Hectares and percentage)

	Juárez		**Saltillo**		**Bajo San Juan**	
TOTAL	-	-	23,583	100.0%	84,757	100.0%
Cycle	-	-	23,583	100.0%	84,757	100.0%
Autumn-Winter	-	-	2,808	11.9%	83,172	98.1%
Spring-Summer	-	-	20,775	88.1%	1,585	1.9%
Perennials	-	-	-	-	-	-

Source: Based on CNA 2004a and SAGARPA 2004

In terms of value added, in 2003 it reached 3.273 million dollars in total. More than four fifths (82.9%) came from the spring-summer cycle, while the remaining belongs to the autum-winter one. In the case of the Bajo San Juan, rainfall value added was 14.4 million dollars, of which 96.8% was harvested during the autumn-winter crop.

[45] Located in the central part of Mexico.

Table 12. Rainfed Crop Groups. Value Added. 2003 (US$ 000 and percentage)

	Juárez		Saltillo		Bajo San Juan	
TOTAL	-	-	3,273	100.0%	14,358	100.0%
Cyclical	-	-	3,273	100.0%	14,358	100.0%
Autumn-Winter	-	-	560	17.1%	13,893	96.8%
Spring-Summer	-	-	2,713	82.9%	465	3.2%
Perennials	-	-	-	-	-	-

Source: Based on Banco de Mexico, FIRA and SAGARPA 2004

Considering value added per hectare in Saltillo, for the autumn-winter cycle in Saltillo, it was US$ 167 in rainfall, compared to US$ 2,891 for irrigated crops. Meanwhile, the spring-summer average value per hectare was US$ 461 compared to US$ 2,014 in irrigated crops. That is to say, in the case of Saltillo, rainfall in the autumn-winter cycle represents 5.8% in comparison to irrigated crops. In the case of spring-summer, rainfall represents 22.8% of irrigated crops, when considering value added per hectare.

3.2. Livestock

Water Consumption

In terms of water consumption, Saltillo required 1.1 million cubic meters for animal production during 2003. Almost half of it (48.5%) was demanded by poultry, followed by 26.3% for beef production. Besides egg output, which stands for 9.3% of the total water demand in the location, the rest of products demand less than five percent of the total. This is the case for pork (2.8%), milk (2.3%) and sheep (0.8%).

As far as livestock is concerned, in Bajo San Juan water consumption rose to 161,584 thousand meters in 2003, being beef responsible for 66.5% of it. Sheep production comes in a second place, with 16.4% of the total water requirements. Pork output demanded 10.4% of the total amount of water, followed by goats (6.1%).[47]

The least demanding location in terms of water for animal production is Juarez, with 134,768 cubic meters in 2003. A high concentration in beef production is ostensible, with 84.5% of the total water consumption. Besides milk production (5.9%) and pork output

[46] Goicoechea, 2005.
[47] Milk production required a minimal amount, i.e. 0.6% of the total water demand.

(5%), the rest of the products demand a small share of the total water required. This is being the case for sheep (2.5%) and poultry (1.7%).

Table 13. Livestock. Water Consumption. 2003 (m^3)

	Juárez		Saltillo		Bajo San Juan	
TOTAL	**134,768**	**100.0%**	**1,114,407**	**100.0%**	**161,584**	**100.0%**
Cattle	121,855	90.4%	292,767	26.3%	108,451	67.1%
Beef	113,875	84.5%	267,062	24.0%	107,481	66.5%
Milk	7,981	5.9%	25,705	2.3%	970	0.6%
Pork	6,738	5.0%	31,321	2.8%	16,834	10.4%
Sheep	3,340	2.5%	8,877	0.8%	26,457	16.4%
Goats	548	0.4%	136,776	12.3%	9,842	6.1%
Chicken	2,285	1.7%	644,655	57.8%	-	-
Poultry	2,285	1.7%	541,003	48.5%		
Eggs	-	-	103,652	9.3%		
Beehives	3	n.s.	12	n.s.	-	-

Source: Based in Banco de Mexico, INEGI 2004a, 2004b and 2004c.

Value Added

Saltillo is the leading location in terms of livestock production in 2003, with a value added of 16.117 million dollars at 2004 prices.[48] In a second place, Bajo San Juan produced 7.041 million dollars, less than half (43.7%) of Saltillo. Juarez turned out with 4.434 million dollars of livestock output, over one fourth (27.5%) of Saltillo output.

Regarding the 16.1 million dollars of livestock production in Saltillo during 2004, two products have a leading position. Poultry reached 41.3% of the total in this location, followed by 16.4% for eggs. In the third place, beef output reached 14.9% of the total value creation in the location.

[48] In what follows, the 2003 livestock output has been deflated at 2004 prices using local price indices, being afterwards converted to US currency using the 2004 exchange rate.

Continuing with Saltillo, milk production represented almost one tenth (9.7%) of the output, followed by pork (7.3%). Goat meat reached 5.8%. The rest of the products represent less than five percent, including goat milk (3.8%).[49]

Table 14. Livestock. Value Added. 2003 (US$ 000 at 2004 prices)

	Juárez		Saltillo		Bajo San Juan	
TOTAL	**4,418.0**	**100.0%**	**17,101.5**	**100.0%**	**7,032.5**	**100.0%**
Dressed	**3,659.4**	**82.8%**	**12,213.0**	**71.4%**	**6,879.7**	**97.8%**
Beef	2,929.7	66.3%	2,383.5	13.9%	3,761.8	53.5%
Pork	482.4	10.9%	1,173.4	6.9%	2,167.7	30.8%
Mutton	217.2	4.9%	84.6	0.5%	598.7	8.5%
Goat	22.0	0.5%	954.8	5.6%	351.5	5.0%
Poultry	8.1	0.2%	7,616.7	44.5%	-	-
By-products	**758.6**	**17.2%**	**4,888.5**	**28.6%**	**152.8**	**2.2%**
Milk						
Cow	680.6	15.4%	1,567.5	9.2%	151.3	2.2%
Goat	-	-	629.3	3.7%	1.5	0.0%
Eggs	-	-	2,646.5	15.5%	-	-
Wool	-	-	2.9	0.0%	-	-
Honey	78.0	1.8%	42.2	0.2%	-	-
Beeswax	-	-	0.2	0.0%	-	-

Source: Banco de México, INEGI 2004a, 2004b and 2004c.

