Chapter

Water Use and Dairy Production System: An Indian Experience

G. Letha Devi, Anjumoni Mech, Sejian Veerasamy, Ravikiran Gorti and Mukund A. Kataktalware

Abstract

Increasing water scarcity and simultaneously growing demands for food and feed challenge agricultural production. Globally livestock feed sourcing is one of the major causes for water depletion; therefore, increasing livestock water use efficiency (LWUE) is necessary. There is a need to synthesise LWUE knowledge generated across different forage based livestock production systems (FLPS) over time and systematically identify entry points to enhance productive uses of freshwater resources. Although these systems vary by their degree of intensification, scale of water-related problems, and therefore in their values of LWUE, a number of common entry points to increase LWUE can be identified. To understand the pattern of livestock water use and social dynamics involved in water use and milk production, around 240 small and medium dairy farms in Karnataka, India, were used for the present study. Direct and indirect consumptive uses of water by animals considered were water used for drinking, water inputs through green and dry fodder, consumptive water usage for on-farm servicing and crop irrigation and water inputs through all upstream inputs such as medicines, vaccines and others. Water use efficiency (WUE) for production of milk alone is operationally defined in this study.

Keywords: water use efficiency, poverty, environment, livestock, socioeconomics

1. Introduction

Water is an essential component that is required in largest quantity by livestock. About 80% of animal water requirements is met by drinking water, and the rest of water needs are met through feed water. Production and reproduction performance of animals is directly affected by water availability and quality. Nonavailability of adequate water may cause adverse effects on animal growth and production. Water resources are shrinking day by day, and it warrants judicious use of water.

Milk production is challenged by increasing water scarcity and simultaneously growing demand for food and feed. Globally livestock feed sourcing is seen one of the major causes for water depletion, and therefore improvement in livestock water productivity is the need of the hour. Feed sources in smallholder production system largely consist of grazing, crop residue and concentrates, etc. Extensive smallholder systems in dryland ecoregions face the major challenge of water depletion for feed production. This demands better understanding of livestock-water interactions and designing strategies to improve water use efficiency (WUE).

Water use efficiency can be defined as the net return for a unit of water used. Improvement in water use efficiency aims at producing more food, income, better livelihoods and ecosystem services with less water. There is a considerable scope for improving water use efficiency of crop, livestock and other allied enterprises at field, thereby achieving sustainable food production. Water harvesting, supplemental irrigation, deficit irrigation, precision water application techniques and soil-water conservation practices are the bouquet of technology choices that we can resort to in achieving this goal. Practices not directly related to water management also impact water use efficiency because of interactive effects such as those derived from improvements in soil fertility, pest and disease control, crop selection or access to better markets.

However, we need to be cautious about achieving water use efficiency gains. Crop water use efficiency is quite high in highly productive regions, and yield (per unit of land area) does not necessarily correlate with water use efficiency in all cases. Water reuse within an irrigated area can compensate for the perceived losses at the field in terms of water quantity, but that will not be of any help in maintaining the water quality. We need to create an enabling environment for enhancing water use efficiency by farmers in field. Apart from this, we need a thorough understanding of the biophysical environment as well as social and economic dynamics existing between different elements of farm and field.

While identifying priority areas for bringing in improvements in water use efficiency and formulating strategies and action points for bringing in substantial improvements in water use efficiency, the following points have to be considered: (i) high-poverty less water efficient areas, (ii) water-scarce areas, (iii) areas neglected for development of water resources, and (iv) areas of faster water resource depletion. However, these are huge challenges to be achieved, and strategies need to be evolved keeping in view complex biophysical, social and economic factors.

2. Water footprint

Water footprint is defined as the extent of water use in relation to consumption of goods and services by people. In a broader sense, a country's water footprint is the volume of water required for the production of the goods and services used for direct and indirect consumption by the population of the country. Water footprint can be of two types: (i) internal water footprint or water used from internal or domestic resources and (ii) external water footprint or water used to produce imported goods and services. The USA has an average water footprint of 2480 m^3/cap/year, and China has an average footprint of 700 m^3/cap/year. Global average water footprint is 1240 m^3/cap/year. Any country's water footprint is determined by factors such as consumption volume (with respect to gross national income); consumption pattern; climate; and water use efficiency of agriculture and allied sectors.

