Urban water in the north of Mexico: prospective scenarios for demand and management.

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ABSTRACT

The city of Hermosillo is the capital of the state of Sonora and one of the largest cities in the north of Mexico. Like most cities in this region, it has a high economic and population growth but it also has limited water resources. However, urban water is not properly managed: the current average price is below water production costs, revenue collection efficiency is low and unaccounted for water levels are high. Scenarios of demand and management policies were projected to the year 2030. In the first scenario (baseline), current levels of water tariffs and management efficiency remain unchanged. In the next two scenarios, an increase in efficiency levels and water price is assumed. According to these scenarios it is concluded that without any improvement in management policies, the water deficit would go up to 57% in 2030; however, if the proposed policies are applied, the city would not have water deficits at least until 2030, if the natural water availability remains at its current level

Key words: sustainable water management, demand projections, price elasticity of water, income elasticity of water, public policy scenarios.

INTRODUCTION

The cities in the north of Mexico face the challenge of providing water to a fast growing population in an arid environment with limited water resources. In order to provide water to this increasing number of people, water utilities can either improve its efficiency or search for new water sources. The latter has been the usual policy in the region. However, water resources are becoming scarcer, so management efficiency improvements seem to be a more adequate policy, since water losses are currently high (around 40%) and there is still an important amount of water that is not being paid for (around 30%). In addition, average water prices are below the cost of production, which

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encourages a higher water demand and sets constraints to the finances of water utilities in the region.

The aim of this paper is to evaluate the impact of different water management policies on the future demand for water in the northern city of Hermosillo, one of the most important in the region. Scenarios are projected to the year 2030, were measures such as increases in revenue collection efficiency and average price are implemented in order to reduce per capita consumption and provide the local utility with resources to reduce water losses (unaccounted for water). These Scenarios are projected in order to determine whether *a)* new sources of water are needed; or *b)* it is enough to make some adjustments in water management.

The paper is organized in sections. In the *Background* section, the situation in the north of Mexico and Hermosillo is described; in the *Methods and procedures* section the econometric model and projection assumptions are explained; in the *Results and discussion* section results of the regression analysis and projections are presented; finally in the *Conclusions* section, main findings are summarized.

