

Building Water Accounts: Physical Supply and Use Tables for India's Water Resources

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Abstract

This paper presents a comprehensive analysis of India's water resources through the construction and application of Physical Supply and Use Tables (PSUT), providing a systematic framework for understanding sectoral water allocation, consumption patterns, and policy implications. Using the System of Environmental-Economic Accounting (SEEA) methodology, we examine water flows across agricultural, industrial, energy, and municipal sectors, revealing critical insights into India's water security challenges. Expectedly, our analysis shows that agriculture dominates water consumption at 859 billion cubic metres (BCM) (81% of total abstraction), with rice alone accounting for 341 BCM, followed by wheat (106 BCM) and sugarcane (70 BCM). The industrial sector consumes 20 BCM, with engineering and pulp-and-paper industries being the largest users, while the energy sector requires 12 BCM, predominantly for coal-based electricity generation. We find that surface water provides 690 BCM and groundwater contributes 239 BCM to total abstraction of 1,122 BCM. The return flows amount to 1,053 BCM, indicating substantial potential for wastewater treatment and reuse expansion. The paper demonstrates how water accounting frameworks can inform evidence-based policy formulation, particularly for demand management, pricing reforms, and intersectoral water reallocation. The research contributes to the growing literature on environmental-economic accounting by providing the first comprehensive PSUT analysis for India's water sector, offering a replicable methodology for other developing economies facing similar water stress challenges.

Keywords: Water accounting, Water Supply and Use Tables, SEEA methodology, sectoral water allocation, sustainable water management

JEL Classification: Q25, E16, Q56, Q28

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1. Introduction

India finds itself at a critical juncture in water resource management, where the interplay between rapidly rising demand and finite availability is intensifying resource stress across the nation. The complexities of India's water landscape are shaped by demographic expansion, rapid urbanization, industrial growth, shifting consumption patterns, and the immediate and long-term effects of climate variability and change. The country supports nearly 18% of the world's population with only about 4% of global freshwater resources, a stark mismatch that underscores the magnitude of the challenge (see Mohapatra et al., 2025).

The temporal variability in rainfall, reliance on the monsoon, recurrent droughts, and climate-induced shifts in precipitation patterns make water security fragile and unpredictable. Water quality also emerges as a pressing issue: only about one-third of municipal wastewater is treated before discharge, and millions of litres of untreated sewage and industrial effluent are released daily into rivers, lakes, and groundwater, affecting human health, agricultural productivity, and ecosystem sustainability (UNICEF, 2019). By 2030, the country's water demand is projected to be twice the available supply, putting millions at risk of severe scarcity (Niti Aayog, 2018).

The studies highlight that comprehensive water accounting enhances the accountability of utilities and government agencies while improving clarity on inputs, uses, returns, and losses—key for minimizing business and policy risks (Tulip et al., 2022). In the Indian context, the National Water Policy 2012 explicitly acknowledged the need for undertaking water balance and water accounting studies to improve water use efficiency at the basin scale (GoI, 2012).

In this context, this paper endeavours to systematically capture and analyse the country's supply and use patterns of water using the internationally recognized framework of Supply and Use Tables for water. To the best of our knowledge, a comprehensive water Supply and Use table has not previously been developed for India. By preparing a detailed Supply and Use Table based on the United Nations System of Environmental-Economic Accounting for Water methodology, this work aims to bridge critical data gaps and establish a foundational baseline for monitoring, analysis, and informed decision-making (United Nations Statistics, 2012). The creation of such a baseline represents a significant methodological advancement, as it provides the first comprehensive, standardized account of water flows across India's economy, enabling systematic tracking of sectoral water use, identification of inefficiencies, and evidence-based policy formulation.

The remainder of this paper is organized as follows. Section 2 reviews the existing literature on India's water challenges and global experiences with Physical Supply and Use Tables (PSUT), identifying the knowledge gaps that motivate this study. Section 3 sets out the methodological framework, explaining the SEEA-Water approach, the construction of India's PSUT, disaggregated sector-wise use of water, the data sources and assumptions applied. Section 4 presents and discusses the results of the Supply and Use Tables, with particular emphasis on water demand, return flows, wastewater reuse, and sectoral imbalances. Finally, Section 5 concludes with the main findings and policy implications, highlighting how PSUT-based water accounting can inform sustainable water management strategies for India.

2. Literature Review

Of late, India's water crisis has garnered significant scholarly attention, with research focusing on declining availability, spatial inequities, and mounting sectoral competition. Venkatesh and Kumar (2021) document a 15 percent decline in average monsoon rainfall across India's

primary agricultural zones over the past twenty years, accompanied by a 12 percent drop in groundwater levels, underscoring rising hydrological variability and resource depletion. Mohapatra et al. (2025) highlight that India's per capita renewable water resources has fallen by nearly 20 percent since 2000, with over 50 percent of the population now living in water-stressed regions. Furthermore, it reports that wastewater recycling policies remain nascent despite urban demand doubling in the past fifteen years. Bassi et al. (2023) use water-account indicators to show that hydrological extremes in the Mahanadi basin produce annual inflow fluctuations of up to 26 percent, advocating for basin-scale accounting to guide interventions. The Composite Water Management Index of NITI Aayog (2018) finds that five of India's 20 most populous cities—Delhi, Bengaluru, Hyderabad, Chennai, and Pune—face “extreme” water stress, with municipal supply deficits exceeding 40 percent on average. Collectively, these studies emphasize the severity of India's water scarcity and the imperative for data-driven policy models.

