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Water-Nexus: Benchmarking water-energy-food nexus for a global urban agglomeration, Hyderabad, India, integrated with socio-economic conditions.

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1. Abstract

Urban population has been on the rise, and as per the European Union Joint Research Commission, urban cities housed 75% of the total population in the year 2015. Urban imports, exports and infrastructure have a vital role in the local economy, consequently in both national and global economies as well. Water is a key element of all the constituents of an urban agglomeration, and it is a known fact that the constituents utilize water not only from the immediate neighborhood but from elsewhere. Thus, most likely, water footprint of an urban agglomeration extends beyond regional, national and international borders. Methods to estimate water footprint and using the information in the policy context are underway. Data availability and its access at different resolutions impose its own challenges.

In this presentation, we present a consumer-centric based approach to understand the nexus of water-energy-food of urban agglomeration and benchmarking nexus elements. The consumer-centric approach helps to assess the elements of nexus at the smallest unit level of urban cities, i.e. at the consumer level. The estimated information assists in policy-making as well as in bringing the social awareness for the efficient use of resources and sustained development of urban agglomeration. This assessment is necessary for urban governments to know their dependence on water resources of their use, which can be used in smart cities development

2. Introduction

It is important for local governments of urban cities to have the information on the water use of a city needs from both consumption and production perspectives [1]. The information can be used in benchmarking (capping) water foot print of water intensive goods so that policies can be drafted towards developing self-sufficient and sustainable cities.

