Working document N° 3/2022

Universidad Privada Boliviana - Sustainable Development Solutions Network (UPB -SDSN Bolivia)

The water footprint of tourism in Bolivia

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Working paper N° 3/2022: report of the water footprint of receptive tourism in Bolivia

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October 2022

Summary: The Water Footprint is an indicator that reflects the use, consumption and contamination of water. It also allows the analysis of the environmental, social and economic implications of water usage. This study estimates the water footprint of receptive tourism in Bolivia in 2019, based on the Evaluation Manual of the Water Footprint of the Water Footprint Network. The results indicate a consumption of 17,906,638 cubic meters of water in 2019, which is approximately equivalent to 5,000 Olympic pools. The consumption of food and purchase of textiles and apparel by tourists represents 97% of the water footprint of the sector, while the remaining 3% is from direct consumption and water contamination. Due to the results obtained, they identified opportunities and actions to improve the sector and its key actors (hotels, travel agencies, tourists, service providers, etc.).

Key words: water footprint, receptive tourism, wastewater
JEL Classification: Q25, L83

1. Introduction

Although the planet has enough freshwater for the entire population, the current distribution of water is not appropriate, they anticipate that by 2050 at least 25% of the global population will live in a country affected by chronic shortage of freshwater (UNDP, 2022). This shortage of water resources, along with poor water quality and insufficient clean-up, affects distinct areas and economic sectors, including tourism.

According to a study by We Are Water Foundation, tourism accounts for 1% of global water consumption. However, in some emerging countries where tourism is one of the pillars of economic development, the consumption of water by tourism exceeds 7%. In some locations, such as the Caribbean and Polynesian islands, the tourism sector is the primary consumer of water (We Are Water Foundation, 2017).

Although in the majority of countries in the world, tourism accounts for only 1% of global water consumption (in contrast to the agriculture sector's 70% and the industry sector's 19%), tourism is often concentrated where water is scarce and/or where there is not enough water, such as treatment systems of wastewater. Therefore, the tourism sector can assume leadership in the most visited tourist destinations and companies, by investing in resources to reduce the use of water.

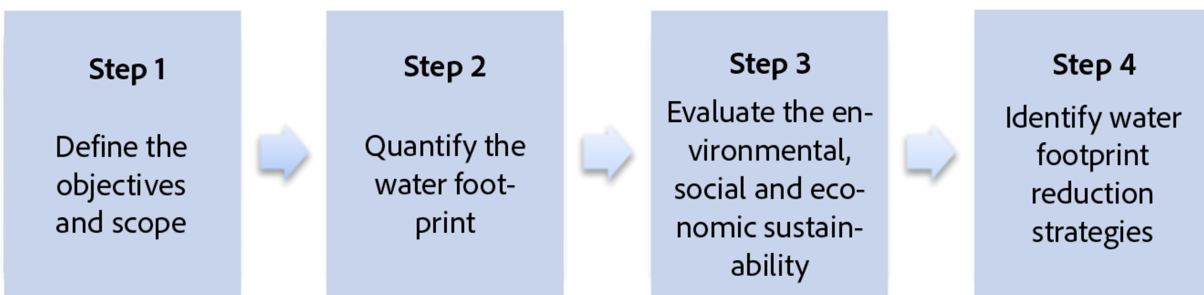
2. Theoretical and conceptual frame

Water Footprint Introduction

The concept and the methodology for the evaluation of the water footprint was developed by Dr. Arjen Hoekstra and spread through the Water Footprint Network Organization, a Dutch network that groups international organizations linked in terms of water and cleanliness since 2008. Therefore, the water footprint is an indicator that allows the understanding of the consumption, contamination and use situation of the sectors, processes and activities, so that later they can implement measures and actions that strengthen sustainable and fair use of freshwater.