In Bajo San Juan, beef production represents more than half (53.8%) of the total livestock output, followed by pork (30.8%). Jointly, they stand for 84.6% of the total value generated in animal production. Mutton has a third place in terms of output, with 8.3%. Two remaining products from goats, i.e. meat and milk, represent 4.9% and 2.1%, respectively.

Output in Juarez is concentrated in beef (66.6%) and milk (15.3%). Pork represents 10.9%, while mutton output is 4.8%. The rest, have a reduced importance, i.e. honey (1.8%), goat meat (0.5%) and poultry (0.2%).

[49] The remaining livestock products in the Saltillo region, comprising mutton, honey, wool and beeswax, have a marginal value.

Comparing the three locations in terms of animal production, Saltillo contrasts with the other two in terms of production heterogeneity, in spite of being specialized in poultry. In this respect, Bajo San Juan and Juarez could develop their potential in this array of economic activities.

Economic Value of Water

In terms of value added generated in relation to water consumed, Bajo San Juan and Juarez lead.[50] Saltillo, despite exposing the largest heterogeneity in terms of products and species, is the least efficient in terms of water consumption. In terms of beef, pork and milk, the efficiency by which the production process takes place, showing considerable differentials. The exception in this pattern is poultry, as Saltillo, is four times more efficient than Juarez. However, in this last location, production of this kind is minimal.

Table 15. Livestock. Economic Value of Water. 2003 (US$/m^3)

	Juárez	Saltillo	Bajo San Juan
TOTAL	33	15	44
Beef	26	9	35
Pork	72	37	129
Mutton*	65	10	23
Goats**	40	12	36
Poultry	4	14	-
Milk	85	61	156
Eggs		26	-
Honey***	26,711	3,649	-

* Includes wool

** Includes goats' milk

*** Includes beewax

Source: Based in Banco de México, INEGI 2004a, 2004b and 2004c.

Besides the case of milk, it is plausible that in terms beef, Juarez and Bajo San Juan might be important centers for a finishing process in raising cattle, instead of breeding it

[50] In so far as water requirements have been estimated in terms of animal inventories, the efficiency with which production takes place, determines differential coefficientes for the same specie.

from the outset. In the case of pork, it could be that Saltillo specializes in piglets, reporting a large stock.

3.3 Other Primary

3.3.1. Forestry

Due to natural conditions, forestry acitivities have a scant importance in the three locations. In the case of Bajo San Juan, in 2003 the value added for the tropical species was 9.9 thousand dollars. In the case of Saltillo, output was 68.5, of which 51.3% was recolection of non-wood forest products, basically (80%) lechugilla wax. The remaining 49.7% was mezquite wood .[51] No forestry products were produced in Juarez.

3.3.2. Fisheries

Out of the three locations selected, only Bajo San Juan shows a minor importance in fish production. Accodring to 1998 economic census data, the last available,[52] value added reached 338 thousand dollars, at 2002 prices.[53] This output is derived from the El Azucar dam.[54]

In Juarez, fish output reached a value added of 4 thousand dollars, as a by product of irrigation based in water derivation in the area. In Saltillo, no fish production took place.

In this paper, water is considered as a production factor only when the object of labor is independent of its means of production. In so far as in fisheries both –object and means- are both undistinguishable, no value is attributed to water.

3.3.3. Mining

Water consumption in mining was 1,613 cubic meters in Bajo San Juan. Most of it (92.1%) was used for coal mining. The remaining amount of water was used in non-metalic minerals. The generation of value added for this location was 667.5 million dollars.

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[51] *Prosopis sp.*
[52] The 2004 economic census data has not been yet released.
[53] In so far as local deflators for 2004 have not yet been published for the following economic activities considered in this report, output data was deflated with local price indices for 2002, after which were being converted to US dollars with the 2002 exchange rate.
[54] Officially known as Marte R. Gómez.

Juarez and Saltillo expose a lesser weight in this sector. Total water consumption was 267.9 and 214.4 cubic meters, respectively. In both cases, non metalic minerals predominate. The amount of value added generated was 1.679 and 1.533 million dollars in the case of Juarez, and Saltillo, respectively.

In terms of efficiency with respect to the use of water, mining in Bajo San Juan has an exceptionally high coefficient of 414 thousand dollars per cubic meter. In the case of Saltillo and Juarez, the efficiency rate was 7.8 and 5.7 dollars per cubic meter, respectively.

3.4. Manufacturing

Water Consumption

Juarez is the largest water consumer in manufacturing, reaching 260,748 cubic meters in 1998. The largest demand comes from machinery and equipment output, representing almost two thirds (64.7%) of the total. In a distant second place comes textile and apparel, with 10.2%, slighlty above food manufacturing (8.3%). Four industries, i.e. paper, chemical, wood and non-metalic industries show a consumption level within a range of 2.9% and 5.3%. Other industries and basic metal have a minimal participation in water demand, both below one percent.

Table 16. Manufacturing. Water Consumption. 1998 (cubic meters and percentage)

	Juarez		**Saltillo**		**Bajo San Juan**	
TOTAL	260,748	100.0%	98,805	100.0%	109,277	100.0%
Food	21,602	8.3%	28,037	28.4%	10,603	9.7%
Textiles & apparel	26,541	10.2%	3,620	3.7%	8,542	7.8%
Wood	8,732	3.3%	6,066	6.1%	1,997	1.8%
Paper	13,837	5.3%	16,105	16.3%	32,565	29.8%
Chemical	11,675	4.5%	9,721	9.8%	20,285	18.6%
Non-metallic minerals	7,559	2.9%	6,213	6.3%	2,263	2.1%
Basic metals	123	0.0%	165	0.2%	46	0.0%
Machinery & equipment	168,749	64.7%	28,294	28.6%	31,670	29.0%
Other industries	1,930	0.7%	581	0.6%	1,305	1.2%

Source: Banco de Mexico, INEGI and US Geological Service

The Bajo San Juan and Saltillo regions show a similar level of water consumption for 1998. The first one demanded 98,805 cubic meters, while Bajo San Juan required 109,277 cubic meters. In Bajo San Juan, the leading sectors demanded a similar level of water, i.e. paper (29.8%), as well as machinery and equipment (29%). Chemical industries required 18.6% of the total water consumed. The rest of manufacturing required less than ten percent of the water utilized, i.e. food production (9.7%), besides textiles and apparel (7.8%). The rest of manufacturing in Bajo San Juan consumed lesser quantities of water, i.e. non-metallic minerals (2.1%), wood (1.8%), and other industries (1.2%).[55]

Saltillo concentrates its water demand in machinery and equipment (28.6%), food industries (28.4%), and paper (16.3%). The rest of industries are below the ten thousand meters range. This is the case in the chemical sector, with 9.8% of the total consumption, besides non-metalic minerals (6.3%) and wood (6.1%). Textiles and apparel demanded 3.7% of the total amount. Basic metals and the group under other industries have a negligible consumption in Saltillo.

