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QUANTIFICATION OF WATER FOOTPRINT OF NATIONAL CAPITAL TERRITORY (NCT) OF DELHI, INDIA

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ABSTRACT

Overexploitation of freshwater caused by the increasing population and urbanization over the past few decades has resulted in water scarcity in National Capital Territory (NCT) of Delhi. Water footprint (WF) is a useful tool to better understand the linkages between humanity's activities and their growing pressure on the freshwater resources. It indicates the amount of water required to produce all the goods and services by the individual or community, or geographic area directly and indirectly (virtual water). It is measured in terms of water volumes consumed (evaporated) and/or polluted per unit of time. Many studies have been carried out pertaining to the water requirement of NCT of Delhi. The present study is focused on the assessment of the WF of NCT of Delhi. The total WF of NCT of Delhi for the year 2010 has been assessed as 15,926 MCM per annum. Out of this 6530, 780 and 865 MCM per annum has been contributed from domestic, agriculture and industrial sector respectively and rest (7751 MCM per annum) is as virtual water import. Certain assumptions were made due to non-availability of some of the data. With the availability of more data, the assessment can be improved. Quantification of WF of NCT of Delhi indicates that domestic sector is the major water consumer. Sector wise results can facilitate authorities to develop improved management policies, action plans and strategies for better management of freshwater resources.

Key Words: Water Footprint, NCT-Delhi, Virtual water, Grey Water

INTRODUCTION

The increasing population and overexploitation of surface and groundwater over the past few decades have resulted in the water scarcity in NCT of Delhi. Efforts are continuously being made by various organizations to develop strategies to meet out the water scarcities. From public as well as private sectors different initiatives have been launched (e.g Reduce-Reuse-Recycle, rain water harvesting, automated irrigation system, anti-boring laws for ground water extraction, water pricing etc.) to prevent and mitigate water scarcity for developing water sustainability. In the recent past few water indicators also have been developed in this regard. Some indicators which are considered to best represent the overall status of water resources of a region are Virtual Water, Water Neutrality, Water Mark, Water Debt, Water Audit, Peaking Water and Water Footprint. Out of these indicators Virtual Water and Water Footprint have been worked out in this study.

Virtual Water: The water required for production of a commodity, goods or services is called virtual water (VW). The virtual water concept is primarily used for measuring the distribution/transportation of water through trade between states/regions/countries. The virtual water of a product may vary from place to place because of the difference in climatic

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conditions. The concept of virtual water helps us to realize how much water is needed to produce different goods and services. In semi-arid and arid areas, knowing the virtual water content of a goods or service can be useful towards determining how best to use the available scarce water. It can be computed by:

$$\textbf{VW Content = Direct VW + Imported VW - Exported VW} \qquad \ldots(1)$$

Water Footprint (WF): The WF is a consumption-based indicator of water use that looks at both direct and indirect water use of a consumer or a producer or a region. The WF of an individual, community or business is defined as the total volume of all kinds of water that is used to produce the goods and services consumed by the individual or community or produced by the business. It is measured in terms of water volumes consumed (evaporated) and/or polluted. It can be calculated for any well-defined group of consumers (e.g. an individual, family, city, or nation) or producers (e.g. an organization). For example, the WF 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 WF of products, countries and companies will help to understand how a more sustainable and equitable use of fresh water can be achieved. The WF of an area is primarily assessed in three important sectors i.e. domestic, agriculture and industrial by considering the direct as well as indirect water consumptions.

Domestic water footprint: The domestic WF of a person is the amount of water he/she uses in and around his/her house throughout the day. This includes the water he/she uses directly (i.e., from a tap) as well as the water he/she uses indirectly (food he/she eats and to dilute the water he/she pollutes etc.) One may not drink, feel or see this virtual water**,** but it makes up the majority of his water footprint. One of the main factors determining the water footprint of the different regions are the consumption habits of its people both through direct water consumption, and virtual water consumption due to a strong demand for industrial products and a diet high in meat. Fig.1 shows the water needed, either used or polluted, to make common consumer goods.

Agriculture water footprint: Agricultural sector (including forest and shrub area) is a major water-consuming sector. The agricultural WF corresponds with the water use in the agricultural sector (i.e. in the form of crop evapotranspiration (ET) or water pollution). The agricultural water footprint measures the volume of ET or water use of a crop per unit mass of yield. Comparing water footprints of different management practices in agriculture can help in evaluating drought tolerance, water use efficiency, effective use of rainfall, and the significance of irrigation.