The information visualized through the water footprint allows the analysis of environmental, social and economic implications of water use in distinct geographic areas. The evaluation of the water footprint is a 4-step process that describes the series of steps for the measurement, analysis of results and evaluation of possible reduction strategies (Hoekstra et al., 2011). Their quantification is developed as a geographical context function and type of water use. The four steps of evaluation are:

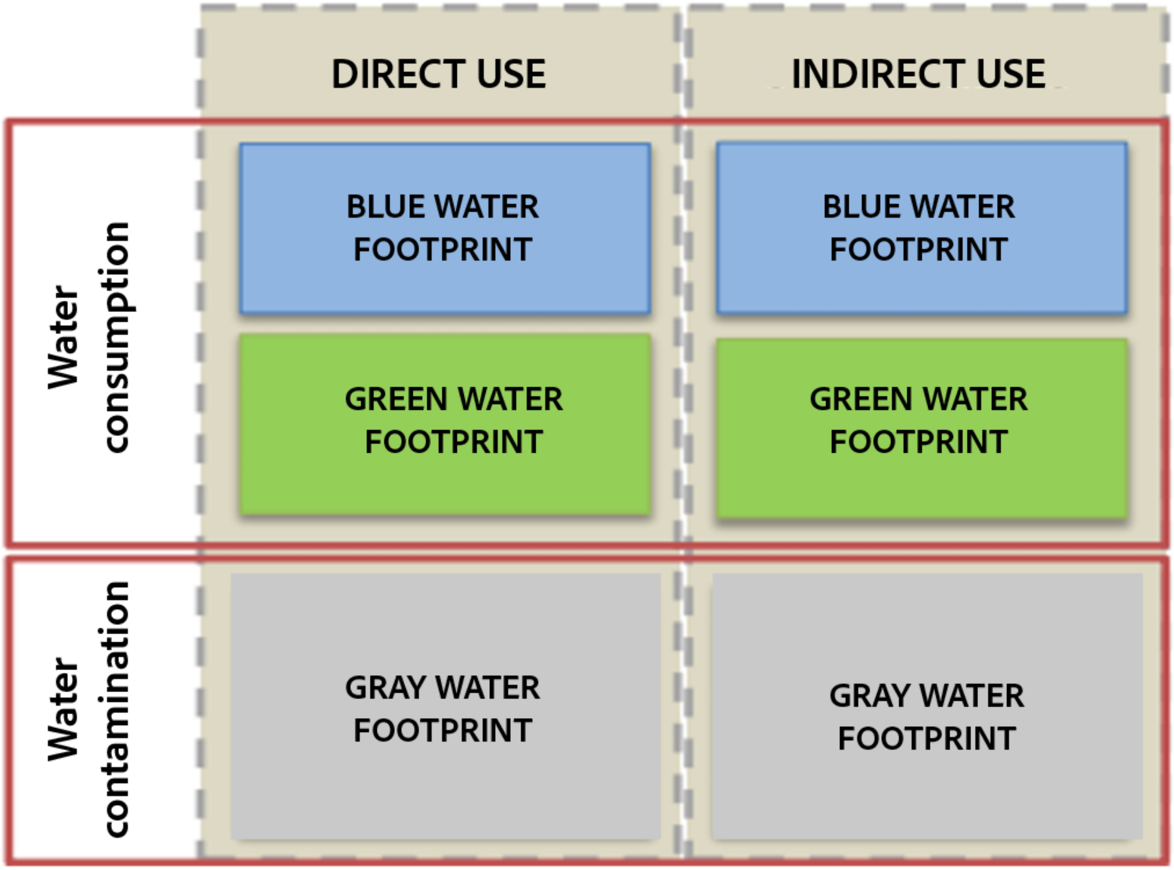
Figure 1. Water footprint evaluation steps



Source: Extracted from Hoekstra et al., 2011

The methodology for the evaluation of the water footprint identifies three types of footprints: “Blue Water Footprint,” “Gray Water Footprint,” and “Green Water Footprint.” These express the volume of water consumed or contaminated over a period of time. However, there are notable conceptual differences between them. The following figure shows a schematic representation of the components and dimensions of the water footprint, and the definition of each type of footprint.

Figure 2. Water footprint types and dimensions



Source: Extracted from Hoekstra et al., 2011

Blue Water Footprint: It is an indicator of "blue" water use, meaning surface or groundwater that is freshwater. water use occurs in one of the following ways:

- Evaporated water
- Water is incorporated into a product
- Water does not return to the same flow zone, and is returned to another zone or the sea
- Water does not return in the same period. For example, it is removed during a dry period and returns during a rainy period

Gray Water Footprint: It is an indicator of contamination that calculates the water required to dilute the contaminated water until the quality of water is above the normal level of the local area.