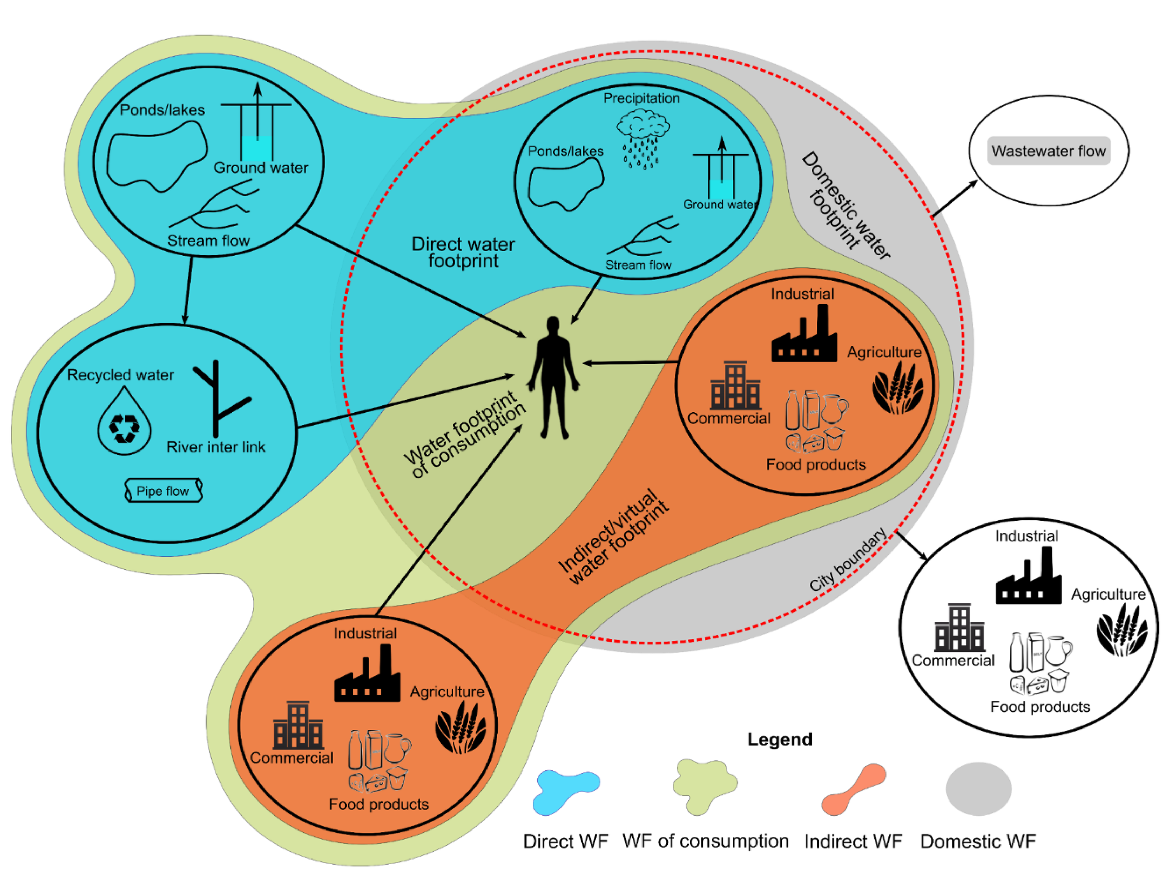

Figure 1. WF components of a urban city and conceptualization of water consumption and its sources for a typical city. [2]

- In urban cities, most of the goods and resources consumed are produced with water elsewhere and large portions of the water foot print (WF) contributed from food and energy.
- Because of more utilization of water resources for production and other needs, water resources in the source (exporting) regions are drying up quickly.
- As a consequence, source regions need to depend on external resources for various water needs, and this behavior, i.e., water scarcity can be seen over surrounding regions as well.
- However, there are not much studies on understand and quantify the dependency of cities on external water resources.
- This highlights the needs for benchmarking or capping to reduce WF of urban cities.

3. Study area & Datasets

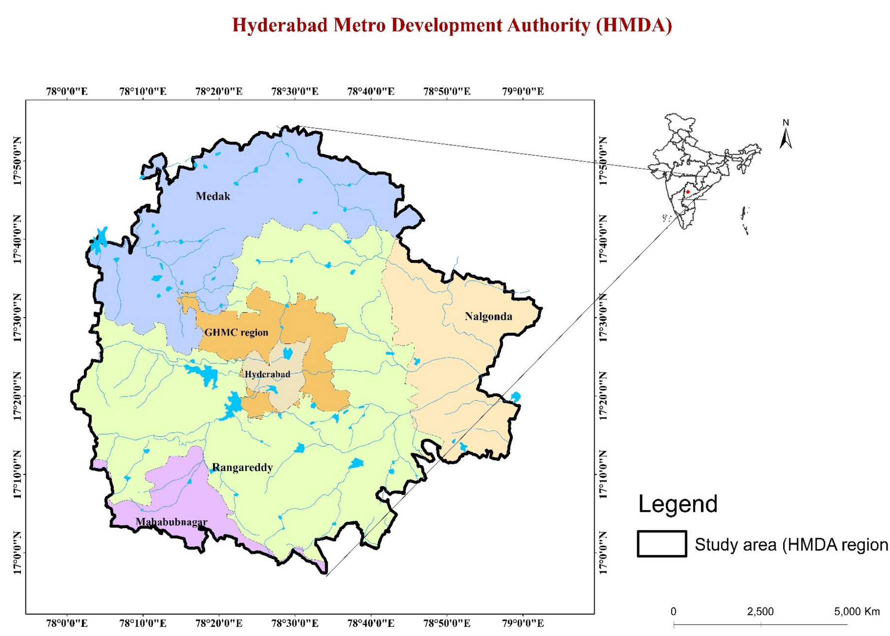

Figure 2: Jurisdiction of Hyderabad Metro Development Authority (HMDA) region in Telangana state, India.

- HMDA region extends over five districts (before reorganization of Telangana state) Medak, Nalgonda, Rangareddy, Mahabubnagar and Hyderabad districts.
- Due to rapid economic, industrial growth and urbanization of Hyderabad, the city became a global agglomeration with population of 9.4 Millions (year 2012)
- Average annual rainfall, minimum and maximum temperatures of Hyderabad region are 961 mm, 6^{o}C and 45^{o}C, respectively.
- Two water supply sources, i.e., Hyderabad Metro water supply & sewerage board (HMWSSB) and Rural Water Supply.