In response to these challenges, the literature increasingly underscores the value of structured water accounting frameworks. The SEEA-Water framework in United Nations (2017) formalizes the Physical Supply and Use Table (PSUT) methodology, detailing how to record flows from the environment, within the economy, and return flows in standardized economic classifications. Martinez and Vardon (2009) illustrate PSUT construction, demonstrating its ability to pinpoint sectoral pressure points and calculate indicators such as the water footprint and return-flow ratios. The WAVES Partnership report of World Bank (2018) provides case studies from Latin America—Peru, Colombia, and Costa Rica—showing that national PSUTs revealed up to 15 percent unaccounted losses in municipal networks and informed tariff reforms that improved cost recovery by 10 percent.

South Africa's pioneering water accounting framework provides valuable methodological insights for developing India's PSUT system (Maila et al., 2018). The South African approach demonstrates the successful implementation of an environmentally extended Supply and Use Table (SUT) architecture that integrates physical flows across multiple sectors while maintaining alignment with national accounting standards. South Africa's approach to handling data quality issues through a tiered classification system is particularly relevant for India as their development of water quality accounts that track pollutant concentrations across water management areas (Maila et al., 2018). Australia's Bureau of Statistics compiles the Water Account Australia (WAA) in alignment with SEEA-Water, publishing both physical and monetary SUTs. These accounts track self-extracted surface and groundwater, distributed and recycled water flows, and return flows, offering policy-relevant indicators on water productivity, efficiency, and sectoral value-addition (BOS, 2017).

Recent advances in environmental-economic accounting have provided new opportunities for comprehensive water resource assessment in India. The Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project, implemented by India's Ministry of Statistics and Programme Implementation in collaboration with the European Union, represents a significant step toward integrating the SEEA framework into national water accounting practices. This initiative has demonstrated the practical application of ecosystem accounting principles to India's diverse water resources, covering terrestrial, freshwater, and coastal ecosystems across the country's 3.28 million km² area. By contrast, India's engagement with PSUTs remains absent. This paper is an attempt to fill up this gap in research in the Indian perspective.

3. Methodology

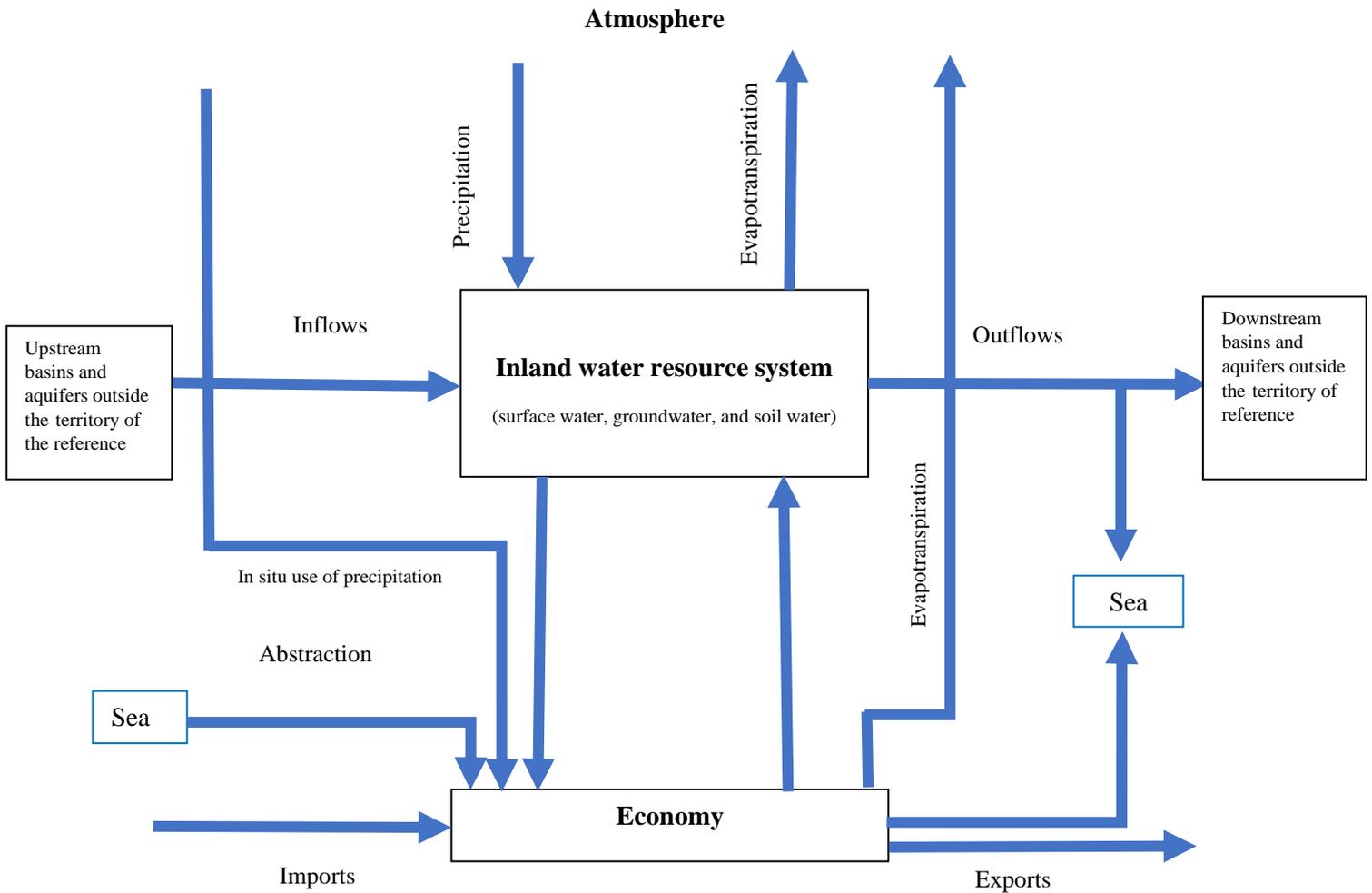
As noted earlier, we have adopted the SEEA-Water framework of United Nations Statistics (2012) to fill up this gap for our analysis. The PSUT records the physical flows of water between the environment and the economy, as well as within the economy. It comprises two interlinked components: the Physical Supply Table, which captures the origin of water entering the economy—including abstractions from surface and groundwater, precipitation collection, and reused water—and the Physical Use Table, which captures the various uses of water across institutional sectors and its return to the environment. The framework also accounts for intermediate transfers of water between industries, water losses during distribution, and net consumption through evaporation or incorporation into products.

