Water Footprint and its Computation using Commonly Available Data

[1]Deepa Chalisgaonkar, [2]Sharad Kumar Jain, and [3]Prabhash Kumar Mishra

[1,2,,3] Scientist, National Institute of Hydrology, Roorkee (U.K.), India.

E-mail: *[1]corresponding author: deepa@nih.ernet.in;*

Abstract

India has more than 17% of the world's population, but has only 4% of world's renewable water resources with 2.6% of world's land area. Country witnesses extreme variability of both temporal and spatial nature in the water availability, distribution and utilization. Water footprint (WF) is a useful indicator to deal with water scarcity. Information about water footprints of products, countries and companies help to understand how a more sustainable and equitable use of fresh water can be achieved. A simple, pragmatic and easy to understand approach is necessary to calculate water footprint. This paper is an attempt to assess the WF of a house by using commonly available data. Simple step-wise demonstrations have been made on the approach and utility of common data within the reach of general public to calculate WF. The common data considered are (i) number of members in a house, (ii)source of electricity in the house, (iii) water saving fixtures used, (iii) number and time consumed by members during bath, (iv) number of times a toilet is flushed, (v) ways of washing clothes and dishes, (vi) availability of car, lawn, swimming pool, etc. (vii) dietary and drinking habits of people, (viii) recycling options, (ix) approaches adopted for water conservation in the house such as roof-top rainwater harvesting. Data on WF will assist in increased the awareness of common man on the water consumption footprint of his/her house, help in finding how to save/conserve water. The information on the WF will also help in understanding the impact of changes in dietary habits and finally life style changes.

Keywords: *Water footprint, Virtual water, Domestic water use.*

1. Introduction

Water is an essential resource and unlike its use in varied forms its availability is limited. India has more than 17% of the world's population, but has only 4% of world's renewable water resources with 2.6% of world's land area. There are further limits on utilizable quantities of water owing to uneven distribution over time and space. Water is used by people for drinking, cooking and washing, but even more for producing products such as clothes, food and paper. The continuous and sometimes indiscriminate use of water is more and more showing its consequences leading to water scarcity. According to recent research, 47% of the world's population will face severe water shortages by 2030. This supply-demand imbalance is mainly caused by population growth, urbanization, climate change and unsustainable use. Beside the obvious implications on the environment and the community directly affected, water scarcity will also generate important problems for Indian economies if nothing is done. From both the public and private sectors different initiatives have been launched to prevent and to mitigate water scarcity and drought situations, emphasizing the priority to move towards a water-efficient and water-saving economy. Virtual water (VW) and water footprint (WF) are two useful indicators to deal with water scarcity. The first one from the perspective of production; whereas the second one from the perspective of consumption.

1.1 Virtual water

The water required for production of a commodity, good or service is called virtual water. This means that the amount of water required for producing a unit amount of that product is the virtual water of that product. So when we consume anything we are actually consuming the virtual water for that product. The virtual water concept is used for measuring the global distribution of water through trade. The virtual water of a product may vary from place to place because of the difference in climatic conditions. Some water scarce countries are likely to import food that is water intensive to produce.

Virtual water consumption of a country = domestic virtual water + imported virtual water - exported virtual water

Virtual water flow refers to the hidden flow of water if food or other commodities are traded from one place to another. For instance, it takes 1,600 cubic meters of water on average to produce one metric tonne of wheat. The precise volume can be more or less depending on climatic conditions and agricultural practice. The water is said to be virtual because once the wheat is grown, the real water used to grow it is no longer actually contained in the wheat. The concept of virtual water helps us realize how much water is needed to produce different goods and services. In semi-arid and arid areas, knowing the virtual water value of a good or service can be useful towards determining how best to use the scarce water available [6].

1.2 Water footprint

The water footprint is an indicator of water use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in terms of water volumes consumed (evaporated) and/or polluted per unit of time [1]. Water footprint can be calculated for any well-defined group of consumers (e.g. an individual, family, village, city, province, state or nation) or producers (e.g. a public organization or private enterprise).

