Water Footprint in a Basket of Exportable Agricultural Products of San Juan Province

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Abstract: This paper calculates the water footprint (WF) and virtual water (VW) for a basket of exportable agricultural products of San Juan province. This basket includes: onion, white garlic and grapes for raisins. The VW of these three productions is calculated and the consumption is evaluated in relation to the theoretical water reservoir capacity of the province. It is compared with results of other jobs. The methodology used is based on the WF assessment manual and on Food and Agriculture Organization’s (FAO’s) CROPWAT 8.0 model to identify the crops’ water requirements and on the CIMWAT 2.0 climate database. Finally, recommendations are made for a more efficient use of water for agricultural production.

Key words: Water footprint, virtual water, agriculture, grapes for raisins.

1. Introduction

The water footprint (WF) is defined as the amount of fresh water that is used for the production of a good (or service); while, the virtual water (VW) shows the volume of water contained in the agricultural products exported. As a second step after calculating the WF, the fresh water used is valued by apparent productivity, which determines the economic value of agricultural production per liter and/or cubic meter of water used ($/L and $/m³). In order to value the VW economically, the value of the exports per comparative product and the WF of each product were used. An analysis of water restriction was carried out as an agricultural production factor comparing the theoretical capacity of reservoir water available with the consumption necessary for production. It also describes the water supply and water demand for agricultural irrigation that is a resource vital for agriculture to define.

The water supply of the Province of San Juan is defined by the module of the two water basins and the storage capacity of the dam system: the San Juan River basin and the Jáchal River basin with the dams and reservoirs Punta Negra, Caracoles, Ullúm Ravine and Cuesta del Viento.

As it is a scarce vital resource, the use of this resource is regulated by a Water Code whose application authority is the Department of Hydraulics (DH) that depends on the provincial government [1].

Another function of the DH is the distribution of water for agricultural use to lands that have those water rights mentioned above. As the Rio has been defined as exhausted, new water rights for agricultural irrigation can no longer be delivered: this condition indicates that the supply of water for agricultural use is inelastic [3].

This water supply can be accurately measured by leveling dams that are located at the beginning of the
irrigation system. Even, you can manage within certain parameters thanks to the dams and their reservoirs. Within this water supply, the largest portion is directed to agricultural irrigation.

The part of this water supply that is granted for agricultural use does not give its owner any right of ownership over public water, but it creates in its favor a subjective patrimonial right, of exclusive use, for the irrigation of its property. The right to use water for irrigation is inseparable from the property for which it is intended, and cannot be seized, encumbered, alienated or expropriated except in conjunction with the land for which it is granted [4].

The individual supply of water is quantified and defined in the code, corresponding to 1.3 L of water per second per hectare of irrigation right which is equivalent to 41 million liters per hectare per year [4]. In practice this amount is not delivered, but is adjusted by a coefficient that varies throughout the year.

This water restriction is also a restriction on the growth of the area destined to agriculture based on the current technological state. A more rational use of this water supply will make it possible to define development alternative for the provincial agricultural sector, such as increasing the amount of cultivated area incorporating more efficient irrigation technologies and converting production to agricultural products with less water use per unit of water value produced.

On the side of water demand for agricultural irrigation there is no measurement. This demand for agricultural irrigation is atomized in thousands of producers who have these rights. As it is a public service, it does not have a provision price, but a fee is paid which is calculated based on the maintenance costs of each channel (there are different values for each irrigation area).

The current practice is that irrigators receive water according to the shifts they have based on these irrigation rights. Irrigators have a passive demand since those shifts are the same throughout the agricultural year regardless of the requirements of the crop. The distribution of water is not done on the basis of the requirements of the crops but on those shifts defined by the rights of water that are distributed according to the order of the irrigators and their properties. In the current system, individual water requirements are not a determinant of water demand [5].

The two large basins of San Juan have a total unit of 67.7 m³/s distributed among the catchment area of San Juan River 60.5 m³/s (the last 10 years) and the one of Jachal River 7.2 m³/s. The first basin has a capacity of a total impounding of 1,490 hm³ spreading out in 440 hm³ in the dike of Ullum Ravine, upstream the Punta Negra dike with 500 hm³ and 19 km upstream it is Caracoles dike with 550 hm³. The Jachal River basin has the reservoir Cuesta del Viento with 180 hm³. The total capacity of reservoir of the province is of 1,670 hm³. There is no possibility of transferring water between the two basins. On these rivers settle the main populations of the province that are urban water users.