This paper focuses exclusively on Physical Supply and Use Tables (PSUT) rather than monetary accounts, as the primary objective is to establish a comprehensive baseline for understanding India's water resource flows, sectoral allocation patterns, and sustainability challenges in volumetric terms. The physical accounting approach enables direct assessment of water balance, resource stress, and environmental sustainability indicators that are essential for informing demand management policies and conservation strategies.

The water PSUT follows the basic accounting identity that total physical supply must equal total physical use of water flow. On the supply side, water flows include both natural inputs from the environment and artificially circulated flows within the economy (see Figure 1). These comprise direct abstraction by industries or households, water supplied by water service providers, and the collection and reuse of wastewater. On the use side, water is allocated to specific economic sectors (such as agriculture, manufacturing, and households) based on their consumption patterns. The table further includes losses during distribution (such as leakages) and return flows to the environment, either as treated or untreated wastewater.

The PSUT uses physical units of measurement (typically cubic metres) to quantify flows. This allows for direct comparability across countries and facilitates the derivation of key indicators such as water productivity, efficiency, and intensity water use by sector.

Figure 1: Flow between the economy and the environment



Source: Adapted from SEEA Water, United Nations Statistics (2012), Vardon et al. (2023)

Figure 1 shows exchanges with the sea and the atmosphere, which are considered outside the inland water resource system. The economy uses water in different ways. It can physically remove water from the environment for activities involving production and consumption, or use water without physically removing it from the environment. In the first case, the economy abstracts water from inland water bodies or the sea, uses the precipitation through rain-fed agriculture or water harvesting, and uses water to generate hydroelectric power. In the second case, the economy uses water for navigational purposes, fishing and other uses that rely on the physical presence of water and often on the quality of the water. Even though these uses may have a negative impact on the quality of the water bodies, they are not directly considered in the water accounts because they do not involve displacement of water. It should be mentioned, however, that in the quality accounts, their impacts on the quality of water resources could, in principle, be identified. In addition, the economy returns water into the environment. As Figure 1 indicates, returns can be either into the inland water system or directly into the sea. Usually, return flows have a negative impact on the environment in terms of quality, as the quality of such water is often lower than that of abstracted water. Although returns to the water resource system alter the quality of the receiving body, they represent an input into the water system, as returned water may be used for other purposes.

Understandably, water accounting in India requires a detailed assessment of both supply and use, capturing the flows of groundwater, surface water, and precipitation as they move through the economy. The assumptions and estimation procedure are described below.

In the supply-use table, annual utilizable surface-water potential is taken as 690 BCM, based on the Central Water Commission's 2022 reassessment (GoI, 2023a). Of the 398 BCM annual extractable resource, 239 BCM is deemed sustainably utilizable; of this, 208.49 BCM (87 percent) is allocated to agriculture (GoI, 2023b). Sustainable capture of rainfall is assumed at 193 BCM, consistent with national recharge estimates (GoI, 2024a). Overall, the abstracted water supply reaches 1,122 BCM. We assume 80 percent of total abstracted water (≈ 743 BCM) is used in agriculture, comprising 535 BCM surface water and 208 BCM groundwater (India Water Portal, 2025); the remaining surface water (147 BCM) is allocated between mining & industry and electricity generation in proportions derived from MoSPI's sectoral demand survey for the year 2022–23 (MoSPI, 2016). Water used by households, services, and sewerage is taken from MoSPI's demand-estimation tables and apportioned identically across the supply and use accounts (MoSPI, 2016). Here we want to mention that though total precipitation in India is 3880 BCM (GoI, 2020), this is not totally utilized in the economy, and hence the part that is used in the economy is considered in the analysis.

Wastewater treatment and reuse play a critical role in addressing India's growing water scarcity and ensuring sustainable resource management. With rapid urbanization and rising water demand, the capacity to treat and recycle sewage has become central to both environmental protection and economic planning. India has developed significant sewage-treatment infrastructure, yet gaps remain between installed and operational capacity, as well as between total wastewater generated and effectively treated volumes. In 2021 India's installed sewage-treatment capacity is 31,841 MLD, of which 26,869 MLD is operational, and it is equivalent to treating ~ 24 BCM wastewater per year. Applying the national rural-urban population ratio yields a total wastewater volume of 44 BCM (GoI, 2021). We assumed the number is the same for the year 2022–23. Annual treated sewage reuse is calculated from daily treatment throughput (per GoI 2021 figures) extrapolated to 365 days. This reuse volume is entered both as an intra-economic supply (reclaimed water distributed) and as a use by relevant sectors.

The return flows constitute a vital component of water accounting, capturing the fraction of abstracted water that re-enters natural systems after use. In agrarian economies, these flows are particularly significant for understanding water balances, ecosystem interactions, and the design of sustainable management strategies. Building on established literature and international frameworks such as SEEA-Water, return flows are typically disaggregated by receiving bodies—surface water, groundwater, and soil water—while also accounting for evaporative and consumptive losses that permanently withdraw water from circulation. In return flow, based on literature for agrarian economies, we assume one-third of abstracted water used in economy returns to inland water bodies; the remainder is lost to evaporation, transpiration, or incorporation into products (Tulip et al., 2022). These return-flow volumes are classified by receiving agents, i.e., surface water, groundwater, and soil water in line with SEEA-Water guidelines. Evaporative loss from surface-water handling (reservoirs, canals) is set at 10 percent, following estimates from reservoir-loss studies. This rate is applied symmetrically in both supply and use tables (Amrish et al., 2024).