The water footprint is the total amount of water used, not only the water used in the home, but also the water used to produce the food and the products. A person's water footprint is the amount of water he uses in and around his home, school or office throughout the day. It includes the water he uses directly (e.g., from a tap). It also includes the water he uses indirectly – this is the water it took to produce the food he eats, the products he buys, the energy he consumes and even the water he saves when he recycles. One may not drink, feel or see this virtual water, but it makes up the majority of his water footprint. For example, the water foot print of a cotton t-shirt is 2,600 litres and covers the water used from cotton plantation until the t-shirt is put on the stores' shelves. Information about water footprints of products, countries and companies will help to understand how a more sustainable and equitable use of fresh water can be achieved [2].

2. Importance of water footprints

Water footprints help reveal the amount of water being used at an individual level all the way to a national level and in the numerous processes involved in manufacturing and production of our goods and services. An accurate water footprint also takes into account the amount of water contaminated during manufacturing and production because that water is essentially made unusable and, therefore, taken out of the system. While there can never be a perfect water use assessment or audit tool, the water footprint gives everyone – from individual consumers to business managers to public officials – a solid water accounting framework and aids us all in our efforts to be more efficient and conservative with our water use.

3. Water footprint component

The water footprint of a product is defined as "the volume of freshwater used to produce the product, measured over the full supply chain." There are three types of water footprints:

- Blue Water Footprint: refers to the volume of surface water and groundwater consumed (i.e. evaporated or incorporated into the product) during production processes;
- Green Water Footprint: refers to the volume of rainwater consumed (i.e. evaporated or incorporated into the product) by the product; and
- Grey Water Footprint: refers to the amount of freshwater required to mix pollutants and maintain water quality according to agreed water quality standards.

The water footprint assessment largely depends on the focus of interest. One can be interested in the water footprint of one specific process step in a whole production chain, or in the water footprint of a final product. Alternatively, one can be interested in the water footprint of a consumer or group of consumers or in the water footprint of a producer or whole economic sector. Finally, one can take a geographic perspective, looking at the total water footprint within a delineated area such as a municipality, province, nation, catchment or river basin. Such a total water footprint is the aggregation of the water footprints of many separate processes taking place in the area [1, 3, 4].

4. Water Footprint for reducing domestic water use

In India, the domestic water consumption per day per capita is being considered as 135 liters. However, in reality this figure vary considerably both spatially and temporally depending on the water availability, duration of water supply, distance of source of water, and above all the socio-economic condition.

As per the study carried out by Abdul Shaban and R.N. Sharma (2007), supply-led water deprivation prevails in major cities in India. The per capita water availability is nowhere near the standards laid down by the World Health Organization or the Bureau of Indian Standards (1993). The availability of water in Indian cities varies with socio-economic groups and areas. Unless water saving is practiced, the grim water scarce scenario will further depleted in coming years.

The total household water consumption, now-a-days, represented as 'direct water footprint' (home water use) can be saved or minimized through number of ways. These practices are easy to follow, however with regular commitment. There are three major areas in a house where maximum water saving can occur: (i) the kitchen; (ii) in the laundry; and (iii) the bathroom. Kitchen is a major consumer, using around 10% of the total household consumption for cooking, cleaning, washing, and drinking. Someone considering dish washing using 'dishwasher' can save a lot of water than traditional hand dish washing. 15-20% of water consumed in the home is used in the laundry. Using a water efficient washing machine, washing with a full load, and adjusting the water level to suit the size of the wash load also reduced domestic water consumption considerably. Improved toilet systems have also the potential to reduce water use. Simple practices such as stopping running taps during brushing teeth or while shaving, using bucket while washing cars, fixing leaky faucets and plumbing joints inside and outside the house, etc. reduces total water footprint in the household.

Changing food habits is also another option where total water footprint consumption can be checked in a house. 'Indirect water footprint' (the water consumption and pollution behind all the goods) is much larger than direct water footprint at home. To reduce the indirect water footprint, one option is to substitute a consumer product that has a large water footprint by a different type of product that has a smaller footprint. Examples: eat less meat or become vegetarian, drink tea instead of coffee, or even better drink plain water. And replacing cotton clothes by clothes from artificial fiber saves a lot of water. For drinking one standard cup of coffee about 140 litres of water is required, whereas the production of one cup of tea requires 35 litres of water in average.

Fig.1 shows the water needed, either used or polluted, to make common consumer goods [5].