The quantification of the flow of these two main basins calculated on the basis of the total theoretical module is 2,135 hm³ which corresponds to 78.2% of the total reservoir capacity of 1,670 hm³. The reservoir capacity is equal to 78.2% of the flow of the theoretical module of both basins.

Table 1 shows the capacity data for the San Juan River basin considering the 1909-2008 period, the average or annual module is 65 m³/s and the average spill is 2,050 per year hm³. High dispersion is observed with maximums of 7,085 hm³ for the period 1919-1920 and the minimum with 627 hm³, less than 10 times the maximum recorded, a standard deviation of 1,206.9 hm³ and a median of 1,685 hm³.

Values of capacity in 100 years (1909-2009) of the San Juan River, Zonda Department, 47.3 km, San Juan province, Cuenca: San Juan River, latitude: 31°32'00", longitude: 68°53'00", altitude: 945 masl, area: 25,670 km².
In the dry cycles the basin of groundwater can provide the volume necessary to the development of crops by using a significant number of drillings approximately 8,000 privates with an average flow of between 100-150 m³/h and 118 official drillings located in strategic places. They are able to provide a maximum flow of 13 m³/s. But the recharge of the groundwater basin comes from the same source of the rivers, which is the melting of snow accumulated in the mountain chain during the months of snowfall and they should be considered part of the same water supply.

The indicators and data are listed before quantifying the restriction of water for human urban consumption, agriculture, industry, mining and the rest of the activities. The capacity of reservoir can be increased from the construction of new dams but not the capacity of recharging since the last is limited by nature (ecosystems services of nature). The 2005 Millenium Ecosystem Assessment (MEA) reports define the services of ecosystem as the benefits human beings obtain from ecosystems and distinguish four categories, from which those called support services are considered the basis for the services of the other three categories. They are: (1) Support Services, dispersion and recycling of nutrients, seed dispersion, primary production; (2) Provisioning Services, products obtained from ecosystems: foods, crops, wild foods and spices, water, minerals, pharmaceuticals, biochemical and industrial products, energy (hydroelectric, biomass fuels); (3) Services of Regulation, benefits obtained from regulation of ecosystem processes: carbon capture and storage and climate regulation, waste decomposition and detoxification, water and air purification, pollination of crops, pest and diseases control; (4) Cultural Services, non-material benefits that people obtain from ecosystems by spiritual enrichment, cognitive development, reflection, entertainment, aesthetic experiences, cultural, intellectual and spiritual inspiration, entertainment experiences (including tourism) and scientific discoveries.

This work calculates the WF and the VW, for a basket of exportable agricultural products from San Juan province and is related to the current storage capacity.

2. Materials and Methods

The methodology used is the one developed by the International WF Network and presented in the WF manual [6].

A source of free software (free source of free software) of general use and acceptance called CROPWAT 8.0 was used, which can be downloaded from the Food and Agriculture Organization of the United Nations (commonly called FAO). It serves to calculate the water need of the crops based on the characteristic of the crop, the type of soil and the climate. As an input of CROPWAT 8.0, CLIMWAT 2.0 was downloaded from the same source. This program is a climate database of more than 5,000 stations all around the world. Within these stations it is the meteorological station located at the D.F. Sarmiento Airport, in Department 9 de Julio, Chacritas, San Juan.

Calculations were made with this climate database but the information from Meteorological National Service (MNS) was also used, which comes from the same meteorological station.

The transpiration values required for the calculation of garlic and onion WF by the CROPWAT 8.0 program were taken from FAO Study Irrigation and
Drainage N° 56, crop transpiration (CT), guidelines for determination of water requirements of crops (ISSN 0254-5293) for garlic and onion study. For grapes values from the National Institute of Agriculture and Livestock Technology (INTA) were used.

Visits were made to four farms located near the meteorological station where the crops that form the basket under analysis are produced: grapes for raisins Flame seedless variety, onions and garlic.

Qualified informants related to agricultural irrigation were interviewed: person in charge of DH of Department of 9 de Julio, irrigators, farmers and members of the Irrigator Assembly of the homonymous department.

3. Results and Discussion

3.1 Scope and Limitation

Calculation of crop water use: It describes “green” or “blue” water that the crop requires for transpiration under optimum growth conditions. In this paper CT value that the program CROPWAT 8.0 generates is taken into account.