4. Methodology

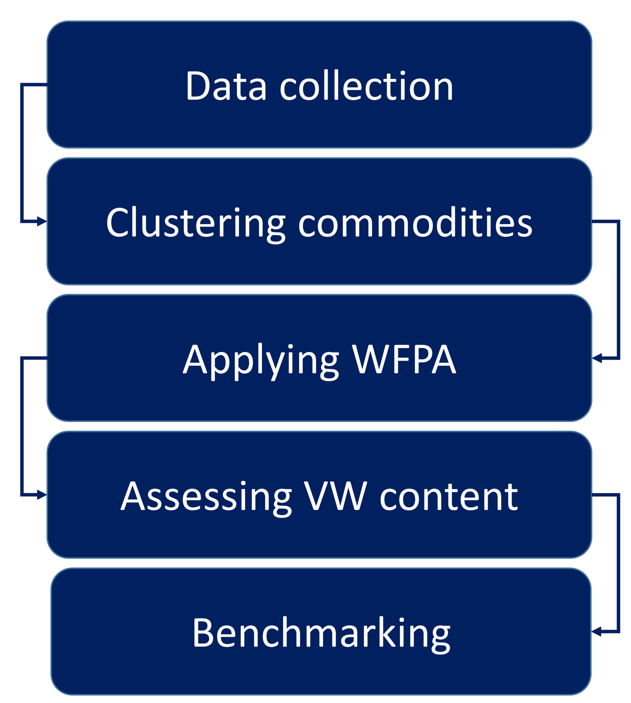

Figure 3. Steps involved in assessing water footprint and benchmarking water-Nexus of HMDA region

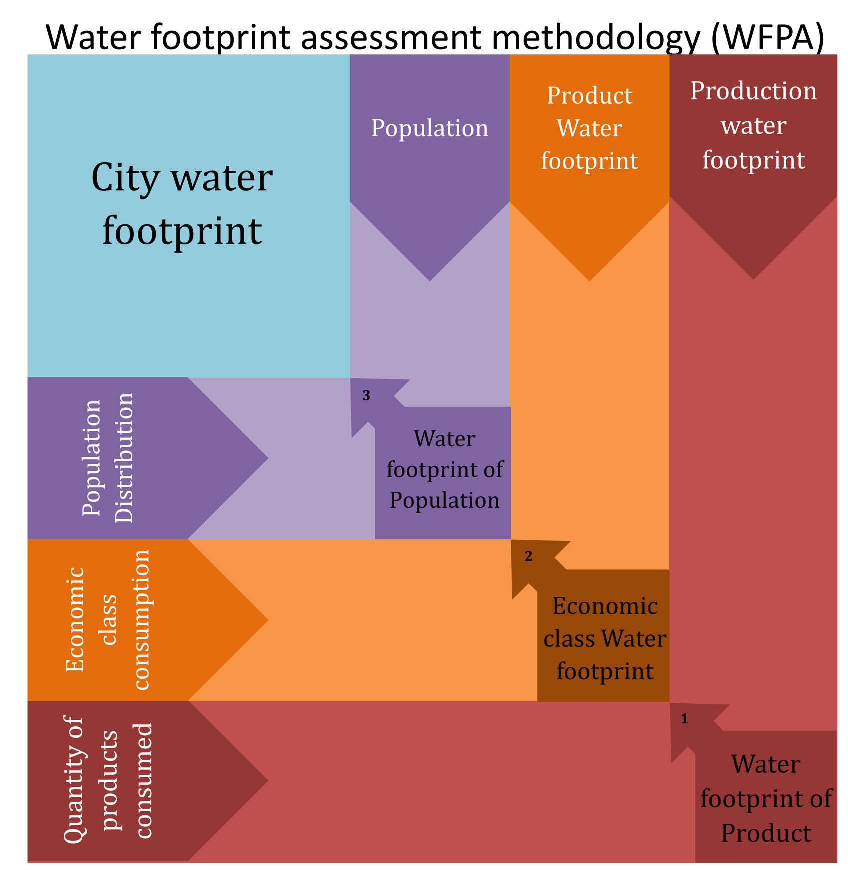

Figure 4. Framework developed to assess water footprint of HMDA. using consumer centric approach.