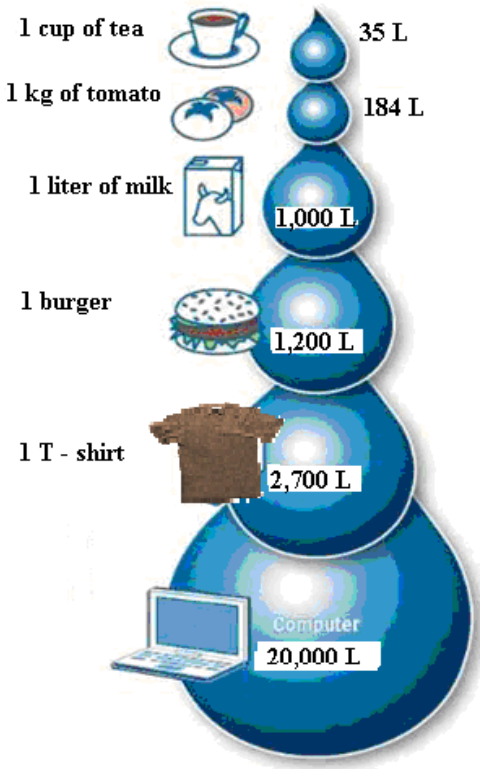


Fig.1: Water needed (used or polluted) to make common consumer goods

5. Computation of water footprint using commonly available data

The water footprints can be calculated for individuals, houses, businesses and countries using data that is based on average water use. This includes direct use at home through toilets, taps, and hoses, but also the water embedded in the production of food crops, electronics, paper products, electricity, transportation fuels, and more. The calculator is meant to be an educational tool that gives users a rough estimate of how much water it takes to keep their daily lives afloat. It is not meant to be a definitive and granular analysis.

The footprint relies on a baseline average that the responses are either added to or subtracted from and has close connection to local temperature and precipitation.

A water footprint calculator has been developed as per Indian domestic water use to give Indian residents an estimate of the water they use on a daily basis. Few snapshots of the calculator are given figure 1, figure 2 and figure 3. The methods, assumptions, and calculations used in the development of this calculator are given in Table 1.