Value Added

In terms of economic importance, Saltillo produced 2,434 million dollars in 1998. Almost two thirds of its output came from machinery and equipment. In a distant second place, chemical and food industries reached a similar level (311 and 293 million dollars). Besides non-metalic minerals, representing 9.3%, the rest of manufacturing has a reduced weight in value generation. This is the case of wood and other industries (0.4% each), while basic metals show a negligible contribution to value generation in Saltillo.

Juarez generated a value added of 2,079 million dollars in 1998 of manufacturing output. Production is heavily concentrated in machinery and equipment, with 68.1%. Textiles and apparel reached 16.8% of value added, followed by food manufacturing, with 7.5%. The rest of activities are below a five percent of contribution to the local value added. This is the case of non-metalic minerals (3.3%), while other industries, i.e. wood, chemical and paper individual contribution, is between one and two percent to the local value generation.

[55] Basic metals show a negligible consumption in Bajo San Juan.

Table 17. Manufacturing. Value Added. 1998 (US$ 000 of 2004 and percentage)

	Juarez		Saltillo		Bajo San Juan	
TOTAL	1,778,890	100.0%	2,083,147	100.0%	734,441	100.0%
Food	133,755	7.5%	246,325	11.8%	32,155	4.4%
Textiles & apparel	233,788	13.1%	66,145	3.2%	70,316	9.6%
Wood	16,187	0.9%	9,490	0.5%	2,648	0.4%
Paper	34,017	1.9%	37,789	1.8%	26,788	3.6%
Chemical	38,187	2.1%	236,687	11.4%	116,723	15.9%
Non-metalic minerals	71,258	4.0%	203,326	9.8%	20,092	2.7%
Basic metals	2,155	0.1%	4,945	0.2%	1,391	0.2%
Machinery & equipment	1,640,167	92.2%	1,160,235	55.7%	438,790	59.7%
Other industries	18,719	1.1%	6,822	0.3%	8,381	1.1%

Source: Banco de Mexico and INEGI

Bajo San Juan shows a heavy concentration of value generation in machinery and equipment (68.2%), a percentage similiar to Juarez. Chemical industries participated with 10.8% of the value added, almost similar to textiles and apparel (9.5%). Besides food industries (4.5%), the rest weight less than five percent within the local value added. This is the case for four industries, i.e. paper (3.6%), non-metalic minerals (2.8%), other industries (1.4%), wood (0.4%), and basic metals (0.1%).

Economic Value of Water

On averge, Saltillo generates an economic value 24.6 thousand dollars per cubic meter consumed in manufacturing. This ratio is more than three times higher than Juarez and Bajo San Juan, in so far as the last two generate slightly under eight thousand dollars per cubic meter. In every single stance except for wood and paper, Saltillo is considerably ahead of the rest of locations in terms of water efficiency when it comes to value generation.

When specific industries of Bajo San Juan and Juarez are compared, the results are mixed. For instance, Juarez ostensibly leads over Bajo San Juan in food, textiles and apparel, wood, as well as the group under the name of other industries. In non-metalic minerals these two locations are similar. In the case of chemical, basic metals, and machinery & equipment, Bajo San Juan has a clear advantage over Juarez, as far as value added production in relation to water consumed is concerned.

Table 18. Manufacturing. Economic Value of Water (US$ of 2004/m^3)

	Juarez	Saltillo	Bajo San Juan
TOTAL	6,822	21,084	6,721
Food	6,192	8,786	3,033
Textiles & apparel	8,809	18,270	8,231
Wood	1,854	1,564	1,326
Paper	2,458	2,346	823
Chemical	3,271	24,347	5,754
Non-metalic minerals	9,427	32,725	8,878
Basic metals	17,520	29,911	30,080
Machinery & equipment	9,720	41,006	13,855
Other industries	9,701	11,733	6,423

Source: Banco de México, INEGI and US Geological Survey

3.5. Other Industries

3.5.1. Construction

The largest consumption of water in the building industry is found in Saltillo, having required 105,431 cubic meters in 1988. Both Bajo San Juan and Juarez expose similar requirements, i.e. 80,759 and 78,617, respectively.

In terms of economic importance, construction activities in Juarez generated 104,330 thousand dollars, at 2002 prices, followed by Bajo San Juan, with 89,471 thousand dollars. In the bottom position is Saltillo, where this activity yieldad a net value of 56,840 thousand dollars.

The largest contribution of water to value creation is observed in Juarez (1,327 dollars per cubic meter), closely followed by Bajo San Juan (1,108 dollars/m^3). In the case of Saltillo, it reached the lowest value, i.e. 539 dollars for each cubic meter consumed in this activity.

3.5.2. Hydro-power Generation

No hydro-power generation takes place in the three locations selected. In the case of Bajo San Juan, there are two plants in the municipality of Rio Bravo, run by turbogas and steam, respectively. Altoghether, the generation was 2,777.4 GWh in 2003, accounting for 1.6% of the Mexican energy output (INEGI, 2004).[56] In the case of Juárez, 1,234.8 GWh were produced during that year, through two plants,[57] representing 0.7% of the output in the country. The value added for electricity in Juarez was 14,583 thousand dollars, while in Bajo San Juan reached US$ 17,912.

