

Water footprint applications in textile sector: an overview

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1.1 Introduction

The volume of water consumed (blue water footprint (WF)) compared to the volume of water polluted is extremely small, not to say insignificant. However, the fluctuation of the blue and gray WF across categories and subcategories can be seen in the patterns. Woven fabric manufacturing factories tend to have a higher proportion of water intake relative to knit fabric manufacturing factories (processing factories) and close to storage and yarn production. Simple processing plants tend to have a higher emission share than complex processing, while complicated processing appears to have a higher water intake than simple processing plants while the blue WF share is incredibly low; it should not be underestimated as it can have local consequences [1,2].

As mentioned previously, the WF varies dramatically depending on the area and cotton cultivation management activities as well as on processes and technology for the processing of the finished textile goods. The gross industrial WF will also therefore be higher or lower than the agricultural WF. However, it is significant that no data are available for the agricultural WF in order to quantify the gray WF dependent on pesticide usage, which has a big contribution to the gray WF in agriculture as seen in previous studies [3].

In the first part of this chapter, a comprehensive analysis was made of water distribution on the earth, the unequal distribution of water in various regions of the world, and forecasts on the challenges of water shortage which mankind will face in the immediate future. The science community is evolving ideas and methods for effective water resources to cope with the condition of water shortage. The creation of virtual water and WF principles was emphasized in this first part of the chapter. The water footprint definition is further defined by water footprint appraisal, which describes the distinction between simulated water and the idea of water footprint, and how all of these terms are used synonymously, contrasting water footprint terms by carbon footprint, environmental footprint concepts, and life cycle assessments (LCAs). The following parts of the series underline the water footprint of the clothing and apparel sectors from fabric processing to finished product processes. Many organizations around the world consider water as an important component of their corporate activities, although an increasing number of businesses are at considerable risk from lack of access to sufficient water quantities and water contamination. Concern over water is illustrated by a 2015 World Economic Forum report of businesses, which reported that there will be serious threats of water shortages over the next 10 years [4–6]. Water is not only the gateway to global security, growth, and peace, according to the World Business Council for Sustainable Development, but also important to corporations' activity. Over the next three decades the market over water in the global food field would grow by 40%–50%, in the urban and industrial sectors by 50%–70%, and in the energy sector by 85%. Increased demand for water resources needs urgent intervention and drastic improvements in the use of water by businesses. The fashion industry impacts everyone's lives by clothes, packaging, and other goods, but it has a huge effect on the world's capital [7].

Earlier analyses of WF are restricted to resource quantification, e.g., groundwater usage, surface water usage, and land water use. The present research expands the definition of WF by quantifying the impacts of emissions. This is

achieved by quantifying the amounts of dilution water used to dilute sewage flows such that the water level stays within accepted water quality levels [8]. The reasoning for adding this water dimension into the concept of the water footprint is close to the explanation for including in the description of ecological footprint the region required for absorption of anthropogenic carbon dioxide emissions. Land and water are not only used as resource bases, but also as waste assimilation schemes. The role of pollutants on water requirements in this analysis may potentially contribute to a similar controversy as the approaches used to turn the consequences of carbon dioxide emissions and into soil requirements. The methodology outlined in the analysis should be taken as a first step; we will comment on potential changes in the results.

1.2 Blue water footprint

The blue WF of the garment factories was measured in the USEPA, 1996 study. The blue WF varies according to the methods and the products used. The processing of tissues typically requires more water than the processing of knit tissues as the tissues require more preparation, such as desizing and mercerization [8]. Stock and yarn processing water use can, depending on the methods used, be comparable to the processing of the woven or knit textiles. According to the different subcategories, the more complicated the mechanism is, the stronger the blue WF. Easy processing factories (also affiliated with hosiery treatment) primarily use dyeing processes while complicated processing factories have additional processes such as printing and finishing. The decorative mills will require many more manufacturing steps and therefore use the most energy. Also, the water footprint will vary from below 1 L/kg of finished commodity to over 70 L/kg in a processing subcategory. The amount of processes added to the cloth, process technology, and process management may be potential explanations for these ranges [9–12].

1.3 Gray water footprint

Easy processing appears to be more gray than complicated processing. It could be because chemical amounts in the effluent are greater than they should be leading to smaller effluent releases. Desizing mills and textile mills for inventories and yarns often have larger gray WFs that can be due to further operations involving harmful materials [13].

The gray WF of the different chemicals used was analyzed in order to examine the variability of the gray WF of the processes included in each group and subcategory. The USEPA (1996) evaluated a total of 129 contaminants through a field monitoring system, during which 64 contaminants were found beyond the concentration level during untreated wastewater. The measured gray WF per pollutant related to each subcategory of textile mill and a total of 39 out of 64 observed pollutants could be determined (see Annex III) gray WF. No overall acceptable environmental amounts were detected for the remaining 25 contaminants [14].

1.4 Identification of possible response strategies

The general recommendation for WF reduction under the Water Footprint Manual is: eliminate, minimize, and make up (by priority). The WF of a given method is inefficient and hence must be minimized if:

- the method WF contributes to the hotspot; or
- the WF can be decreased or eliminated fairly quickly, whatever the geographical environment. With increased output of water-intensive products in places where ample water is abundant, it is important to surpass output limits in water-poor areas [15].

WFs may be popular in two separate forms. In one production chain, a technique can be substituted by another technique which results in a lower or even zero WF or a particular ingredient or final product can be fully avoided. Types of improved growth technologies are: replacing agriculture with drip irrigation; substituting traditional irrigation with organic farming. Sources in minimizing the usage in hazardous substances occurring in soil or groundwater are: It is also necessary to consider all paths while finding strategies to that WFs. Possible WF reduction options for growing sector by WF part. Technically, all blue and gray WFs may be reduced to nil by total recycling of water in manufacturing systems, but this target can be constrained in relation to its implementation costs. There

should be no evaporation damages or contaminated effluents during a closed period. In manufacturing, the related blue WF cannot be prevented even where fresh water may be introduced into a component, but blue WFs, reflecting water evaporation in industrial processes, will usually be prevented through water recapture [16–19]. In the cotton manufacturing industries in the supply chain, C&A is able to primarily aim for a zero blue and gray WF while cost factors can contribute to the need to recognize rates just above zero. To receive more detailed guidelines in this matter, more study of the expense of recycling and wastewater management systems required to that the blue and gray WFs to zero.

