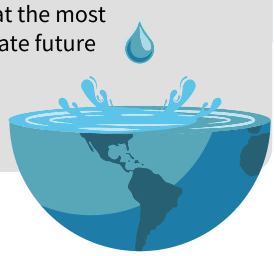
# FS 3.5 Water Footprint Estimation in Latin America

## Introduction

Latin America and the Caribbean is home to approximately one-third of the world's freshwater supply; however, the geographic distribution of this abundance is not aligned with demand, making much of the region vulnerable to water scarcity [1]. This vulnerability is only expected to increase as average global temperatures continue to rise, with the Intergovernmental Panel on Climate Change predicting increases in the frequency and duration of droughts, changes in rainfall patterns, and more intense storms [2]. In this context, it is essential to understand the role of water in the economy to predict the effects of climatic changes on economies and develop strategies for improving water consumption efficiency within them [3]. Water footprint analysis is a tool that allows policymakers to analyze the virtual flow of water through various economic sectors and relates water as an input to economic output. A recent technical note by the IADB's Water and Sanitation Knowledge Team, entitled "Water Footprint Estimation in Latin America", describes water footprint analyses for Brazil, Colombia, and Costa Rica, uncovering trends in sectoral water consumption throughout the three countries.

### Key Points

1. Brazil, Colombia, and Costa Rica show many common trends for consumption throughout sectors; however, direct water footprint estimates show that water volumes per unit of economic output vary significantly between countries and sectors.
2. Incorporating water footprint linkages drastically raises agriculture and water and sanitation sectors' water consumption indicators, making their incorporation vital when performing economic-environmental analysis.
3. It is crucial to have water data at the most granular sectoral level to facilitate future water footprint analyses and identify subsequent areas for future research.



## Methodology

The water footprint analysis utilizes input-output tables to track virtual water flow across economic sectors and relate water as an economic input to gross output. Water footprint analysis requires coupling physical sectoral water accounting with input-output data.

- **Water data:** All three countries in the study follow the System of Environmental and Economic Accounting for Water (SEEA-Water), the UN's international statistical standard for economical water accounting, resulting in compatible data generated via relatively consistent methodologies for all three countries. These data consist of physical supply and use tables, asset tables, and hybrid and economic tables, allowing users to link physical water data to economic activities. Differences in sectoral aggregation across countries resulted in the need to adjust them to the highest common aggregation, which limits the sectoral breakdown to the Agricultural Sector, the Water and Sanitation Sector, and a catch-all rest of the economy.
- **Economic data:** Sectoral economic data was available as input-output tables from the OECD and therefore, standardized across countries. All values are expressed in 2015 USD.

This study relates the direct water requirements to economic output, isolated within a given sector and considering forward and backward linkages. Table 1 shows the key terms of water footprint analysis and Table 2 presents the main data features for all countries. For a more detailed description of data and method, please see the Technical Note "Water Footprint Estimation in Latin America".

*Table 1: Key Terms of Water Footprint Analysis*

| Key Terms of Water Footprint Analysis | |
|---|---|
| **Direct water requirements** | Sectoral water consumption plus any losses (see Figure 1), measured in cubic hectometers |
| **Direct water footprint** | Direct virtual water flows per unit of sectoral economic output, based on direct inputs required by the sector's output, measured in cubic meters per 2015 USD. |
| **Backward linkages** | Total virtual water flows per unit of sectoral economic output, based on direct and indirect inputs required by the sector's output, measured in cubic meters per 2015 USD. |
| **Forward linkages** | Total virtual water flows per unit of economic output related to downstream sectors for which the sector produces inputs, measured in cubic meters per 2015 USD. |

*Source: Author's elaboration*

*Table 2 – Main features of SEEA-Water for Brazil, Colombia, and Costa Rica*

| | Brazil | Colombia | Costa Rica |
|---|---|---|---|
| **Covered period** | 2013-2017 | 2010-2020 | 2012-2017 |
| **Water physical unit** | Cubic hectometers ($hm^3$) | Cubic hectometers ($hm^3$) | Cubic hectometers ($hm^3$) |
| **Economic sectoral disaggregation** | 6 sectors | 12 sectors also detailed in 61 activities | 5 sectors (2012-2016) |
| **Consumptive use** | Explicit and estimated as the difference between water abstraction and return | Bottom-up estimation of off-stream and on-stream water consumption | Estimation based on fixed coefficients |
| **Losses during abstraction and distribution** | Implicit. Return flows to the environment include the losses | Explicit | Explicit |
| **Irrigation by public perimeters** | The water supply is explicit, but the losses are not | There is no identification of irrigation in agricultural water demand | Explicit both water supply and losses |
| **Electricity generation** | Distinguish hydro and non-hydro water use | 100% hydro (non-consumptive use) | 100% hydro (non-consumptive use) |

