Bio Vet Innovator Magazine
(Fueling The Future of Science…)
Volume 3 (Issue 4) APRIL 2026
OPEN ACCESS World Veterinary Day – 25th April Popular Article

Every Glass of Milk Has a Water Bill: Understanding the Water Footprint of India's Livestock Sector

Shruti Gupta and Sanchit Pal Singh
PhD Scholar,
ICAR-Indian Veterinary Research Institute, Izatnagar
***Corresponding Author:** shruti.gupta0202@gmail.com
DOI: https://doi.org/10.5281/zenodo.19980510

Received: April 01, 2026
Published: April 12, 2026

Abstract:

Water is rapidly becoming one of the most contested resources of the 21st century, yet the vast majority of its consumption remains invisible to the average person. The concept of the water footprint, the total volume of freshwater used across the entire production chain of a commodity from cradle to retail, reveals that the livestock sector is among the most water intensive activities in global agriculture. The study highlights the water footprint of livestock production with a particular focus on India, exploring the three components of water use (green, blue, and grey), the dominant role of feed in driving water consumption, species-wise comparisons, and the effect of different farming systems and the evidence based solutions from farm level efficiency measures to national level virtual water trade policy that can help India's dairy and livestock sector move toward a more water-sustainable future without compromising food security or livelihoods.

Keywords: Water footprint, livestock, dairy, virtual water, feed conversion efficiency, water scarcity, sustainability

Introduction: The Water We Cannot See

The animal requires, on average, 1,369 liters of water to produce just 1 liter of milk in India. Similarly, 1 kilogram of beef requires somewhere between 15,000 and 26,000 liters of water, depending on how and where it is produced. (Chapagain, A. K., & Hoekstra, A. Y., 2004; Mekonnen and Hoekstra, 2010). This is the world of the water footprint, an accounting of every drop of freshwater that goes into producing the food we eat, long before it reaches our plate.

Agriculture accounts for roughly 70% of all freshwater consumed on Earth, dwarfing domestic use at 10% and industry at 10% (Thakur *et al.,* 2018). Within agriculture, the livestock sector is among the most water intensive of all activities. Globally, about one-third of all agricultural land is devoted to livestock, and the sector accounts for nearly 29% of the total water footprint of global agriculture. (Yadav, G., 2020; Steinfeld *et al*., 2006). Yet this consumption remains largely invisible in public discourse, particularly in India, the world's largest milk producer.

With a growing population, rising incomes, and an expanding middle class shifting toward more protein rich diets, India's demand for animal products is set to climb sharply in the coming decades (Thakur *et al.,* 2018). Understanding and managing the water cost of that demand is no longer a matter for researchers alone. It is a national priority.

Decoding the meaning of Water Footprint: Green, Blue, and Grey

The water footprint of a product is the total volume of freshwater used across its entire production chain, measured at each step from farm to consumer. The concept, developed by Hoekstra and colleagues, functions as a water use analogue to the carbon footprint, making visible what is otherwise hidden in our food system (Yadav, G., 2020; Thakur *et al.,* 2018)

A water footprint breaks down into three components:

a. Green water footprint refers to rainwater stored in the soil and taken up by crops and pastures through evapotranspiration.

b. Blue water footprint refers to freshwater drawn from surface and groundwater sources like rivers, lakes, and aquifers primarily for irrigation.

c. Grey water footprint is an indicator of freshwater pollution: it represents the volume of water needed to dilute agricultural pollutants such as fertilisers and pesticides to acceptable quality standards. (Yadav, G., 2020; Doreau *et al.,* 2012).

Of the three, blue water is the most consequential for water scarcity. Rainwater falling on a pasture does not deprive a household of drinking water, but irrigation pumped from an already-stressed aquifer does. India, where about 64% of irrigated land depends on groundwater (Thakur *et al.,* 2018), faces an acute blue water challenge that the livestock sector significantly amplifies.

Feed Is the Elephant in the Room:

The single most important driver of the livestock water footprint is feed. Across all animal species and production systems, feed production accounts for approximately 98% of the total water footprint (Yadav, G., 2020; Mekonnen and Hoekstra, 2010). Drinking water for the animals, service water for cleaning farm premises, and water for mixing feed collectively contribute less than 2%. This means that when you drink a glass of milk or eat a piece of chicken, you are primarily consuming the water that irrigated the crops that fed the animal. Globally, around 37% of all cereals produced are used as animal feed (Steinfeld *et al*., 2006). The water footprint of feed ingredients varies widely: roughages such as grass, crop residues, and fodder crops carry a global average water footprint of around 200 m^3 per tonne, while concentrate feeds like grains and oilseed meals average around 1,000 m^3 per tonne, roughly five times more (Yadav, G., 2020; Thakur *et al.,* 2018). The blue and grey water footprints of concentrates are even more disproportionate, 43 and 61 times higher than roughages, respectively, because concentrate crops are more often irrigated and fertilized (Yadav, G., 2020).

This single fact has enormous implications. Systems that rely more on roughage are, from a blue water perspective, far less damaging than those that rely on irrigated grain, even if they appear less efficient in terms of total feed conversion (Doreau *et al.,* 2012)

Species-wise requirement: Who Drinks the Most?

