An Assessment of Water Footprint and Water Balance Towards Sustainable Water: A Case Study on Cut & Saw Apparel Facility in Sri Lanka

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***Abstract*—The water footprint and Water balance are comprehensive metrics that quantify the total volume of freshwater used across the entire supply chain of a product or service. By considering both direct and indirect water consumption, water input & outputs these assessments offer valuable insights into the environmental impact of various activities. The textile sector is water-intensive. Textile industries consume a large quantity of water and discharge polluted water to the environment. Therefore, water footprint and water balance assessment are important for textile processes (domestic and production) and products. In this study, the Bluewater footprint, greywater footprint, and water balance of the cut and saw facility in Sri Lanka on a single cut and sew garment factory in Sri Lanka are considered. Primary data was collected through on-site measurements of water consumption and interviews with key personnel within the selected factory. Data was collected monthly and analyzed to determine the components of the Water sources, identify areas of heightened water consumption, and assess the associated environmental impact. total Bluewater footprint in 2022 is 18422.06m^3/year. The total Greywater footprint in 2022 is 2956.57m^3/year This study will help policymakers, apparel brands, and industry management to take necessary steps to reduce water use and pollution in textile operations.**

***Keywords*—Water footprint, greywater, Bluewater, water balance**

I. Introduction

Water is an indispensable resource, crucial for life and industrial processes. With an ever-growing global population and increasing industrialization, the demand for freshwater resources is intensifying. Sustainable water resource management is an urgent global concern. A key step in achieving sustainable water utilization is the assessment of water footprints.

A water footprint is a comprehensive metric that quantifies the total volume of freshwater used across the entire supply chain of a product or service. By considering both direct and indirect water consumption, water footprint assessment offers valuable insights into the environmental impact of various activities. The textile and apparel industry, renowned for its substantial water consumption, is an ideal context for this research. Sri Lanka, a major player in the global textile and apparel industry, presents an opportunity to explore the significance of water footprint assessment, particularly within the context of a cut-and-sew garment factory [1].

The concept of the water footprint was introduced by Hoekstra and Hung in 2002, gaining wide recognition as a valuable tool for quantifying water use and its environmental impacts. Different methods, including blue, green, and grey water components, have been developed for water footprint assessment. The textile and apparel industry is notorious for its significant water consumption and pollution, affecting every stage of the supply chain, from cotton cultivation to fabric dyeing and finishing. Numerous studies have highlighted the environmental and social consequences of excessive water use in this industry. Sri Lanka plays a pivotal role in the global textile and apparel market, significantly contributing to the nation's economy. However, the industry's rapid expansion has raised concerns about water resource management and pollution, necessitating water footprint assessments for sustainability. Sustainable water utilization is vital for environmental conservation and business continuity. Companies that actively manage their water footprints mitigate risks associated with water scarcity and compliance while enhancing their corporate image.

In a cut-and-sew garment factory, water plays a crucial role, despite the absence of printing, washing, and water used in the manufacturing process. While these specific processes are not employed in such facilities, water is still an essential resource utilized for various purposes. Research has shown that similar facilities often employ water for essential tasks such as cooling, sanitation, and general facility maintenance [2]. Water is used for cooling machinery and equipment, ensuring that they operate at optimal temperatures, which is crucial for maintaining production efficiency [3]. It is also essential for maintaining a clean and hygienic working environment in line with industry regulations [4]. This includes the cleaning and disinfection of production areas, restrooms, and common spaces to ensure a safe and healthy workplace [2]. Additionally, research into comparable industrial settings indicates that water is employed for employee amenities like drinking fountains and bathroom facilities [5]. This usage aligns with providing a comfortable and conducive workspace for the factory's workforce.

II. Methodology

A. Data Collection

This study was concentrated on a single-cut-and-sew garment factory in Sri Lanka. Primary data was collected through on-site measurements of water consumption and interviews with key personnel within the selected factory [6]. As primary data facility main meter and submeter readings, no of working days, average monthly employees, drinking water quality reports, wastewater quality reports, and some water test parameters were taken.

Secondary data was sourced from government reports, industry publications, and relevant academic studies.

B. Water Footprint Assessment

Assessment of the Water footprint of each type is different depending on the sector. [7]. In This assessment, the Bluewater footprint, Greywater footprint, domestic water, and water balance (e.g., water used in domestic uses) were calculated. The Bluewater footprint was calculated using total extraction from the related water sources. The domestic water footprint was calculated based on the domestic consumption per person per day who worked in the selected factory [8].

C. Data Analysis

The collected data was thoroughly analyzed to determine the components of the water sources, identify areas of heightened water consumption, and assess the associated environmental impact.