3.5.3. Water Provision and Assimilative Services

Due to availability of information on water supply, only Ciudad Juarez, Saltillo and Reynosa themselves are being considered.[58]

Table 19 . Urban Water Supply.* 2003
(Mm^3 and US $ 000 at 2004 prices and percentage)

	Juarez		Saltillo		Reynosa	
Mm^3						
Input	155.0	100.0%	40.2	100.0%	50.5	100.0%
Invoiced	115.6	74.6%	n.a.	-	36.9	73.1%
Collected	79.5	51.3%	13.0	32.5%	28.6	56.7%
US $ 000$_{2004}$						
Revenue	48,387	100.0%	7,928	100.0%	n.a.	-
Expenses	56,185	116.1%	10,038	126.6%	n.a.	-
Surplus/Deficit	-7,797	-16.1%	-2,110	-26.6%	n.a.	-
Value Added	44,810.1		6,906.7		18,305.4	
Price (US$/m^3)						
Market	0.61		0.61		n.a.	
shadow*	0.71		0.77		n.a.	

* Provided by the local water body, i.e. Excludes provision by privately operated well facilites.

* Market price plus aliquot deficit.

Source: Banco de Mexico and CNA 2004d

[56] For the country as a whole, 178,510 GWh were generated.
[57] Operated by turbogas and steam.
[58] Ramos Arizpe (Saltillo), and the following places in Bajo San Juan: Ciudad Aleman, Ciudad Camargo, Ciudad Gustavo Diaz Ordaz, Mier and Río Bravo, are not being considered (CNA 2004d).

Out of the 155 millions of cubic meters provided in Ciudad Juarez during 2003, three quarters (74.6%) are invoiced, while only half (51.3%) is being collected. In other words, one quarter of the volume supplied is provided whithout metering, while only half of the total water supply is metered as well as collected. The average price reported, without taking into account different uses, is US$ 0.61 per cubic meter. In terms of revenue, the operating organism ran a deficit of 7.8 million dollars. In order to cover in full the reported expenses should have been US$ 0.71/m^3, i.e. an increase of 16.1% would be in order to balance the accounts.[59]

In the case of the town of Saltillo,[60] the availability of water supply was 40.2 million of cubic meters. Half of these supplies are collected, while no mention is given regarding the percentage of water invoiced, as the efficiency in revenue collection can not be gauged. The operating expenses of the local operating organism left a deficit of 2.1 million dollars. An average price of US$ 0.06/m^3, from the present US $ 0.61/m^3 would be necessary to cover in full for the operating costs.

Regarding Reynosa, water provision is 50.5 Mm^3. While 73.1% of this amount was invoiced, 32.5% was actually collected. Therefore, most of the water supplied is not being charged for, despite the fact that it was invoiced. No data on operating revenue and expenses is reported for this town, the reason for which no data on price appears in the official survey (CNA 2003)

In the case of Juarez and Saltillo prices are similar per average cubic meter, regardless of the specific use.[61] The gap between the provision of water and the amount charged is 31.2% in the case of Juarez and 22.5% in the case of Reynosa. In both cases, the data shows the scope to improve the financial fortunes of the water operating agencies.

As far as assimilative services are concerned, in Ciudad Juarez most of the water output (90 Mm^3) undergoes a primary process according to official data (CNA 2003). However, this water is poured either to the Rio Bravo or reused for agricultural irrigation. A minimal

[59] This assumption is made leaving aside the scope for balancing returns by improving the collection of invoiced water.
[60] That is to say, excluding Ramos Arizpe.
[61] There is no information available for Reynosa.

amount of water is subject to basic processing, i.e. 1.6 Mm^3, further used in an irrigation ditch.

The predominance of primary assimilative services in Ciudad Juarez contrasts with the other two cases. In Saltillo, there is an estimated output of 30.1 Mm^3. Only a fraction of it (11.1%), undergoes a basic treatment, while using less than half of its installed capacity. Two thirds of this treated portion is poured to a golf course,[62] as the remaining is devoted to industrial reuse.[63] It is assumed that the rest of the drainage (89.9%), goes for agricultural irrigation.

Table 20. Assimilative Services. Output and Processing. 2003
(Mm^3 and percentage)

	Juarez		Saltillo		Reynosa	
Mm^3						
Output	90	100.00%	24.1	100.00%	37.8	100.00%
Processing						
Basic*						
Installed	1.6	1.80%	6	24.90%	23.7	62.50%
Utilized	1.6	1.80%	2.7	11.10%	37.8	100.00%
Primary**						
Installed	110.6	122.80%	n.a.		n.a.	
Utilized	88.4	98.20%	n.a.		n.a.	

* Activated sludges and stabilization tanks.

** Unspecified. Assumed to include oxidation ditches, biological filters and Imhoff tanks.

Source: CNA 2003

Regarding Reynosa, the output of wastewater is estimated at 37.8 Mm^3. It is assumed that all of it undergoes a basic processing, through a facility equipped to deal with 23.7 Mm^3 yearly, while it is being used to process 37.8 Mm^3, i.e. 59.5% above its capacity. Its flows are drained to the Rio Bravo.

[62] Processed by means oxidation ditches.
[63] Having being subject to activated sludges.

Fiscal Rebates for Water Treatment

Municipal water demand is modest, not only due to its requirements, but also when it is compared to irrigated crops. Further, it is stimulated due to tax rebates provisions designed to make firms extend their water treatment.

The rebates are granted on a cubic meter of water, depending on the location of the municipality involved. For the Juarez and Saltillo both clasified under zone 3, the current rate is at US$ 0.87, and for San Juan, it is US$ 0.53 (zona 6).[64] These rebates also stimulate the water reuse, and therefore, a reduction in demand.

3.6. Non-Financial Private Services

Water Consumption

In terms on non-financial private services, water consumption reached 2,244 thousand cubic meters in the Juarez location, whose consumption is almost twice of Saltillo and Bajo San Juan. In Juarez, half of the volume of water consumed went for restaurants and hotels, with 1,123 thousand cubic meters. Trade, both comprising wholesale and retail, represented 25.1% of the total. The group under other private services, represented 20.5%. In the case of transport and communications, the water consumed was below 100 thousand cubic meters, equivalent to 4.4% of the local consumption.