Not all livestock carry the same water cost. Using global averages, the water footprint of different meats rises as follows: chicken at roughly 4,300 litres per kilogram, goat meat at 5,500, pork at 6,000, sheep meat at 10,400, and beef at the top at approximately 15,400 litres per kilogram (Mekonnen and Hoekstra, 2010). For dairy, the global average is around 1,020 litres per kilogram of milk (Mekonnen and Hoekstra, 2010).

These differences are explained by two factors working in opposing directions. The first is feed conversion efficiency, the amount of feed required to produce one unit of product. Beef cattle require about eight times more feed per kilogram of meat than pigs, and eleven times more than chickens (Yadav, G., 2020; Mekonnen and Hoekstra, 2010)

The second factor is feed composition. Broiler chickens, though efficient converters, get 73% of their diet from concentrate, water-intensive grains, and oilseed meals. Beef cattle, by contrast, get only about 5% from concentrates, relying heavily on roughages (Yadav, G., 2020).

The water footprint per calorie for beef is 20 times larger than that for cereals and starchy roots (Mekonnen and Hoekstra, 2010). Per gram of protein, beef requires six times more water than pulses. For milk, eggs, and chicken, the figure is about 1.5 times more than for pulses (Mekonnen and Hoekstra, 2010). These comparisons carry important dietary and policy implications, especially for a country where pulses have historically been the primary protein source.

India in Focus: A Dairy Giant with a Water Problem

India ranks first globally in milk production, contributing over 18% of world output (Thakur *et al.,* 2018). The achievement is built on the backs of millions of smallholder farmers, buffaloes, crossbred cows, and indigenous breeds spread across vastly different agro-climatic zones. But it comes with a water cost that is higher than the global average.

The world average water footprint for milk is 990 litres per kilogram. India's average is approximately 1,369 litres per kilogram (Chapagain, A. K., & Hoekstra, A. Y., 2004), driven by lower crop yields per unit of water, climatic stress, and traditional feeding practices. In Gujarat, studies found water productivity as low as 0.3 litres of milk per m^3 of water, roughly three times below the global benchmark (Singh, O. P., & Kishore, A., 2004)

Breed choice matters significantly. Higher-yielding animals produce more milk per unit of water consumed. Crossbred cows consistently show lower water footprints per kilogram of milk than indigenous breeds or buffaloes.

Research from Karnal, Haryana, found the consumptive water use for milk production in Karan Fries to be 1,212 m^3 per tonne, compared to 1,269 for Murrah buffalo and 1,583 for Sahiwal and Tharparker (Upadhyay *et al.,* 2013). Higher productivity, lower footprint, the relationship is direct and consistent.

Interestingly, a study in Karnataka found that farmers in water-scarce, overexploited groundwater zones produced milk more water-efficiently than those in water-abundant areas. (Sharif, M., and Dixit, P., 2015). Scarcity had compelled those farmers to adopt drip irrigation, precision land levelling, and smarter feeding strategies. The implication is significant: water efficiency in livestock is achievable, and the tools are already known.

Farming Systems: The Grazing vs. Industrial Paradox

One of the more counterintuitive findings in water footprint research involves the comparison between farming systems. Industrial systems (conventional farming), where animals are confined, fed concentrated diets, move less, and grow rapidly, are more efficient in feed conversion. Per kilogram of product, they use less total feed, which in volume terms translates to a smaller overall water footprint for most species (Yadav, G., 2020; Doreau *et al.,* 2012). Yet this efficiency comes with a catch. Industrial systems rely heavily on irrigated feed crops and chemical inputs, giving them a substantially larger blue and grey water footprint.

Grazing systems draw mostly on green water rainfall on pastures, which is often water that would not otherwise be available for food crops. Mixed farming systems, where animals consume crop by-products, and their manure returns nutrients to fields, often represent the most sustainable balance, particularly for dairy (Mekonnen, M. M., and Hoekstra, A. Y, 2012).

In India, where most cattle are still fed on pasture and crop residues with minimal or no irrigation, the blue and grey water footprints of traditional systems are inherently low (Thakur *et al.,* 2018). The ongoing industrialization of Indian dairy and poultry, while improving feed conversion, risks shifting the water burden from green to blue from rainfall to groundwater. That is a trade-off that demands careful policy attention.

Pathways to Sustainability: What Can Be Done?