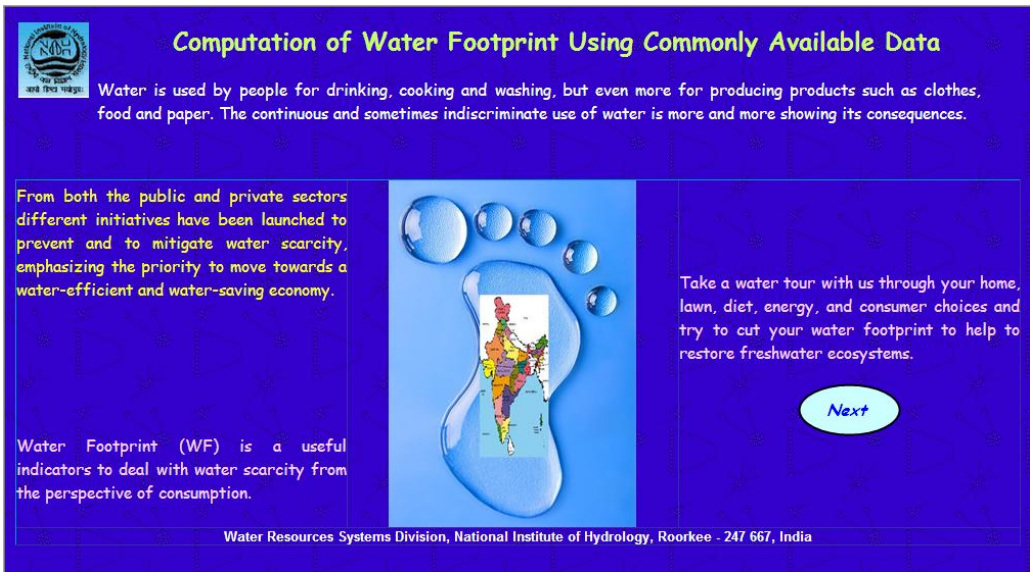


Fig.1: Main screen of the water footprint calculator

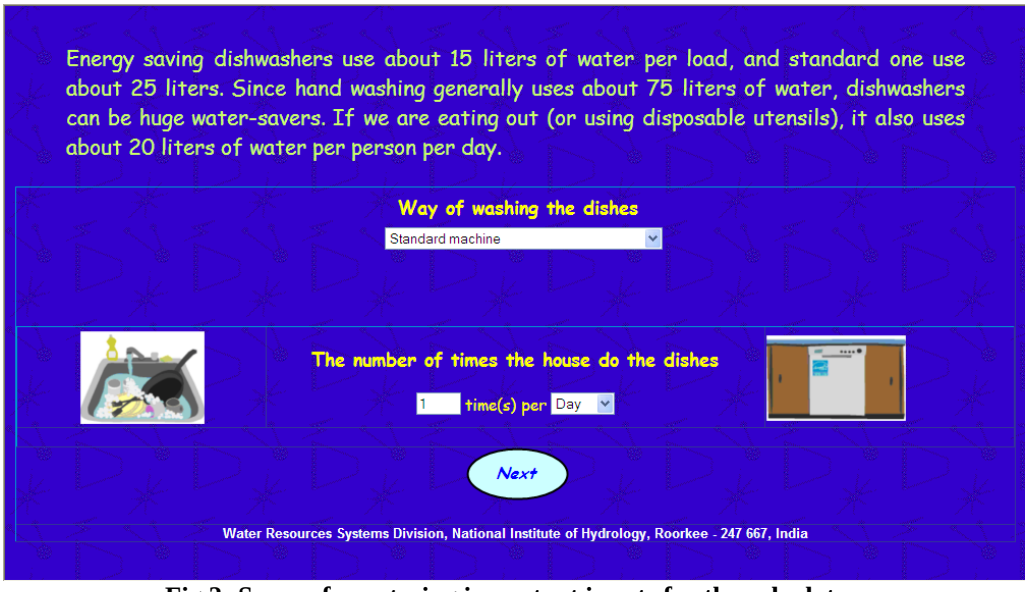


Fig.2: Screen for entering important inputs for the calculator

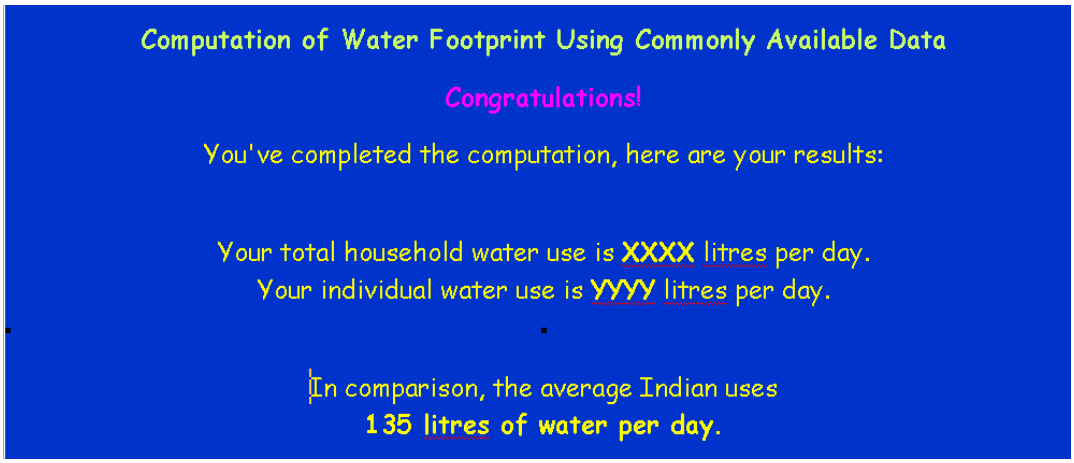
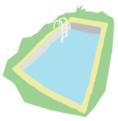
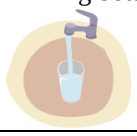
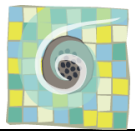


Fig.3: Screen showing the results

Table 1: Assumptions in calculating water footprint

Sl. No.	Queries	Explanations
1.	Number of people living in the house. 	Many of the calculations of WF are based on water use by all members of the house which includes the people that live in the home and who share a kitchen.
2.	Usage of water-saving fixtures in the house • Shower heads • Toilets • Faucets   	Low-flow showerheads spray about 3 liters per minute, while standard showerheads spray 5 liters per minute. Low-flow toilets need 5 liters per flush, while standard toilets need 12 liters per flush Low-flow faucets flow 2 liters per minute, while standard faucets flow 5 liters per minute.
3.	Buckets of water consumed for bathing in the house each day. 	Every minute a person spends soaping, lathering, conditioning, exfoliating, shaving or just hanging out in the shower, he drains between 3 to 5 liters of water.
4.	Time spent by the people in the house at the washbasin. 	Standard faucets flow at liters of water per minute, while low-flow faucets can flow as low as 2 liters per minute.
5.	Turning off water while brushing the teeth.	Turning off the water while brushing the teeth saves 7.5 to 19 liters of water each time.