Where national estimates were not directly available, methodological alignment and indicative parameters were guided by international PSUT studies for the Netherlands and Malaysia (Statistics Netherlands, 2019; Binns, 2016), as referenced.

In our accounting framework, sectoral water consumption includes both direct water abstraction by each sector and water obtained from other economic entities. This approach

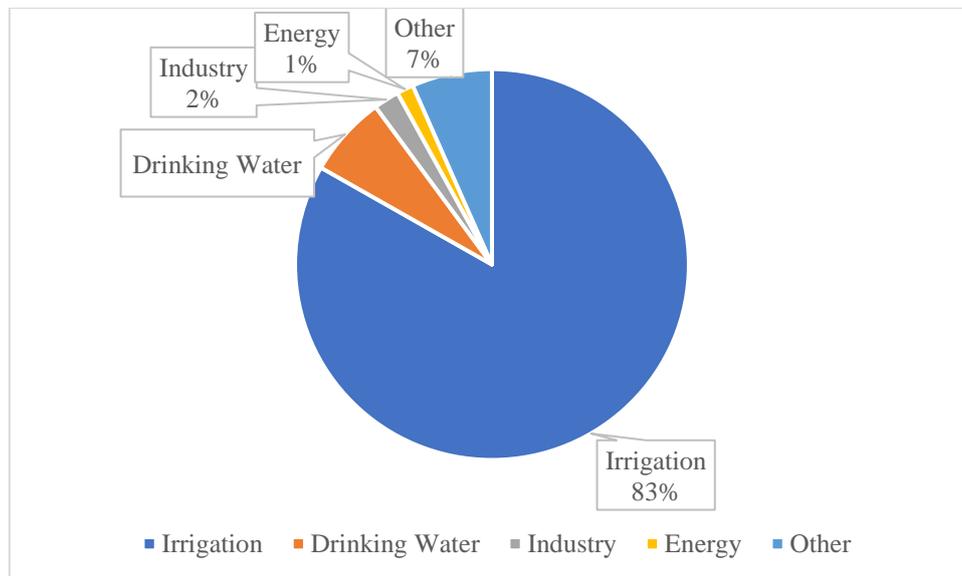
addresses potential concerns about double-counting: while water extracted by distribution utilities appears both as their direct use and as subsequent delivery to end users, the extraction by these utilities constitutes legitimate water consumption within the distributing sector, regardless of the ultimate destination.

Inter-sectoral water transfers represent flows between different economic units within the system. These transfers are measured after accounting for distribution losses and typically occur through pipeline networks, though alternative delivery methods such as open channels and transportation may also be employed. Cross-border water flows are treated as imports when supplied by entities outside the national economy.

4. Results

Table 1 and Table 2 show our estimated Supply and Use Tables of India for the year 2022-23. The Supply and Use Tables constructed for India reveal the magnitude of imbalance between available water resources and their sectoral allocation, underlining the structural crisis that is unfolding. On the supply side, the total abstracted water amounts to 1,122 BCM, drawn primarily from surface water (690 BCM), followed by groundwater (239 BCM) and precipitation capture (193 BCM). This reliance on a narrow resource base places enormous pressure on freshwater ecosystems, especially groundwater aquifers, where the rate of withdrawal now exceeds sustainable recharge in several states. The Use Table shows how these abstractions are absorbed within the economy: agriculture alone accounts for 859 BCM, representing more than four-fifths of national water use, while mining and manufacturing consume 20 BCM, the energy sector consumes 12 BCM (Figure 2). In contrast, households and services receive only a small share, underscoring the chronic urban water shortages that are expected to intensify with population growth and increasing urbanisation.

Figure 2: Water Demand Sector-wise (BCM)

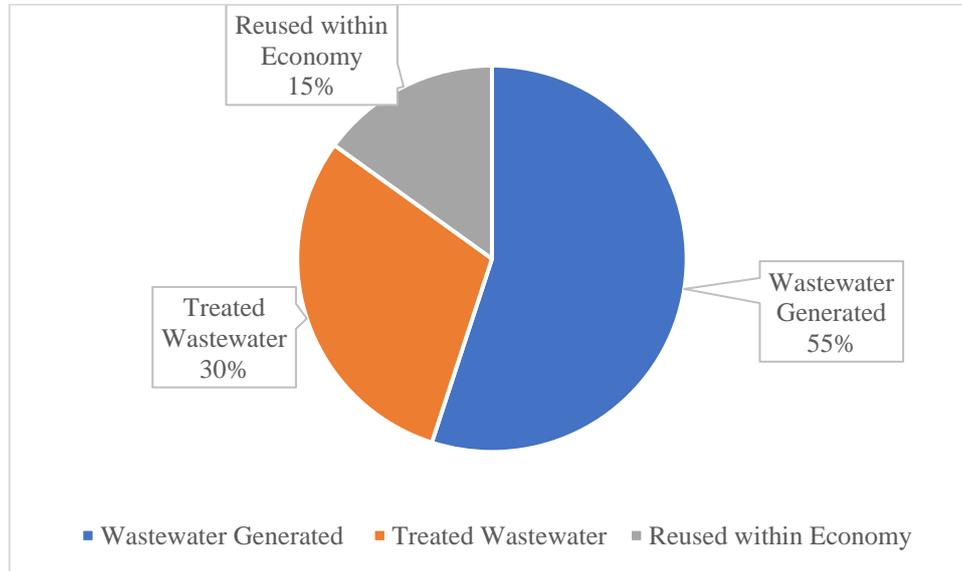


Source: Adopted from MoSPI (2016) and authors' calculation from SUT Table

A central insight from the PSUT is the scale of wastewater generation, treatment, and reuse. The analysis shows that India produces approximately 44 BCM of wastewater annually, a figure derived from the existing urban treatment capacity of 26,869 MLD, extrapolated across

the national population distribution. However, only 24 BCM is actually treated under the present operational capacity, and an even smaller share—roughly 12 BCM—appears in the tables as being reused within the economy. This means that almost three-quarter of wastewater flows remains untreated (Figure 3).