Table 21. Non-Financial Private Sector Services. Water Consumption. 1998
(Cubic meters and percentage)

	Juarez		Saltillo		Bajo San Juan	
TOTAL	2,244,875	100.0%	1,177,170	100.0%	1,214,370	100.0%
Trade	563,990	25.1%	271,830	23.1%	273,300	22.5%
Restaurants & hotels	1,122,925	50.0%	506,890	43.1%	711,990	58.6%
Transport & communications	98,460	4.4%	69,710	5.9%	29,060	2.4%
Other	459,500	20.5%	328,740	27.9%	200,020	16.5%

Source: Banco de México, INEGI and US Geological Service

In Bajo San Juan, the non-financial private sector services required 1,214 cubic meters. Almost two thirds (58.6%) went for restaurants and hotels. Slightly over one fourth went

[64] CNA 2004b.

for trade. Other private services demanded 16.5% of the water consumption in the Bajo San Juan, while the remaining 2.4% was consumed by transport and communications.

In the case of Saltillo, slightly over two fifths (43.1%) was consumed by restaurants and hotels. Other private industries account for 27.9% of the water demanded. Trade required 23.1%, while the remaining 5.9% was used by transport and communications.

It should be added that there is no data for tourism in the location at a municipal level. Therefore, restaurants and hotels are being taken as a proxy for this activity.[65]

Value Added

The leading location in terms of value added with regard to non-financial private services is Juarez, where 2,128 million dollars were generated in value added during 1998. This activity is heavily concentrated in other non-financial private services (43.5%), as well as trade (43%). Restaurants and hotels as well as communications show a small weight in their contribution to the generation of value, with 8% and 5.4% respectively.

Table 22. Non-Financial Private Services. Value Added. 1998
(US$ 000 of 2004 and percentage)

	Juarez		**Saltillo**		**Bajo San Juan**	
TOTAL	1,978,982	100.0%	826,220	100.0%	753,845	100.0%
Trade	930,600	47.0%	267,383	32.4%	361,693	48.0%
Restaurants & hotels	179,775	9.1%	39,832	4.8%	51,135	6.8%
Transport & communications	127,187	6.4%	48,385	5.9%	43,377	5.8%
Other	741,420	37.5%	470,620	57.0%	297,640	39.5%

Source: Banco de México and INEGI

As far as Saltillo is concerned, most of the value added (65.4%) comes from other private non-financial services, underlining its importance as a leading administrative and educational center. The second activity in terms of contribution is trade, with 25.8% of the total value added. Transport and communications as well as restaurants and hotels have a lesser weight in terms of value generation, with 5.1% and 3.7% respectively.

In the case of Bajo San Juan, the weight of trade and other non-financial private services show similarities, each with over two fifths of the total value generated. Restaurants and hotels, as well as transport and communications are within the same range, i.e., between five and six percent of the total net product.

Economic Value of Water

Juarez generated 948 dollars in non-financial private services, being the highest ratio when compared to the rest of locations. Saltillo reached 762 dollars per cubic meter, still ahead of Bajo San Juan (680 dollars per cubic meter).

In every single economic activity, Juarez shows an advantage over the other two locations, with the exception of transport and communications, as well as the group under other services, where Bajo San Juan is at a similar level as the former. In terms of efficiency in the use of water for value generation, in general Saltillo shows an ostensible lag, vis a vis the border locations.

Table 23. Non-Financial Private Services. Economic Value of Water (US$ of 2004/m^3)

	Juarez	Saltillo	Bajo San Juan
TOTAL	882	702	621
Trade	1,650	984	1,323
Restaurants & hotels	160	79	72
Transport & communications	1,292	694	1,493
Other	1,614	1,432	1,488

Source: Banco de México and INEGI

3.7. Additional Services

3.7.1. Navigation

In the three locations selected, no navigation takes place. Besides, due to its geological formation the Rio Bravo and affluents lack depth and water spate, a system of dams have been built alongside the river.

[65] In this respect, both Juarez and Bajo San Juan have a high demand in terms of short term visits (weekend) by foreign tourists when compared to Saltillo, as shown in terms of water demands, due

3.7.2. Residential Consumption

In Juarez, estimates of water demand are in the region of 345 litres a day per inhabitant. Reynosa has similar water consumption (324 litres) per person, reaching 48.9 Mm^3. In the case of Saltillo, residential demand is 176 litres per day, equivalent to 37.7 million of cubic meters per year.

Table 24. Residential Demand. Per Capita and Population. 2003
(Mm^3 and population)

	Juarez	Saltillo	Reynosa
Total (Mm^3)	152.3	37.7	48.9
Per Capita*	344	176	324
Population**			
Total	1,274.2	607.9	435.2
Suplied w/water	1,210.5	583.6	413.4

* liters/day
**Inhabitants

Source: CNA, 2004d

3.7.3. Recreational

At presa el Azucar, in Bajo San Juan, recreation associated with water is not a relevant activity.[66] In the other two locations, Juarez, beneath the Rio Bravo, recreation is negligible. In the case of Saltillo, there is no recreation derived from surface water.

4. Economic Aggregation

Water Consumption

When considering the array of activities conducted in the three representative locations, irrigated crops and residential consumption are the overbearing water consumers in the three locations. Bajo San Juan is the largest user among the three locations with 437.7 million of cubic meters, followed by Juarez with 286 million cubic meters. In the case of Saltillo, consumption reached 160.1 million of cubic meters. The weight of water

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to the location of the two former across the Mexican-U.S. border.

consumption irrigated crops can go from 88.5% in Bajo San Juan, to 62.1% and 45.8% in the case of Saltillo and Juarez, respectively. In relative terms, Juarez demands 53.2% for residential consumption, being 35.5% for Saltillo and 11.2% in Bajo San Juan.

Considering the demand for water among the rest of economic sectors, the activities which demand more than one percent of the total amount of water are private non-financial services in Juarez (3.7%), and 3.5% for livestock in Saltillo. In the case of Bajo San Juan, the largest consumer of water, besides irrigated crop production is private non-financial services, with one percent participation.