		
6.	Flushing the toilet each time after urinating. 	Flushing the toilet each time after urinating? Every time flushing, allows 5 to 12 liters of water to go down the drain, so the use of a mug several times a day saves a lot of water.
7.	✚ The way of washing clothes ➢ Automatic washing machine ➢ Semi-automatic washing machine ➢ No machine (hand wash) ✚ Number of times the people in the house do the laundry	Washing machines can use a lot of water if they aren't used properly. A fully automatic washing machine uses about 150 liters of water per load, while semi-automatic use about 75 liters.   
8.	✚ The way of washing the dishes? ➢ Standard machine ➢ Energy saving machine ➢ No machine (hand wash) ➢ No Dishes (Disposable or eating out) ✚ The number of times the people in the house do the dishes.	Energy saving dishwashers use about 15 liters of water per load whereas standard machines use about 25 liters. Since hand washing generally uses about 45 liters of water, dishwashers can be huge water-savers. Eating out (or using disposable utensils) uses about 20 liters of water per person per day. Also, it takes roughly 17 liters of water to produce 3 meals' worth of paper and plastic utensils, plates and cups.  
9.	Lawn or pots for plants in the house. • The number of times of watering the lawn. • The number of times of watering the pots.	On average, it takes 1000 liters to water a 1,000 square feet lawn or garden.  
10.	Swimming pool in the society. • If yes, then how much is its capacity? • How many persons are the members of this pool? • How many persons of your family use it?	The average-sized pool takes 72,000 liters of water to fill, and if it is not covered, an additional 4,000 liters of water per month can be lost due to evaporation.  
11.	Car in the house. • If yes, then how many times washing it? • How much fuel is used? 	Washing a car uses about 40 liters of water. Refining fuel takes water—for every liter of fuel burnt, 4 to 10 liters of water is used.
12.	Dietary habits of the people in the house. • Number of vegetarian (no meat). • Number of non-vegetarian (meat).	Since it takes more water to produce some foods than others, a person's diet has a significant impact on his water footprint. Besides just drinking water, we indirectly consume many liters to grow plants and raise the animals we eat. Meat and dairy products are especially water-intensive (because

	 	animals consume drinking water and feed, which is made from crops grown with water). Since animals also eat plants and drink water, people who eat meat and dairy consume more water than those who only eat vegetables and grains.
13.	Drinking bottled water  	Drinking from disposable plastic bottles consumes more water than expected. The plastic used to make the average 16-32 ounce water bottle requires over 6 liters of water to produce. So even if drinking a small bottle of water actually consumes liters.
14.	Recycling paper and/or plastic  	Manufacturers use a lot of water to make the products. The average Indian can save over 38 liters of water per day by recycling plastic. The plastic used to make 500ml-1 liter bottle requires about 6 liters of water to produce it. Similarly recycling 1 kg of paper, saves about 30 liters of water
15.	Donation of or re-use old clothing, sheets, blankets and towels  	It takes about 380 liters of water to grow and process one kg of cotton, and the average Indian goes through about 35 kg of new cotton material each year.
16.	Using gray water system or a rainwater collector?  	A gray water system allows reusing water from sinks, showers and washing machines for watering trees and gardens outdoors and can save about 152 liters of water per person per day. A rain water harvesting system can collect 34 liters of water per day or more with heavy rainfall.

6. Conclusions

An attempt at developing a globally accepted standard on water footprint is going on rigorously. With the growing population and rapid urbanization, domestic water consumption is increasing every passing day. For India, water footprint assessment aids immensely in analyzing and understanding how activities and products relate to water scarcity, pollution and related impacts. Water footprint analysis, further, helps in what can be done to make sure activities and products do not contribute to unsustainable use of water. The study will help every individual in quickly calculating its own water consumption. The insights will also assist in developing guidelines, to extend guidance to business on reducing the impacts of their water use, both in their own operations and in their supply chains. State-of-the-art water footprint approaches and their application in different sectors are very relevant in present scenario.

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