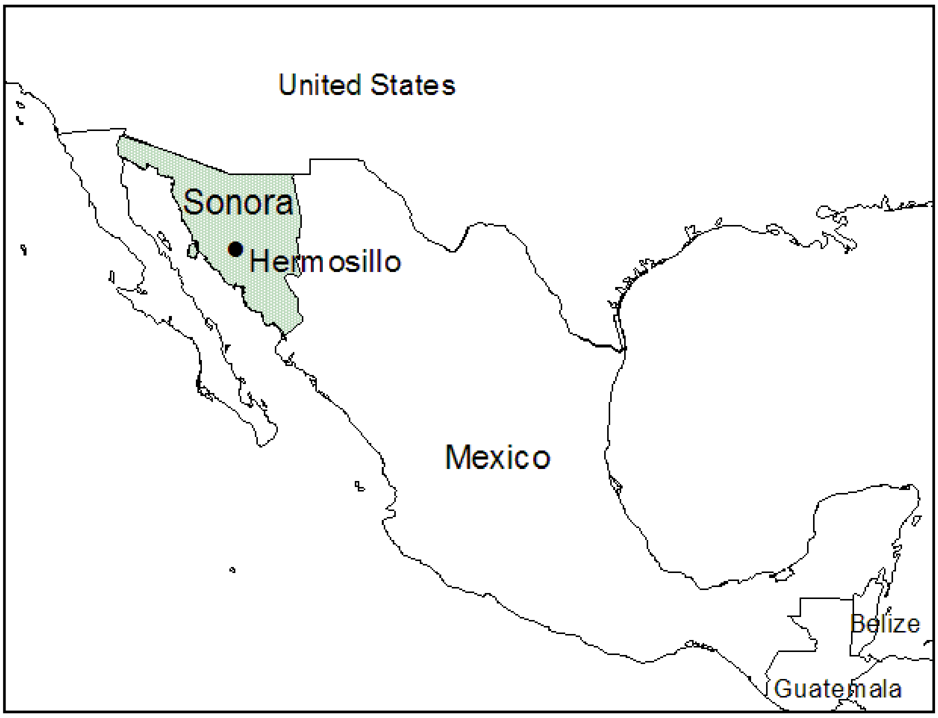
BACKGROUND

The north of Mexico is the region with the highest economic and population growth in the country. The GDP of the region grew at an annual rate of 4.2% from 1993 to 2004, while the GDP of the rest of the country only at 2.4%. Being next to the USA, this area became attractive for American companies to establish manufacturing and assembly plants (called maquiladora) seeking for cheap labor and tax incentives from the Mexican government, through an industrialization plan for the region started in the 1960s. Thus, population in urban areas along the border has increased significantly during the last three decades of the 20th century, as a consequence of the increase in jobs opened by the maquiladora industry and the trade opportunities brought about by the North American Free Trade Agreement implemented in 1994 (Turner 2006). While this region was grossly underpopulated up to the 1950s, the total population of the region has grown from 7.9 million in 1970 (a few years after the implementation of the maquildora policies) to 19 million in 2008, that is, an average annual growth of 2.3 percent. Projections suggest that the population of the region will grow at an annual average rate of 1.1% within the next two decades, almost twice the estimated rate of the rest of Mexico (Conapo 2008).

This region, with such an important economic development and high population growth is also the most arid region in Mexico. The average precipitation ranges from 202 to 463 millimeters a year. In contrast, in the south and southeastern regions of Mexico (which are also the most underdeveloped) the range goes from 1171 to 2300 millimeters. In addition, the north of Mexico is a drought-prone region that has faced significant shortages in precipitation through long periods in the past, and most groundwater sources are already overexploited. Thus, high economic and population growth of the region and water scarcity make water management an important issue for the sustainable development of the industrialized cities in the region. One of these cities is Hermosillo.

Hermosillo is the capital and also the most populated and fastest growing city of the state of Sonora. In the year 2005 its population was 642,000. The annual population growth rate for the period 2000-2005 was 2.8% and it is expected that the population of Hermosillo will be close to one million by the year 2030 (Conapo, 2008).

Figure 1. Location of Hermosillo, Sonora.



However, the city has limited water resources. During the 1970s water was obtained from the Abelardo Rodriguez dam, located next to the city. However, due to the high population growth, it was necessary to resort to other water sources, and thus, groundwater started to be drawn from wells located close to the dam. Therefore, the city obtained water both from the dam and from the wells. However, during the 1990s the water level of the dam started to go down and the city now depends entirely from groundwater drawn from wells (Pineda, 2006).

But the problem does not end there: between 2000 and 2005 it was realized that groundwater sources were being over exploited, since the total maximum water production capacity of the city decreased from 3,625 liters per second to 2,649 liters per second, i.e., a 30% decrease. Thus, the total annual water production has decreased from 95 million m^3 in 1995 to 87 million m^3 in 1996, to 78 million m^3 in 1997. Since then, the total volume of annual water production has been in the range of 70 to 80 million m^3.

Despite the fragile situation of the water supply for the city, urban water has been inefficiently managed. In 2006, the city produced a little more than 85 million m^3, but the publicly owned local water utility, Agua de Hermosillo, billed only 62% of the total volume (53 million m^3) which means that 38% of the water produced (32 million m^3) was lost due to leakages and illegal connections (unaccounted for water).

On the other hand, current prices are below operation costs and, as a consequence, the water pipe network is not adequately maintained. The current average price is 5.30 pesos for one m^3 of water, and it has been estimated that in order to recover the costs of production as well as for providing maintenance to the network in a sustainable manner, it would be necessary to raise the price to, at least, 9.70 pesos (Centro de Estudios del Agua, 2006). In addition, 28% of users do not pay for the service, and there is no wastewater treatment plant in the city. This situation has been going for years, and though there have been some reductions in the amount of unaccounted for water (in previous years it was more than 50%) the population growth of the city poses a challenge for the sustainability of water provision, therefore, it is necessary for the local utility to increase its efficiency.

However, Agua de Hermosillo, instead of trying to induce a more efficient use of water, it has tried to reduce the total quantity consumed by applying rationing policies. This measure was applied in 1998, 1999 and 2005. On the other hand it has also proposed two big projects to get water from additional sources: 1) by means of building a desalination plant in the coast (more than 100 km away from the city) and 2) bringing water from another river basin (also more than 100 km away from the city) (Agua de Hermosillo, 2006), projects that would be too costly, considering there is room for recovering water by means of reducing unaccounted for water levels and reducing the demand by means of an adjustment of water prices.

METHODS AND PROCEDURES

In order to project scenarios of water demand it is necessary to have a demand function. Since there is not enough information to estimate a function exclusively for the city of Hermosillo, a national water demand function was estimated for a sample of Mexican cities, by using data from of 57 cities with population greater than 50,000.