Table 25. Water Consumption by Sector. 1998* (m^3 and percentage)

	Juarez		Saltillo		Bajo San Juan	
TOTAL	286,018,210	100.00%	106,080,934	100.00%	437,680,700	100.00%
Irrigated Crops	131,018,770	45.81%	65,904,070	62.13%	387,223,100	88.47%
Rainfed Crops	-	-	-	-	-	-
Livestock	134,768	0.00%	1,114,407	1.05%	161,584	0.04%
Forestry	-	-	-	-	-	-
Fisheries	-	-	-	-	-	-
Mining	214	0.00%	268	0.00%	1,613	0.00%
Manufacturing	260,748	0.09%	98,805	0.09%	109,277	0.02%
Electricity	-	-	-	-	-	-
Water Utilities	-	-	-	-	-	-
Building	78,617	0.03%	105,431	0.10%	80,759	0.02%
Private Services**	2,244,875	0.78%	1,177,170	1.11%	1,214,370	0.28%
Residential	152,280,218	53.24%	37,680,784	35.52%	48,889,998	11.17%

* 2003 for crops, livestock, forestry, electricity and water utilities.

** Non-financial.

Source: CNA 2004b, INEGI 2003, 2004a, 2004b and 2004c, Tate & Sharf 1995 and US Geological Service

Value Added

Based on the economic sectors for which data is being reported in the present report, Juarez generated 4,387.6 million dollars, followed by Saltillo and Bajo San Juan with 3,431.5 and 2,523.3 million dollars, respectively.

[66] It contrasts with nearby Falcon and La Amistad dams, located upriver. These last two are embedded along the Río Bravo itself, where recreation is a foremost activity (TWDB, 1990).

In terms manufacturing output, the indisputable leader is Saltillo, with 2,434.8 million dollars, in spite of occupying a second place in terms of total value added generated. In this location, this activity represented 71% of the total value generated, significantly higher than Juarez (47.4%) and Bajo San Juan (34%).

After manufacturing, private non-financial services systematically stands in a second place, except in the case of Juarez.[67] Manufacturing reached 48.5% in Juarez itself, followed by Bajo San Juan (32.7%) and Saltillo (26.1%). The construction sector is within a range from 1.7% in Saltillo to 3.6% in the case of Bajo San Juan. Mining is important only in Bajo San Juan.

Table 26. Value Added by Sector. 1998* (US$ 000 at 2004 prices and percentage)

	Juarez		**Saltillo**		**Bajo San Juan**	
TOTAL	4,387,645	100.00%	3,431,461	100.00%	2,523,327	100.00%
Irrigated Crops	9,976	0.23%	14,087	0.41%	24,317	0.96%
Rainfed Crops	-	-	3,273	0.10%	14,358	0.57%
Livestock	4,418	0.10%	17,101	0.50%	7,033	0.28%
Forestry	-	-	69	0.00%	10	0.00%
Fisheries	4	0.00%	-	-	338	0.01%
Mining	1,679	0.04%	1,533	0.04%	667,523	26.45%
Manufacturing	2,079,182	47.39%	2,434,800	70.96%	858,421	34.02%
Electricity	14,583	0.01%	-	-	17,912	0.01%
Water Utilities	44,810	0.02%	6,907	0.20%	18,305	0.73%
Building	104,330	2.38%	56,840	1.66%	89,471	3.55%
Private Services**	2,128,664	48.51%	896,851	26.14%	825,640	32.72%
Residential	-	-	-	-	-	-

* 2003 for crops, livestock, forestry, electricity and water utilities.

** Non-financial.

Source: CNA 2004a, Banco de México, INEGI 2003, 2004 and 2005, Tate & Sharf 1995, US Geological Service

In spite of consuming the majority of water in the three locations, irrigated crops at the most represent 1% of the total value added in Bajo San Juan. In the case of Saltillo and Juarez, they reached 0.4% and 0.2% of the value added, respectively.

[67] In this location, both sectors are similar in terms of value added.

Except for Saltillo, livestock in the other two locations are below irrigated crop production. Altogether, primary activities show a considerable lack of development in the three locations, contrasting with the weight of secondary and service activities.

Economic Value of Water

On an aggregate basis, Saltillo is the most efficient in generating value in relation to the amount of water consumed. It averaged 46.7 dollars for cubic meter. Juarez has an efficiency of less than a half of Saltillo, with 19.1 US$/m^3. Bajo San Juan has a value added roughly a fifth (US$ 9.7/m^3) in relation to Saltillo.

Table 27. Economic Value of Water by Sector. 1998* (Value Added in US$/m^3 and proportion)

	Juarez		Saltillo		Bajo S Juan	
TOTAL	19.07	1.000	46.65	1.000	9.68	1.000
Irrigated Crops	0.13	0.007	0.42	0.009	0.12	0.012
Rainfed Crops	-	-	-	-	-	-
Livestock	32.78	1.719	15.35	0.329	43.52	4.494
Forestry	-	-	-	-	-	-
Fisheries	-	-	-	-	-	-
Mining	7,831.88	410.594	5,723.59	122.681	413,950.12	42,747.999
Manufacturing	7,973.93	418.041	24,642.59	528.198	7,855.49	811.224
Electricity	-	-	-	-	-	-
Water Utilities	-	-	-	-	-	-
Building	1,327.07	69.573	539.12	11.556	1,107.88	114.409
Private Services**	948.00	49.700	762.00	16.333	680.00	70.223
Residential	-	-	-	-	-	-

* 2003 for crops, livestock, forestry, electricity and water utilities.

** Non-financial.

Source: Banco de México, INEGI 2004 and 2005, SAGARPA 2003, Tate & Sharf 1995, US Geological Service

In terms of economic activity, mining in the Bajo San Juan reached the highest value for cubic meter consumed, with 413,950 dollars per cubic meter.[68] Mining in the other two locations, besides being a marginal activity, has a ratio of between 5.7 and 7.8 thousand dollars per cubic meter

Manufacturing is close to the 8 thousand dollars per cubic meter both in Juarez and Bajo San Juan, approximately one third of the level observed in Saltillo. Construction yielded between 539 US$/$m^3$ in the case of Saltillo, and 1,327 US$/$m^3$ Juarez. Private non-financial services are below the one thousand dollar mark in terms of water consumed.