The green footprint value is very low due to the characteristics of desert climate the province presents. The “grey” water is not included in this calculation because the program CROPWAT 8.0 only allows to calculate green and blue WF, while grey WF is obtained through another method, since it is the fresh water necessary to assimilate the load of contaminant (fertilizers), beyond natural concentration of the place and water quality and not the water the crop needs to grow. It is also considered that San Juan soils have sufficient amount of phosphorus and potassium.

Only fertilization with nitrogen has been considered, taking into account the crop requirements. Therefore it is concluded that there is no waste of it. For example, vine farming needs 5 kg of nitrogen (N) per ton produced and for farming that produces 25 t/ha the amount of N for the soil is 125 kg. It is considered a fertilization with 500 kg of ammonium sulfate ((NH₄)₂SO₄) (21-0-0-24S) that replaces the one extracted by the culture without leaving residues.

The tendency towards other consulted papers is not to consider the calculation of grey WF. The measurement of hydrological footprint is considered up to the farm gate.

The calculation of the hydrological footprint of the production process of the main crops of San Juan province was carried out, starting from the beginning of the growth up to the moment of the harvest or the end of the cycle. Because of this, only the consumption of fresh water is considered until the merchandise is harvested or/and packed on the farm.

This is why there are no systematic necessary information data about WF of the supplies and material for the harvest and packaging. For example, there are no WF values for the grape for fresh consumption: wooden boxes or cardboard boxes, performed high density polyethylene bags or plastic baskets, corners, pallets, metal bands, buckles, zippers, self-adhesive labels, sulfur dioxide generators and others (such as the cold chain in and from the refrigerator up to the goods shelf or the fuels for transportation) to address the measurement until the product reaches the consumer’s hands.

3.2 Blue Hydrological Footprint Calculation per Product

This section presents the result of the program used for the chosen product basket: grapes, raisins, white garlic and onion.

3.2.1 Grapes for Raisins: Flame

San Juan is the main producer of grapes for raisins with 96% of the raisins from all of Argentina. The National Institute of Viticulture indicates that out of a total of 47.9 thousand hectares been planted with vines in San Juan, 3,200 ha (6.7%) are destined to raisins.

Since the forms of crop management differ according to destination, in this section irrigation is analyzed when the grapes are destined for raisins. This crop has a sprouting date for September 9, harvest for
January 20 and an average yield of 35 t/ha. Next, the WF of the grapes necessary to produce the raisins is calculated. Transpiration values were considered under optimal condition which means that the CT is equal to the water needs of the crops (CWR). The conditions are: (a) to be free of diseases; (b) well-fertilized crops; (c) that is cultivated in large fields; (d) under optimal conditions of water in the soil; (e) the full realization of production associated with certain current climate conditions. The option of water requirements for crops can be calculated only with climate and crop data. The evaporation and perspiration (CT) value of 805.6 mm calculated with the CROPWAT program.

Taking into account that a sheet of 1 mm in 1 ha is equivalent to 10 m³ of water, the amount of water needed for a sheet of 805.6 mm corresponding to 8.05 million liters of water is calculated to achieve a production of 35,000 kg of water/grape per hectare. This indicates that 230.17 L of water is needed to produce 1 kg of grapes under ideal conditions. That value must be affected by the irrigation efficiency:

(A) Irrigation by dripping, irrigation efficiency of 80%: 287.71 L of water is needed to produce 1 kg of grapes.

(B) Traditional irrigation or mantle, irrigation efficiency of 50%: 460.34 L of water is needed to produce 1 kg of grapes.

Effective precipitation was not taken into account since in reality the producers do not take into account this water supply at the moment of making calculations to define the irrigation. It should be noted that for 1 kg of raisins, 4.7 kg of Flame seedless grape is required.

This ratio indicates the amount of grapes per one kilogram of raisins and the required VW is obtained.

Table 2 summarizes the values of liters of water according to the rights of irrigation with the water footprint of the Flame seedless grape, the average number of kilos per hectare, the amount of liters required for that production and the minimum irrigation coefficient is determined to allow the normal development of the grape.

With the data obtained it is observed that to produce 1 kg of raisins, 2,162 L of blue water is required. This value is the WF of the raisins.