The idea of WF is an extension to the biological footprint definition developed in the 1990s [20]. Whereas the ecological footprint reflects the environment is required for sustaining a community, the WF describes the amount of water available (cubic meters per year). Around 53% of the world cotton area is irrigated and 73% of the world cotton supply is produced. Irrigated cotton is mostly grown in the Mediterranean and elsewhere in warm environment, where there is no fresh water. The major areas of irrigated cotton are dry: Egypt, Uzbekistan, and Pakistan. China's Xinjiang region is entirely irrigated, though additional irrigation meets a large part of cotton's crop water requirements in Pakistan and Northern India. As a result, 31% of all irrigation water has already been drained from groundwater in Pakistan and the heavy usage of groundwater triggers declines in water levels in China. About 70% of world supply of cotton is produced in China, the United States, India, Pakistan, and Uzbekistan [21–24]. Many cotton factories are based on a furrow irrigation method. In water-poor areas, sprinkler and drip systems are also used as an irrigation tool. But barely 0.7% of the world's soil is irrigated by this process.

Some of the earlier research on the impacts of cotton processing have only been limited to industrial impacts, thus leaving out agricultural impacts. Many cotton effect research use the life cycle approach which therefore require all development processes, but these research are not based on quantification but on methods. Nonetheless, in this chapter, we try to analyze the WF and demonstrate how certain countries are particularly pressurizing water war in especially textile industries.

Cotton is the world's top natural product in the fashion sector. Today, cotton accounts for about 40% of textile output, while synthetic fibers account for about 55%. Global trade in cotton products accounted for 2% of total commodity exchange during 1997–2001. The environmental effects of cotton processing are easy to see and have many names. There are, on the one hand, the consequences of water scarcity and on water safety, on the other. In most big textile production areas, riparian downstream can see the new color in the upstream textile industry from the water. The Aral Sea is the most prominent example of the irrigation impact of water abstractions. In 1960–2000, in Central Asia, the Aral Sea lost about 60% of its surface and about 80% of its depth as a result of annual water abstractions from the Amu Darya and the Syr Darya rivers, which feed the Aral Sea, to cotton growing in the desert [25].

India, the United States, Brazil, Germany, the United Kingdom, France, and Japan are the nations with the greatest effects on global water supplies. Around half of China's cotton consumption-related WF is in China (internal water footprint); in other nations, the other half is pressed (external footprint) primarily by India (mainly green water usage) and Pakistan (mainly blue water usage) [26].

The WF may be measured by nation as a consequence of domestic cotton use, as has been done for the United States. The textiles and apparel sector is the hungry one for water as it is one of the largest sources of water from fiber to finished goods. Sadly, all research studies and opinions of renowned water professionals in many parts of the world predict the extreme water shortage in the near future, especially in developed countries where textile and fashion industry operations are located on account of cheap labor and less strict environmental legislation. The dim image of water scarcity is sufficient enough to alert the clothing and apparel industry to take effective steps to allow better use of water sources and to make every attempt at every level of the supply chain in order to conserve energy [27].

1.5 Regional inequity in water distribution

Water quality in different areas of the world differs considerably. Although some countries are abundant in rainfall, some are in danger of being arid and unable to support their inhabitants in the future. The top five water-rich countries were French Guyana, Iceland, Guyana, Suriname, and the Congo early in the new millennium. Kuwait, the Gaza Strip, the UAE, the Bahamas, and Qatar are at the edge of the scale [28].

In these conditions, an increasing number of countries are facing different types of water pressure, either due to plant drying, water scarcity, river and lake contamination, or years of drought in Africa. More than half of the world's countries have been deemed either “dangerously empty” or “under the poverty line.” North America is especially lucky to be home to the Great Lakes Basin, Earth's greatest reservoir of surface fresh water with around

21% of world freshwater sources. In comparison, most of the planet, which includes vast parts of Australia, Africa, and Asia, is arid. Northern China, wide regions of Asia and Africa, the Middle East, Australia, the Midwest of the United States, and portions of South America and Mexico are the so named “hot spots,” which are deprived of drinking water.

India depletes its resources so rapidly as to endanger potential food crops and sources of drinking water. With the second-largest population in the world, Indian water scarcity will continue to have a significant effect. Interestingly, in many areas of India substantial rainfall exists, but it can be erratic or volatile and Indian farmers are at the mercy of the storm. In recent years, extreme weather conditions have plagued India with the “curses of drought and flood.” Climate change has been suspected of worsening problems [29].

1.6 Climate change

In the simple term “Climate change is marked by abnormal climate patterns which lead to droughts, floods, natural disasters, and more frequent and extreme phenomena.” There is a range of research on the environmental effects of climate change, including water shortages. This chapter is not meant to review the literature but to discuss just the opinions of some of the specialists on the global impact of climate change on water supply. Many of these opinions are cited below. “Environmental change would impact the volume of precipitation rainfall” [30]. Just 2° higher temperature may have a detrimental effect on water quality for three billion citizens, according to a report.

According to the UN, the consequences of water shortages on society are very alarming and already over 700 million citizens are threatened by water shortage in 43 countries. By 2025, 1.8 billion citizens will live under extreme water pressures in countries or areas with severe water scarcity and two-thirds of the world’s population. Almost half the world’s people would reside in places of considerable tension by 2030 in the present climate change scenario and moreover, the most water-stressed countries are in sub-Saharan Africa in any area [31].

Given all the science controversy surrounding the question of climate change, and in spite of the several years of political turmoil which have stalled the adoption of the Climate Change Agreement, nature continues to take matters in its own hands to prove that mankind cannot accept further violence. As a consequence, natural hazards are normal. Speak to any senior resident, and you can learn that these events are less common in the past and not as alarming as they now appear. These reports may be speculative because in certain areas of the planet there seem to be significant climatic changes creating mayhem. Textiles and apparel are the thirstiest for water as it is one of the growing sources of water from fabric processing to finished goods. The above scenario of water shortage is strong enough to alert the textile and pattern industry against avoiding adequate steps for safe water usage and make attempts at all levels of the supply chain to conserve water. The latest collection of publications illustrates clothing and apparel industries’ WFs from cotton to finished goods [32].