In the case of livestock, Saltillo, with the lowest ratio reached 15 dollars per cubic meter. Juarez turned out US$ 33/m^3, while Bajo San Juan achieved US$ 44/m^3. Irrigated crop production has a reduced coefficient, with 15 US cents per cubic meter in Juarez, US 20 cents in Bajo San Juan and US 43 cents in Saltillo. Irrigation techniques as well as the value of current crops, need to be reconsidered in terms of crop mix and production techniques. At present, agriculture constitutes a fetter for the development of economic activities with a higher value added. The reduced value added obtained by the use of water in irrigated crops at present, implies a very high opportunity cost in terms of alternative output which is already under production, whether it is livestock, or it is high value added in manufacturing and services. Reestructuring of irrigated crop production to turn it into an efficient activity constitues a means in abatting the considerable gap separating this activity from the rest of production.

[68] This is basically due to coal mining, demanding 92.1% of the water in this sector.

5. Policy Issues and Discussion of Findings

Irrigated crop production exposes an heterogeneous perfomance in the three locations selected, i.e. Juarez, Saltillo and Bajo San Juan, within the Rio Bravo Basin. There is an inverse relation between the total area harvested and the value added per hectare, and to a lesser degree, in relation to the net productivity of water, measured as a ratio between value added and water demands after ground returns have been estimated. Saltillo, with a scant 6.1 thousand hectares, yielded US$ 2,321/hectare and US$ 0.42/m^3 in 2003. Bajo San Juan, at the other end, with 66.8 thousand hectares generated US$ 364/Ha and US$ 0.12/m^3. In between is Juarez, with 10.5 thousand hectares, yielding US$ 949/Ha and US$ 0.13 per cubic meter. The improvement of high value crops and a higher value both per unit of land as well as per unit of water is plausible, while there is ample room for the introduction of high value crops, as well as an improvement in irrigation techniques.

Systematically, there is a considerable degree of crop concentration in every location both for cyclical and perennials, in terms of acreage as well as in value added. Therefore, policies to improve the quality of crop mix would benefit *ex-ante*, with scale economies.

Crop production in the most efficient location, i.e. Saltillo, is wholly dependent on ground water. Juarez, the middle of range region in terms of efficiency, derives 18.9% of its water sources from ground water. The rest is derived from the Rio Bravo itself. Bajo San Juan irrigated crops are fully dependent from surface waters. The last two locations are been subject to a considerable variation in terms of yearly water supplies for crops, exposing a reduction of 2.5% and 2.7% on a yearly basis, as from 1986. However, Juarez has reduced the area under cultivation at a rate of 3%. In contrast, Bajo San Juan has incrased its surface for crops at a yearly rate of 2.7%. As a result, the volume of water for irrigation measured in terms of meter-hectare, in Bajo San Juan has diminished at a rate of 3% during the same period, while in Juarez it has increased at 1.9%. The performance of these two regions basically dependent on surface water in a scarcity scenario shows the virtuous behaviour of Juarez, while Bajo San Juan exposes a low degree of adaptation to the downward trend of water supplies in the region. Besides, water supply changes in Bajo San Juan result in a reduced impact in area harvested, while Juarez exposes a high degree adjustment, restraining its surface while being able to increase the amount of water per unit of surface.

When comparing the economic value water among individual crops with outcomes obtained elsewhere, the three locations are within medium to upper limits of what is rated as a well runned irrigation scheme, i.e. US $ 0.05 per cubic meter.

In terms of water volumes, there are two basic sectors determining its demand in the three locations under study. These sectors are irrigated crops besides residential consumption. The rest of sectors require less than one percent, with the exception of livestock in Saltillo (1.1%), a foremost poultry production area. In this sense, demographic growth is competing with agriculture for water resources. In the case of Juarez, with a total of 286 Mm^3, 45.8% goes for irrigated crops and 53.2% for residencial consumption. In Saltillo, with 106 Mm^3, crops require 62.1% of this amount, while households demand 35.5%. In Bajo San Juan, by far the largest consumer of water (437.7 Mm^3), 88.5% was consumed by crops and 11.2% by the population in their dwellings. In consequence, with the exception of Saltillo, crop production is the largest water consumer.

Considering that value added by agriculture reaches the highest participation in value added with 1% in Bajo San Juan, while requiring 88.5% of total water supplies, exposes the need to improve techniques and production methods in crop production. It would not only make better use of water economically speaking, but would also help to generate more value and wealth. The assimetry is even higher in Juarez, where irrigated crops contribute with 0.23% of the local value added, while requiring 45.8% of the volume of water used. In Saltillo, the proportions are 62.1% of water supplies and a generation of 0.4%. The increase in efficiency in crop production would help to unleash volumes of water to guarantee the demographic development, besides providing assurances to prospective investors about water availabilites.

Private and Social Values of Water

Private values express what economic agents actually pay in the market for the water used. Social values are structured taking into account four elements:

First. The value of water as a ratio between value added per unit of water, as specified previously in this paper.

Second. Water for crop production costs as much as the electricity to be paid per cubic meter,[69] as water itself is not charged for. In the case of surface water, the price is negligible.

Third. The shadow price of municipal water, i.e. including in the social value the deficit generated by the local water board in terms of current expenses.[70]

Fourth. The additional cost of assimilative services for municipal supplies to fulfill a primary treatment, in so far as residual water is subject only to an elementary process.

In the case of Saltillo, there is an additional social value, as officially water exploitation is 27% above its replenishment capacity. Therefore, each sector is charged an additional cost on the basis of its respective value added per unit of water, in proportion to the water it contributes to overexploit.

Table 28. Private and Social Value of Water by Sector. 1998* (US$ /m^3)

	Juarez		**Saltillo**		**Bajo San Juan**	
	Private	**Social**	**Private**	**Social***	**Private**	**Social**
TOTAL	0.33	15.42	0.25	35.32	0.07	3.90
Irrigated Crops	0.005	0.130	0.027	0.515	0.000	0.120
Rainfed Crops	-	-	-	-	-	-
Livestock	0.61	33.50	0.61	19.59	0.61	44.24
Forestry	-	-	-	-	-	-
Fisheries	-	-	-	-	-	-
Mining	0.61	7,832.60	0.61	7,014.21	0.61	413,950.84
Manufacturing	0.61	7,974.65	0.61	30,196.68	0.61	7,856.21
Electricity	-	-	-	-	-	-
Water Utilities	-	-	-	-	-	-
Building	0.61	1,327.79	0.61	661.39	0.61	1,108.60
Private Services**	0.61	948.72	0.61	934.50	0.61	680.72
Residential	0.61	0.72	0.61	0.78	0.61	0.72

* 2003 for crops, livestock, forestry, electricity and water utilities.