Figure 3: Wastewater Treated (BCM)



Source: Authors' calculation from PSUT Table, CSE (2022)

Table 1: Supply Table for Water for India for 2022–23 (Unit: BCM)

Unit BCM	Abstraction of water: Production of water, Generation of return flow							Flows from the Rest of the World (ROW) Import	Flows from the environment used in the economy	Total Supply
	Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and construction	Electricity, gas, steam and air conditioning	Water Collection, treatment and supply		Sewerage	Other Industries			
				Total (excl. HH)	HH Activity					
Sources of Abstracted Water										
Inland Water Resource										
Surface Water									690	690
Ground Water									239	239
Soil Water										
Total									929	929
Other Water sources										
Precipitation									193	193
Sea Water										
Total									193	193
Total Supply abstracted water									1122	1122
Abstracted Water										
For distribution				94						94
For own use	859	20	12		70	60	7			1028
Wastewater and reused water										
Wastewater										
Wastewater to treatment	2	9	4		29		0			45
Own treatment										
Reused water produced										
For distribution						12				12
For own use		1								1
Return flows of water										
To inland water resources										
Surface Water	133		6			84	7			230
Ground Water	145	6		47	37					234
Soil Water										
Total	278	6	6	47	37	84	0			464
To other sources	409	42				139				590
Total Return flows	687	48	6	47	37	223	0	0		1054
Evaporation of abstracted water	57	2	1		4	4				69
Transpiration										
Water incorporated into products										
Total Supply	1605	80	24	141	140	298	14	0	1122	3424

Source: Authors' estimates

Table 2: Use Table for Water for India for 2022-23 (Unit: BCM)

	Abstraction of water: Production of water, Generation of return flow						Final Consumption		Flows to the ROW Export	Flows to the environment	Total Use	
	Agriculture, forestry, fishing	Mining & quarrying, Manufacturing & construction	Electricity, gas, steam, air conditioning	Water Collection, treatment and supply		Sewerage	Other Industries	Household				Accumulation
				Total (excl. HH)	HH Consumption							
Sources of Abstracted Water												
<i>Inland water resources</i>												
Surface Water	535	50	12	47			7	39			690	
Ground Water	208				0			31			239	
Soil Water												
Total	743	50	12	47	0	0	7	70	0	0	929	
<i>Other Water sources</i>												
Precipitation						193					193	
Sea Water												
Total						193					193	
Total Use abstracted water	743	50	12	47	0	193	7	70	0	0	1122	
Abstracted Water												
Distributed water				94							94	
Own use	859	20	12			60	7	70			1028	
Wastewater and reused water												
<i>Wastewater</i>												
Wastewater received from other units						45					45	
Own treatment	2.8	9.6									12.4	
Reused water												
Distribution reuse												

	Abstraction of water: Production of water, Generation of return flow						Final Consumption		Flows to the ROW Export	Flows to the environment	Total Use	
	Agriculture, forestry, fishing	Mining & quarrying, Manufacturing & construction	Electricity, gas, steam, air conditioning	Water Collection, treatment and supply		Sewerage	Other Industries	Household				Accumulation
				Total (excl. HH)	HH Consumption							
Own use												
Total	3	10	0	0	0	45	0	0	0	0	57	
Return flows of water												
<i>Return of water to the environment</i>												
To inland water resources											464	
To other sources											590	
Total Return flows											1053	
Evaporation of abstracted water, transpiration and water incorporated into production												
Evaporation of abstracted water											69	
Transpiration												
Water incorporated into products												
Total Use	1605	80	24	141	0	298	14	140	0	0	1122	

Source: Authors' estimates

This underutilization of wastewater constitutes a major lost opportunity. In water-stressed economies, treated wastewater has become an essential “second source” for industrial cooling, irrigation of non-food crops, and aquifer recharge. In India’s case, the 44 BCM of generated wastewater could, if fully captured and safely reused, substitute for a significant portion of industrial and energy sector withdrawals, which together account for 38 BCM annually. In effect, the country already generates enough recoverable wastewater to offset the water demand of entire non-agricultural sectors, but weak institutional frameworks, poor enforcement of reuse standards, and inadequate infrastructure mean that this potential remains unrealized.

The implications of this gap are severe. First, untreated wastewater released into rivers and aquifers exacerbates water quality degradation, compounding scarcity with pollution and raising treatment costs for downstream users. Second, the failure to expand reuse locks India into a “linear” water economy, where fresh abstractions continue to rise unchecked despite mounting scarcity. Third, the neglect of wastewater as a resource intensifies inter-sectoral conflicts, particularly between urban and agricultural demand. Expanding reuse to even 50 percent of the current wastewater generation would free up approximately 22 BCM annually, enough to alleviate deficits in many of India’s water-stressed cities or provide supplementary irrigation for millions of hectares of farmland.

Table 2 also highlights the broader circulation of water within the economy. Only about one-third of abstractions of surface water (≈ 230 BCM) return to inland water bodies. Evaporative losses from reservoirs and canals alone account for nearly 10 percent of surface-water abstractions, reflecting inefficiencies in infrastructure. In agriculture, these losses combine with the sector’s overwhelming dependence on groundwater—208 BCM annually—to create unsustainable pressures on aquifers, particularly in Punjab, Haryana, and Rajasthan, where withdrawals now exceed annual recharge. Increased dependence on groundwater is also observed in the literature for the United States (Bagstad et al., 2020).