*Source: Author's elaboration*

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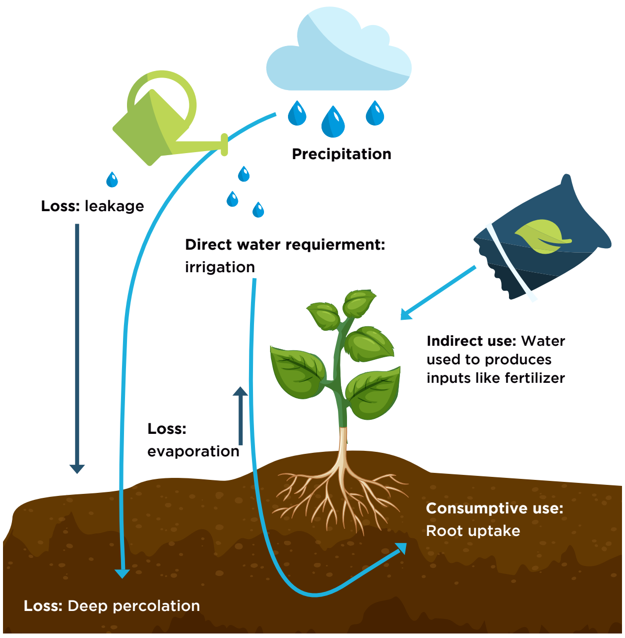


*Figure 1: Diagram showing an agricultural example of the terms used in water accounting. Direct water requirements are consumptive use + loss*

## Results

### Direct Water Requirements

Despite substantial differences in the composition and size of the economies, some commonalities in water consumption are apparent. The agricultural sector consistently had the highest direct water requirements for all three countries, accounting for approximately 4-6% of national gross output. Simultaneously, the rest of the economy tend to have relatively small water demand while accounting for larger gross output.

While the economies follow similar macro trends concerning their compositions and water consumption, there are relevant differences in the magnitude and efficiency of water consumption. To look at the efficiency of water consumption throughout the economy, we can examine the direct and total water footprints per sector. Such indicators represent cubic meters required directly and indirectly to accomplish the gross output of 1 USD (adjusted to 2015 USD).

