Technical coefficients of direct use of water in monetary terms for agriculture and urban water use
M. M. G. A. de Moraes, A. C. G. Carneiro, M. P. R. da Silva and G. F. Marques

ABSTRACT

The San Francisco Integration Project is a Brazilian government project aiming to bring water to the semiarid region of the northeast. The project provides funding for two diversions of the San Francisco River, supplementing the supply of local water in four Brazilian states. The Piranhas-Açú and Jaguaribe basins will become the largest recipients of these water deliveries. In this paper, we propose methodologies to state in monetary terms the technical coefficients of water use for the economic sectors associated with urban supply (US) and agricultural irrigation (AI) in different regions of these basins. These coefficients show that for the US economic sectors, at a certain level of urbanization the productivity of water is decreasing. The coefficients of AI obtained are much lower than those of US. The coefficients of AI, when calculated by crop, showed that there is generally an inadequate crop mix in the two basins. When this is associated with the low efficiency of water use, the result is a low economic value per cubic metre of water allocated to the sector. This implies, for both sectors, a need for incentives to use water in a more efficient way.

Key words | agriculture water use, technical coefficients of water use, urban water use, water economic value

INTRODUCTION

The Piranhas-Açú watershed is an important river basin for two Brazilian states located in the northeastern region: Paraíba (PB) and Rio Grande do Norte (RN). Water management and planning at this basin is a very complex and there are many different water uses, both upstream and downstream from the reservoirs. Conflict over water use exists, involving users from both states. The Jaguaribe basin river is situated almost entirely within the boundaries of the State of Ceará (CE). This previously predominantly agricultural basin is experiencing rapid urban growth. Municipal and industrial demands require water reallocation for agriculture. In addition, the basin exports water to the Metropolitan Region of Fortaleza (MRF) through the Eixão or Channel Integration, designed to ensure water for the population and MRF industry for the next 30 years.

Technical coefficients of direct use of water measure the input of water use as a primary factor for various economic sectors. In this study, they were obtained in monetary terms for two sectors associated with urban supply (US) and for the agricultural irrigation (AI) sector. The coefficients used are a means of presenting the input coefficients of exogenous inputs. This is also called the intervention coefficients, one of the basic components of input–output analysis (Nakamura & Kondo 2009), in general measured using the unit cubic metres by quantities of the goods produced. Another configuration of these coefficients is presented in Hubacek & Guan (2008) as direct water consumption coefficients. Their coefficients are measured in the Chinese currency Yuan per unit of cubic metre of water, instead of goods produced per cubic metre. In the present study, the unit used is the Brazilian currency, the Real, the value of

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goods produced, per cubic metre of water. Our coefficients were obtained for both economic sectors, US and AI, and for different hydrological and economic characteristics, called hydro-economic regions (HER). These economic sectors are the main water users in the two basins receiving water from the San Francisco Integration Project (SFIP).

METHODS

The technical coefficients of direct water use represent the direct or the first round effects of the sectoral interaction in the economy (Hubacek & Guan 2008). These technical coefficients also have other uses, including the possible effects on the economy of a limitation in water resources resulting from changes in the management of supply or demand watersheds.

To start with, we divide the inputs necessary for production into endogenous and exogenous inputs. The endogenous inputs \( x'_i \) are economic and the exogenous \( z'_i \) are natural resources. In this work the exogenous ‘input’ is water. The output of the commodity or economic sector \( x \) is given by \( x' \). If we divide the output of the commodity or sector by the endogenous and exogenous inputs, we will have the average amount of endogenous and exogenous input required to produce a unit of the final product of \( x' \) given by: \( a_i = x'_i/ x' \) and \( b_i = z'_i/ x' \), respectively.

If we consider a model with \( n \) sectors, dividing the demand for the output of each commodity or sector into two parts: the intermediate and final demand, we will have in a matricial form, the well known equations of basic input–output analysis:

\[
X = AX + Y \tag{1}
\]

\[
X = (I - A)^{-1} Y \tag{2}
\]

where \( X \) = total output of all commodities or sectors (vector, \(-n \times 1\)); \( Y \) = final demand of all commodities (vector, \( n \times 1 \)); \( A \) = endogenous inputs coefficient matrix \((n \times n)\); \((I - A)^{-1} \) = Leontief matrix \((n \times n)\).