Green Water Footprint: This refers to the volume of rainwater absorbed by the soil and vegetation that does not become runoff water or get absorbed by underground water sources. This is part of the precipitation that will evaporate or be absorbed by the plants. “Green” water can be productive for the growth of cultivation (although not all the “green” water is absorbed by cultivation, so that there always exists evaporation in the ground, and because not all of the annual phases or zones are sufficient for the growth of cultivation). This footprint is particularly relevant for agricultural and forestal products.

Indirect Water Footprint: Is an indicator of the volume of water consumed and contaminated in bodies of water, associated with the production of goods and services. This footprint is calculated by multiplying the quantity of products consumed by their respective water footprint equivalents.

Because of these different dimensions and types of water footprints, they can analyze how the activities of each sector are related to the shortage and amount of water, directly or indirectly.

3. Scope of the study

3.1 Definition of limits and scopes of the measure

The present estimation considers the activities, uses and consumptions that generate the water footprint of foreign tourists that visited the country for tourism reasons in 2019 (receptive tourism). The water footprint generated by local tourists has not been considered in the estimation, since the water footprint generated simply replaces the water footprint local tourists would have generated if they had stayed home. (Mekonnen, M. & Hoekstra, A., 2012).

3.2. Identification of water footprint types and dimensions

The water footprint types and dimensions considered in this document are detailed in the following table:

Table 1. Types of water footprints considered

Type of footprint	Consumption/contamination source
Direct footprint (blue)	Direct consumption of water (consumption use)
Direct footprint (gray)	Contamination from wastewater
Indirect footprint	Consumption of products and food

Source: authors’ calculations based on Hoekstra et al., 2011

3.3. Selection/development of calculation methodologies

Below are the formulas for the quantification of each type of water footprint, conforming to the global standards described in the Evaluation Manual of the Water Footprint:

(1)$WF_{Total} = WF_{Blue}$(2) + WF_{Gray}(3) + $WF_{Indirect}$(4)

$$(2) WF_{Blue} = Evaporation + Incorporation + Return\ Flow\ of\ Lost\ Water$$

$$(3) WF_{Gray} = ((Ww * Conc_{Ww}) - (Afl * Conc_{alf}))/(Conc_{max} - Conc_{nat})$$

$$(4) WF_{Indirect} = \sum_{p}(Q_p * WF_{Prod})$$

Where:
WF = water footprint
Ww = Wastewater
$Conc_{Ww}$ = Wastewater concentration
$Conc_{Inf}$ = Inflowing water concentration
$Conc_{max}$ = Maximum concentration
$Conc_{nat}$ = Natural concentration
Q_p = Quantity of products
WF_{Prod} = Water Footprint equivalent to product

3.4 Collection of data and organization of information

3.4.1 Direct Water Footprint

Blue Water Footprint: The "blue" direct water footprint was calculated from the estimation of water consumption per capita in Bolivia (214 cubic meters/year) defined by the Water Footprint Network (FAO, 2021). The "blue" direct water footprint is generated by the incorporation of water during consumption activities and not due to evaporation processes and/or return flow of lost water (unloaded in other basins).

Gray Water Footprint: Calculated by means of the generation factors of the "gray" water footprint per capita in Bolivia (SASA, 2019) for the largest cities (La Paz, Santa Cruz de la Sierra, Tarija, Cochabamba and El Alto). These factors have been developed considering the local characteristics in the cities with respect to the volume and consumption of water and the generation of wastewater in cubic meters. They also consider the amount of water consumed and wastewater in terms of the Biological Demand of Oxygen (BDO) and the Chemical Demand of Oxygen (CDO), the amount of water in natural conditions and the maximum concentrations established for the local regulations with regards to the BDO and CDO.

The maximum concentrations permitted for the bodies of water were based on the limits established in the *Material Rules of Water Contamination of the Environmental Law #1,333 of Bolivia for the "D" Class* considering that it is the minimum standard required by the rule (Zeballos and Franken, 2019). On the other hand, the natural concentration of the bodies of water in terms of BDO and CDO, under an environmental state where water capacity is not impacted, obtained from the registers of current water capacities in the Report of Water Capacity in the Katari River Basin Bodies of Water, during 2009 to 2011, in the PROLAGO/USAID Project (EYE, 2011).