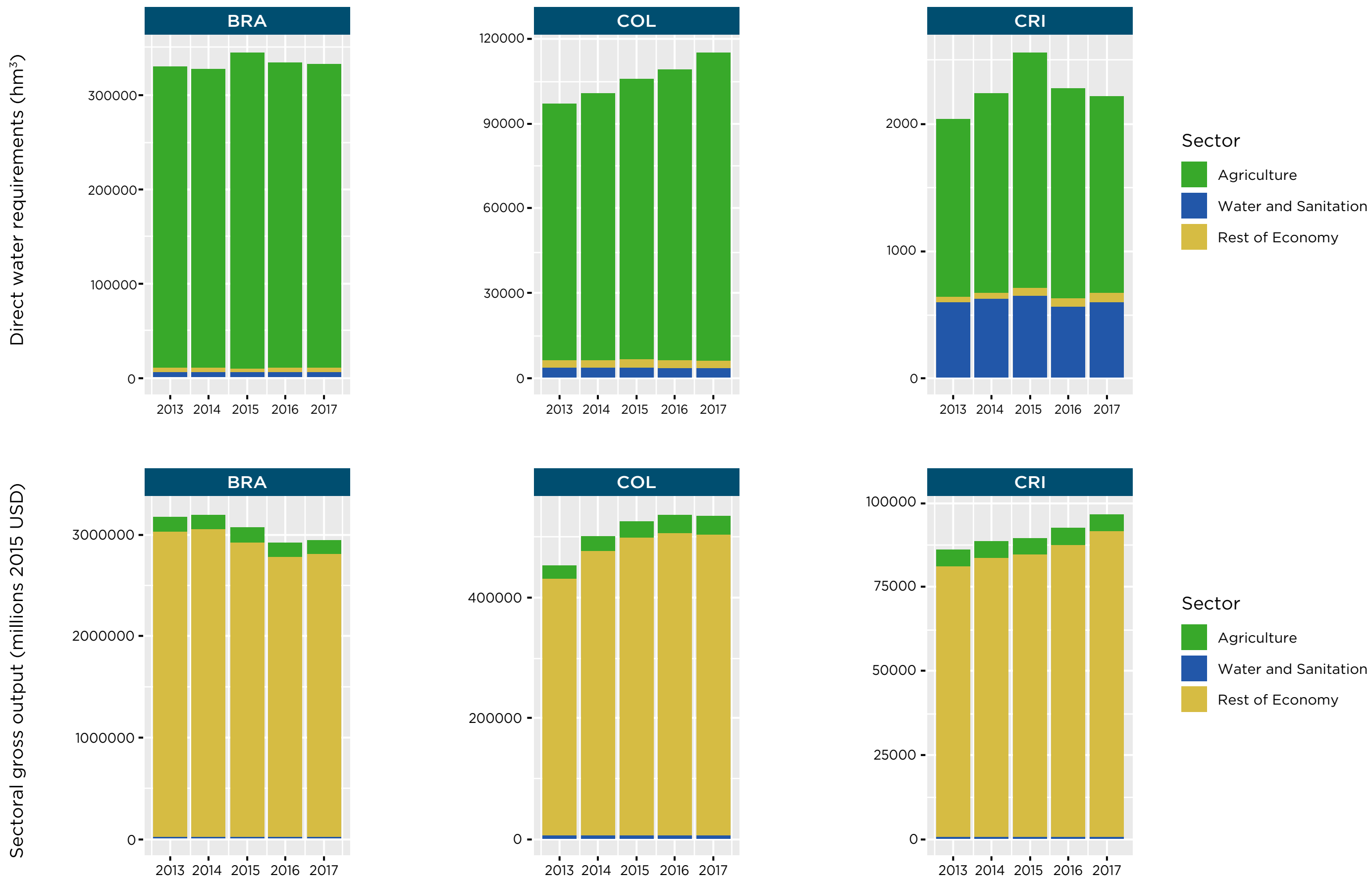


*Figure 2: Direct water requirements (hm³) and Sectoral gross output (millions 2015 USD) for each country by year.*

### Direct Water Footprints

Direct water footprints, which show the direct water consumption in each sector per unit of gross output, tell a more nuanced story. For example, while Brazil's agriculture has a much higher total water demand, its direct water footprint is less than that of Colombia, meaning that the agricultural sector in Brazil generates more economic value per use of unit water than that of Colombia. Costa Rica has the lowest direct water footprint for the agricultural sector among the countries analyzed.

A lower direct water footprint could imply water consumption is more efficient. Still, differences in direct water footprints can also stem from differences in each country's economic system. In the case of the agricultural sector, which makes up the largest proportion of the direct water footprint for Brazil and Colombia, the role that water plays depends heavily on the crop portfolio within the agricultural sector, specifically the ratio of a given crop's water demand to its economic value-added. Investigating the cause of differences in water footprint among countries is an essential first step to inform water-efficient policy-making.

Looking at direct water footprints within a sector over time can also lead to exciting research questions. For example, in Colombia's water and sanitation sector, the direct water footprint more than doubled between 2013 and 2014. As gross output in the sector grew between the two years, the cause of this increase is not immediately apparent. On the other hand, the water and sanitation sector in Costa Rica makes up the largest proportion of the direct water footprint, a position occupied by agriculture in Brazil and Colombia. The cause of such an effect requires further investigation of the features of the Costa Rican economic system.

### Total Water Footprints

Examining backward and forward linkages provides a comprehensive view of total water footprints. For example, an increase in sectoral output usually demands an increase in production inputs, which triggers an increase in the economic activity of other sectors, ultimately leading to greater water demands across supply chains.

By incorporating these linkages, a more complete perspective of water consumption emerges within these economies (Table 2). For instance, in Colombia, the agricultural sector directly required 0.21 cubic meters of water per 1 USD of sectoral gross output. However, for the same economic output, the total water input (direct and indirect, embedded in other products along the supply chain) was 3.86 $m^3$/USD. Additionally, downstream product generation added another 4.11 $m^3$/USD. **This contrasting accounting emphasizes the relevance of simultaneously assessing backward and forward linkages alongside direct water footprints when analyzing sectoral water usage.**

Overall, Colombia has the most water-intensive economic system, with an average total water footprint of 4.88 $m^3$/USD/year, followed by Brazil (2.85 $m^3$/USD/year) and Costa Rica (1.25 $m^3$/USD/year). Colombia likewise has the highest forward and backward linkages of the 3 countries, suggesting that water consumption throughout the economy may have room to improve in terms of efficiency.