In relation to the exogenous inputs, intermediate demand only is considered, i.e. demand for the exogenous inputs among the productive sectors in the economy, which is in a matricial form:

\[
Z = BX \tag{3}
\]

where \( Z \) = demand of exogenous input; given \( m \) exogenous inputs \((m \times 1)\); \( B \) = exogenous input coefficient matrix \((m \times n)\).

Substituting Equation (2) into Equation (3), we obtain

\[
Z = B(I - A)^{-1} Y \tag{4}
\]

Equation (4) measures how much of the exogenous input \( Z \) is needed to meet the level of production \( X \) required by the demand \( Y \).

As the exogenous inputs are usually scarce, their supply is limited. Using Equation (3) and considering that \( Z \) is limited, we will have a constraint on the level of production of the commodities, i.e. on the level of production in all sectors of the economy:

\[
X < B^{-1}Z \tag{5}
\]

This means that production is limited by the water input. Using the technical coefficients \((B^{-1})\) obtained for this study for each beneficiary region we can predict maximum economic return for all economic sectors (the vector \( X \)), depending on the different water distributions, i.e. different values of availability \( Z \) that can be simulated for different water management decisions.

The beneficiary regions that will receive water are not federal divisions, but sub-basins called HERs. Our study regionalized the technical coefficients of direct water use for each HER. These HERs are the ones that receive different amounts of water allocated to the various economic sectors, depending on the decisions made. They are defined by the area of its contribution to a large reservoir in each one of the two basins (Curemas-Mãe D’água and Armando Ribeiro in the Piranhas-Açu basin and in the Jaguaribe basin: Orós, Castanhão and Banabuíú reservoirs). In Piranhas-Açu basin, the HER2 was divided into two – HER2′ and HER2″- depending on the state (PB (HER2′) and RN (HER2″)) to which it belonged. These HERs constitute the
contribution of smaller water basins, associated with *ottobacias*, along the stretch of the main channel. These *ottobacias* are coded according to the methodology proposed by Brazilian engineer Otto Pfafstetter (Pfafstetter 1989; Verdin & Verdin 1999). Using an existing factor of proportionality relating the geographical area of the municipalities to these *ottobacias* (FUNARBE 2011), we were then able to relate the municipalities to the HERs. Thereafter, all data relating to municipalities and *ottobacias* – economic and hydrological – was regionalized by the HERs, which is why they are called hydro-economic units.

**Obtaining technical coefficients of water use in monetary terms for AI in the different HERs, as defined for the basins**

In this section, we will discuss how we arrived at the coefficients of direct water use for AI (\(B^{-1}\)). The description uses as its monetary value the currency of Brazil, the Real (R$), per cubic metre per year. We used the ratio of the value of the yearly contribution of production from a particular sector (AI) into the HER, in millions of Reais, to the water volume, in cubic metres, allocated annually to that sector. The value of the yearly contribution of production from AI into the HER (numerator of the ratio) was obtained from the data reported in Instituto Brasileiro de Geografia e Estatística – IBGE (2012) for the base year. The value of the Municipal Agricultural Production year (Table 1612) was used, excluding the resulting value of non-irrigated agricultural products and then regionalized for the HER. To arrive at this regionalization, the geographical factor between the HERs and the municipalities was obtained through the relationship between the *ottobacias* and the municipalities (FUNARBE 2011). To determine annual water consumption of HERs within the AI sector (denominator of the ratio), we used data in hectares of irrigated area per month, crop and municipality. This information was used together with the monthly water use technical coefficients by crop and county, both calculated and published by Ministry of Environment in 2011 (FUNARBE 2011). With this information in hand, the data were aggregated annually and regionally for each HER, using the same geographic factor described above to relate the HER and the municipalities (Table 1).