Industrial water footprint: The industrial sector needs an appropriate quantity and quality of water for consumption as an elementary ingredient for various processes and operations. Although, many industries have high shares of effluents leading towards pollution to hydro-ecosystems, risking water reserves for sustaining long run operations. Industrial WF is defined as the total volume of freshwater used directly or indirectly to run and support a business (rather industrial or commercial). It is an indicator of water use for industry quantifying the total amount of water volumes consumed, their destinations, flows standards and volumes of water pollution flowing back to an environmental system.

As the WF is the volume of freshwater used to produce the product, measured over the full supply chain, all the three sectoral WFs i.e. domestic, agriculture and industrial WFs are further sub-divided in to three components given below:

Blue water footprint: It is the volume of surface water and groundwater consumed (i.e. evaporated or incorporated into the product) during production processes (also includes irrigation water used for crop growth)

Green water footprint: It is the volume of rainwater consumed (i.e. evaporated or incorporated into the product) by the product. In other words it is the consumptive use of rainwater for crop growth (Evapotranspiration)

Grey water footprint: It is the amount of freshwater required to mix pollutants and maintain water quality according to agreed water quality standards. In other words, it is the water required to dilute the water pollution that is caused by the production of the commodity to acceptable levels.

The present study estimates the water footprints of NCT of Delhi from consumption perspective by quantifying the green, blue and grey water footprints for all the major water consuming sectors (domestic, agriculture and industrial) within NCT of Delhi. The results of the study could be useful in quantifying the overall water scenario of NCT of Delhi.

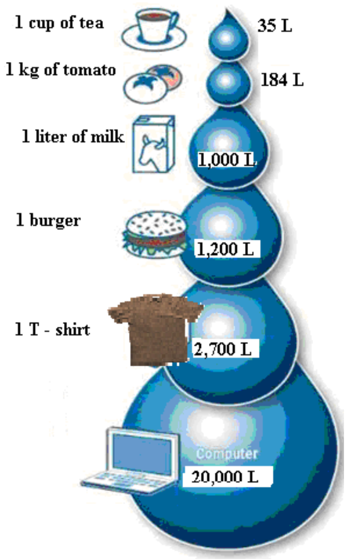

Fig.1: Water needed (used or polluted) to make common consumer goods
(*Source*:https://fosteringeducationandenvironmentfordevelopment.files.wordpress.com/2012/11/water-footprint-analysis-for-water-management-education.pdf)

Water Footprint: Status Quo

The conceptual tools necessary to compare, quantify, and price the water consumption and trade have emerged within the last 15 years. In 2004, the first global study including Water Footprint and Virtual Water Trade analysis was published (Chapagain & Hoekstra, 2004), containing virtual water flows per country related to international trade of crop, livestock and industrial products for the period 1997-2001, and the water footprint of national consumption for almost every country in the world. A refined analysis was presented in the book "Globalization of Water" (Hoekstra & Chapagain, 2008), in which specific case studies were discussed in detail. Water Footprints were presented versus water scarcity, self-sufficiency and water import dependency of various countries. The figures presented demonstrate the nature of water as a geopolitical resource and urge decision-makers to give priority to this resource in their political agendas. Several water footprint assessment studies have been undertaken since 2004 at different geographical levels. Megan K. Holcomb (2010) quantified water footprint for growing crops sustainably in Northwest India. In 2011 a collaborative study on water footprint was done by Korea International Cooperation and UNEP for analyzing corporate water accounting for resource efficiency. Later Julian Fulton (2014) studied the impact of outcomes of the water footprint of California State on policy relevance changes concluding with a comparison with results at the national level. This reveals that calculating water footprints helps to findout the global nature of freshwater. The Water scarcity can only be measured locally, but accounting for the water footprints of products means that the amounts of water being “traded” can be monitored.

Keeping this in view, the major objective of the present study is to quantify the various components of water footprint of National Capital Territory (NCT) of Delhi, India for all the three important sectors i.e. domestic, agriculture and industrial by considering the direct as well as indirect water consumptions. This study also estimates the virtual water import to the NCT of Delhi.