**Further sectoral disaggregation could provide more insight into water consumption throughout the economy.** As the technical note aimed to describe water footprint estimation and compare results in three different Latin American economies, the country with the highest level of sectoral aggregation in their SEEA-Water data decided the sectoral aggregation. With climate change threatening to increase water scarcity in many countries in Latin America, countries could consider producing SEEA-Water data at the lowest level of aggregation possible to enable more granular future analyses.

*Table 3: Direct water footprint and forward and backward linkages*

| $m^3$/USD | | Direct water footprint | | | | Backward linkages | | | | Forward linkages | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | Year | AGRI | WASA | RoE | TOTAL | AGRI | WASA | RoE | TOTAL | AGRI | WASA | RoE | TOTAL |
| BRA | 2013 | 0.10 | 0.01 | 0.05 | 0.17 | 2.38 | 0.38 | 0.10 | 2.85 | 2.49 | 0.35 | 0.00 | 2.85 |
| | 2014 | 0.10 | 0.01 | 0.05 | 0.16 | 2.39 | 0.37 | 0.09 | 2.85 | 2.51 | 0.34 | 0.00 | 2.85 |
| | 2015 | 0.10 | 0.01 | 0.06 | 0.16 | 2.47 | 0.38 | 0.10 | 2.94 | 2.59 | 0.35 | 0.00 | 2.94 |
| | 2016 | 0.10 | 0.01 | 0.06 | 0.16 | 2.29 | 0.38 | 0.10 | 2.77 | 2.42 | 0.35 | 0.00 | 2.77 |
| | 2017 | 0.09 | 0.01 | 0.05 | 0.16 | 2.35 | 0.38 | 0.09 | 2.82 | 2.47 | 0.35 | 0.00 | 2.82 |
| COL | 2013 | 0.22 | 0.01 | 0.11 | 0.37 | 4.03 | 0.85 | 0.19 | 5.07 | 4.28 | 0.77 | 0.02 | 5.07 |
| | 2014 | 0.22 | 0.04 | 0.10 | 0.34 | 3.77 | 0.83 | 0.18 | 4.78 | 4.01 | 0.75 | 0.01 | 4.78 |
| | 2015 | 0.20 | 0.04 | 0.10 | 0.33 | 3.55 | 0.82 | 0.18 | 4.55 | 3.79 | 0.74 | 0.01 | 4.55 |
| | 2016 | 0.19 | 0.04 | 0.10 | 0.35 | 4.07 | 0.77 | 0.19 | 5.03 | 4.07 | 0.69 | 0.01 | 4.78 |
| | 2017 | 0.21 | 0.04 | 0.10 | 0.35 | 3.86 | 0.78 | 0.18 | 4.82 | 4.11 | 0.70 | 0.01 | 4.82 |
| CRI | 2013 | 0.03 | 0.07 | 0.009 | 0.11 | 0.31 | 0.84 | 0.02 | 1.17 | 0.31 | 0.85 | 0.00 | 1.17 |
| | 2014 | 0.03 | 0.04 | 0.010 | 0.08 | 0.33 | 0.86 | 0.02 | 1.21 | 0.34 | 0.87 | 0.00 | 1.21 |
| | 2015 | 0.04 | 0.04 | 0.012 | 0.09 | 0.41 | 0.95 | 0.02 | 1.38 | 0.42 | 0.96 | 0.00 | 1.38 |
| | 2016 | 0.03 | 0.04 | 0.010 | 0.08 | 0.35 | 0.82 | 0.02 | 1.19 | 0.36 | 0.83 | 0.00 | 1.19 |
| | 2017 | 0.02 | 0.04 | 0.010 | 0.08 | 0.31 | 1.02 | 0.02 | 1.35 | 0.32 | 1.03 | 0.00 | 1.35 |

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## Conclusion

Water footprint analysis is valuable for understanding water usage throughout the economy and opening areas for future research. This preliminary evaluation shows that water consumption within the three economies varies extensively, with Colombia having the most water-intensive economic system. In addition, water consumption behavior also varies across countries and within sectors over time, with the sector with the highest direct water footprint being agriculture in Brazil and Colombia and the water and sanitation sector in Costa Rica. Backward and forward linkages provide a complete picture of water usage across the economic system, increasing the water intensity of economic activities compared to direct consumption indicators.

These overarching trends between countries and over time within countries and sectors pose several interesting questions for future research, some of which will be addressed in the upcoming IDB publication "Direct water requirement patterns in Latin America: A Structural Decomposition Analysis". With climate change threatening to severely alter water dynamics throughout Latin America, future analyses could be enriched via countries' publication of SEEA-Water data at the most granular sectoral level possible. This would enhance the understanding of water usage throughout national economies and allow for more targeted policy conclusions.


### References

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