### Table 1 Annual contribution of production and water consumption from AI in the base year for the two basins

<table>
<thead>
<tr>
<th>Basin</th>
<th>Yearly contribution of production from AI into each region (in millions of Reais)</th>
<th>Annual water consumption of each region within the AI sector (in millions of cubic metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Piranhas-Âçu basin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HER1 (Coremas)</td>
<td>7.3</td>
<td>15.3</td>
</tr>
<tr>
<td>HER2* (Armando Ribeiro – PB)</td>
<td>31.18</td>
<td>70.96</td>
</tr>
<tr>
<td>HER2‘’ (Armando Ribeiro – RN)</td>
<td>40.76</td>
<td>20.56</td>
</tr>
<tr>
<td>HER3 (low Açú)</td>
<td>46.15</td>
<td>33.54</td>
</tr>
<tr>
<td><strong>Jaguaribe basin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HER1 (high Jaguaribe)</td>
<td>75.33</td>
<td>69.39</td>
</tr>
<tr>
<td>HER2 (medium Jaguaribe)</td>
<td>19.47</td>
<td>36.06</td>
</tr>
<tr>
<td>HER3 (Banabuiu)</td>
<td>55.08</td>
<td>36.11</td>
</tr>
<tr>
<td>HER4 (low Jaguaribe)</td>
<td>130.83</td>
<td>88.99</td>
</tr>
</tbody>
</table>

Sources: *IBGE (2012); FUNARBE (2011); FUNARBE (2011)*.

### Obtaining technical coefficients of water use in monetary terms for the sectors associated with US in different HERs, as defined for the basins

The coefficients of direct water use for US were obtained for the economic sectors associated with it: Commerce and Public Administration. We choose these sectors to match them with the categories of consumption registered by the Facilities of Water Supply Company (Industrial, Commercial and Public, respectively) used by the company to allocate water. As industrial use was almost nil in the basins studied, the coefficients were obtained only for the latter two sectors.

The coefficient for each sector associated with US was obtained by using the ratio of its production value for the HER in millions of Reais annually; and the annual water consumption of the HER with the US sector in cubic metres allocated for that year. The production value indicator used for the sectors studied was the gross value added (GVA). We decided to use this measurement since the GVA constituted the only indicator of production associated with these economic sectors available in the Regional Accounts in 2010, both at the municipal level and as an aggregate by state. Regarding the consumption of water, data cataloged by IWR-MAIN (Dziegielewski & Boland 1989) were used...
(Baumann et al. 1997). The issue of adopting the number of employees in the construction of the coefficients of direct use is criticized in the industrial sector. As expected, however, there is a stronger positive correlation with production processes that use little water or where the largest fraction of water is applied to general purpose activities. This is the case of activities that we associate with US, namely: Commerce and Public Administration. The value of production value in each HER for each sector associated with US in millions of Reais annually (numerator of the ratio) was obtained from the annual aggregate GVA in 2010 municipalities divided by economic sector using the number of employees in each sector (Tables 2 and 3). This information was taken from the Instituto Brasileiro de Geografia e Estatística (IBGE) (IBGE 2013a and IBGE 2013b). Thus, first we obtained the GVA per municipality and per economic sector. Then, to obtain this for each HER, we used the geographical factor relating the HERs to the municipalities. The annual water consumption in the HER by the US sector in cubic metres per year (denominator of the ratio) was obtained using the number of employees associated with that sector already regionalized as to HER (Table 2). Thereafter using the coefficients of water use of IWR-MAIN per employee for each sector (Commerce: 456.45 and 520.50 L employee\(^{-1}\) day\(^{-1}\); Public Administration 400.10 L employee\(^{-1}\) day\(^{-1}\)) (Dziegielewski & Boland 1989) we obtained annual consumption of that sector for each HER (Table 4).

### RESULTS AND DISCUSSION

#### Coefficients of AI in the different HERs

The methodology used makes it possible to calculate the monetary value resulting from the consumption of water not only for each HER (see Table 5), but also by crop. These values were used to classify the crops irrigated in three groups: Group 1 (crops with average coefficients in the basin higher than R$3.00/m\(^3\)), Group 2 (between R$1.00 and R$3.00/m\(^3\)) and Group 3 (less than R$1.00/m\(^3\)) (Table 6).

In the Piranhas-Åçu basin, the low value of the HER1 coefficient can be explained since 94% of the water in this HER was consumed by crops classified in the group (Group 3) with coefficient values below R$1.00/m\(^3\), namely: goiaba, cotton, rice, sugarcane, beans, tobacco, watermelon and corn. These crops account for 61.5% of the production value

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**Table 2 | Number of employees per sector and regionalized per HER for the two basins**