Water footprint assessment methodology (WFPA):

WF of HMDA region is assessed using consumer-centric approach. Because of not availability of trade data at city level, food and energy commodities information based on Monthly per Capita Consumption Expenditure (MPCE) are considered. The MPCE, varies with the economic status and lifestyle of urban consumers. As part of this approach, consumers commodity information is coupled with population of HMDA, production WF of each commodity and population in each economic class [2]. In assessing WF of energy we followed the approach of Mekonnen [3].

Assessing virtual water (VW) content:

VW is the amount of water that embedded in production of various commodities that are consumed by a consumer or a region. In this study, VW of commodities are assessed by quantifying the ratio between WF of consumption and quantity of commodities of HMDA region.

Benchmarking Water-Nexus:

First, we ranked the WF of food consumption, for each food group, for each economic class in ascending order. Then, plots were developed for cumulative food consumption WF and percentage of cumulative WF. Finally, savings of WF quantified for reduced WF at 10, 20, 25 and 50 percentiles.

Data Sets used:

Due to paucity of city level trade data we considered the consumers commodity data from National Sample Survey Organization(NSSO).

1. Cereals	8. Livestock products
2. Pulses	9. coffee/Tea
3. Sugars	**Energy products:**
4. Milk products	10. Electric power
5. Fats & oils	11. Coal
6. Vegetables	12. Kerosene
7. Fruits	13. Petrol & diesel, LPG

Production WF data considered from various sources:

1. WF of crop derived products	Mekonnen & Hoekstra 2011 [4]
2. WF of livestock	Mekonnen & Hoekstra 2012 [5]
3. WF of energy products	Gleick, 2015 [6]
4. Consumers commodity data	NSSO & MSPI 2012 [7]
5. Census data of HMDA	HMDA, 2012