Taken together, the Supply and Use Tables paint a stark picture of a country on the brink of a water emergency. By 2030, demand is expected to double sustainable supply, with agriculture continuing to dominate withdrawals and urban demand rising steeply. Unless systematic measures are undertaken to regulate groundwater extraction, mandate and incentivize wastewater reuse, and promote crop diversification, India risks sliding into chronic scarcity, where both food and water security are simultaneously imperilled. The PSUT framework thus not only signifies the scale of the crisis but also underscores the urgency of moving toward integrated demand management, stronger regulation, and reuse-oriented policies to avert an impending breakdown of the country’s water economy.

Water is a foundational input across all sectors of India’s economy, but its consumption patterns, sources, and efficiencies differ markedly between agriculture, mineral extraction, and electricity generation. The PSUT is further utilized to analyse detailed accounting of water use across these sectors, using the most recent official statistics and expert-informed estimates.

4.1 Water Use in Agriculture

Agriculture continues to dominate water consumption in India, accounting for approximately 859 billion cubic meters (BCM) of total annual use across all major crops (Table 3). The pattern of water use varies significantly by crop due to differences in crop characteristics, regional climatic conditions, and irrigation practices.

Table 3: Gross cropped area and water used in agriculture in India in 2022-23

Crops	Gross Cropped Area in 2022-23 ('000 hectares)	Water Used in 2022-23
		(BCM)
Rice	47,832	341
Wheat	31,868	106
Coarse cereals	24,900	76
Gram	11,071	21
Arhar	4,068	16
Other pulses	13,787	27
Groundnuts	4,560	14
Rapeseed & mustard	9,183	17
Other oil seeds	2,165	6
Cotton	12,688	31
jute-hemp-mesta	647	2
Sugarcane	5,885	70
Tobacco	410	1
Tea	619	5
Coffee	433	4
Rubber	753	8
Fruits	9320	34
Vegetables	10,895	82
Total	188956	859

Source: CMIE (2023), FAO (2023), GoI (2024b), TNAU (2022), and authors' estimates

The agricultural water consumption patterns in India reveal significant disparities in water use efficiency across different crops, with profound implications for sustainable agricultural development and water resource management. This analysis of the 2022–23 crop season data, encompassing 188.956 million hectares of gross cropped area and 859 billion cubic meters (BCM) of total water consumption, demonstrates the complex relationship between cropping patterns and water resource utilization across the country.

Rice emerges as the dominant water consumer, accounting for 341 BCM or approximately 39.7% of total agricultural water use despite occupying only 25.3% of the gross cropped area. This disproportionate water consumption reflects the flood irrigation practices traditionally employed in rice cultivation, where fields are maintained under waterlogged conditions throughout the growing period. The water use intensity of rice, calculated at 7.5 BCM per thousand hectares, positions it as the fifth most water-intensive crop per unit area, highlighting the substantial groundwater stress associated with its cultivation, particularly in states like Punjab and Haryana where groundwater depletion has reached critical levels.

The cereals category, comprising rice, wheat, and coarse cereals, collectively consumes 523 BCM, representing 60.8% of total agricultural water use while covering 51.9% of the cropped area. Wheat, the second-largest water consumer at 106 BCM, demonstrates relatively better water use efficiency compared to rice, requiring 3.5 BCM per thousand hectares. However, the concentration of wheat cultivation in water-stressed regions of north-western India raises sustainability concerns, particularly given the government's continued subsidization of these water-intensive crops through minimum support price mechanisms.

Sugarcane presents an interesting paradox in water consumption analysis. While consuming 70 BCM across 5.8 million hectares, it exhibits the highest water intensity per unit area at 12.9 BCM per thousand hectares. Recent research by the ICAR–Indian Institute of Sugarcane Research challenges conventional assumptions about sugarcane being inherently water wasteful, demonstrating that modern sugarcane varieties can achieve superior water use efficiency compared to other major crops in an ideal situation, producing 7.14 kg of cane per cubic meter of water which is equivalent to 0.0112 BCM per thousand hectares (ChiniMandi, 2024).

The horticulture sector, encompassing fruits and vegetables, presents a more balanced water consumption profile. Vegetables, covering 10.8 million hectares and consuming 82 BCM, demonstrate water intensity at 7.5 BCM per thousand hectares, while fruits require similar intensity at 3.6 BCM per thousand hectares across 9.3 million hectares. The combined horticultural sector accounts for 13.5% of total water use while occupying 16% of the cropped area, suggesting relatively efficient water utilization patterns.

Table 4 compares crop-specific water footprints across three methodological approaches: this study's findings based on India's Physical Supply and Use Table framework, global crop modeling simulations in Mialyk et al. (2024), and Chiarelli et al. (2020).

Table 4: India's Water footprint and Global average water footprints of crops (cubic metre/tonnes/year)

Crop	India Water foot print in 2022-23(our study)	Global average water footprints of crops (Mialyk et al.)	Global average water footprints of crops (Chiarelli et al.)
Rice	2640	946	1848
Wheat	950	1013	1879
Groundnuts	2361	2374	2539
Cotton	4886	2444	2731
Sugarcane	154	141	156
Coffee	20082	9346	13959

Sources: Authors' estimates, Mialyk et al. (2024), Chiarelli et al. (2020).

The analysis reveals significant variations in water intensity estimates across methodologies, with India consistently demonstrating higher water consumption for most crops compared to global standards. Rice cultivation shows the most dramatic disparity, with India's water footprint of 2,640 m³/t/yr, substantially exceeding both Mialyk et al.'s global average and falling between the range suggested by Chiarelli et al. This pattern extends to wheat production, where India's 950 m³/t/yr contrasts sharply with both global benchmarks of 1,013 m³/t/yr (Mialyk et al.) and 1,879 m³/t/yr (Chiarelli et al.), positioning India's wheat cultivation as relatively more efficient than the global average in one comparison while remaining significantly lower than Chiarelli's estimates.