<table>
<thead>
<tr>
<th>Basin</th>
<th>Number of employees (in thousands of persons)*</th>
<th>Total number of employees in each sector in the associated state (PB, RN, or CE) (%)†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Piranhas-Åçu basin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HER1 (Coremas – PB)</td>
<td>19.67</td>
<td>3.3% 3%</td>
</tr>
<tr>
<td>HER2’ (Armando Ribeiro – PB)</td>
<td>90.24</td>
<td>3.3% 5%</td>
</tr>
<tr>
<td>HER2” (Armando Ribeiro – RN)</td>
<td>51.88</td>
<td>3.3% 15.5%</td>
</tr>
<tr>
<td>HER3 (low Åçu – RN)</td>
<td>18.20</td>
<td>3.3% 5%</td>
</tr>
<tr>
<td><strong>Jaguaribe basin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HER1 (high Jaguaribe – CE)</td>
<td>63.28</td>
<td>4.4% 5.26%</td>
</tr>
<tr>
<td>HER2 (medium Jaguaribe – CE)</td>
<td>16.90</td>
<td>1.1% 1.6%</td>
</tr>
<tr>
<td>HER3 (Banabuiu – CE)</td>
<td>42.90</td>
<td>3% 3.5%</td>
</tr>
<tr>
<td>HER4 (low Jaguaribe – CE)</td>
<td>34.06</td>
<td>2.3% 2.3%</td>
</tr>
</tbody>
</table>

Sources: *IBGE (2013b); FUNARBE (2011); †IBGE (2013a).
in this region (Figure 1). On the other hand, in HER1, a little more than 5% of the irrigated water is applied to the crops classified in the first group, i.e. the crops with the highest average coefficients (greater than R$3.0/m³: cashew, papaya, passion fruit, banana, onions, flatbeans, castor oil, agave and cassava), or to crops belonging to the intermediate Group 2 (between R$1.0 and R$3.0/m³): tomato, melon, mango and coconut, representing around 38% of its production value.

### Table 3

Annual aggregate GVA divided by economic sector using the number of employees, regionalized per HER

<table>
<thead>
<tr>
<th>Basin</th>
<th>Commerce (commercial and services)</th>
<th>Public administration</th>
<th>Total aggregate GVA by each sector for the associated state (PB, RN or CE) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piranhas-Açú basin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HER1 (Coremas – PB)</td>
<td>242.21</td>
<td>186.35</td>
<td>2.13% 1.95%</td>
</tr>
<tr>
<td>HER2’ (Armando Ribeiro – PB)</td>
<td>1,329.42</td>
<td>655.56</td>
<td>11.69% 6.87%</td>
</tr>
<tr>
<td>HER2” (Armando Ribeiro – RN)</td>
<td>788.63</td>
<td>358.62</td>
<td>6.01% 4.43%</td>
</tr>
<tr>
<td>HER3 (low Açú – PB)</td>
<td>408.04</td>
<td>215.06</td>
<td>3.11% 2.66%</td>
</tr>
<tr>
<td>Jaguaribe basin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HER1 (high Jaguaribe – CE)</td>
<td>796.76</td>
<td>357.049</td>
<td>2.36% 2.31%</td>
</tr>
<tr>
<td>HER2 (medium Jaguaribe – CE)</td>
<td>223.97</td>
<td>119.76</td>
<td>0.66% 0.77%</td>
</tr>
<tr>
<td>HER3 (Banabuiu – CE)</td>
<td>586.37</td>
<td>269.21</td>
<td>1.74% 1.74%</td>
</tr>
<tr>
<td>HER4 (low Jaguaribe – CE)</td>
<td>634.42</td>
<td>244.27</td>
<td>1.88% 1.58%</td>
</tr>
</tbody>
</table>

Sources: IBGE (2013a); FUNARBE (2011); IBGE (2013a).