Modeling Framework

The average per capita water consumption is modeled as a function of per capita income and average price of water. In addition, temperature, precipitation and household size are included as demand shifters. The model to estimate was:

$$Q_i = a + b_1 * ln(Y_i) + b_2 * ln(P_i) + b_3 (House) + b_4 (Temp) + b_5 ln(Precip) + e$$

where:

Q_i is the per capita consumption of water in city i

Y_i is per capita GDP as a proxy of income in city i

P_i is the average price of one m^3 of water in city i

House is the average household size in city *i*.

Temp is the average temperature in city *i*

Precip is the average annual precipitation in city *i*.

a and *b* are fitting constants

e is the econometric error

Data and projection assumptions

Consumption and billing data for 57 Mexican cities with population over 50,000 were obtained for the year 2006 from data published by the Comisión Nacional del Agua (Conagua 2007). Data for temperature and precipitation were obtained from the Servicio Meteorológico Nacional (Nationa Weather Service). Table 1 summarizes the descriptive statistics of the variables for the 57 cities.

Table 1. Variable Descriptive Statistics

Variable	Unit	Mean	Std. Dev.	Min.	Max.
Q	liters/day/person	176	66	28	318
P	pesos/m^3	4.9	2.6	1.2	13.0
Y	Pesos	74,304	28,498	29,475	191,404
House	residents/household	4.6	0.3	4.2	5.3
Temp	degrees Celsius	21.8	2.8	17.3	26.6
Precip	Mm	707	344	203	1,492

Average price was calculated to take into account revenue collection efficiency (*RCE*) for the projection of management scenarios. Revenue collection efficiency is defined as the total revenue collected (*TR*) divided by the total billing (*TB*).

$$RCE = {}^{TR}/_{TB}$$

When the total revenue equals the total billing, this implies *RCE*=1, i.e., revenue collection efficiency is 100%. The average price billed (*Pb*) is the average price the utility actually charges for every m3 of water. However, since not all of the water is paid for by the users, the average price (*P*) used for modeling the demand, is the price billed (*Pb*) times the revenue collection efficiency (*RCE*):

$$P = Pb \times RCE$$

Thus, the average price (P) takes into account only the proportion of the price billed (Pb) that is actually being paid for, so an increase in revenue collection efficiency will produce an increase in the average price.

Data for population growth projections were obtained from the Consejo Nacional de Población (National Council of Population). The population of Hermosillo is assumed to grow at an annual average rate of 1.6% to the year 2030. GDP growth projections were obtained from projections of the Energy Information Administration (2007), where GDP is assumed to grow at an annual average rate of 3.6%. Table 2 shows a summary of the projection assumptions.

Scenarios

The next four scenarios were projected:

Scenario 1: Business as usual (Baseline)

No improvements are made on water management. The levels of unaccounted for water (36%) and revenue collection efficiency (72%) remain unchanged.

Scenario 2: Increase in revenue collection efficiency

In this scenario revenue collection efficiency is gradually increased until a level of 95% is attained within a five year period.

Scenario 3: Scenario 2 + Average price increase.

Once the revenue collection efficiency has been increased, a higher level of the average price would induce a reduction in the demand and it would increase total water utility's revenue. An increase of 100% in the current price is proposed in this scenario, which is approximately the increase estimated to allow for the financial sustainability of the water utility.

Scenario 4: Scenario 3 + Reduction of unaccounted for water.

Reduction of unaccounted for water would reduce the aggregated requirements of the city. A gradual reduction from 38% to 15% is assumed for this scenario.

Table 2. Projection Assumptions

Year	Population	Per capita GDP (pesos 2006)	Revenue collection efficiency [a]	Average price [b]	Unaccounted for water [c]
2008	687,968	91,520	72%	5.3	38%
2010	717,711	96,481	85%	6.3	38%
2015	788,044	110,798	95%	10.6	35%
2020	853,534	128,095	95%	10.6	15%
2025	913,751	148,970	95%	10.6	15%
2030	966,821	174,459	95%	10.6	15%

a Scenarios 2, 3 and 4
b Scenarios 3 y 4, Pesos of 2006
c Scenario 4

RESULTS AND DISCUSSION

The regression results are presented in the next table:

Tabla 3. Estimated regression parameters

Variable	Coeficient	Standard error	t statistic
ln(P)	-44.89**	14.20	-3.16
ln(Y)	38.37*	20.74	1.85
Temp	3.09	2.931	1.06
House	-27.97	24.42	-1.15
ln(Precip)	-42.48**	18.54	-2.29
Constant	142.74	353.89	0.40

* significant at the 10% level
** significant at the 5% level
$R^2 = 0.4145$

The estimated coefficients for variables price (*P*) and precipitation (*Precip*) are significant at the 5% level. The sign of the coefficient for variable Precip is negative, thus indicating that an increase in the precipitation is correlated to a decrease in the demanded quantity of water. The estimated coefficient for income (*Y*) is significant at the 10% level, and has positive sign, which indicates that an increase in the income is correlated to an increase the demanded quantity of water. The estimated coefficients for variables *House* and *Precip* are not significant at any level. Income and price elasticities for the national average are 0.21 and -0.27 respectively. Income and price elasticities for Hermosillo are 0.18 and -0.23 respectively.