III. Results

The Water balance analysis of 2022 is shown in Tab. 1

TABLE 1. WATER BALANCE

Water Balance			
Input		***Output***	
Groundwater Extraction Tubewell"	4566.02	Production Washroom 01(handwashing and bathing purposes)	4956.98
Groundwater Extraction Dug Well 01	8121.02	Production Washroom 02(handwashing and bathing purposes)	317.67
Groundwater Extraction Dug Well 02	3306.98	Boiler (Steam for production)	481.2
Rainwater Meter	2428.04	Canteen	5234.03
Recycled water	2990.34	Toilet Flushing	6297.32
		Evaporative Coolers	3066.09
	21412.4		**20353.29**
		difference	**1059.11**
		% Difference	**5%**

Discrepancies between water input and output occur due to factors such as evaporation losses, leakages, and unaccounted water consumption through non-metered sections.

The primary sources of water supply, as depicted in Tab. 1, encompass groundwater, rainwater, and recycled water. These water sources cater to various needs, with domestic applications categorized into flushing, handwashing, cooking, and cleaning, while industrial purposes encompass steam generation for production and evaporative cooling, as outlined in Table 01.

Tab. 2 shows the Bluewater footprint of the facility in 2022

TABLE 2. BLUEWATER FOOTPRINT

Bluewater Footprint		
Month	***(f) Bluewater Footprint (m^3) ****	***Bluewater Footprint (L/day/person)***
January	1150.29	22.31
February	769.72	15.56
March	1157.15	19.98
April	1201.72	26.97
May	1980.97	34.38
June	2055.5	35.56
July	1426.68	24.63
August	1861.33	31.26
September	1353.44	27.17
October	1866.68	38.10
November	1801.15	36.95
December	1797.43	35.00
2022	18422.06	29.00

Sustainability is a key theme in water resource management, with a particular emphasis on Water footprint. Sources of Bluewater in the facility are groundwater and harvested rainwater. The total Bluewater footprint in 2022 is 18422.06 m^3/year. The daily Bluewater footprint per person is 29.00L/day/Person.

Tab. 3 shows the Greywater footprint of the facility in 2022.

TABLE 3. GREYWATER FOOTPRINT

Greywater Footprint Analysis		
Month	**(f) Greywater footprint (m3) ***	**Greywater Footprint (L/day/person)**
January	263.52266	5.11
February	283.57203	5.73
March	212.11304	3.66
April	275.38573	6.18
May	255.46141	4.43
June	235.43749	4.07
July	232.28302	4.01
August	239.06307	4.02
September	201.28245	4.04
October	249.55072	5.09
November	237.94056	4.88
December	270.96126	5.28
2022	**2956.5734**	**4.65**

The source of Greywater of the facility treated was wastewater portion of domestic use excluding treated recycled water used for flushing purposes. The total

Greywater footprint in 2022 is 2956.57m^3/year. The daily greywater footprint per person is 4.65/day/Person. The greywater footprint of the facility can be reduced via full utilization of treated wastewater from the sewage treatment plant (STP). The reduction of greywater footprint also effects on reduction of Bluewater footprint.

Tab. 4 shows the Domestic usage of the facility in 2022.

TABLE 4. DOMESTIC USAGE

Domestic Usage Analysis		
Month	***(f) Potable Water (Domestic Use) (m3) ****	***Daily Consumption per Employee (L/day/person)***
January	1310.18	25.41
February	1435.31	29.01
March	1515.45	26.16
April	873.39	19.60
May	1328.34	23.05
June	1606.89	27.80
July	1460.92	25.22
August	1451.01	24.37
September	1394.29	27.99
October	1378.2	28.13
November	1680.2	34.47
December	1371.82	26.72
2022	**16806**	**26.45**

The domestic water footprint of the facility is 26.45 L per day per employee according to Table 03. The monthly variation of water consumption due to fluctuation of No of workers worked per month, weather conditions, infrastructure changes, etc.

Several measures are implemented in the facility to optimize domestic water footprint such as water-saving fixtures used for the canteen, washrooms, dipping system, and automated dishwasher implanted for plate washing. Also conducting awareness via training, group activities, and using other communication tools such as PO systems, display boards, social media, etc.

Rainwater and Treated recycled water are the sustainable water sources that are utilized in the facility. Rainwater serves as an environmentally friendly resource and finds its application in evaporative cooling systems. Recycled water, on the other hand, constitutes the treated component of wastewater from sewage treatment plants (STPs). This treated water is integrated with groundwater for flushing purposes.

The following data shows the average number of employees worked and no of days worked in 2022

TABLE 5. NUMBER OF WORKERS AND WORKING DAYS

Avg No. of Employees	**No. of Days Worked**
2285.25	278

IV. CONCLUSION

This analysis shows that periodical monitoring and analysis of water consumption data can be used for environmental management system decision-making processes in the facility. Further, Critical consumption points identification, Water consumption patterns, and trend monitoring can be used towards shifting to sustainable water sources such as recycled water and rainwater to reduce groundwater extraction.

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