** Non-financial.

Source: Banco de México, INEGI 2004 and 2005, SAGARPA 2003, Tate & Sharf 1995 and US Geological Service

[69] An average electromechanical efficiency of one kilowatt hour per cubic meter is assumed.

Systematically, social values are well above the private ones. Were this difference to represent the hidden costs for economic agents, manufacturing would be the most fragile sector, in so far as water scarcity would be affecting it most, precisely on the basis of its capacity to generte wealth due to its social value, no to mention the importance it conveys in the three locations.[71]

Building and private services follow in terms of social costs. The first represents the most dynamic sector in the country, while the last one is associated with the urban and dempographic importance of these locations. Livestock represents a modest figure. Irrigated crops, in spite of the considerable difference between social and private values, express the low contribution of water to the generation of wealth.

In consequence, the fraility of water resources would endanger manufacturing activities in the first place, which happen to be the economc power house in the three locations. Crop production becomes the least important in terms of social value.

Equity, Productivity and Efficiency

In terms of availability of water resources and the need to make the urban development sustainable, two alternatives are faced by irrigated crops at a local level. The first would be to substantially raise the crop mix, besides improving water saving techniques. Alternatively, for producers who can not undertake a technological change, a life annuity could be instrumented in exchange for their water rights. Alternatively, the water rights are to be exchanged for a lump sum. In both cases, a government agency operating as a trust could become a broker, while guaranteeing water rights for urban and demographic expansion, and in the case of Saltillo, to also reduce the overexploitation of its present water source. Legal difficulties as well as an institutional framework are to be established, in order to guarantee the expansion or the basin. Besides, the public agency or trust could become an agent for water transactions, making transparent a procedure for which at present there is no reference offered to the public.[72]

[70] Based on available information, a single price is published by CNA (2004d) for each location regarding municipal water supply.

[71] Mining is not taken into consideration here, as it faces difficulties to relocate, due to its extractive nature, as well as the sunk costs in terms of capital invested.

Productivity of value exposes the ranking of the various activities, and the need to make sure that manufacturing, private services as well as building, can find an adequate ground for expansion in terms of natural resources, including water, not to hinder its growth.

In terms of efficiency, there is the need to increase the municipal water tariffs to terminate with the financial deficit with which the water operators work. Besides, the level of unmetered water, alongside recurrent underinvoicing, water losses in distribution pipes as well as the political environment in which water tariffs evolve, would imply the possibility of an improvement for the local water supply. There is also the need for further transparecy and accountability from these enterprise, regardless of whether they are public agencies of private firms providing a key public service.

[72] Water rights transfers among private agents in terms of value, is known only by the incumbent parties, or remains a matter of hearsay.

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Appendix 1. Regression Estimates. Irrigated Crops

Trend estimates have been calculared for selected variables, i.e. water volume used in crop producion (million of cubic meters), the area under cultivation (hectares), and the density of water used (hectare-meter), which is a ratio of the previous two.[73] Due to data availability, the estimates were done for Bajo San Juan and Juarez, for the 1986-2003 period.[74] Equations 4 and 8 express the capacity of a crop production to adjust in face of water availability. This indicador is particularly useful in surface agriculture when it is subject to considerable variance and stress.[75]

Bajo San Juan

$$\underset{(62.33)^{***}}{\log \text{water volume} = 13.089\,c} - \underset{(-2.71)^{**}}{0.057\,\text{trend}} \qquad (1)$$

$\bar{R}^2 = 0.31$ D.W. = 1.18 n = 18

$$\log \text{area} = \underset{(113.72)^{***}}{11.248\,c} - \underset{(-2.73)^{**}}{0.027\,\text{trend}} \qquad (2)$$

$\bar{R}^2 = 0.32$ D.W. = 1.46 n = 18

$$\log \text{hectare-m} = \underset{(-3.46)^{***}}{-0.462\,c} - \underset{(-2.24)^{**}}{0.030\,\text{trend}} \qquad (3)$$

$\bar{R}^2 = 0.24$ D.W. = 1.53 n = 18

$$\Delta \log \text{area} = \underset{(4.22)^{***}}{0.24\,\Delta \log \text{water}} \underset{(-3.29)^{***}}{-1.78\,\text{MA}(1)} \qquad (4)$$

$\bar{R}^2 = 0.88$ D.W. = 2.49 n = 18

[73] That is to say, equations 1 to 3 and 5 to 7. In these equations, c stands for the intercept with the y axis, while the slope is indicated by the coefficient of the specific independent variable. When this last one is the trend itself, a value of -0.057 indicates a decrease of 5.7% yearly, for the time period 1988-2003, on average.

[74] Due to the time period available, it was not possible to model these trends through stationary data. Meanwhile, the presence of spurious coefficients cannot be discarded.

[75] All variables in these two univariate equations are integrated of first order (denoted by Δ). In the case of equation four, it was necessary to introduce a moving average variable [MA(1)], in order to ammend autocorrelation of first order.

Juarez

log water volume = 12.343 c - 0.025 trend (5)
(62.33)*** (-2.71)**

$\bar{R}^2$ = 0.24 D.W. = 1.49 n = 18

log area = 9.944 c - 0.044 trend (6)
(98.30)*** (-4.38)**

$\bar{R}^2$ = 0.54 D.W. = 1.59 n = 18

log hectare-m = 0.097 c + 0.019 trend (7)
(1.91)* (3.83)**

$\bar{R}^2$ = 0.45 D.W. = 1.09 n = 18

Δ log area = 0.86 Δ log water (8)
(14.07)***

$\bar{R}^2$ = 0.93 D.W. = 2.33 n = 18

Note. Significance: ( )***: 99%; ( )**: 95%; ( )*: 90%, while t values appear in parenthesis.

Appendix 2. Aquifer Balance. 2004 (Mm^3)

	Bajo San Juan	Juarez*	Saltillo
1. Use of water granted	45.7	292.2	45.4
2.Committed discharge	2.0	8.0	5.4
3. Extraction	45.7	310.0	37.3
4. Recharge	45.1	318.2	29.5
5. Explotaition Index	1.01	0.97	1.27

* Includes 120 Mm^3 granted to the local water board.

Source: CNA (Direct communication)