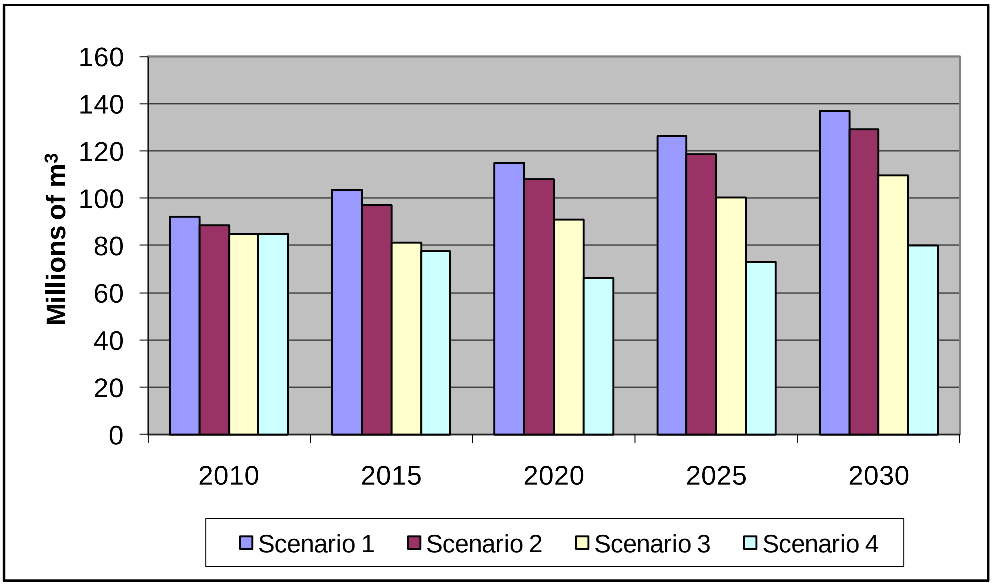
Figure 2 shows the results for the projected scenarios. In Scenario 1 (baseline, no changes) the per capita daily consumption increases from 214 liters in 2006 to 241 liters in 2030. The total annual water consumption in the city increases from 85 million m^3 to 136 m^3 in 2030, i.e., an increase of more than 57%.

In Scenario 2 (with an increase in revenue collection efficiency up to 95%) the per capita consumption increases to 227 liters in 2030. The total water consumption in the city increases from 85 million m^3 to 129 m^3 in 2030, i.e., an increase of more than 48%.

In Scenario 3 (once revenue collection efficiency has gone up to 95%, and the average price is increased in 100%) the per capita daily consumption is 207 liters in 2030 and the total annual water consumption in the city increases to 110 m^3 in 2030, i.e., an increase of more than 26%.

In Scenario 4 (in addition to changes in revenue collection efficiency and average price, unaccounted for water is reduced from 38% to 15%) the total annual water consumption in the city is to 80 m^3 in 2030, a quantity that could be provided if the natural availability of water remains at its current level.

Figure 2. Water demand in the city of Hermosillo



If the current levels of water availability remain unchanged, i.e., the total volume of water produced by the current sources remains at around 80 to 85 million m3, the total water deficit would be a little more than 50 million m^3 by 2030. If revenue collection efficiency and average price were increased as it has been assumed, the water deficit would be of 25 million m^3. Thus, increases in both revenue collection efficiency and in the average price would have an important impact on the reduction of the per capita consumption, but the total quantity of water consumed by the city would not be reduced unless proper maintenance of the pipe network were carried out and thus the levels of unaccounted for water were reduced, as it is shown in scenario 4.

CONCLUSIONS

The provision of water for the city of Hermosillo can be sustainably managed through the implementation of changes in the management of water. Increases in revenue collection efficiency and average price, plus reduction of unaccounted for water could help to provide water to the city in the future, at least until 2030, with the current water sources available. These three management changes should be carried out together, since the application of increases in revenue collection and price alone would not be enough to reduce the per capita and total quantity of water demanded. If no management changes were carried out, the water deficit for the city would go up to 57%, which could lead to the rationing of water as it has been the done in the past.

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