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Assessment of Water Use Efficiency in Dairy Production Systems

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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. In this direction, primary data was collected from 240 small and medium sized dairy farms in Karnataka, India during the period 2018-2021. Water inputs (by animals) considered were drinking water, water contained in forages, water for on-farm servicing, water for crop irrigation and water for all upstream inputs other than feeds and milk was considered as output. The water inputs through forage and other feed ingredients were more as compared to water inputs through drinking water and that used for on farm servicing operations such as cleaning etc. Average direct consumptive water use by smallholder system was found to be 130 litres per day per animal and 205 litres per day for commercial dairies. Water use efficiency for the smallholder system was 0.85 and for the commercial dairying it was 1.62

INTRODUCTION

Milk production is challenged by increasing water scarcity and simultaneously growing demand for food and feed. Globally livestock feed sourcing is a major cause for water depletion, and optimum livestock water use is essential. Feed sources in smallholder production system consist of grazing, crop residue, concentrates etc. Extensive smallholder systems in dry-land eco-regions face water depletion for feed production. This demands understanding of livestock-water interactions, and designing strategies to improve Water Use Efficiency (WUE). Livestock Water Productivity is the ratio of livestock products and services to the amount of water depleted and degraded in producing these products and services, usually expressed at L m^{-3} (Peden et al., 2007). Since 2002 livestock water use has been analysed across scales: regions, systems, farm-herd and animal. Generally with increasing intensification and integration of crop-and livestock systems livestock water use value tends to increase (Descheemaeker et al., 2011). But this may not always guarantee system sustainability. Comparison between these values might not be relevant as the studies were based on different data sources and addressing different scales. What is more appealing is the enormous gap between minimum and maximum values of LWP, illustrating potential for improvement.

About sixty four per cent of irrigated area in arid and semi-arid regions of India relies on groundwater resources as reported by Sirohi *et al.*, (2013) & Mahin et al., (2013). Declining water table aggravates overexploitation of groundwater and threatens livelihood security of small and marginal farmers (Mahin & Ashok, 2011). The majority of farmers have high knowledge levels of agro-ecological principles and hydrological cycle and high consensus with high importance points the need for synergy between surface and aquifer storage to attain sustainable water policy and practices in sustainable manner (Gupta et al., 2021). About 93 per cent of farmers try to ensure the sufficient supply of clean and fresh water to the animal, as water is one of the major critical component of dairy farming. (Sudhanshu, 2019) and 95 per cent of respondents reported that meeting out the water requirement of animals was

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challenge during drought periods (Letha Devi et al., 2021). Generally, reproductive /productive performance of indigenous breeds are inferior compared with the cross-breeds (Haileslassie et al., 2011a). Haileslassie et al., (2011b) also emphasized strong intra and interbreed variability. Livestock mortality and morbidity are the major causes of economic loss and low productivity, mainly in grazing, and in mixed-rainfed systems.

In north Gujarat the farmers produced 0.31 litre of buffalo milk and 0.49 litres of crossbred cow milk by using a m^3 of groundwater (IWMI, 2004). Similar studies carried out in different parts of Gujarat state showed that water productivity of buffaloes was 0.31 l/m^3 in south and central Gujarat and for crossbred cows it was 0.53 l/m^3 (Singh et al., 2009). The water use efficiencies in crossbred were higher than the buffaloes and local cows. Interestingly farmers in the water scarce areas (overexploited and critical) were more efficient than the farmers of water sufficient areas (safe and semi-critical) in utilization of groundwater (Mahin & Dixit, 2015). An effort was made to assess and analyse LWUE in smallholder and commercial production and to analyse the factors affecting water use efficiency and their relation with performance in dairy animals and to formulate for strategies for improving LWUE.

METHODOLOGY

The study was a primary field study using survey method. Primary data was collected from small and medium sized 240 dairy farms from Kolar and Shimoga district, Karnataka, India. The consumptive use of blue water (direct and indirect) was assessed using primary data through personal interview and observation in particular farms. Water use efficiency (kg/animal) was estimated and compared for small holder as well as commercial dairy production systems using the following formula.

$$WUE = (Y/U) \times 100$$

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 level of requirement and Mekonnen & Hoekstra (2011) method was used for calculation of LWP of feed (recommended by 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 was analyzed 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.