1.7 Virtual water and water footprint concepts

1.7.1 Virtual water

Professor John Allen of King’s College London developed the simulated water principle in 1994. It was focused on analyses by Israeli water experts who noticed that importing water-intensive products from their arid countries appeared more important than farming them themselves. Allen presented the idea of virtual water to shed light on how the water needs of Middle East countries have surpassed the useable supplies since 1970. While seeking to understand why a conflict over water took place because many Middle East countries had just half the water they need, it can be argued that economic mechanisms had addressed the region’s water shortage crisis through providing water by exchange. In other terms, water shortage was handled in those countries by importing simulated water from the foreign market in the form of agricultural products [33]. The water is supposed to be synthetic, since, relative to the overall amount of water currently used for its processing, the finished product includes just a tiny fraction of water. This implies that the actual water used to develop as the crop is produced is no longer present in the plant. Digital water can be described as the water required to create a commodity or to make a service. Digital water often includes the real volume of water required as moisture in some materials. The definition of “embedded vapor” (coined before 1994) could not be embraced. It’s a novel idea as it defines something that was never before conceptualized. Digital water also allows to explain how digital water moves in foreign exchange between countries

or regions. Global trade in commodities has allowed low-water countries to depend on water supplies from other nations to meet their people's needs. As food and other items are globally traded, they are monitored in virtual water with their WF [34].

In an effort to provide comprehensive explanations of virtual water, two separate meanings have been suggested: according to the first interpretation, virtual water relates to the water which is currently needed for the processing of a certain amount of a commodity at a particular production site (concept of production site). The first concept applies to the viewpoint of the manufacturer, and the second to the viewpoint of the customer.

1.8 Importance of virtual water concept

As nations aspire to secure food, water, electricity, and other vital inputs for the well-being, livelihoods, and economic growth of their citizens, most countries depend on imports as well as exports of products and services. A nation should strive to be self-sufficient solely by utilizing products that can be made within its borders. Alternatively, by importing water-intensive goods from other nations, a nation may opt to reduce the pressure on natural resources within its borders. It may also be desirable for water-poor countries to import virtual water (by importing water-intensive products), thus alleviating the burden on domestic water supplies. It is the case, for instance, in European, Middle East, and Mexico nations. This is the product of the conservation of their domestic water supply, land access, and land usage. Via their foreign trade ties, countries may import and export virtual water. The world's biggest manufacturing firms include the United States, China, India, Brazil, Argentina, Canada, Australia, Indonesia, France, and Germany. North Africa and the Middle East, Mexico, Europe, Japan, and South Korea are the main net importers of simulated water. There are several instances of water-poor countries which are exporting water-intensive products to conserve their domestic water supplies, e.g., Mexico imports maize, saving 12 billion cubic meters of its national water supplies each year [35].

1.9 Merits of virtual water

Digital water, especially in water shortage regions, has important consequences for global commercial policies and study and has redefined water policy and management discourse. It illustrates how and why states such as the United States, Argentina, and Brazil "send" trillions of liters of water per year, and certain countries such as Japan, Egypt, and Italy "take" trillions of liters per year.

The idea of simulated water opens the path to more efficient usage of energy. It can be improved by moving water-intensive goods from areas where they are commercially feasible to manufacture to locations where they are not. In the Middle East analysis of water shortages, Prof. Allan introduced a hypothesis of utilizing virtual water imports by food as an alternate "bank" for water, in order to minimize the burden on household water supplies that have not been accessible there and in other short-water places.

1.10 Limitations of virtual water

Main flaws in the definition of virtual water are:

- It is expected that all the water supplies, whether in rainfall or irrigation systems, are similarly beneficial.
- It indirectly means the water produced by rising high water uses is automatically useable for usage in a less aquatic operation.
- It struggles as a measure of environmental degradation and does not show that water supplies are used beyond the boundaries of safe extraction. Consequently, the usage of simulated water assessments does not offer guidelines for officials trying to ensure sustainability goals are achieved [36–38].

Building upon the concept of virtual water in 2002 Arjen Hoekstra, Professor of Water Conservation at Twente University and Cofounder and technical director for the Water Footprint Network, cofounded the WF definition and, when employed at the UNESCO-IHE Center for Water Education, measured the amounts of water used and wasted for the production and distribution of products. An example of the value chain of cotton goods is the WF in the supply chain.

1.11 Supply chain of cotton product

The WF is a measure of the usage of fresh water and not only looks at the actual utilization of water by an adverse row. A company's WF is the volume of direct and indirect fresh water the commodity uses, estimated in the full supply chain.

The idea of WFs implies the evaporation of water from the soil and/or evapotranspiration of water from plants and the water found in the substance itself. That is because agricultural or manufacturing goods do not consume water during their production but as the normal moisture content of the commodity itself. The percolation/runoff of water during crop growth that results in crop regeneration is removed from water use. Fig. 1.2 shows the two components of the WF, that is, primary water and indirect water consumption. It indicates that the nonconsumption portion (the return flow) of water drains is not part of the WF. It also indicates that, contrary to the calculation of "water escape," the "water foundation" contains green and gray water and the indirect components of water use. The WF therefore gives an increased and broader view into the usage of freshwater structures by the user or manufacturer. It is a volumetric indicator of water and emission. It is not a representation of the tidal effect of water use and emissions on the natural climate. Previous WF experiments were restricted to the quantification of utilization of land, i.e., the usage of soil and surface water. The WF definition was then further developed by quantifying the consequences of emissions [39,40].

By quantifying the dilution water quantities required to dilute waste products, water quality has been calculated to such a degree that the quantity of pollutant stays within the accepted water quality levels. The most comprehensive publications on how to determine water sprints are the UNESCO-IHE Water Sprint Survey of 2004 [42], the 2008 *Globalization of Water Book*, and the 2011 *Water Sprint Evaluation Handbook: establishing a regional norm*. Cooperation of global leaders in the sector contributed to the Water Footprint Network's establishment in 2008.