### Table 4

Annual consumption of water for each sector regionalized for each HER

<table>
<thead>
<tr>
<th>Basin</th>
<th>Commerce (commercial and service sectors)</th>
<th>Public administration</th>
<th>Total of the annual consumption of water for each sector for the associated state (PB, RN or CE) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piranhas-Açú basin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HER1 (Coremas – PB)</td>
<td>3.18</td>
<td>2.18</td>
<td>3.35% 5%</td>
</tr>
<tr>
<td>HER2’ (Armando Ribeiro – PB)</td>
<td>14.3</td>
<td>6.64</td>
<td>15.06% 16%</td>
</tr>
<tr>
<td>HER2” (Armando Ribeiro – RN)</td>
<td>8.47</td>
<td>3.49</td>
<td>9.34% 9%</td>
</tr>
<tr>
<td>HER3 (low Açú – PB)</td>
<td>2.98</td>
<td>1.41</td>
<td>3.28% 4%</td>
</tr>
<tr>
<td>Jaguaribe basin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HER1 (high Jaguaribe – CE)</td>
<td>1.02</td>
<td>4.35</td>
<td>4.36% 5.26%</td>
</tr>
<tr>
<td>HER2 (medium Jaguaribe – CE)</td>
<td>2.78</td>
<td>1.35</td>
<td>1.18% 1.63%</td>
</tr>
<tr>
<td>HER3 (Banabuiu – CE)</td>
<td>6.99</td>
<td>2.91</td>
<td>2.98% 3.52%</td>
</tr>
<tr>
<td>HER4 (low Jaguaribe – CE)</td>
<td>5.49</td>
<td>1.94</td>
<td>2.34% 2.34%</td>
</tr>
</tbody>
</table>

Sources: IBGE (2013b); Baumann et al. (1997); FUNARBE (2011); IBGE (2013b); Baumann et al. (1997).
Among the crops with higher coefficients (Groups 1 and 2), those with above-average water consumption values in the basin, account for approximately 22% of the production value for HER1. This means that in this HER there is room for improvements in irrigation efficiency even after a change in the mix of crops being cultivated.

The water consumption distribution among the crop groups used in HER2 of Piranhas-Açú is also shown in Figure 1 and the associated production values obtained. One can easily note that the crop mix is more adequate than the one in HER1 (22% of HER2 water consumption used for Group 1 and 2 crops irrigation compared with 5% in HER1), even though the HER2′ coefficient is lower.

This is because in HER2′ almost all the crops in Groups 1 and 2 have above-average water use in the basin. Investments in more efficient irrigation techniques for these crops in HER2′, could raise this coefficient rapidly and result in a coefficient higher than in HER1, even without changing the cultivation types in HER2′.

It is interesting to note that in HER2″, the region with the highest aggregate coefficient, almost 70% of the water is used to irrigate Group 3 crops. Around 50% of this is
invested in beans, corn and rice, which means that there is
a need for changes in the crop mix. Aside from the percen-
tage of water used for Group 1 and 2 crops in HER2”, which
is higher than in the other regions (30%, as opposed
to 22% in HER2” and 5% in HER1), 3.8% of this consump-
tion is used for the crops with the higher coefficients in
Group 1. Because of this, the HER2” coefficient results
are higher than the others so far, even though there is
still a need to change the crop mix. And there is still also
room for improving the efficiency of irrigation techni-
ques. Of the more than 25% of the water applied on crops in
Groups 1 and 2 in HER2”, approximately 21% of these
crops have values of water usage in the region above the
average value.

Finally, HER3, despite not having the highest coeffi-
cient, is the one that has the most appropriate mix in
terms of use of Group 1 and 2 crops. Besides, almost all of
the water usage in Group 1 crops (54% of water usage) is
for crops that have intakes above the basin average (passion
fruit, banana, onions and castor oil). If we combine the
crops in Group 1 with Group 2, this percentage becomes
greater than 80% of the water applied to crops with already
high coefficients and with potential to be higher, provided
that there is improvement in the efficiency of irrigation.

In the Jaguaribe basin, individual coefficients by crops
are also used, then categorized into the same groups
(Groups 1–3 – Table 6). Using them we could evaluate the
coefficients obtained in each HER. In this basin, looking
at the four HERs together, it can be observed that the
crops in Group 3 (consisting mainly of rice and sorghum)
consume significant percentages of water in HER1, HER3
and HER4 (45.8%, 34.19% and 48%, respectively) associ-
ated with low production values (10%, 9% and 12%). Crops in Groups 1 and 2 consume 52% (HER1), 61%
(HER3) and 48% (HER4) of all water consumed in each
HER. These values are associated with the following percen-
tages of the production value of each (82%, 83% and 80%).