The water footprint of India's livestock sector is large, but it is not fixed. A combination of farm-level practices, technological adoption, dietary awareness, and national policy can collectively move the needle (Thakur *et al.,* 2018).

a. Improving Animal Productivity:

The most direct route to reducing water footprint per unit of milk or meat is increasing the productivity of the animal. Higher-yielding dairy breeds, better veterinary care, improved nutrition, and scientific herd management can substantially reduce the water cost per kilogram of output (Thakur *et al.,* 2018).

b. Smarter Feed And Crop Management:

Since feed drives 98% of the water footprint (Yadav, G., 2020; Mekonnen and Hoekstra, 2010), improving the water use efficiency of fodder crops is the highest-leverage intervention available. Drip and sprinkler irrigation can reduce water use by 15-30% while maintaining yields (Thakur *et al.,* 2018). Precision land levelling, mulching, and timely irrigation at critical crop growth stages all contribute. Selecting fodder crop varieties with high nutritional value but lower water consumption is another practical option (Doreau *et al.,* 2012).

c. On-Farm Water Conservation:

Practical farm-level measures include fixing leaky pipes and troughs, recycling wash water, using high-pressure low-volume cleaning systems, collecting rooftop rainwater, and cycling cow cooling systems. None of these requires major investment, but together they can measurably reduce direct water use (Thakur *et al.,* 2018).

d. Dietary Shifts:

Research suggests that replacing some animal-sourced calories with nutritionally equivalent plant-based foods like pulses, cereals, and oilseeds could reduce food-related green water footprints by around 23% and blue water footprints by about 16% globally (Mekonnen, M. M., and Hoekstra, A. Y., 2011). In the Indian context, this is not about eliminating meat or dairy. It is about recognizing that pulses, millets and legumes carry a fraction of the water cost of animal protein, and that their revival in everyday meals serves both nutrition and water security.

e. Virtual Water Trade As Policy:

Water-scarce countries can effectively import water by importing water-intensive commodities rather than growing them domestically (Thakur *et al.,* 2018). India is projected to face increasing fodder deficits in the coming decades. Strategically importing water-intensive feed ingredients from water-abundant regions could relieve pressure on overstressed Indian aquifers. This concept of virtual water trade is an underutilized policy instrument that deserves serious attention from Indian planners and policymakers (Schlink *et al.,* 2010; Chapagain, A. K., & Hoekstra, A. Y., 2004).

Conclusion: Making the Invisible Visible

The water embedded in India's livestock products is a resource flowing largely unaccounted, unmeasured, and unmanaged. Every litre of milk, every kilogram of mutton, every tray of eggs carries with it a water bill paid not at the counter but in the gradual depletion of rivers, wetlands, and aquifers often far from where the product is consumed (Yadav, G., 2020; Doreau *et al.,* 2012).

Understanding the water footprint of livestock is not an argument against animal agriculture. It is an argument for doing it better. India's dairy sector supports the livelihoods of over 70 million households.

It cannot simply be downsized. But it can and must become more water-smart: through better breeds, smarter feeding, efficient irrigation, and policies that price and govern water as the finite, precious resource it is (Thakur *et al.,* 2018).

Wise water governance is ultimately a shared responsibility of consumers, farmers, businesses, and governments. (Yadav, G., 2020). As global water demand is projected to increase by 50% between 1995 and 2025, with much of that growth in agriculture (Doreau *et al.,* 2012), the time for incremental action has already passed. "The water in your food is borrowed from the future. Whether India returns it wisely is a choice being made today."

References

Chapagain, A. K., & Hoekstra, A. Y. (2004). Water footprints of nations.

Doreau, M., Corson, M. S., & Wiedemann, S. G. (2012). Water use by livestock: a global perspective for a regional issue? *Animal Frontiers*, *2*(2), 9-16.

Mekonnen, M. M., and 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.

Mekonnen, M. M., and Hoekstra, A. Y. (2012). A global assessment of the water footprint of farm animal products. *Ecosystems*, *15*(3), 401-415.

Mekonnen, M., & Hoekstra, A. Y. (2010). The green, blue and grey water footprint of farm animals and animal products. Volume 2: Appendices.

Schlink, A. C., Nguyen, M. L., and Viljoen, G. J. (2010). Water requirements for livestock production: a global perspective. *Soil and Water Management & Crop Nutrition Subprogramme*, *6*, 603-619.

Sharif, M., and Dixit, P. (2015). Dairy farming in southern Karnataka: an economic analysis under varying groundwater regimes. *Indian Journal of Dairy Science*, *68*(1), 65-72.

Singh, O. P., & Kishore, A. (2004, July). Water productivity of milk production in North Gujarat, Western India. In *Proceedings of the 2nd Asia Pacific Association of Hydrology and Water Resources (APHW) Conference* (Vol. 1, pp. 442-449).

Steinfeld, H., Gerber, P., Wassenaar, T. D., Castel, V., and De Haan, C. (2006). *Livestock's long shadow: environmental issues and options*. Food & Agriculture Organisation.

Thakur, A., Kumar, A., Vanita, B., Panchbhai, G., Kumar, N., Kumari, A., and Dogra, P. (2018). Water footprint: A tool for sustainable development of Indian dairy industry. *International Journal of Livestock Research*, *8*(10), 1-18.

Upadhyay, R. C., Hooda, O. K., Aggarwal, A., Singh, S. V., Chakravarty, R., & Sirohi, S. (2013). Indian livestock production has resilience for climate change. *Climate Resilient Livestock and Production System. (Eds) Singh SV, Upadhyay RC, Sirohi S, and Singh, A K. National Dairy Research Institute, Karnal, Haryana*.

Yadav, G. (2020). The water footprint of livestock production system and livestock products: A dark area: A review. *International Journal of Fauna and Biological Studies*.