The outer portion of the WF of a nation differs greatly from country to country. There is no outward WF for a variety of African countries including Sudan, Mali, Nigeria, Ethiopia, Malawi, and Chad, precisely because it is of no value. On the other side, several European nations, e.g., France, Austria, the United Kingdom, and the Netherlands, are publicly identified by 50%–80% of their overall WF. On average, agriculture that adds most to the external WFs of nations is: bovine beef, soybean, wheat, cocoa, rice, cotton, and maize.

1.12 Components or colors of WF

The overall WF is calculated by taking account of the absorption of rainwater, land water, surface water, and level of water contamination. The WF components reflect green water (rainwater or precipitation), blue water (ground and surface water), and gray water (fresh water amount needed to dilute pollutants). The overall WF is the number of the three water colors. The production and export of synthetic water is often taken into consideration in the case of national WF [41].

1.13 Green water footprint

Green waters have been described as infiltrated rainfall in the unsaturated layer of the soil. Therefore, the green WF applies to precipitation absorbed by crops by soil evaporation (surface evaporation) and plants and soil moisture evaporation (known also as effective or active precipitation) [32]. For agriculture, horticultural, and forest goods, green water is especially important. The usage of "natural" water is usually not limited to goods and services produced industrially or commercially.

1.14 Blue water footprint

It is supplied from air or groundwater. Irrigated irrigation, manufacturing, and the use of domestic water each will have a blue WF. The amount of "gray" water present inside such items is defined as the amount of the used water emitted to the environment through evaporation or sublimation and evapotranspiration, and

as the water is not intended to return to the area involved, it can be assumed to be ingested. The same relates to sources of utilities and domestic energy. The word “ice water” is distinct from “hot water.” The full description of the blue WF encompasses both surface water and active usage of water in agriculture or in homes, minus groundwater returns. The green and blue carbon footprints of the catchment area carbon balance.

For recognizing human freshwater exploitation in relation to the hydrological process, a river system should be called. Many words generally employed for “river system” include “catchment region,” “drainage area,” and “watershed.” The overall annual supply of water in the catchment area is determined by the annual precipitation rate. The net annual precipitation runoff exits the lake again, partly due to evapotranspiration and partly through the catchment discharge. Human beings will accommodate both evaporative flow and runoff. The green WF applies to the human use of the evaporative flow from the ground surface, primarily for agriculture or processing. The blue WF applies to the consumptive usage of the runoff drain, in other terms, the absorption of the catchment riverbed to the degree that the catchment is not added to in the context of a return flood [31].

1.15 Gray water footprint

The gray portion of a water floor is the amount of fresh water needed for the processing of any pollutant from output, to fulfill appropriate requirements for water quality. The gray WF is also a calculated indicator of the possible water emissions generated by agricultural and nonagricultural goods output and supply chain development. Gray WF takes into consideration point-source contamination, emitted directly from a pipe or indirectly from drainage or sludge from the ground, impermeable surfaces, or other dispersed outlets, to a freshwater network.

The amount of dilution is calculated for items other than farming in relation to the contaminant concentration which requires the greater volume of water in order to get the contaminant concentration to an appropriate level. Whereas the contaminant concentration is usually determined in the case of a flood in farming, estimating that 10% of the nitrogen fertilizer added to the crops was lost through leaching and bringing the average nitrogen application amount per grain into the area under consideration [30].

Blue and green WFs are measured for agriculture goods by multiplying the model amount of blue and green water usage (m³/output unit, i.e., m³/ton). In this sense, the moisture used in situ by the field (green water) is defined both by the WF and by the irrigation quantity (blue) water expected to contribute to each field. The gray WF is an estimation of the water needed for nutrient assimilation to soil and surface water in agriculture. Water baseprint applies to water used to make an object.

1.16 Difference between virtual water and water footprint

There is little distinction in this case between simulated water and reality. Nevertheless, the WF is a multidimensional metric, not only for the consumed water quantity, but also for the position of the WF, the source of water, and the application of the product. The most common feature of the WF is therefore the value of time and energy. It is important since the quality of water in space (regions) and time vary significantly, and the usage of water in its local sense is also to be remembered.

For instance, certain uses of the WF include the recognition of WF areas for other goods, customer groups, or businesses and the creation of WF reduction responses strategies. Such extra knowledge is important to determine the impacts of a product's WF. The word simulated water is used specifically for the import or export of the commodity in the event of foreign exchange. This implies, for example, that when an agriculture or goods commodity is manufactured one imports virtual water, which was needed to manufacture the commodity in the country of origin and vice versa, in order to export the product [22].

Literature suggests that the quantity of water needed to manufacture products and services is identified as a physical measure and that the WF is described as the amount of water necessary to generate certain goods and services which will be used by a nation or a person. Digital water is then integrated as an indicator for development potential, while WF is an indicator for use. The distinction between virtual water and WF is important, as it offers us the chance to take advantage of two metrics identified by multiple viewpoints and can classify those who are accountable, whether farmers or users, for water use. Although the two definitions are obviously distinct, there may be an

increasing misunderstanding around both definitions. Both were also used as synonyms, thus partially sacrificing the value associated with the distinction. The importance of these two principles is therefore so important that both government and major companies (Danone, Nike, Levi-Strauss, Coca-Cola) have agreed to investigate the possibility of incorporating them in their policy-taking processes to promote different alternatives [11,33].

1.17 Groundwater footprint

Scientists also introduced the idea of “world water footprint,” which reveals the regional aquifer water balance. Under this definition, the water equilibrium between groundwater inflows and flows is converted into the surface area size defined as “groundwater footprint” which can be contrasted with the groundwater aquifer surface region.

Groundwater stress arises because the soil region of the aquifer itself is greater than the aquifer field, which relies on the ratio between the surface area and the aquifer portion. The footprint concerns only “hydrologically healthy” aquifers that are replenished and therefore not depleted waters. The definition of groundwater footprint does not apply to the utilization of irrigation for manufacturing and supply chain use of goods. Gleeson et al. suggest that at least 20% of the world’s “full” aquifers are overexploited, some of them are extensively utilized, and 1.7 trillion people actually reside in areas of freshwater danger.