RESULTS AND DISCUSSION

The data indicated that the average agricultural land owned were 2.1 acres by small holders. Only in 3 per cent land is being practiced for fodder production. The animals were fed with average 4 kg of concentrate, 15 kg of green fodder and 2.5 kg of dry fodder daily by the small holder system. The animals under the commercial dairy farms were fed with average 6.5 kg of concentrate, 21 kg of green fodder and 1.5 kg of dry fodder daily. Average milk yield (litres/ animal/ day) was 7.15 litres; the corresponding figures for small holder system was 7.4 litres and for commercial system it was 15.4 litres; and 4 per cent of total produce was retained for home consumption. KMF feed, Wheat bran, flakes, rice bran, mineral mixture, salt, horse gram husk, ragi straw etc., were used in general for feeding. The major water sources are Bore well and panchayat supply.

Table 1. Direct and Indirect Water use (litre/day/animal) in different dairy production systems

Operations	Small holder system (n=200)	Commercial dairying (n=40)
Drinking	57	52
Washing shed	74	90
Washing animals	71	58
Cleaning cans and other equipments	66	41
Direct Consumptive Use	268	241
Water contained in feed and fodder	605	740
Total	873	945

The water intake by animals through forage and other feed ingredients were more as compared to water intake through drinking water and that used for on farm servicing operations such as cleaning etc (Table 1). Average direct consumptive water use by smallholder system was found to be 268 litres per day per animal and 241 litres per day for commercial dairies. The water use efficiency was calculated as 0.85 for small holder system and 1.62 for commercial dairying. This indicates that the commercial system was more efficient in water use. This may be because there was a lot of water reuse and recycling in case of commercial dairy farms covered under the study and most of them were growing fodder on their own thereby reducing the water footprint involved in transporting fodder and feed from far away locations.

The major challenges connected with Livestock Water Use (LWU) as perceived by farmers were analyzed and ranked based on rank coefficients (Table 2). 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

There were various factors affecting water use by livestock. The major factors are seasons, different weather parameters, fodder, feed and other inputs etc. The source of water, animal conditions like lactation stage, age, body and health conditions also play a role in water use efficiency (Table 3). Availability and quantity of green fodder was the major concern during summer months. Quality of green fodder was also a concern during summer season, which causes a drop in total milk yield. There was a price variation in milk due to variation in milk fat across different seasons. The water wastage points mainly in summer season were identified. Water wastage while growing fodder and washing sheds constituted the maximum, as perceived by the respondents.

Prediction model for water use

A prediction model for optimum water use was developed with the variables such as milk yield, ambient atmospheric temperature, body weight of the animal, daily dry matter intake by the animal and sodium intake by the animal.

Table 2. Problem matrix showing the scale of importance of Livestock Water Use related problems across seasons

Key LWP related problems	Seasonal variations Dairy Production Systems								
	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	√			√			√		
Post-harvest feed quality & quantity	√				√				√

Table 3. Water use and perceived effect on livestock production

S.No.		Rank
Factors affecting water use		
1	Seasonal variation	I
2	Weather parameters (Temp, Rainfall, humidity)	II
3	Fodder, Feed and other inputs	III
4	Source of water (Borewell, Canals, Ponds etc.)	IV
5	Animal conditions	V
6	Animal output	VI
Seasonal impact of water use		
1	Availability/Quantity of fodder (Green/Dry)	64
2	Quality of fodder (Green/Dry)	59
3	Drop in milk yield (l)	55
4	Milk Fat (%)	59
5	Major Diseases	49
6	Reproductive issues	47
7	Animal growth	36
Perceived water wastage points in summer season		
1	Washing sheds	40
2	Washing animals	30
3	Cleaning cans and other equipment	20
4	Water used for growing green/dry fodder	49

Daily water intake (litres/day) = 16.12+ 1.516t + 1.299 y + 0.058w + *0.71i* + 0.406s

Whereas, y = Milk yield (kg/day), t = Ambient Temperature (^{o}C), w= Body weight (kg), *i*= daily dry matter intake (kg/day), *s* =sodium intake (g/day)

This prediction model was evaluated in a non study village and the optimum water use for a milk yield level of 7.5 litres and 10 litres were calculated in a population of 35 lactating animals. The same was repeated for summer and rainy seasons in the same animal samples.

CONCLUSION

The study indicated that water inputs through forage and other feed ingredients are more as compared to water inputs through drinking water and on farm servicing operations. Water inputs considered were drinking water, water contained in forages, on-farm servicing, crop irrigation and output considered was milk. The water inputs through forage and other feed ingredients are more as compared to water inputs through drinking water and that used for on farm servicing operations such as cleaning etc. Average direct consumptive water use by smallholder system was found to be 130 litres per day per animal and 205 litres per day for commercial dairies. Water use efficiency for the smallholder system was 0.85 and for the commercial dairying it was 1.62. Proper management strategies are highly essential for sustaining the livestock production and meet demands of growing population with available water resources.

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