From these percentages we can see that, at least in terms of
the percentage of crops in the three established groups, the crop
mix in these three HERs is very similar and, because of that,
their technical coefficients are similar as well. Thus, a decrease
in the percentage of crops in Group 3 for all of them ought to
increase their coefficients. At the same time, with respect to
the crops in Groups 1 and 2, there are differences among the
HERs, so the potential for improving the aggregate coefficient,
without changing the crop mix, is different. The analysis of
HER2 is slightly different, since the technical coefficients of
the major crops in that region deviate considerably relative to
the average standard for the basin. In HER2, the crops occup.
ing significant proportions in that region, such as corn and
beans, have a technical coefficient of water use in monetary
terms much less than the average of these coefficients for the
same crops in the whole basin. So, these two major crops in
HER2, corn and beans, are in Group 3 (see Table 6). This
explains the low value of the coefficient in HER2, which is
smaller in relation to other HER coefficients, mainly because
the individual coefficients of its two significant crops are
much lower than in the other HERs.
Coefficients of the economic sectors associated with US in different HERs

The results for the two basins studied concerning the economic sectors associated with US: Commerce and Public Administration are presented in Table 7 and Figures 2 and 3.

In the Piranhas-Açú basin for the two studied sectors associated with US, we have tried to show in Figure 2, the relation between the technical coefficients values and the urbanization of each HER. The horizontal axis of the figure organizes the HERs according to their representation in the two sectors associated (see pie charts associated), reflecting the urbanization of the region. Thus, the HERs to the right are the more urbanized.

We can see that initially the more urbanized regions are associated with higher technical coefficients in the two sectors (see HER3 and HER1). However, as urbanization becomes greater, we begin to see lower values of the technical coefficients for the sectors (see pie charts associated). In the same way, in the Jaguaribe basin (see Figure 3), the coefficient of HER2, a less urbanized region, has both coefficients lower than that of HER4 (more urbanized than HER2). From that point on, however, the HER3 and HER1 coefficients are lower than that of HER4, even though both HER3 and HER1 are more urbanized than HER4.

As we utilized the same coefficient of water use for each sector in all HERs, based on the number of employees, the average value of production in relation to water resources followed the same logic with respect to number of employees. The technical coefficients are able to measure the average value of production owing to water resource input within a particular economic sector among the HERs. It is expected that initially, average values will increase as water inputs increase, but as the production levels increase, the marginal productivity of the water and average values will decrease.

Results combining the technical water use coefficients for the US and AI sectors with water allocation model strategies

Recently, the results of a water allocation model simulating a real system operation for the Piranhas-Açú basin in both present and future scenarios (Martins et al. 2013) were combined with our results of technical water use coefficients for
Figure 2 | Technical coefficients in monetary terms US sectors in Reais per m³ in each HER in Piranhas-Açu basin.

Figure 3 | Technical coefficients in monetary terms for US sectors in Reais per m³ in each HER in Jaguaribe basin.
the main economic sectors (US and AI) and HERs in the Piranhas-Açu basin. This was done to obtain an economic evaluation of different water allocation strategies in the basin. This combined model indicated that water allocation strategies that resulted in improved results for both economic sectors were those that combined greater hydro supply and additional infrastructure (SFIP) with a less conservative reservoir operation, still giving highest priority to urban demands. Other results showed that some water strategies currently used are inferior (reduced economic results for both economic sectors). These are the ones that set minimum water values between the two states (PB and RN). The results of future climate change scenarios show that maintaining the current water allocation strategy (highest priority to urban demands and lowest to irrigation demands) under a situation of climate change could negatively impact AI by as much as US$24 million per year on average, or a 41 per cent reduction in the economic return of the AI, with little or no additional benefits to the US sector. Placing higher priority on AI (but still less so than on US) could result in a US$6 million per year gain on average for the AI, with little or no losses to US. So, there are potential benefits from improving demand management. These benefits might increase even more if the return value of the AI in the basin became higher.

CONCLUSIONS

Analysis of the individual technical coefficients obtained by type of crop allows us to conclude that in general in the two basins, there is a mix of unsuitable crops associated with inefficient water use, which results in low coefficients for water use in monetary terms. So, opportunities for improvement in the regional economy should be explored via incentives to plant crops with higher economic return per cubic metre of water applied, as well as to use more efficient irrigation technologies. In economic sectors associated with US in general, values and behavior of the technical coefficients were quite similar in all the HERs studied, initially increasing with higher urbanization and then decreasing after a certain point. This means that, also for the US sectors, there is a need for incentives to use water in a more efficient way.

Combination of these coefficients with water allocation model results might be useful in supporting policy makers in the design of water policies that improve demand management and encourage efficient use of water.

REFERENCES