5. Results & Discussions

- ***Green, blue and grey WF of food consumption***

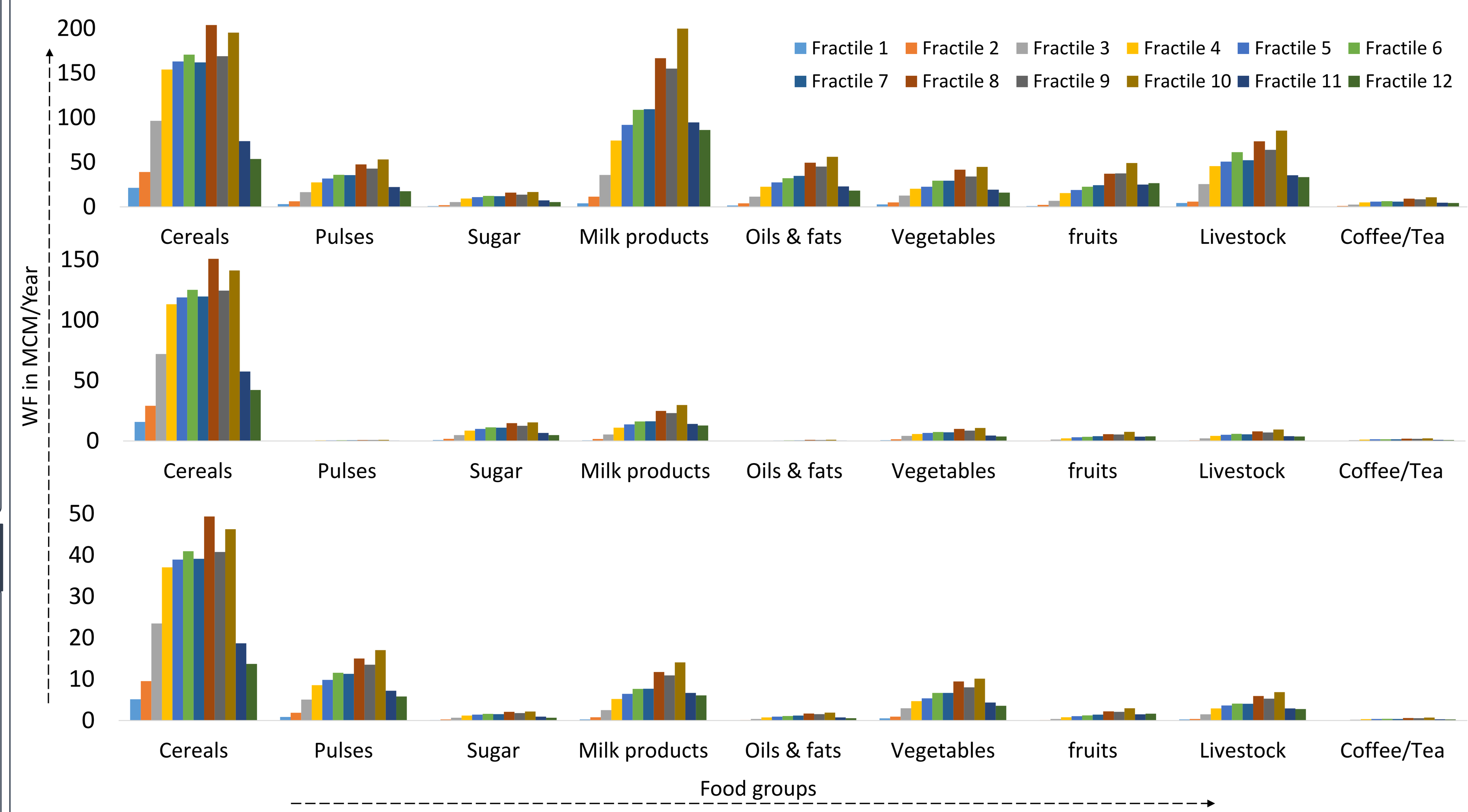

Figure 5: Green, blue and grey WF of food consumption is assessed for every food group with respect to their economic class (Source: Koteswara Rao, Chandrasekharam, 2019)

- In food consumption WF more than 70% is contributed from cereals, milk products and live stocks. Of total WF of the HMDA, 67%, 23% and 10% contributed from green, blue and grey WF, respectively.
- Among the fractile economic classes, WF patterns for green, blue and grey water are same, but there is significance difference in WF patterns across food groups.
- WF of cereals, milk products and livestock are with high green, blue and grey WFS. This suggests adverse effects on ecological footprints.

- ***Virtual water content of food consumption:***

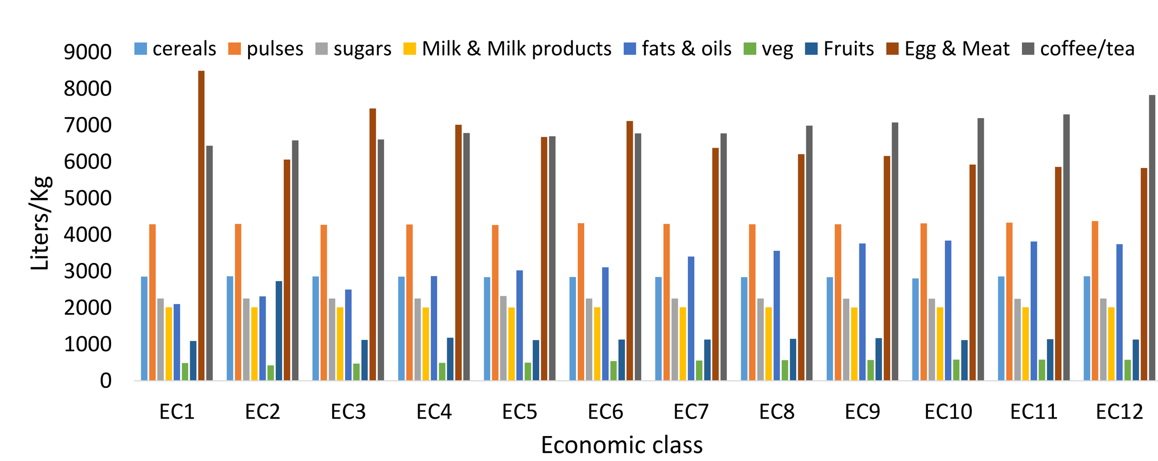

Figure 6: The virtual water embedded in food groups of every fractile economic class.