This new definition will complement the sustainability evaluation of the WF which focuses on the water balance of catchment areas. Groundwater aquifers are physically distinct from those in catchment areas, but they are hydrologically related. Water stress in catchment areas may contribute to degradation of groundwater. As a consequence, there is a wide spatial difference between water-stressed catchment areas and water-stressed surface aquifers. The groundwater footprint method is valuable for WF evaluation as it carries out areas of flood risk in addition to water shortage catchment areas. That often assumes that the source of the water (surface water, low groundwater, or deep soil water) is knowledge important to assessing the magnitude of the effect on the ecosystem [42].

1.18 Relationship between water, carbon, and ecological footprints

A “footprint” is commonly regarded as a measurable indicator that indicates human beings “misuse of natural capital or environmental strain.” The WF definition is part of a broader family of ideas established over the last decade in the environmental sciences. There are certain parallels methodically between the various fingerprints, but each of them has their own peculiarities linked to the singularity of the material. Carbon footprint analyzes volume of greenhouse gases emitted and estimated as carbon dioxide equivalents (in tons) demonstrate the characteristics of soil, oil ecological, and nitrogen footprints. The carbon footprint calculates the consumption of water (in cubic meters per year). Carbon footprint is about global change; the carbon footprint is about the problem of the lack of fresh water. A supply chain insight is advocated in all situations. However, it does not matter that it occurs with fossil dioxide, but it does matter about a WF. The removal or sequestration of carbon pollution in one area will balance carbon emissions in another area, but is not specific to WF. The environmental effect of water usage in one location cannot be minimized by saving water in another [1–4].

1.19 Environmental impacts of a water footprint

The main environmental impacts related to a WF are listed below:

- Environmental consequences for blue water shall be in the context of water contamination to the flow, decreased water rates in waterways and reservoirs, decreased groundwater rates, and a reduced ability to remove contaminants from the environment. That will in effect that the supply for many consumers and the environment of high quality blue water.
- Green water may also have decreased rivers and drainage in water-intensive plants that evaporate faster than normal vegetations, contributing to a diminished supply of blue water with consequences, as mentioned above.
- The environmental effects of toxins released to water can be induced by surface and groundwater emissions, which contribute to danger of human safety and potential destruction of the ecosystem [15].

Both these impacts can contribute to water supply and consistency issues and to impacts on humans and habitats across the planet. According to the 2050 OECD Environmental Forecast, increased water demand in many river basins, especially highly populated areas in rapidly growing economies, would intensify water stress. It is anticipated that more river basins will experience extreme water stress by 2050. The amount of citizens residing in exhausting rivers is projected to rise from 1.6 billion in 2000 to 3.9 billion in 2050, covering more than 40% of the world's population at the period, almost the entire of South Asia and the Middle East, and significant sections of the North China region.

1.20 Direct water footprint

Direct water footprint are very much involved and important to care in many field such as: installation of energy-saving toilets, conserve power, closure of tap while brushing of teeth, less energy in the garden, and no dumping of pharmaceutical items, paints, or other contaminants in the bath.

1.21 Indirect water footprint

In fact, the indirect WF of a company is far higher than the actual WF. In fact, a customer has two ways to reduce the indirect WF. One choice is to replace a consumer product with a wide WF with a product with a lower WF. Examples involve consuming less beef, or being vegetarian, drinking tea rather than coffee, or having even better plain juice. Not use cotton, however, clothes with plastic fabric saves more energy. The second choice is to adopt the same trend, but to prefer cotton, meat, or coffee with a fairly small water footprint or a footprint in a region with no high water scarcity. Nonetheless, if customers have enough knowledge to make the decision, that is likely. Since such detail is usually inaccessible in today's society, it is increasingly necessary for customers to call for quality disclosure from businesses and policy regulators. Once knowledge about the effect of a specific product on the water supply is visible, customers may select actively what they are purchasing [1,5].

1.22 Water footprints in life cycle assessments

LCA is a framework for the environmental impact evaluation of a good and service over a production cycle from cradle to grave, examining basically the environmental consequences generated by the usage of fossil fuels and other natural resources as well as the release to air, water, and soil of hazardous substances. The life cycle inventory (LCI) quantifies raw resources and energy flows, while the impacts on the atmosphere resulting from resource utilization and pollution, as well as higher risk categories such as safety, habitat efficiency, and resource degradation, are quantified in a life cycle impact assessment (LCIA) [1–3].

1.23 Development in water footprint methodology

In the first few years of the growth of the definition of WF (2002–08) the emphasis was on measuring the overall size of the footprint. For example, one apple costs 125 L of water and one cotton shirt costs around 2500 L. Such huge quantities of water linked to goods caught the attention of others and have been used by NGOs to increase public consciousness of the scale and geographical nature of the water usage of consumer products by customers, suppliers, and governments. The place and spatial background of the footprint components provided little consideration. Since 2008, more focus has been given to the location and spatial background of footprints. The WF philosophy has developed from a predictor accounting scheme to a WF measurement approach, in which an impact or mitigation appraisal accompanies the reports. The study by the Climate Footprint Network has centered on modeling global water scarcity and emissions [42].

It should be remembered that changes in the definition of WF have contributed to some uncertainty over the precise nature of the footprint. The WF was initially synonymous with its overall amount, which culminated in the well-known water quantities for goods. Nonetheless, it is regarded actually as a geographically specific metric in the sense of a biodiversity evaluation of the WF, reflecting not just the quantities and emissions of water but also the position of the footprint. That is rational, as a management calculation of the WF focuses on the WF elements of

multiple catchments and catchments rather than on the overall WF scale. Various publications of the Water Footprint Network and in particular the assessment manual have often generated ambiguity about the concept of WF, which utilizes all concepts side by side.

1.24 Water footprint assessment

A full WF assessment as described in the Water Footprint Network manual consists of four phases as shown in Fig. 1.1. Studies on virtual water trade and studies carried out to estimate the WF indicator for products only typically consist of the first two phases. If the emphasis is on WF impacts, the assessment should consist of the first three or four steps (Fig. 1.1).