### 3.2.2 White Garlic

As for white garlic, in San Juan approximately 23,500 tons are produced, placing the province as second producer of the country and first in the production of excellent quality white garlic. Potential yields of dried and cut garlic in San Juan can reach under test conditions up to 30,000 kg/ha, in medium plots up to 21,000 kg/ha and in large farming up to 18,000 kg/ha. The most used varieties are the white garlic with a participation of 70% of the cultivated surface, being one of the main export vegetables of the province.

Another variety is late white garlic. This variety, misnamed “French garlic” (as they are supposed to be of that origin), grows well in temperate and cold temperate environments, grows during the autumn and late winter, has long cycle (March-November), average dormancy and late delivery. This crop has a sprouting date for March 20, a harvest for February 6, and an average yield of 20 t/ha.

| GRAPE flame seedless |  |
|----------------------|--|
| Liters of water by right | 41,000,000 |
| Liters of water × kilogram of flame grape | 460.34 |
| Amount of kilogram × hectare of flame | 35,000 |
| Amount of liters of water required | 16,111,900 |
| Minimum coefficient required | 0.39 |

Indicative table of the liters of water determined by the irrigation rights, liters of water to produce per kg of grapes and minimum irrigation coefficient.
Water Footprint in a Basket of Exportable Agricultural Products of San Juan Province

The CT value of 513.5 mm was calculated with CROPWAT. Taking into account that a sheet of 1 mm in 1 ha equals 10 m$^3$ of water, the amount of water needed for a sheet was calculated as 513.5 mm, which equals 5,135,000 L of water to achieve a production of 20,000 kg of white garlic per hectare. The water requirement is 256.75 L of water to produce 1 kg of white garlic under ideal conditions. This value must be affected by the irrigation efficiency:

- **A** (Irrigation by dripping, irrigation efficiency of 80%): 320.93 L of water are needed to produce 1 kg of white garlic.
- **B** (Traditional irrigation or mantle, irrigation efficiency of 50%): 513.5 L of water are needed to produce 1 kg of white garlic.

### 3.2.3 Onion

The cultivation of onion in the province of San Juan counts with a surface of approximately 2,500 ha, which represents the 26% of the devoted area destined for cultivation of vegetables. The most produced varieties are “Valencian” of long cycle and “little Valencian” of short cycle. In 2014, the sales abroad of fresh onions from the province were of US$ 5,794,238.19, representing a volume of 23,282.14 tons. The onion has sprouting date for April 10, harvest for November 5 and efficiency of average production is 50 tons per hectare.

The value of CT of 595.2 mm was taken calculated with CROPWAT.

Taking into account that a 1 mm leaf is equivalent to 10 m$^3$ of water, the amount of water required for a 595.2 mm leaf that is equivalent to 5,952,000 L of water was calculated to achieve the production of 50,000 kg of onion per hectare. In this way, 119.04 L of water are required to produce 1 kg of onion in ideal conditions. This value is affected by irrigation efficiency:

- **A** (Drip irrigation, with irrigation efficiency of 80%): 148.8 L of water are needed to produce 1 kg of onion.
- **B** (Traditional irrigation or mantle, irrigation efficiency of 50%): 238.08 L of water are needed to produce 1 kg of onion.

### 3.3 Valuation through the VW of the Selected Agricultural Basket

#### 3.3.1 Grapes for Raisins

The province is the main producer of grapes for raisins and is the main exporter of processed grapes from Argentina, accounting for 97% of the total of raisins exported.

The calculation of the WF for the raisins is presented in the following Table 3. In the first row is the volume of raisins exported for the years 2016 to 2018. In the second row is the conversion of these raisins to kilogram of grapes at a rate of 4.7 kg of grapes/kg of raisins. Considering an irrigation efficiency of 460 L/kg of grape, the amount of water assigned to the export of raisins is obtained. For the year 2018 it is 89 hm$^3$ of blue water that indicates the WF.

The required amount of water is converted to hm$^3$, which is the measure of the reservoirs and its proportion is obtained in relation to the total (maximum level of dams). It is observed that the exports of raisins require 5.34% of the total blue water of the province for the year 2018 calculated on the theoretical maximum base of storage of water in the dams and the historical average spill.

This percentage increases for years of drought while it will decrease for years with greater water spill. It also decreases for more efficient irrigation systems.

In following Table 4 the three irrigation efficiency levels are presented from 2016 to 2018 and the percentage of the theoretical storage capacity of water.