The water footprint gives an account of amount of water used to produce each of the goods and services we use. It can be measured for a single process, such as growing a crop, for a product and fuel, etc. It also gives an idea about volume of water being consumed by a country in a specific basin or from a specific source. The water footprint looks at both direct and indirect water use of a product. It includes water consumption and pollution throughout production cycle from supply chain to consumer.

Water footprint can be measured in terms of per unit of goods produced and per hectare of area under crops or in any other functional units. This also gives us an idea about different uses of our limited freshwater resources and the ways and means by which they get polluted. If the water is sourced from a water-scarce area, the impact of low water productivity to high water footprint can be significant and require immediate attention.

For the purpose of quantifying its use, water can be divided into three components: green, blue and grey. The three components together provide a comprehensive picture of water use by demarcating water source, either as rainfall, groundwater, or surface water, apart from freshwater requirement for removal of pollutants, to make it reusable.

3. Types of water footprint

1. **Green water footprint**: water from precipitation/rainfall that is accumulated in deep soil and includes the evapotranspiration component and water incorporated by plants. This is the most relevant water component for agricultural and allied products.

2. **Blue water footprint:** surface water or groundwater resources and is either evaporated or incorporated into a product across a temporal and spatial regime. Irrigated cropping, industry and domestic consumption of water falls into blue water footprint.

3. **Grey water footprint:** volume of freshwater essentially needed to remove pollutants and make it reusable. This component takes into account point source pollutants discharged to any freshwater source directly or indirectly or other diffuse sources.

Livestock plays a vital role in supporting rural livelihoods in the Indian context. At the same time, there are growing concerns regarding highly water-intensive operations in livestock rearing, which is considered as one of the major enterprises for water depletion and putting huge pressure on depleting and water-scarce resources. In forage-based livestock production systems, be it grazing, mixed-irrigated or mixed-rain fed, feed sourcing is largely contributed from pasture or crop residue. In dryland areas of arid and semi-arid ecosystems, extensive forage-based livestock production systems are in place, and in such situations, water used for feed production is a major concern. Thus, such situations warrant the pressing need for understanding the livestock water dynamics and better strategies and framework for developing comprehensive entry points to improve livestock water use efficiency.

Based on global experiences from different livestock production systems, the entry points for improving livestock water use efficiency can be categorised into different groups, based on their operational limits. They are:

i. Feed water productivity.

ii. Feed sourcing and feeding management.

iii. Livestock feed use efficiencies.

iv. Institutions to create enabling environment, for better water use management.

v. Market linkages for bringing out water saving technologies to consumers.

4. LWUE in forage-based livestock systems: challenges and opportunities

In the major **forage-based livestock systems** like grazing, mixed-rainfed and mixed-irrigated systems of dryland production environments, the basic objectives of production as well as intensity of production operations have a great diversity within and among those systems [1]. This diversity creates many challenges for water efficiency of these livestock production systems. This creates implications and prospects at the same time for achieving efficient water use in such production systems. To elaborate further, dry and green fodder constitute major feed component in dryland production systems. Like in the case of the most intensive systems, say mixed-irrigated production system as practised in India, concentrate feed use does not exceed 10% [2]. Feed acts as a major interface between water and livestock, and such diversity in managing feed sourcing and feeding practices poses challenges and implications for the type, scale of importance and method of quantifying and strategising livestock water use efficiency.