STUDY AREA

The India’s capital city Delhi has a specific position in the Indian institutional system. Although, about 75% of the total geographical area (1483 km^2) is urbanized, the urban agglomeration of Delhi extends its limits out of the NCT, with satellite towns like Gurgaon, Noida, Faridabad, and Ghaziabad, growing in the immediate vicinity of Delhi in the neighboring states of Haryana and Uttar Pradesh. The location of NCT of Delhi is shown in Fig 2.

The climate of the NCT of Delhi region is semiarid in nature. About 87% of the annual rainfall is received during the monsoon months viz. June to September. The average annual rainfall of the Delhi of NCT is about 800mm. NCT of Delhi’s population grew at an annual growth rate greater than 4% during the last decade. Although the NCT of Delhi is said to be 75% urban but the 25% rural area contributes a variety of livestock presence at Delhi. The travel and transport demands of NCT of Delhi are increasing with the growth of population and economic activities. The agricultural activities in NCT of Delhi include (i) growing of field crops, fruits, seeds, and vegetables and (ii) management green area and forest plantations. As per forest department of NCT of Delhi, the tree cover area is 229.6 km^2 consisting of forest area of 85 km^2. There are more than 18000 parks and gardens in NCT of Delhi spread in about 8000 ha in various locations. Delhi has 29 planned industrial areas and 5 multistoried factory complexes. In addition, 22 non confirming industrial clusters have been notified for development. All the major activities in NCT of Delhi are based on electricity. Delhi being a city state with diminishing rural areas and agricultural activities, the thrust on energy front in Delhi is mainly to have uninterrupted power supply and to take care of increasing power demand. In order to meet this demand of electricity NCT of Delhi has State-owned power generation facilities and also imports from the neighbouring states.

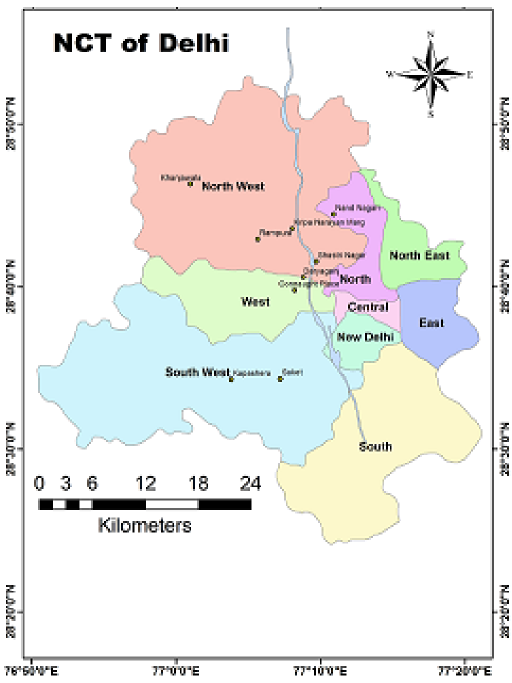

Fig 2: Location and administrative boundaries of NCT of Delhi

Water Management in NCT of Delhi

Delhi Jal Board (DJB) is responsible for procurement and treatment of allocated raw water to NCT of Delhi. Because of small size of the NCT, the DJB relies heavily on surface resources which are mobilized outside the NCT. Table 1 shows that the three major Himalayan rivers viz. Ganga, Yamuna and Sutlej are primary source of surface water that is being made available to NCT of Delhi through the canals and directly from river (in case of Yamuna) which accounts to 85% of the total water supply source and rest 15% is being met out from the ground water that is being explored through Renny Wells and Tube Wells of DJB. The groundwater, the only resource available to fill the gap between drinking water requirement of the NCT and the raw water available is in a very critical condition as the pace of groundwater recharge is far behind the pace of ground water draft.

Table 1: Supply Water Resources of Delhi Jal Board in March 2011

S. No.	Resources	Quantity (MGD)
A.	**Surface water sources**	
1	Yamuna River	310
2	Ganga River	240
3	Satluj River (Bhakra Storage)	140
	Sub-Total (A)	**690**
B.	**Groundwater sources**	
1	Renny Wells/Tube Wells	115
	Total (A+B)	**805**

Source: - Delhi Jal Board (2010).