#### 3.3.2 White Garlic

San Juan is the second producer of garlic for export from Argentina: 20% of exports originate in this province for the years 2016 to 2018. Table 5 presents the calculation of the WF for garlic. In the first row is the volume of garlic exported for the years 2016 to 2018. Considering an irrigation efficiency of 513 L/kg of
Table 3  Calculation of the water footprint (WF) for the raisins.

|                   | 2016            | 2017            | 2018            |
|-------------------|-----------------|-----------------|-----------------|
| Total kilogram of raisins | 34,246,418      | 27,502,766      | 42,127,178      |
| Total kilogram of grape     | 160,958,164     | 128,880,419     | 193,841,899     |
| Total USD raisins exports   | 53,360,921      | 49,433,361      | 82,290,155      |
| Total water consumed WF    | 74.1 hm$^3$     | 59.3 hm$^3$     | 89.2 hm$^3$     |

Table 4  Values for the three levels of calculated irrigation efficiency for the raisins.

| WF efficiency | 2016 | 2017 | 2018 |
|---------------|------|------|------|
|               | hm$^3$ | % total reservoir | hm$^3$ | % total reservoir | hm$^3$ | % total reservoir |
| 230.17        | 37.02 | 2.22% | 29.64 | 1.77% | 44.58 | 2.67% |
| 287.71        | 46.28 | 2.77% | 37.05 | 2.22% | 55.73 | 3.34% |
| 460.34        | 74.04 | 4.43% | 59.28 | 3.55% | 89.17 | 5.34% |

Table 5  Calculation of the WF for garlic.

|                   | 2016            | 2017            | 2018            |
|-------------------|-----------------|-----------------|-----------------|
| Total kilogram of garlic | 15,912,000      | 17,005,000      | 21,892,000      |
| USD total exports of garlic | 53,360,921      | 49,433,361      | 82,290,155      |
| Total water consumed WF    | 8.2 hm$^3$      | 8.7 hm$^3$      | 11.3 hm$^3$     |

Table 6  VW required for garlic.

| White garlic |                   | 2016            | 2017            | 2018            |
|--------------|-------------------|-----------------|-----------------|-----------------|
| Liters of water by right | 41,000,000      |                 |                 |                 |
| Liters of water × kilogram of flame grape | 513            |                 |                 |                 |
| Amount of kilogram × hectare of flame | 20,000        |                 |                 |                 |
| Amount of liters of water required | 10,260,000    |                 |                 |                 |
| Minimum coefficient required | 0.25          |                 |                 |                 |

The required amount of water is converted to hm$^3$, which is the measure of the reservoirs and its proportion is obtained in relation to the total (maximum height of the levees). It is observed that garlic exports require 0.67% of the total blue water of the province for the year 2018 calculated on the theoretical maximum basis of storage of water in the levees and the historical average spill.

It also decreases for more efficient irrigation systems. Table 7 shows the values for the three irrigation efficiency levels calculated: with irrigation to the mantle 513 L/kg, with drip irrigation 320 L/kg and under ideal conditions 256 L/kg.

3.3.3 Onion

San Juan is the second onion export province in Argentina with 18% between 2016 and 2018. Considering an irrigation efficiency of 238 L/kg of onion as is presented in Table 8, the amount of water assigned to the export of garlic is obtained. For the year 2018 it is 3.7 hm$^3$ of water that indicates the WF of this product.

As in the other two products analyzed, the required amount of water is converted to hm$^3$ and its proportion is obtained with respect to the maximum height of the dykes that represent 1,670 hm$^3$. It is observed that onion exports require 0.22% of the total blue water of the province for the year 2018 calculated on the theoretical maximum basis of water storage in the levees and the historical average spill. It also decreases for more efficient irrigation systems.
Table 7  Values for the three irrigation efficiency levels for garlic.

| WF efficiency | 2016  | 2017  | 2018  |
|---------------|-------|-------|-------|
|               | hm³   | % total reservoir | hm³   | % total reservoir | hm³   | % total reservoir |
| 256.75        | 4.09  | 0.24%            | 4.37  | 0.26%            | 5.62  | 0.34%            |
| 320.94        | 5.11  | 0.31%            | 5.46  | 0.33%            | 7.03  | 0.42%            |
| 513.5         | 8.17  | 0.49%            | 8.73  | 0.52%            | 11.24 | 0.67%            |

Table 8  VW required for onion.