Strategies to improve quality of locally available feed and feed management are core to any framework to improve livestock water use efficiency in any production system. We need to focus on activities like selection of crops, intercropping for maximum land and water utilisation, urea treatment of crop residues, chopping of coarse residues, etc. In mixed-irrigated systems, an improvement of feed quality (from 7 to 8.5 ME MJ kg^{-1}) can lead to saving of >50 m^{-3} of water/cow/year [2]. Similarly, in mixed-rainfed systems, urea treatment of crop residues led to a considerable improvement in livestock water use efficiency [3–5]. While considering better animal management practices, livestock water productivity (LWP) can be enhanced, by reducing animal's energy requirement by means of limiting animal movement, especially in peak summer seasons. Descheemaeker et al. [3] reported that in mixed-rainfed systems, approximately 12% of the metabolisable energy of animals is spent for walking long distances for feed and water. This energy loss can be avoided by better feed sourcing and feed management.

5. Method of assessment of livestock water use

An effort was made to assess and analyse LWUE in smallholder and commercial production and to formulate for strategies for improving LWUE. Primary data was collected from small- and medium-sized dairy farms in Kolar and Shimoga district, Karnataka, India. The total sample size was 240 dairy farms. The consumptive use of blue water (direct and indirect) was assessed using primary data through personal interview and observation in particular farms. Primary data from smallholders and commercial dairy units in Kolar and Shimoga district of Karnataka, India, were collected. Water use efficiency (kg/animal) was estimated and compared for smallholder as well as commercial dairy production systems using the following formula:

$$WUE = (Y/U)*100 \tag{1}$$

where Y = Marketable yield (kg/animal) and U = Seasonal consumptive use of water (m^3).

Water use efficiency for crop biomass used as fodder = Total Biomass/water applied at different levels of requirement [6] method was used for calculation of LWP of feed (recommended by the IWMI). Different water wastage points in different operations were identified, and strategies to reduce water wastage were formulated using participatory focus group discussions.

The major challenges associated with LWU as perceived by farmers were analysed and ranked based on rank coefficients. Scarcity of water for livestock drinking, other livestock operations and feed quality due to low water quality used for crop production were the major challenges across all the seasons (**Tables 1** and **2**).

The water intake by animals through forage and other feed ingredients is more as compared to water intake through drinking water and that used for on-farm servicing operations such as cleaning, etc. The average direct consumptive water use by smallholder system was found to be 97 litres per day and 127 litres per day for commercial dairies. The calculated water use efficiency for smallholder system was 0.85, and for commercial dairying it was 1.62. The water use efficiency was more in the case of commercial dairy farming and less in the case of smallholder production system.

There are various factors affecting water use by livestock. The major factors are seasons, different weather parameters, fodder, feed and other inputs. The source of

Key LWU-related problems	Seasonal variations								
	Summer			Winter			Rainy		
	1	2	3	1	2	3	1	2	3
Scarcity of water for livestock drinking	✓				✓				✓
Scarcity of water for livestock operations	✓				✓				✓
Scarcity of water for feed production					✓				✓
Inefficient use of available water			✓			✓	✓		
Soil/nutrient loss	✓					✓		✓	
Poor feed/fodder quality	✓					✓			✓
High feed scarcity	✓				✓				✓
Use of common property resources	✓			✓			✓		
Postharvest feed quality and quantity	✓				✓				✓

Table 1.
Problem matrix showing the scale of importance of LWU-related problems across seasons.

Operations	Smallholder system	Commercial dairying
Drinking	40	52
Washing shed	55	90
Washing animals	25	38
Cleaning cans and other equipment	10	25
Water contained in feed and fodder	743	740
Total	**873**	**945**
Milk yield/day/animal	7.4	15.4
WUE = (Y/U)*100	**0.85**	**1.62**

Table 2.
Direct and indirect water use (litre/day/animal/kg of milk) and WUE in different dairy production systems (n1 = 200, n2 = 40).

Factors	Rank
Seasonal variation	I
Weather parameters (temperature, rainfall, humidity)	II
Fodder, feed and other inputs	III
Source of water (bore well, canals, ponds, etc.)	IV
Animal conditions	V
Animal output	VI

Table 3.
Factors affecting water use (ranking; n = 240).