3.4.2. Indirect water footprint

The indirect water footprint related to the products and/or goods consumed by tourists has been estimated considering the water footprint of an average diet, consisting of meat, milk, bread, fresh fruits and vegetables (banana, orange, apple and grapes). They also considered in an illustrative way the water footprint of textiles and apparel (assuming that each tourist purchases at least one article of clothing).

Table 2. Sources of information used

Water Footprint Source	Information to collect	Data in liters/unit	Source
Consumption of water	Data of water consumption per capita per day	5.8 liters	Hoekstra et al., 2011
Contamination from wastewater	Gray water footprint per capita per city and national average	La Paz: 6,497 L/day Cochabamba: 6,659 L/day Santa Cruz: 6,658 L/day Sucre: 326 L/day Tarija: 6,497 L/day Other municipalities: 5,914 L/day	SASA, 2019
Use of products and services	Amount of products consumed per day per tourist, water footprint per product	Water footprint from food production in cubic meters/kg: Beef: 3294 Milk: 563 White bread: 486 Vegetables: 0.87 Fruits: 0.88	Hoekstra et al., 2011
		Textile water footprint: 10,000 L/kg	Mekonnen, M. & Hoekstra, A. (2012).
		Amount of products consumed per tourist in kg/day: Beef: 0.1	Wilson, 2022

		Dairy: 0.7 Cereal: 0.3 Vegetables: 0.14 Fruits: 0.32 Textiles: 0.2	

Source: authors' calculations

4. RESULTS

Total Water Footprint

Below are the results obtained from the methodology and the estimations that consider the use, consumption and generation of waste water from foreign tourists that visited Bolivia in 2019, according to the data from Bolivia's National Institute of Statistics.

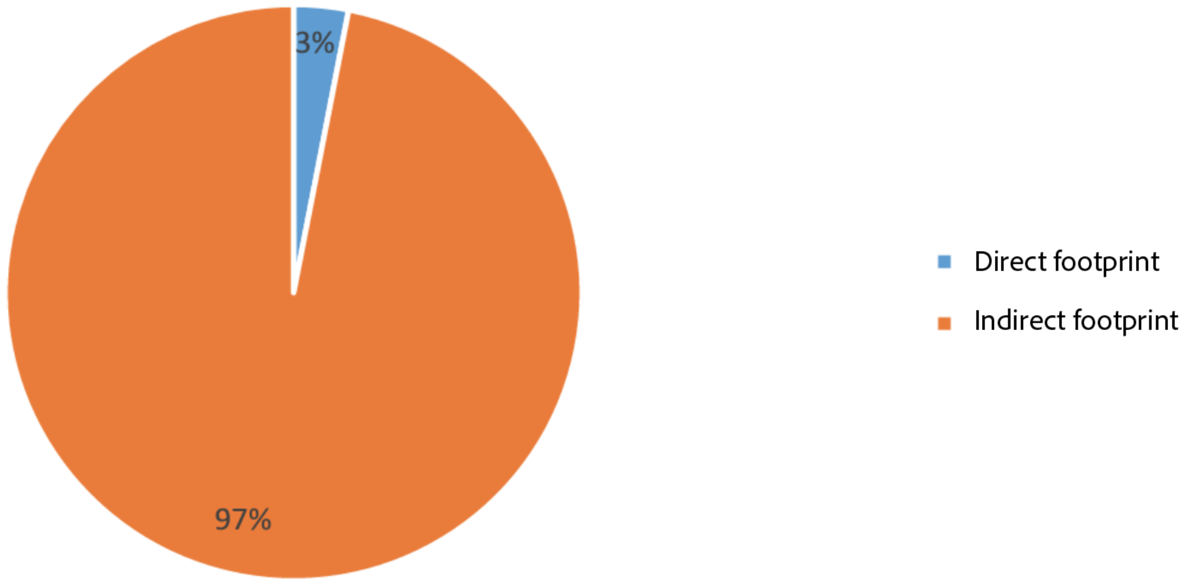
Table 3. Results of the Water Footprint of Receptive Tourism in Bolivia in 2019