1.25 Setting goals and scope

For several different purposes, a WF analysis may be performed by government, river basin authority, and business organizations. A national government might be involved, for example, in understanding its reliance on international water supplies or in understanding the viability of water usage in the areas from which water-intensive goods are produced. A river drainage authority might be interested in understanding if the total water impact of human activities in the watershed at any point meets groundwater flow criteria or water quality regulations. The River Basin Authority will even like to learn how limited water supplies in the river are reserved for export crops of low value. An organization may be interested in understanding the reliance on its supply chain limited water supplies or whether they might try to reduce the impacts on water infrastructure in its supply chain and throughout its own operations [43].

1.26 Water footprint accounting

The key purpose of the accounting stage is to report green, blue, and gray water quantities relevant to manufacturing activities and the supply chain before the commodity hits the customer. Such details are used to measure the WF metric by combining all water volumes collected. They may also be used to measure components of WF such as the orange, blue, and gray WF or the imported “internet” water from different countries as components of the regional WF indicator. The WF metric is often referred to as the “true” water quality of the commodity when

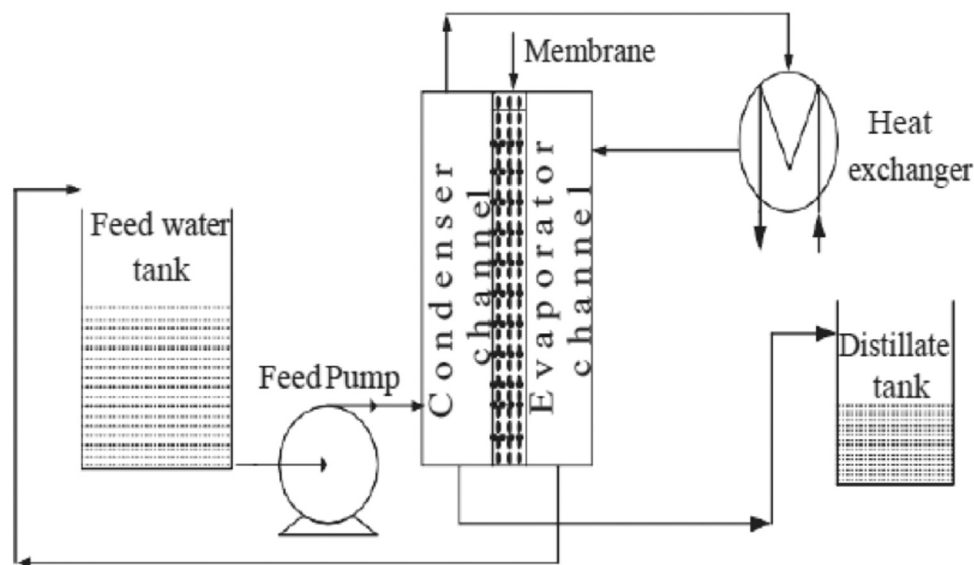


FIGURE 1.1 Virtual roadmap for water management [1].

measured for a given product thus avoiding application of the drug. The WF accounting process may also be the foundation for a mitigation appraisal, based on the form of analysis.

1.27 Water footprint sustainability assessment

It may be carried out from the point of view of:

- (a) Water sustainability
- (b) Social or human sustainability
- (c) Economic sustainability [1–3].

1.28 Water sustainability

The key purpose of a sustainability evaluation of WF is to map processes in or in association with the manufacturing and supply chains that are in unhealthy hot spots. A situation where the manufacturing cycle requires water from overexploited water supplies pollutes water above requirements for water safety or where the distribution and usage of water are deemed unequal or economically ineffective. In order to map hot spots, the main WF components are presented at catchment or subcatchment stages throughout their geographical setting [2,3].

The catchment areas involved are measured on safe water usage and all significant statements on water quality and water pollution within the catchment region or subsurface region are addressed. In the absence of evidence, independent catchment studies can be performed. The degree of blue and green water insecurity and the degree of water contamination are calculated by the future environmental unsustainability of the catchment and the time considerations are weighed, since water shortages and emissions may be clustered during some times of the year.

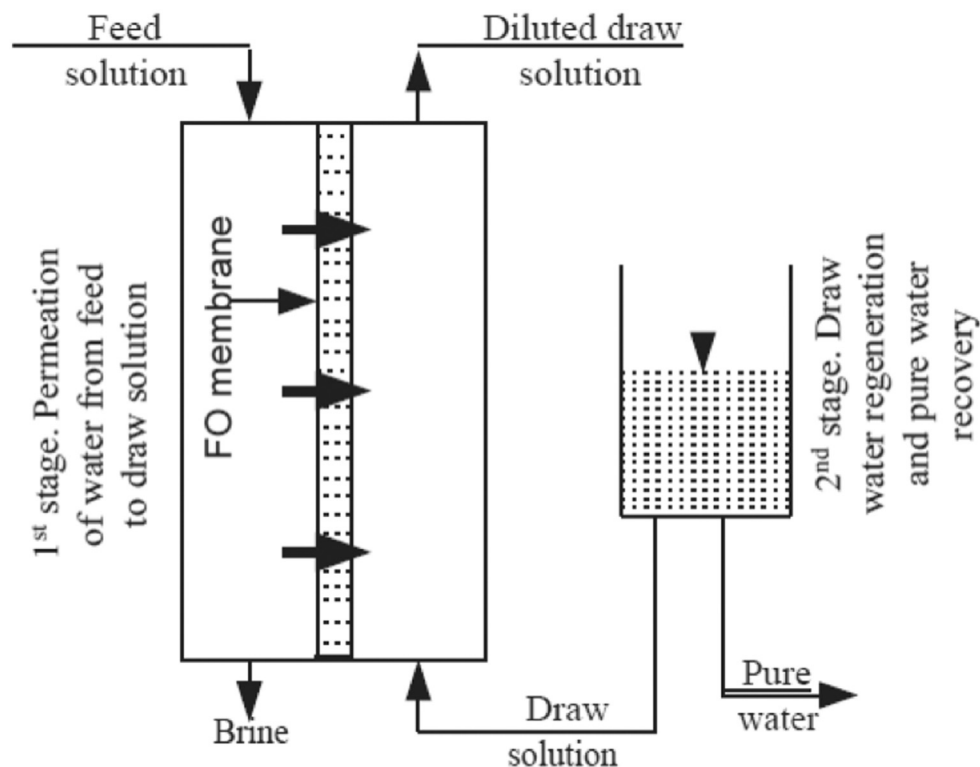


FIGURE 1.2 Two stage water filtration process [1].