| Onion          | Liters of water by right | Liters of water × kilogram of onion | Amount of kilogram × hectare of onion | Amount of liters of water required | Minimum coefficient required |
|----------------|--------------------------|------------------------------------|--------------------------------------|-----------------------------------|-----------------------------|
|                | 41,000,000               | 238                                | 50,000                               | 11,900,000                        | 0.29                        |

Table 9  Total onion exported in kilogram, total value in US$ and total water in hm³.

|                         | 2016     | 2017     | 2018     |
|-------------------------|----------|----------|----------|
| Total kilogram of onion | 14,196,000 | 6,051,000 | 15,631,000 |
| USD total onion exports | 3,402,117 | 1,077,229 | 3,766,931  |
| Total water consumed WF | 3.4 hm³  | 1.5 hm³  | 3.7 hm³  |

Table 10  Values for the three levels of calculated irrigation efficiency for onion.

| WF irrigation efficiency | 2016  | 2017  | 2018  |
|--------------------------|-------|-------|-------|
|                         | hm³   | % total reservoir | hm³   | % total reservoir | hm³   | % total reservoir |
| 119.04                   | 1.69  | 0.10%            | 0.72  | 0.04%            | 1.86  | 0.11%            |
| 148.80                   | 2.11  | 0.13%            | 0.90  | 0.05%            | 2.33  | 0.14%            |
| 238.08                   | 3.38  | 0.20%            | 1.44  | 0.09%            | 3.72  | 0.22%            |

Table 9 presents the calculation of the WF for onions. In the first row is the volume of onion exported for the years 2016 to 2018.

Table 10 shows the values for the three levels of calculated irrigation efficiency: with mantle irrigation 238 L/kg, with drip irrigation 149 L/kg and under ideal conditions 119 L/kg.

4. Conclusions

The supply of water is determined by the summer spills coming from the melting of snow accumulated in winter and stored in the dam system. The flows assigned to agriculture are measured permanently and can be managed. The demand for water varies according to the type of crop and the season of the year. It is relatively stable for perennial crops (grape, olive, fruit) and more unstable for non-perennial crops (onions, garlic, tomatoes). However, the amount of water to be demanded changes every year based on the planting decisions of the producers and the restriction defined by the agricultural rights they have. Some of these rights are not used or used in a smaller amount, but water is also delivered because the demand is not known and the supply is determined by the water rights it has.

To solve this management problem, the HH is proposed. The annual calculation of the HH of each producer can be used for better water management. It allows defining the location of use, the total amount for the entire agricultural period and the critical moment of water use.

The values obtained from WF for the different products are similar to other studies.

Argentina is among the 10 countries that export the
most VW since its basket of export products has mainly agricultural base but it is not considered as a
desert country and is even evaluated as 100% self-sufficient and no dependency. San Juan, which is
part of Argentina, has shortages of water and bases its exports on agricultural production, emulating the
country it integrates, but with different agro-ecological conditions characterized by being a
desert area. This situation poses a problem when
statistics analyzed from the DH show a trend of
annual spills with a negative trend. Based on 100
years of flow measurement, it is observed that the
maximum spillage values observed in the first half of
the 20th century are greater than the peaks of the
second half. The registered minimum was in the years
1968-1969 and the registered maximum was in the
years 1919-1920. Maintaining this tendency is more
necessary to discuss efficient allocation, since
agricultural production is an important pillar of the
provincial economy. Using generalized drip irrigation
would be a way to alleviate water restriction. Another
possibility is the identification of the water
requirements with greater precision to deliver the
water according to a demand relieved more than with
a fixed water supply determined by the concession
rights held by each producer. Identifying WF in each
product is also a possibility to begin to become aware
of the use of blue water in the province.

The present finds the province with a low
population growth (in the last 30 years less than the
nation) that indicates less pressure on the water
resource. According to INTA:

In the twentieth century, global water consumption
increased six times, more than twice the rate of
population growth, with an average value of
1,243,000 L per inhabitant per year and a wide range
of variation between countries and regions
(technology and water management in rainfed,
Portfolio Integrator 2013-2019).

Given this demand for human consumption,
approximately 880 hm³ is required given the current
population of the province. Even with this level of
population consumption, the province of San Juan is
within the theoretical average values of the 2,050 hm³
spill. However, the sum of the demands for human
and agricultural consumption far exceeds the
minimum values recorded, a situation that should
generate an alert to those who design development
policies. Activities of low water consumption, low use
of irrigated land (by surface or underground water),
low level of waste and intensive workforce are
activities compatible with the local development of
the province of San Juan.

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