Type of footprint	**Water footprint (m^3)**	**(%)**
Direct footprint	**548,369**	**3%**
Direct consumption (blue footprint)	5,039	0.9%
Contamination (gray footprint)	543,329	99%
Indirect footprint	**17,358,270**	**97%**
Food	7,819,200	45%
Textiles	9,539,070	55%
Total	**17,906,638**	**100%**

Source: authors' calculations based on data from INE, 2020

The water footprint of receptive tourism for 2019 in Bolivia is 17,906,638 cubic meters. This volume of water is equivalent to more than 5,000 Olympic pools. The graph below shows the indirect water footprint associated with the consumption of food and the acquisition of textiles and apparel by tourists, representing 97% of the water footprint of the sector.

Graph 1. Water footprint of receptive tourism in Bolivia by type of footprint (%)

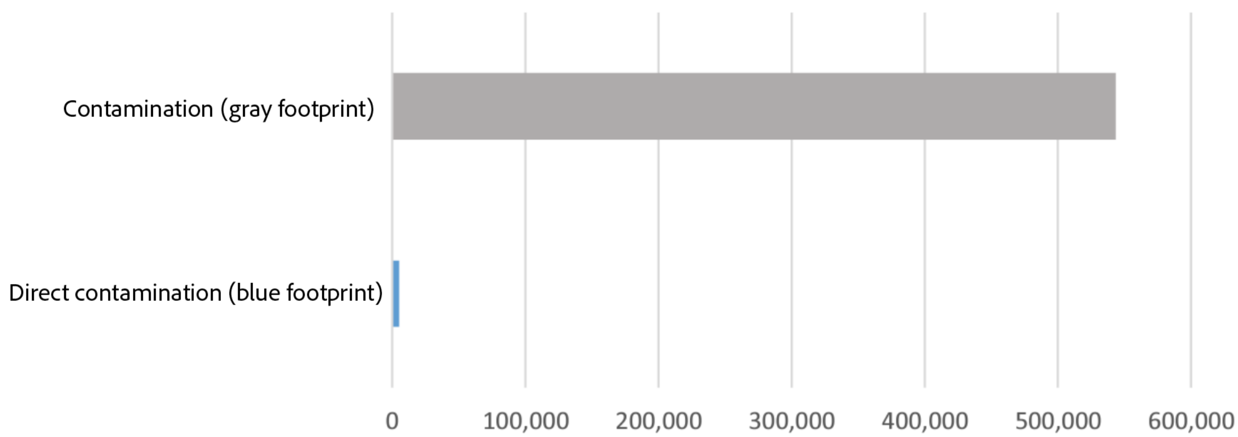


Source: authors' calculations

Direct Water Footprint

With respect to the analysis of the direct water footprint, we observed that 99%, or 543,329 cubic meters, represents the direct "gray" water footprint. This value represents the volume of water that is required to clean the contaminated water generated to maintain water quality at the level required by the quality rules for water in Bolivia (Category D) in terms of BDO and CDO.