1.29 Social unsustainability

Human unsustainability is deemed where fundamental human requirements are not fulfilled by all residents in the catchment or subcatchment region and where universal justice standards regarding water-related matters are not enforced.

1.30 Economic unsustainability

Climate unsustainability may imply a condition in which water is neither released nor used commercially. The temporal dimension of water scarcity (time) is becoming more relevant because climate change can affect precipitation trends and total quantities. Theory, techniques, and instruments for the measurement of the total WF and its functional implementation continue to be established and experimental.

1.31 Assessment tools

The first move will be to examine current water management activities, related effects, danger, and response options in order to will the impacts of WFs through sustainable water management. A variety of instruments have been established to this end from multiple points of view, such as sustainable management of commercial resources, sustainable management of wastewater processing and supply chains, and sustainable management of drainage basins. The following is the list of the most important tools.

1.32 Water footprint network

The Water Footprint Network platform provides a variety of resources and various articles, such as a Water Footprint Measurement Manual, WF calculators, regional WF case studies, and a database. The approach mentioned in the manual can be used for various forms of WF assessment, including those at product and enterprise level. Data from numerous research on WFs, simulated energy, wastewater, and contamination are found in the Water Stat database. The Water Footprint Assessment Tool is a free Web application that allows users to measure water footprint, evaluate biodiversity, and react.

1.32.1 Eureka

The EU sponsored a One World Economy Network (OPEN: EU) under its seventh Phase System for Scientific and Technical Growth. This research contributed to the free usage of the EUREKA Internet resource, which provided comprehensive ecological, carbon, and water footprint results. This instrument forms the movement of products and services between 45 countries and regions representing 57 sectors of the global economy. The industries span a number of fields, from agriculture and construction to travel, recreation, wellness, and financial services.

1.33 Global water tool

The Global Water Tool (GWT), introduced in 2007, is a free-standing resource for businesses working in several countries from the World Business Council for Sustainable Development (WBCSD), to monitor water use and determine threats for their regional activities, distribution, and supply chains. There is no precise guideline on local circumstances which need to be studied in greater detail. The platform has been established under the guidance of WBCSD founder and multinational innovation firm CH2 M HILL. The pilot tests were led by an advisory board of 21 other major organizations. The Nature Conservancy and the Environmental News Project provided skills. The platform is routinely upgraded by more than 300 organizations with new data sets and functionalities [1,2].

1.34 Local water tool

The Local Water Tool (LWT), launched in March 2012, is a free to use tool from the Global Environmental Management Initiative (GEMI) that will help companies conduct systematic assessments of their relationship to water in order to create site-specific sustainable water management strategies. GEMI is a nonprofit association comprising 26 organizations dedicated to supporting sustainable protection, health, and education. The tool was developed in partnership with the WBCSD to connect the resource to the Global Water System. This is also funded by a variety of other companies such as AkzoNobel and Exxon.

1.34.1 Aqua gauge

The Ceres Aqua Gauge is a popular tool for water risk control firms. Development, supply chains, and the effect of the usage of commodity on water are taken into account. Ceres is an innovation and conservation organization located in the United States that partners alongside businesses to solve ecological issues, such as climate change and water shortages. The resource has been developed by Ceres, in partnership with the World Business Council for Sustainable Development (WBCSD), Irbaris, and IRRIC Institute. Members of over 50 financial organizations, businesses, and NGOs such as Robeco Asset Management, WWF, and The Nature Conservancy have participated.

1.35 Water risk filter

The Water Risk Filter is an electronic program operated by the WWF, designed to assist businesses and investors in evaluating and directing water risks. The policy includes all specific areas of water hazards such as the physical risks, and those of the production and supply chain (water scarcity, water contamination, environment challenges, and hydroelectricity dependence), legislative risks, and reputational risks. Such threats involve those linked to the basin and linked to the product. Risk thresholds are calculated by the outcomes on a series of factors compounded by an acceptable weighting. Such values are collected from an installation-specific questionnaire or are extracted from a variety of global data outlets, including Blue Water Scarcity and Water Footprint Network results. The program was established for the DEG KWF Bankengruppe for the WWF.

1.36 Corporate water gauge

The Corporate Water Monitor is a resource in the Sustainable Organizations Center, which offers a metric for the ecological quality of water use in the enterprise using a watershed-centered method. Aspects of the supply chain are not addressed. The device is not free of charge. Licenses are given to consumers using the CSO with at least one transaction on the platform of their preference.

1.36.1 Aqueduct

The WRI is creating the Aqueduct Water Hazard Atlas with which a first edition is accessible now free of charge. The center of Aqueduct is a global water risk knowledge database which helps businesses, investors, governments, and others to construct detailed water risk maps. The Aqueduct Partnership, through the Netherlands Ministry of Foreign Affairs, financially sponsors the Aqueduct Partnership workgroups and professional consultants from businesses, policy departments, Charities, and academics.

1.36.2 GWP toolbox

The Global Water Collaboration toolbox is a downloadable, open archive for comprehensive management of the water supply, with a collection of history documents, policy briefs, professional briefs, and prospective articles, as well as significant sections of case studies and references. The toolbox focuses only on elements of the supply chain and on the WF principle.

1.37 Future of water footprints in textile and in general

The Water Services Network study on the possibility of closing the increasing distance between (blue) water availability and demand by 2030. Charting Our Water Future study offers an empirical structure to promote decisions and expenditure in steps to improve water quality and productivity. A main instrument is the “water-marginal cost curve” that offers a microeconomic estimate of the expense and potential of a number of current technological interventions aimed at closing the expected gap between demand and supply in a particular basin region. The study provides case reports from four nations with significantly different water challenges and a detailed set of interventions [37].