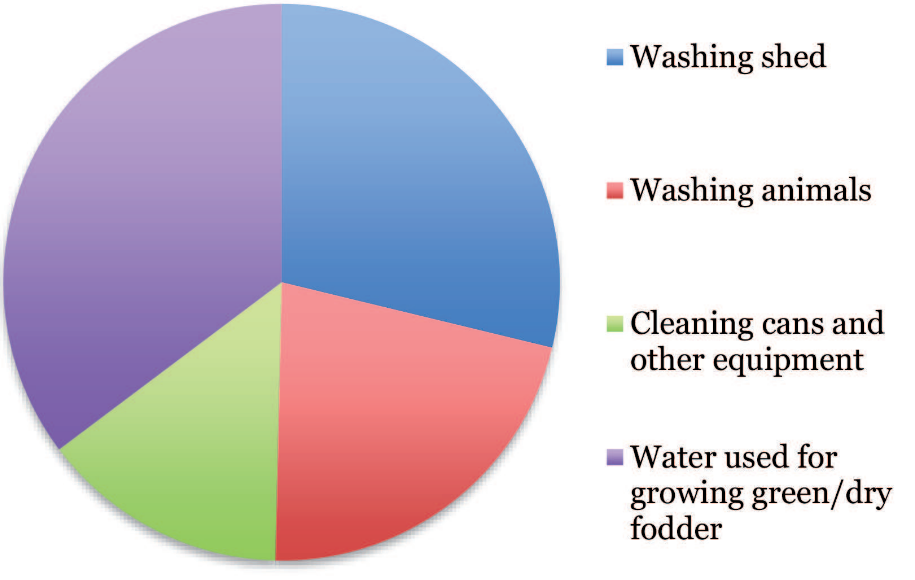

Figure 1.
Perceived water wastage points in summer season (%respondents), n = 240.

water and animal conditions like lactation stage, age and body and health conditions also play a role in water use efficiency (**Table 3**).

The water wastage points mainly in summer season were identified, which is presented in **Figure 1**.

6. Conclusion

Water availability and quality are the major challenges that are faced by the livestock and crop production systems in recent times. The observations in the study show that water inputs through forage and other feed ingredients are more than the water inputs through drinking water and that used for on-farm servicing operations such as cleaning, washing, etc. Proper management strategies are highly essential for sustaining the livestock production systems and meet the food demands of a growing population with the available water resources, for which water saving technologies and strategies are the need of the hour.

Author details

G. Letha Devi[1]*, Anjumoni Mech[1], Sejian Veerasamy[1], Ravikiran Gorti[1] and Mukund A. Kataktalware[2]

1 ICAR-National Institute of Animal Nutrition and Physiology, Bangalore, India

2 ICAR-National Dairy Research Institute, Bangalore, India

*Address all correspondence to: lethaayur@gmail.com

References

[1] Seré C, Steinfeld H. World Livestock Production Systems: Current Status, Issues and Trends. Rome: FAO Animal Production and Health Paper 127; 1996

[2] Haileslassie A, Blummel M, Clement F, Ishaq S, Khan MA. Adapting livestock water productivity to climate change. International Journal of Climate Change Strategies and Management. 2011;**3**:156-169

[3] Descheemaeker K, Bossio D, Amede T, Ayalneh W, Haileslassie A, Mapedza E. Analysis of gaps and possible interventions for improving water productivity in crop-livestock systems of Ethiopia. Experimental Agriculture. 2011;**47**:21-38

[4] Haileslassie A, Blümmel M, Murthy MVR, Samad M, Clement F, Anandan S, et al. Assessment of livestock feed and water nexus across mixed crop livestock system's intensification gradient: An example from the indo-Ganaga Basin. Experimental Agriculture. 2011;**47**:113-132

[5] Peden D, Tadesse G, Misra A. Water and livestock for human development. In: Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. Earthscan, Cambridge Publishing, Oxford University Press; 2007. pp. 485-514

[6] Mekonnen MM, Hoekstra AY. The green, blue and grey water footprint of crops and derived crop products. Hydrology and Earth System Sciences. 2011;**15**:1577-1600