The DJB has around 1.48 Million domestic water supply connections. The data related to NCT of Delhi indicates that Yamuna River is the most prominent source which not only enables supply of drinking water but also serves as sink for waste of Delhi. This dumping of waste has tremendously increased the pollution level in the Yamuna water in the region of Delhi. The water supply need and projected capacities show a huge gap. Thus it’s an indication to search for alternatives sources, technologies and approach in order to be able to meet the demands of future population and also to safeguard the riverYamuna. With the growth of city of Delhi, the environmental concerns have assumed greater importance. Twenty two Sewerage Treatment Plants (STPs) and Thirteen Common Effluent Treatment Plants (CETPs) are operational in various area of NCT of Delhi.

METHODOLOGY

The methodology used in this study is largely based on earlier studies supported by Water Footprint Network (www.waterfootprint.org), which already calculated International virtual water flows and water footprints of nations (Hoekstra and Chapagain, 2007) and a comprehensive introductions to water footprints (Hoekstra, 2008). In the present study, these previous methodologies are integrated as per the data availability. The study of existing water management schemes of water supply and treatment of NCT of Delhi reveals that sources of water in NCT of Delhi, consumption of water for different purposes and processing of water at the treatment plant influence the water use. The water footprints thus consist of two components: consumptive water use and waste water pollution. The current study is focused on the quantification of consumptive water use. The impact of water pollution has been assessed by quantifying the dilution water volumes required to dilute waste flows to such extent that the quality of the water remains below agreed water quality standards. The WF of the NCT of Delhi has been computed based on the available data of direct (real) as well as indirect (virtual) water consumption for the period 2006-2010. The related data have been collected from various sources, published reports from various departments of government of NCT of Delhi, from important websites, and other reports. The virtual water content related data are available at country level not at NCT of Delhi level, so these were used for NCT of Delhi as well. The data which were not available have been assumed with justification.

Assessment of domestic water footprint

As the study area is an urban dominated area, so the green component of the domestic sector is negligible. The blue component of domestic WF has been calculated by first calculating the total volume of water available for human consumption out of the total volume of water supplied by DJB. This has been done by subtracting the water requirements of all the animals (livestock) and vehicles (transport) in NCT of Delhi from the total volume of water supplied by DJB. The blue water footprint was then computed by dividing this figure by the human population in NCT of Delhi. As the computation of grey water footprint includes the amount of freshwater required for mixing pollutants and maintaining water quality according to agreed water quality standards, the water quality data of the outlets of sewage treatment plants (STP) for the year 2010 of NCT of Delhi has been used. The water quality criterion of Central Pollution Control Board (‘C’ Class water) has been taken as the water quality standards for the computation of dilution water requirement. The ‘Dissolved Oxygen’ (DO) parameter for the STPs is not available so it has been ignored. The grey water footprint has been taken as the highest of the dilution water requirement of each of the component. Different steps of computation are presented below:

Water requirements (litres/day) of the livestock in NCT of Delhi have been computed. The water requirements (litres/day) for the domestic vehicles in NCT of Delhi have also been computed. Based on the above data, the water available for the human population has been computed as shown in Table 2.

Table 2: Computation of Water Consumption by Human Population

Total Domestic Water Supply	37.68 Lakh kLper day
Livestock Water Consumption	0.22 Lakh kL per day
Domestic Vehicle Water Consumption	0.48 Lakh kL per day
Water Supply Available for Human Population	36.98 Lakh kL per day

Based on the Census 2011 and DJB data, the available water supply for both urban and rural settlement, the domestic water consumption was calculated as 220.79 litres per capita per day (lpcd), but due to significant transmission losses as well as 'unaccounted for water (UFW)' factors the water consumption per capita was found to be at the order of 99.35 lpcd which is far below the standard set by Central Public Health & Environmental. Engineering Organization (CPHEEO) i. e. 220 lpcd as well as it does not meet the standard set Bureau of Indian Standard (BIS) i.e. 135 lpcd. The details are shown in Table 3.

Table 3: Water Consumption Per Capita per Day

Year	Population (Lakhs)	Computed LPCD	Actual LPCD*	BIS Recommended LPCD
2011	167.53	220.78	99.35	135

* Assuming 'Unaccounted for Water' is ranging from 40-50%

Grey component of the domestic water footprint was calculated using ratio method. Based on the available water quality data of the various STP outlets of NCT of Delhi the grey component of domestic water footprint was estimated to be 5155 MCM per Annum (843 lpcd). The blue and grey WF added together give domestic water footprint.