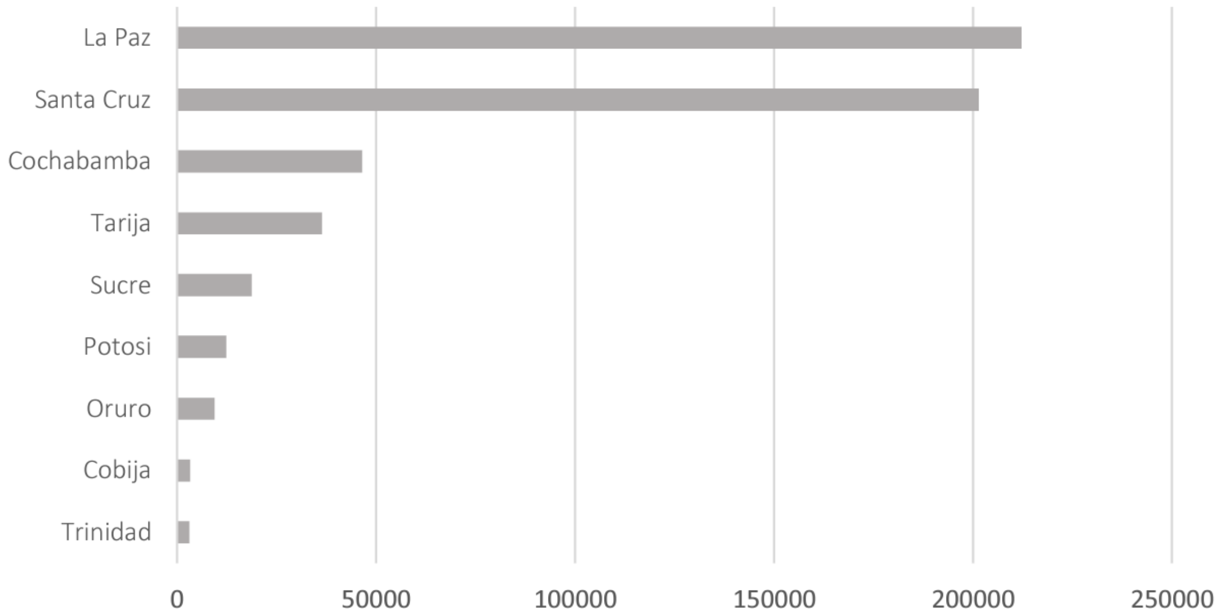
Graph 2. Direct Water Footprint of receptive Tourism in Bolivia, in cubic meters



Source: authors' calculations based on the results of the measurement

This value of the gray water footprint allows the visualization of the definitions that Bolivia has in terms of wastewater treatment. To estimate this type of water footprint, we take into account the local characteristics in terms of concentrations of wastewater and inflows that are treated at the Wastewater Treatment Plants (WTP) in Santa Cruz, La Paz, Cochabamba, Tarija and Potosí. For the rest of Bolivia they applied average data.

Graph 3. Gray water footprint for the department in a year, in cubic meters

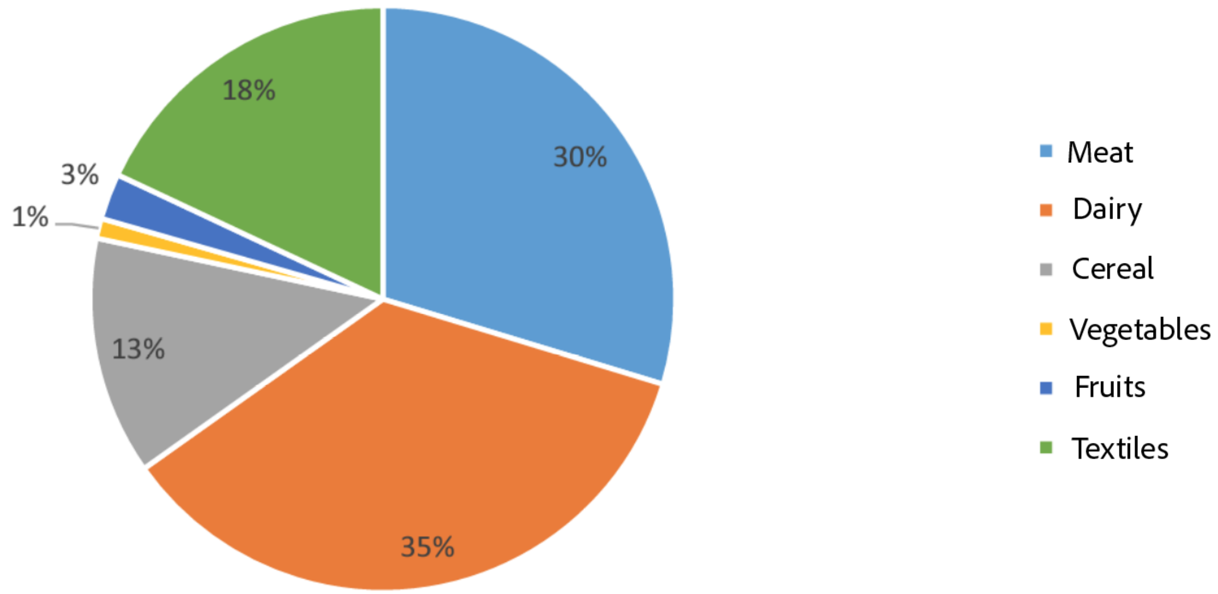


Source: authors' calculations

Indirect water footprint

For the estimation of the indirect water footprint, they considered a basic balanced diet and the acquisition of textiles (sweaters) by tourists (1 kg of textiles per 5-day stay). According to the results obtained they observed that the indirect water footprint is primarily generated by the consumption of meat and dairy products by tourists. Graph 4 shows the water footprint values per product, which have been estimated by the Water Footprint Network, and the weight per product which has been consumed by tourists.