The comparative framework illuminates critical insights into India's agricultural water management challenges and opportunities across different crop categories. Cotton emerges as particularly problematic, with India's water footprint of 4,886 m³/t/yr substantially exceeding both global references. This might be caused by the divergence in climate conditions and irrigation intensity. India's cotton cultivation practice is often criticized for groundwater depletion, particularly in water-scarce regions. Conversely, sugarcane demonstrates remarkable consistency across all three studies, with India's 154 m³/t/yr closely aligning with other estimates, suggesting more standardized cultivation practices globally. Coffee presents the most extreme case, where India's estimated consumption of 20,082 m³/t/yr dramatically surpasses other estimates—likely reflecting India's small-scale, rain-fed coffee cultivation systems and methodological differences in calculating water requirements for plantation crops. These variations underscore the complex interplay between local climatic conditions, irrigation infrastructure, crop varieties, and methodological approaches in determining agricultural water efficiency metrics.

There are significant regional variations in water use efficiency, largely influenced by irrigation infrastructure, cropping patterns, and groundwater availability. States with high irrigation coverage, such as Punjab (98%), Haryana (94%), and Uttar Pradesh (84%), tend to concentrate

on water-intensive crops like rice and sugarcane, while states with lower irrigation coverage often focus on drought-tolerant crops. This disparity underscores the need for region-specific water management strategies that align cropping patterns with natural water resource endowments (Chand et al., 2021).

The adoption of micro-irrigation systems presents substantial opportunities for improving water use efficiency across all crop categories. Research indicates that drip irrigation can reduce water consumption by 39-55% while increasing crop yields by 33-41% compared to conventional flood irrigation methods. However, the current coverage of micro-irrigation in India remains at only 8% of irrigated area, significantly lower than developed countries like the United States (68.6%) and China (13.7%). The economic viability of micro-irrigation systems, which can account for more than 25% of total production costs in crops like sugarcane, remains a primary constraint to widespread adoption (ICAR, 2019).

The sustainability implications of current water use patterns are particularly concerning given India's growing groundwater stress. Research demonstrates that increased cultivation of water-intensive crops like rice correlates strongly with groundwater depletion, with a one standard deviation increase in rice cultivation area associated with a 5.44 percentage point increase in defunct wells. This relationship is exacerbated by government policies that provide guaranteed purchase of rice and wheat at above-market prices, creating incentives for continued cultivation of these water-intensive crops despite regional water constraints.

The path forward requires a multi-faceted approach combining policy reforms, technological adoption, and regional specialization based on water resource availability. Priority areas include reducing the area under water-intensive crops in groundwater-stressed regions, promoting crop diversification toward less water-intensive alternatives, expanding micro-irrigation coverage through targeted subsidies and technical support, and implementing differential pricing policies that reflect the true cost of water resources. The identification of 1.93 million hectares of rice cultivation area requiring gradual transition, primarily in northwestern and western India, along with 0.65 million hectares of wheat area in water-stressed regions, provides a concrete framework for targeted policy interventions.

The water-use analysis demonstrates that achieving sustainable agricultural intensification in India requires moving beyond maximizing production to optimizing water productivity across different crops and regions. The substantial variations in water use efficiency across crops and regions indicate significant potential for improving overall agricultural water productivity through strategic interventions in cropping patterns, irrigation technologies, and policy frameworks.

4.2 Water Use in the Mining/Manufacturing sector

We find that the water use in mining sector is about 20 BCM. However, it remains crucial due to the local impacts on groundwater, river systems, and competing social demands, especially in mining-intensive districts. Table 5 summarizes water use by major minerals and select manufacturing sectors.

Table 5: Production of Minerals/ Manufacturing goods and water used by select Industries in India in 2022-23

Mineral/ Manufacturing	Production in 2022-23	Water Use in 2022-23 (BCM)
Coal	893 MT	0.10
Crude oil	29 MT	0.01
Natural gas	34 BCM	0.01
Pulp and paper	26 MT	5.00
Textiles	3 MT	1.92
Steel	127 MT	2.54
Sugar	33 MT	0.33
Fertilizers	48 MT	0.96
Others	---	9.55
Total		20.00

Source: Joseph et al. (2019), GoI (2025a), GoI (2025b), GoI (2025c), CPPRI (2025) and authors' estimates

Table 5 assesses water requirement across different industries. For the assessment, water demand per unit production for industries as estimated by Joseph et al. (2019) is utilized. As Table 5 shows, the pulp and paper industry's consumption of 5 BCM represents its inherently water-intensive nature across all production stages. Water is essential for fiber preparation, pulping processes, bleaching operations, paper machine operations, and extensive washing cycles between processing steps. The industry requires water for diluting chemical solutions, maintaining proper consistency in pulp mixtures, cooling equipment, and achieving the cleanliness standards necessary for high-quality paper products. Modern mills are implementing water recycling systems and closed-loop processes to reduce consumption while maintaining production efficiency. Textile industries utilize 1.9 BCM primarily for wet processing operations including desizing, scouring, bleaching, dyeing, printing, and finishing processes. Dyeing operations alone can require 20-45 litres per kilogram of fabric processed, with specific water consumption ranging from 28 litres/kg for denim dyeing to as high as 285 litres/kg for complex knit composites (Uddin et al., 2023). The sector's high-water usage stems from multiple washing cycles needed to remove chemicals, achieve colour fastness, and ensure fabric quality standards. Counter-current washing systems and low bath-ratio dyeing equipment are being adopted to reduce water consumption while maintaining textile quality.