Assessment of agricultural water footprint

The blue component of Agriculture WF is negligible since NCT is an urban dominated region. The green component in crop water use (CWU, m^3/ha) has been calculated by accumulation of daily evapotranspiration (ET, mm/ day) over the complete growing period.

$$CWU_{green} = 10x\sum_{d=1}^{lp} ET_{green} \text{ , volume/ area} \qquad \textbf{...(2)}$$

Where, lp = crop growing period

The green component has been assessed by computing crop water requirements (CWR) for different crops in NCT of Delhi by estimating evapotranspiration rates for a specific crop, in the specific climate of NCT of Delhi. This computation has been done using the CROPWAT 8.0 and CLIMWAT 2.0 software of Food and Agriculture Organization (FAO) of the United Nations. The CROPWAT uses precipitation data, crop growth inputs, and general soil data to calculate crop water requirements. The crop water requirements and irrigation requirements for all the crops of NCT of Delhi added together are presented in Table 4.

Computation of grey water footprint is a different segment of quantifying available water resources. While studying the agricultural sector, it is important to include the grey water in the total water footprint because non-point pollutants such as fertilizers, pesticides, and insecticides have a significant impact on the water demands of a farm. Often times, enforced water quality standards require pollutants to be diluted by freshwater to attain certain ambient legal levels. The grey component in water footprint of growing a crop or tree has been calculated by using the formula given below:

$$WF_{proc,grey} = [(\alpha x AR)/(C_{\max} - C_{nat})]/Y \text{ , } m^3\text{/ ton} \qquad \textbf{...(3)}$$

Where,

AR = Chemical application rate to the field per hectare (kg/ha)
α = Leaching runoff fraction
C_{max} = Maximum acceptable concentration (kg/m^3)
C_{nat} = Natural concentration for the pollutant considered (kg/m^3)
Y = Crop yield (ton per hectare)

Table 4: Crop Water Requirement and Irrigation Requirement for All Crop Types

Crop type	ET_c mm/Annum	Eff rain mm/Annum	Irr. Req. mm/Annum	Area in Ha	CWR Million litre/Annum
Wheat	303.7	34.8	269.5	20135	61150
Rice	807.1	470.2	608.5	6848	55270
Barley	345.8	107	292.5	70	242
Millet	351.4	348	143.1	1531	5380
Maize	470.5	426.1	187.8	40	188
Sorghum/ Jowar	414.4	426.1	160.9	3341	13845
Pulses	250.4	35.6	213.2	8	20
Potato	354.3	36.8	315.9	51	181
Sugarcane	2031.4	515.3	1522	3	61
Perennial grass	1192	515.3	750.1	8000	95360
Perennial shrubs	1182.6	515.3	858.7	29958	354283
Forest	1771.5	515.3	1302.2	8500	150578

The grey water component was calculated based on the application of Nitrogen (N) fertilizer to NCT of Delhi crop fields. Lacking Delhi-specific data, several assumptions regarding fertilizer use and transport has been made based on Hoekstra's Manual. The leaching fraction (quantity of N that reaches water bodies) was assumed to be 10% of the applied fertilizer rate. Due to unavailable local ambient N water quality standards, the United States Environmental Protection Agency (USEPA) recommendation (maximum of 10mg of nitrate per L of water) was used (Hoekstra, 2009). The natural concentration of N in the receiving water body was assumed to be zero. Only the nitrogen fertilizer use was incorporated into the grey water footprint, because the grey component is expressed as a dilution water requirement. This means only the most critical pollutant with the greatest application rate need be considered (Hoekstra, 2009). By the addition of the total crop water requirement and grey component total agriculture WF had been calculated.

Assessment of industrial water footprint

Being an urban area, the green component of the industrial WF was assumed almost negligible. The blue component of industrial WF has been assessed by calculating the total volume of supplied by DJB for commercial and industrial purposes. As per Delhi Electricity Regulatory Authority about 7000 million units are locally generated in various power plants in Delhi. It has been reported in few of the industrial reports that production of one unit of thermal power requires around 3 litres of water and in case of hydropower the water requirement is 17 litres per unit. The water consumption for electricity generation has also been considered.

The water quality data of the outlets of common effluent sewage treatment plants (CETP) of NCT of Delhi has been used for the computation of grey water footprint in the similar way as it has been done in the case of domestic grey water footprint. The blue and grey WF have been added to get the final value of industrial water footprint of NCT of Delhi.