The definition of WF is a significant development in the evolution of freshwater storage methodologies, methods, and metrics and in the measurement of wastewater discharge. Industrial water footprint methodology (IWF), which focuses on industrial processing processes, will provide a simple view of the freshwater use and the impacts on both the commodity and infrastructure of wastewater release. Such case studies have shown that the majority of IWFs are triggered by gray industrial WFs, the amount of water required for contaminant dilution. Freshwater-intensive techniques include tinting, bleaching, and cleaning. This may usually be one of the traditional features of thin and finished fabrics. It is beneficial to reduce the use of freshwater in hot spots by enhancing the management system of freshwater and processing techniques. The report also suggested detailed guidelines for more work in this area. For human sustainability and ecological equilibrium, fresh water is important. The spread in the earth and the seasons is nevertheless inconsistent. Different human activities, particularly farming and industrial, consume large amounts of fresh water and trigger extreme water contamination. The massive population growth, continuing industrial progress, and global climate change over the last few decades have ensured that fresh water is a very limited resource [36]. The strain on the availability of fresh water could contribute to a number of social and environmental issues. Measuring the use of groundwater and evaluating its environmental implications are critical measures to mitigate its consequences. Previous research concentrated primarily on the depletion of groundwater from dams, lakes, deep aquifers, etc., from various areas of economies. The definition of virtual water (VW) and WF was established in later work. VW was described as the freshwater volume used in the development of a commodity and was often referred to as “embedded water.” The definition of WF proposed by Hoekstra and Hung is an analogy to the definition of ecological footprint that denotes the region required to sustain the community in the 1990s. WF has three elements in general: green WF, blue WF, and brown WF. The green WF applies to rainwater absorption, but will not wash down. The blue WF applies to land and groundwater energy use [1,17,29]. The gray WF is a climate contamination measure. It is known as the amount of fresh water needed to assimilate the load of contaminants to provided rates of natural resources or established requirements of environmental water quality.

Textiles are essentials in the everyday lives of human beings. The entire clothing life cycle includes several phases, including cultivation, manufacturing, storage, usage, and recycling. In recent years, political and social focus has been given to clothing development and use in relation to environmental impacts. Research discussing the effect of the textiles on environmental supplies found that the bulk of the impacts are related to the manufacture of raw materials, pollution contamination from the manufacturing of textiles, and the servicing of finished goods. Of the three key types of rural, commercial, and domestic freshwater uses, commercial freshwater uses are expected to have risen by around 76% between 1976 and 2025 [7,11,20,29].

Today, publications using WF methods primarily concentrate on agricultural products and foodstuffs, such as pasta and pizza, corn, cotton, wheat, seed and vegetable goods, etc. In this chapter we concentrated on the use of fresh water and its impact on the industrial production chain from yarn to cloth. Water pollution The IWFs of the seven styles of knitted fabrics were measured to test the effectiveness of the IMF technique at the product stage. For this case study knitted fabrics have been selected because knitted fabrics were commonly used in textiles and primarily in clothes. The world’s knitted textiles and garment output amounts to over 17 million tons, one-third of the world’s fashion markets. They were also supposed to have somewhat specific IMFs which were considered useful for the intent of the project [42].

For selected knitted fabrics, IWFgrey was the highest IWF of all industrial processing technologies, and for the most chosen knitted fabrics. This may usually be a common feature of tinted and finished fabrics. Textile producers have the best awareness of plant freshwater use. Nonetheless, they can neglect knowledge on freshwater use and water contamination by particular industrial technologies. This poses a significant obstacle for monitoring water and evaluating environmental effects in order to separate groundwater use and wastewater pollution from continuous production of a variety of goods. Freshwater shortages and wastewater are globally in certain aspects but they are notably local and national issues in many ways. IWF work has created a comprehensive understanding of water-

intensive phases in the production process of rising clothing, in which the usage of dwellings is growing more rapidly in the coming years. This establishes a basis for designing policies and prioritizing steps to raising the use of freshwater textiles. For teared knitted garments, the biggest influence would be the elimination in freshwater used by tinting as this method accounts for nearly 95% of the IMFs related. This also offers a framework for the risk evaluation of global distribution chains and potential water source shortages [4]. The IMF approach, on the other side, has the potential to endorse sustainable positive company claims and organizational sustainability analyses. Fresh water that is suited to the agricultural supply chain is primarily concerned due to the relatively small availability that therefore influences the equilibrium between humans and habitats. To date, the new WF approach focuses primarily on the whole development cycle including livestock, business, and the usage level. The first problem is the quality of data on freshwater use and water contamination in the process. It can only clarify approximately the use of fresh water and the pollution of wastewater. The whole life cycle is a long and complex chain for textiles. Via field experiments, constant data with a great deal of accuracy can be collected in the manufacturing sector, and IMF analysis provides a simple image of the use of water and its effect on chemical and technical water emissions. It is useful to compare textiles and to interact between producers on the basis of high-quality data [6].

1.38 Conclusions

Their development is highly based on water, from the creation of raw materials to industrial processing levels. Increasing demand for resources is also impacting textiles, and the plight of supply chain staff becomes similarly critical as working conditions in developed countries still struggle to reach basic human rights and decent labor standards. Cotton is the most common textile fabric. He is, though, the biggest suspect for drinking water and polluting it. With just 2.4% of the world's cropland, cotton constitutes 24% of global insecticide use and 11% of pesticides. Toxic substances that flow through the rivers and penetrate the environment, through particularly in developed nations, have become a significant source of contamination. The depletion of the Aral Sea in Central Asia results from wasteful cotton cultivation. The Aral Sea was the world's fourth biggest lake in the 1960s. And the populations around it became a significant source of life and habitat to millions of species. It now covers only 10% of its original territory. The local Uzbek populations experienced lack of livelihoods and food supplies as well as new health effects. The lake's sediment is carcinogenic and coats several settlements.

This knowledge illustrates the intense techniques and additives in fresh water such as tinting, bleaching, and cleaning, offering a foundation for the implementation of policies and prioritizing measures to minimize allocations of fresh water and its influence on wastewater. The existence of water quality data is currently the limiting factor of IMF study. True statistics on freshwater utilization and disposal for most agricultural activities are sparse since few farmers collect or record this knowledge. In the potential implementation of the IMF technique, collecting this knowledge in a coherent format is a required move.

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