The steel sector's 2.54 BCM consumption reflects water's critical role in blast furnace cooling, coke quenching, steam generation, and dust suppression. Blast furnaces operating at temperatures around 2,200°C require intensive cooling systems using staves and closed-loop water circulation to prevent equipment overheating and ensure operational safety. Water is also essential for ash handling in slurry form, cleaning scrap metal during recycling processes, and various chemical reactions including steam generation for reduction processes. The industry is adopting dry quenching technologies and improved circulation systems to enhance water efficiency. Coal, crude oil, and natural gas extraction demonstrate remarkably low water consumption, highlighting that extractive industries are significantly less water-intensive than manufacturing processes. These sectors primarily use water for equipment cooling, dust suppression during coal handling, and occasional cleaning operations, rather than as a primary process medium, explaining their minimal water footprint compared to manufacturing industries that rely on water for chemical processes, cooling, and product quality assurance.

In the international context, India's pulp and paper sector uses roughly 192 m³ of freshwater per tonne of product, which is nearly four times higher than typical global averages of 10–50 m³/tonne (Sousa et al., 2023). India's textile sector uses roughly 640 m³ of freshwater per tonne of product. Textile wet-processing in practice consumes far more water than best-practice

benchmarks: while denim dyeing can be achieved at about 28 m³/tonne and knit composites at around 285 m³/tonne; studies of factories report real-world averages of 136–164 m³/tonne, highlighting substantial scope for water-efficiency improvements in the sector (Pervin et al., 2023). By comparison, integrated steel plants globally achieve actual water consumption as low as 3.3 m³/tonne due to high recycling rates (versus India’s 20 m³/tonne), indicating substantial potential for further reuse and closed-loop cooling improvements in India’s steel sector (Colla et al., 2017).

4.3 Water Use in the Electricity sector

The electricity sector, though often considered less water-intensive at the national scale (12 BCM), displays considerable variance depending on the generation technology employed (Table 6). The breakdown is as follows:

Table 6: Electricity generation Mix (BU) and water used (BCM) by different sources of Electricity for the year 2022-23

Energy	Electricity Generation Mix 2022-23 (billion units)	Water Use in 2022-23 (BCM)
Nuclear electricity	46	0.38
Solar electricity	102	0.02
Wind electricity	72	0.01
Hydro electricity	162	4.74
Gas electricity	24	0.14
Coal electricity	1182	6.05
Other electricity	1158	0.67
Total	1624	12.00

Source: GoI (2025d), MoSPI (2016), Vasudha Foundation (2025) and authors’ estimates

As Table 6 shows, coal- and hydro-based electricity production dominate water withdrawals. By contrast, renewable sources like solar and wind have negligible water footprints (<0.02 BCM combined), underscoring the sustainability benefits of accelerating the energy transition toward renewables. Nuclear power accounts for less than half a BCM, while gas-based generation uses even less.

5. Conclusions and the Way Forward

From a policy perspective, the Supply and Use Table acts as a critical decision-support tool. It provides a common, evidence-based foundation for cooperation across ministries, state governments, and sectors, fostering the integrated and adaptive management approaches advocated in India’s National Water Policy and recent reform efforts. The Supply and Use Table reveals not only how much water is used and where, but also who uses it, in what form, and to what effect on people and ecosystems. For researchers and civil society, the creation of a rigorous Supply and Use Table fills an important data void, establishing a credible baseline for future studies, investment planning, public awareness, and accountability.

Agriculture accounts for over 80 percent of India’s total water use, underscoring the urgent need for crop diversification and improved irrigation efficiency. At the same time, less than one-third of generated wastewater is treated, and much of it is not reused, representing a critical

missed opportunity. Equally concerning is the unsustainable exploitation of groundwater, particularly in northwestern India, where abstraction far exceeds natural recharge.

The PSUT baseline underscores an urgent need for evidence-based interventions to avert an impending water crisis. To begin, institutionalizing annual water accounting under the SEEA-Water framework across all states will create consistent, basin-level SUTs by integrating India-WRIS, MoSPI, and Jal Shakti data streams (GoI, 2023c). Such integration will improve resource allocation decisions, guide investment planning, and monitor progress toward Sustainable Development Goals.

Effective demand-side management requires volumetric pricing mechanisms and regulatory reforms that decouple groundwater extraction rights from land ownership, curbing over-abstraction. Comprehensive metering and subsidy rationalization in irrigation and urban supply can reduce consumption by up to 30 percent. Wastewater treatment and reuse must be expanded to fully utilize existing sewage-treatment capacity and promote decentralized systems, recovering at least half of municipal return flows for industrial and non-potable urban applications.

Investments in urban distribution infrastructure, particularly leak detection, smart metering, and real-time monitoring, can reduce non-revenue water, enhancing service reliability and equity. Ecosystem-based solutions such as rainwater harvesting, wetland restoration, managed aquifer recharge, and Source-to-Sea (S2S) governance frameworks will bolster local supplies, protect riverine and coastal ecosystems, and build resilience to monsoon variability. Policy-mapping exercises should identify existing legal and regulatory gaps, paving the way for integrated water legislation along the lines of the proposed National Water Framework Law, and harmonizing central and state mandates (GoI, 2016).

This paper relies primarily on secondary data drawn from multiple sources, with wastewater treatment and reuse figures extrapolated from available urban treatment capacity, while rural and informal reuse practices remain poorly captured due to unavailability of data. Water quality aspects are also outside the scope of this paper, as return flows are treated only in volumetric terms. Finally, in the absence of consistent basin- or state-level water accounts, the analysis is restricted to the national scale, which masks significant spatial heterogeneity in India's water stress. Future research can focus on developing comprehensive basin- and state-level water accounts to capture spatial heterogeneity in water availability and stress. Incorporating primary data on rural and informal wastewater reuse, as well as water quality parameters, would provide a more nuanced understanding of return flows and their environmental implications.

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