Assessment of virtual water

In the present study, for the assessment of agriculture products including livestock based products, the data related to import of these products has been obtained from Delhi Agricultural Marketing Board. Virtual water contents for the crops from water foot print network have been considered for computation of virtual water import.

NCT of Delhi heavily depends on the neighboring states for fulfilling the electricity requirements. It imports around 17,764 million units/year (66%) of its total electricity requirements from other states. Therefore, the assessment of the virtual water import in terms of electricity has also been included in the study. Crude oil is often attributed as the “Mother of all Commodities” because of its importance in the manufacturing of a wide variety of materials. In NCT of Delhi crude oil in various forms like LPG, petrol, diesel, aviation fuel etc is procured from other states. Therefore, the assessment of the virtual water import in terms of crude oil has also been included in the study.

RESULTS AND DISCUSSION

In the present study an attempt has been made to quantify the overall water footprint of NCT of Delhi including direct and indirect water consumptions. The direct WF assessment has been done for domestic use (Blue and Grey), agricultural use (Green and Grey) and industrial use (Blue and Grey). To account for the indirect water uses, the concepts of virtual water import and grey water have also been applied. The various results of the study have been given in Tables 5 to 8 and discussed in further sections below:

Domestic Water Footprint

Analysis and results pertaining to the domestic water footprint of NCT of Delhi are given in Table 5. It can be seen that DJB supplies about 220.78 LPCD of water which is about 163% more than the BIS recommended norms of water supply i.e. 135 LPCD. But because of ‘unaccounted for water (UFW)’ ranging from 40-50% a citizen of NCT of Delhi is eventually getting 99.35 LPCD which is 74% of the recommended BIS norm. Domestic WF of NCT of Delhi comes of to be 6530.51 MCM per annum (4.4 $MCM/km^2/annum$) which also includes 5155.11 MCM per annum of indirect water consumption in the form of dilution water required for bringing the output of STPs to an acceptable level. The grey water footprint is 78% of the total domestic water footprint of NCT of Delhi.

Table 5: Domestic Water Footprint of NCT of Delhi

Details	Quantity		MCM
Water Supply of DJB	13754.00	Lakh kL/Annum	1375.40
Livestock Water Requirement	79.43	Lakh kL/Annum	7.94
Water Requirement for Domestic Vehicles	173.68	Lakh kL /Annum	17.36
Water Supply for Human Population	13500.89	Lakh kL/Annum	1350.09
BIS Recommended Water Supply (LPCD)	135.00	LPCD	-
Computed LPCD	220.78	LPCD	-
Actual LPCD (Assuming UFW as 45%)	99.35	LPCD	-
Dilution Water Requirement	51551.17	Lakh kL/Annum	5155.11
Grey Water Footprint	843.00	LPCD	-
DOMESTIC WATER FOOTPRINT (MCM/Annum)			**6530.51**

Agriculture Water Footprint

The agriculture sector is the primary water user sector in general, but being an urban setup the NCT of Delhi does not uses much of the water for its agricultural practices. The agriculture water footprint for NCT of Delhi has been computed as 779.72 MCM per annum. As shown in Table 6 it has about 5% of grey water component. It also shows that a significant part of the agriculture water component of NCT of Delhi (76%) is utilized by perennial grass, perennial shrubs and forests and very less part goes for the production of food grains and vegetables.

Table 6: Agriculture Water Footprint of NCT of Delhi per Season

Crop Type	CWR Million litre	CWR MCM	Grey WF (m^3/ton)	Grey WF MCM	Footprint MCM
Wheat	61150	61.15	329.49	30.47	91.62
Rice	55270	55.27	354.07	10.10	65.36
Barley	242	0.242	177.3	0.04	0.28
Millet	5380	5.38	265.96	0.79	6.17
Maize	188	0.19	56.92	0.06	0.25
Sorghum/ Jowar	13845	13.85	51.12	1.62	15.46
Pulses	20	0.02	568.18	0.04	0.06
Potato	181	0.19	2	0.04	0.23
Sugarcane	61	0.06	11.28	0.003	0.06
Perennial grass	95360	95.36	NA	NA	95.36
Perennial shrubs	354283	354.28	NA	NA	354.28
Forest	150578	150.58	NA	NA	150.568
AGRICULTURE WATER FOOTPRINT		**736.56**		**43.161**	**779.72**

Industrial Water Footprint

Being an urbanized residential area, there are very less industries in NCT of Delhi. The industrial water footprint of NCT of Delhi has been assessed as 864.83 MCM per annum (Table 7) including 718.21 MCM per annum of indirect water consumption in the form dilution water required for bringing the output of CETPs to an acceptable level. It is also assessed that 20.7 MCM/annum water is used for generation of electricity in its various thermal power plants. The grey water footprint is 83% of the total industrial water footprint of NCT of Delhi.