- VW contents of livestock and coffee/tea are on top of the list, but cereals & milk products have less VW contents.
- In WF of food consumption, cereals, milk products and live stocks top the list, however, in terms of VW volumes livestock and coffee/tea are in top.

- ***Benchmarking water-nexus:***

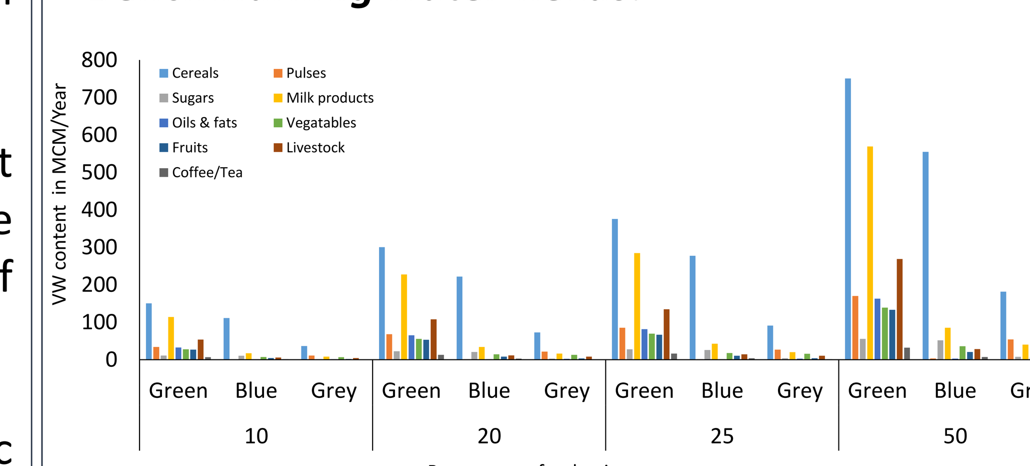

Figure 7: Amount of water saved by benchmarking green, blue & grey WFs at 10, 20, 25 & 50 percentiles.

- Livestock, coffee/tea, pulses and cereals are water intensive products in dietary habits of HMDA with more VW content.
- Dietary habits of HMDA need to shift from water intensive diets to less water intensive diets. This can be done by benchmarking or capping the water intensive food trade and water usage in production process.
- On average, 1795 and 670 MCM of water will be saved by capping the WF of food & energy consumption.

- ***Conclusions:***

- VW in food consumption of HMDA region is quantified and benchmarked based on the consumer-centric approach using WF assessment methodology.
- Food, energy consumption of HMDA region is water intensive. This suggests capping of WF of various commodities used by the HMDA region.
- VW trades between the regions may need to monitored and quantified by the concerned government authorities. This helps in planning VW trades between wet and dry regions.
- Local governments may want to actively involve in quantification of the VW and WF of imports and exports so that dependency of city on external water resources will be known and consequently polices can be drafted for self-reliant and sustainable cities.

- ***References:***

[1] Hoekstra, A. Y., & Mekonnen, M. M. (2011). The water footprint of humanity. *Proceedings of the National Academy of Sciences*, *109*(9), 3232–3237.
[2] Koteswara Rao, D., & Chandrasekharam, D. (2019). Quantifying the water footprint of an urban agglomeration in developing economy. *Sustainable Cities and Society*, *50*, 101686.
[3] Mekonnen, M. M., Gerbens-Leenes, P. W., & Hoekstra, A. Y. (2015). The consumptive water footprint of electricity and heat: a global assessment. *Environ. Sci.: Water Res. Technol.*, *1*(3), 285–297.
[4] Mekonnen, M. M., & Hoekstra, A. Y. (2011). The green, blue and grey water footprint of crops and derived crop products. Hydrology and Earth System Sciences, 15(5), 1577–1600.
[5] Mekonnen, M. M., & Hoekstra, A. Y. (2012). A global assessment of the water footprint of farm animal products. Ecosystems, 15(3), 401–415.
[6] Gleick, P. H. (1994). Water and energy. Annu. Rev. Energy Environ. 19, 267–299.
[7] NSSO, & MSPI (2012). Household consumption of various goods and services in India 20ll-12, 558.

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