Graph 4. Indirect water footprint generated by foreign tourists in 2019 (%)



Source: authors' calculations

5. Conclusions

The water footprint estimation carried out has considered the activities, uses and consumption that generate the water footprint of foreign tourists that visited Bolivia in 2019. The water footprint generated by local tourists has not been considered in the estimation, since the footprint generated would simply replace the water footprint.

The water footprint generated by tourists visiting Bolivia in 2019, considering the number of tourists, and the numbers of overnight stays in different departments, is 17,906,638 cubic meters, which is equivalent to more than 5,000 Olympic pools. The principle type of water footprint is associated with 97% of the indirect water footprint, which represents the water that is necessary to produce food and goods (textiles) that would have been consumed by tourists. The remaining 3% is associated with the direct water footprint, of which 99% (543,329 cubic meters) is from the gray water footprint, or the volume of water that is required to clean the contaminated water, until the quality of water from those wastewaters is above what is required in the Material Rules for Water Contamination in the Law #1,333 of Bolivia (Category D) in terms of the BDO and CDO. Finally, the remaining 1% is associated with the blue water footprint, due to direct consumption of water by the tourists.

6. Recommendations

The estimation of the water footprint revealed that the majority of the indirect water footprint is from the consumption of food and goods (textiles), understood as the water used in the production, manipulation, storage, post-harvest, processing and distribution of food. Considering this situation and with the proposal to decrease the use of water, it is important that the central government and the Autonomous Territorial Entities (ATEs) promote more efficient water use such as micro spraying, dripping, etc., by creating systems of local information that allow the monitoring of ground humidity and the loss of water in agricultural territory, to determine how water is needed for cultivation and the removal of excessive waste.

On the one hand, they should continue raising the population's awareness of the responsible consumption of food. For this reason, the strategy of responsible consumption, understood as "a careful consumption with the environment and people, and a conscious front to an excessive, superfluous and unnecessary consumption," is a method of reducing the indirect water footprint.

On the other hand, since the direct water footprint of receptive tourism in Bolivia is 99% due to "gray" water, they should prioritize more efficient treatment of wastewater in Bolivia. This is a viable action that can be increased due to the construction of the Wastewater Treatment Plants (WTPs) or the improvement in treatment efficiency of the plants that already exist. Although this solution requires a large economic investment and has high operation costs, it can help reduce the water footprint of tourist activity, as well as in other sectors (ex. commercial, residential).

Another proposed action for the reduction of the water footprint of the tourism sector is to promote the adaptation of water distribution systems in the interior of hotel infrastructures to reuse the water of health products. For example, the wastewater of indoor toilets, or the wastewater of showers for risk activities in green areas. The installation of rainwater harvest systems will provide water to hotels, and does not necessarily require large investments. The quality of water stored in tanks during the period of rain probably does not cover total demand, but it can cover part of the water demand for activities such as washing clothes, and watering gardens and green areas.

They also propose the implementation of actions meant to encourage reusing and/or recycling water, similar to the application of incentives that support the incorporation of new water saving technologies and sanitary products of the distinct infrastructures of the tourism sector. Some incentives can be subsidies to the sale price of these products, so that they are more costly with respect to other available products in the market. Likewise, although more complicated in terms of monitoring, they can reduce the taxes per commercial activity for hotels that have installed this type of product in their hotels, which also allows them to meet the green construction standards in Green Building Council. Similarly, the National Government and/or the ATEs can create incentives so that the new constructions that meet these standards receive benefits such as tariffs of reduced water use, as well as lower property or cadaster taxes.

Finally, to encourage better use of water, it is necessary to provide information to tourists. Their caution and awareness is very important due to the threats to the supply of water to the population due to the effects of climate change. This information should be translated to different languages and should always accompany the results of scientific studies, involving civil society organizations and universities.

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