Table 7: Industrial Water Footprint of NCT of Delhi

Details	Quantity		Qty/Annum
Water Supply of DJB	3.45	Lakh kL/day	125.92 MCM
Water Consumption for Generation of Electricity	-	-	20.7 MCM
Grey Water Footprint	19.87	Lakh kL/day	718.21 MCM
INDUSTRIAL WATER FOOTPRINT	5.51	Lakh kL/day	**864.83 MCM**

The sum of domestic, agriculture and industrial WF of NCT of Delhi is 8175 MCM per annum including the grey component.

Virtual Water

In addition to the earlier discussed water consumptions, a huge quantity of virtual water is also being transferred to/from NCT of Delhi in the form of various goods, commodities and products etc. Based on the available data, the indirect WF has been assessed due to virtual water transfer of agricultural products (crop based), animal based products, petroleum products and electricity as 7750.78 MCM per annum as shown in Table 8

Table 8: Virtual Water Import

Electricity Purchased from other states in Annually	25823 Million Units
Virtual Water Import due to electricity Import assuming hydropower as the main source (15 lit per KW)	387.35 MCM
Virtual Water Import due to crude oil (4080 thousand tones) annually	326.30 MCM
Virtual Water Import due to import of crop based products annually	5138.7 MCM
Virtual Water Import due to import of animal based products annually	1898.43 MCM
Total Virtual Water Import	**7750.78 MCM**

Total Water Footprint

The total WF of NCT of Delhi has been assessed as 15926 MCM per annum which is due to water consumption of 41% in domestic sector, 5% in agriculture sector, 5% in industrial sector and 49% because of virtual water transfer.

CONCLUSIONS

The present study has been done to have insight of water consumption in NCT of Delhi, India in the context of WF. The WFs have been assessed for domestic, agriculture and industrial uses of water in the NCT of Delhi. Water consumed per annum by various types of crops, grass, shrubs and forests in various forms as well as water consumed by other various activities including virtual water import have been assessed in the study. The total WF of NCT of Delhi has been assessed as 15,926 MCM per annum which is due to water consumption of 41% in domestic sector, 5% in agriculture sector, 5% in industrial sector and 49% because of virtual water transfers. The WF comes out to be approximately 950 m^3/capita/annum which is almost equal to the National WF average. In addition to this, the water is brought in Delhi in through unauthorized tankers. The WF of the average global consumer is 1,385 m^3/capita/annum. The average consumer in the United States has a WF of 2,842 m^3/capita/annum, whereas the average citizens in China and India have WFs of 1,071 and 1,089 m^3/capita/annum, respectively.

The present assessment has been carried out based on the best possible available data sets related to virtual water transfer as the data of all the commodities was not available. Moreover huge amount of water is utilized in NCT of Delhi which is brought in via tankers but there is no complete record of these tankers. With the availability of more data, the WF of NCT of Delhi is expected to increase. The results of the study will enable authorities to develop improved strategies by quantifying the fresh water demands for all the three major sectors viz. domestic, agriculture and industrial. It will also help the authorities to identify the sectors/commodity with large water footprint so that a check can be made in order to optimize the resources. The study reveals that the grey water footprint in all the sectors is the major shareholder which implies that water is facing huge environmental problems in NCT of Delhi and the efforts should be taken to minimize the grey water footprint.

LIMITATIONS

There is still no consensus with regards the standardized approach to be employed for the assessment of WF. The physical properties of water such as its spatial and temporal availability, along with its many different sources and types or “colours” make it exceptionally difficult to value across varying contexts or locations. One of the main factors determining the domestic water footprint is the consumption habits of its people both through direct water consumption, and virtual water consumption. There are quite a number of practical issues that one will encounter when carrying out a water footprint assessment. As the water footprint studies are data intensive in nature and many a times all of the required data are not available, so a major Issue is to handle the lack of requisite data.

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