Tropentag 2022
September 14-16, 2022

Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the Czech University of Life Sciences, Prague, Czech Republic

Water footprint of small-scale dairy farms in the central coast of Peru

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Abstract

Dairy sector consumed 19% of the water in the livestock sector. However, in Latin America the amount of water used in this sector is unknow, especially in arid zones. In Peru, dairy production is the second most important economic activity and one of the most important dairy basin is located in the arid zone of the Peruvian coast (47% of the milk production). The aim of this work was to estimate the water footprint (WF) of dairy production in the arid zone of the Peruvian central coast. Data from five dairy farms were used to estimate the WF. The WF was calculated in its three dimensions: green water (rainwater stored in the soil and absorbed by the plants), blue water (consumptive use of surface or groundwater) and grey water (polluted water). In addition, the WF was measured for categories: feed, drinking and service. To measure the WF of feed production, the CROPWAT software was used. The reference unit was m3 per kg of fat and protein corrected milk (FPCM). In average, 99% of the WF comes from feed production, followed by drinking water (0.4%). From the three dimensions of the WF, green water is responsible of 60% of the WF, followed by the blue water (30%). Imported water represented 63% of the WF. In general, WF of dairy production in these systems was 0.66 m3/kg FPCM. In conclusion, feed production, as the main source of WF from which most is imported, shows the possibility of reducing the WF of these systems by prioritising and optimising water consumption by crops using local resources with lower water requirements.

Keywords: Arid, Cow, Latin America, milk, water footprint

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Introduction

Water crisis is one of the ten most relevant risks for humanity for the next years (WEF, 2022). Agriculture uses ~70% of the freshwater worldwide for food and non-food production (Mekonnen and Hoekstra, 2012), where the livestock uses 20% of the water (FAO, 2019). Water footprint (WF) is the quantity of water used to produce a product (milk, meat, rice…) (Owusu-Sekyere et al., 2017) or in one part of the chain (Hoekstra, 2012). To measure the WF, the water is divided into green water (rainwater stored in the soil and absorbed by the plants), blue water (consumptive use of surface or groundwater) and grey water (polluted water) (Hoekstra, 2012). Economically, the dairy sector is the third most important activity of the Peruvian livestock sector after poultry and beef production (Hinostrosa, 2021). On the other hand, the main dairy production comes from the Peruvian coast (47% of the national milk production) which only have

2% of the freshwater of Peru and with minimum or no rainfall (Hinostrosa, 2021). In arid and semi-arid zones, such as the Peruvian coast, the climatic change and the water scarcity has increased the social and environmental pressure of water use in livestock (Mekonnen and Hoekstra, 2016). However, no data is available to know the WF of dairy systems under the arid Pacific coast conditions of Latin America. For these reasons, the objective of this work was to estimate the WF of dairy systems under the arid Peruvian coast conditions.

Material and Methods

The study was carried out in the municipality of Huacho, Lima, Peru (10'96"S – 77'64"W), in the central coast. Data from five milk production units were used. The herd average was 25 ± 4.2 animals (Holstein was the predominant race), of which 13 ± 1.9 were lactating cows. The average milk yield was 26.9 ± 1.2 kg milk/cow/d. Milk fat and milk protein was 4.1 ± 0.3% and 3.0 ± 0.1%, respectively. Corn (Zea mays) is the only forage produced inside the farm under surface irrigation and no rain-fed. Water footprint of milk production was estimated following the methodology of Mekonnen and Hoekstra (2012). To measure the green and blue WF of the home-grown crops, the CROPWAT 8.0 program (FAO, 2022) was used. WF of feed produced off the farm was taken from Mekonnen and Hoekstra (2010). Following the methodology of Mekonnen and Hoekstra (2012), for the crop residues (straw, bran, leaves, etc.), WF was zero because the whole WF have been accounted for in the main product. Equations of the NRC (2001) were used to calculate the water consumption of the animals. Finally, WF grey was calculated with information obtained from the producer of the water used for cleaning services on the farm.

Results and Discussion

Green water represents 60% of the WF of the feed production, followed by the blue water (30%). In these systems, 100% of the green water was imported, whilst 97% of the blue water comes from the home-grown ingredients. In general, the rations consumed 706 ± 19 m^3/ton DM. Between the different groups of animals, lactating cows were the main responsible of the WF of the feed (76%), which represent 50% of the herd, followed by the heifers (32% of the herd and 13% of the WF).

The present study considers the prevalent dairy production system in the Peruvian coast, in which WF for feed production was similar to the observed by Sultana et al. (2015) and Mekonnen and Hoekstra (2012) worldwide (97% and 98%, respectively). However, the WF of feed production was higher than the observed by Bai et al. (2018) in China (92%) and by Naranjo et al. (2020) over 50 years in California (93% - 98%). In Peru, there is only one work published about WF of dairy systems, conducted in a pastoral system in the Amazonian region (Yalta et al., 2021), with a WF of feed production of 99.4%. This corroborates that the production of feed for cattle is the main cause of the WF in dairy farms, which ranges from 94% to 99% (Sultana et al., 2014; Sultana et al., 2015).

Drinking water consumption was mostly carried out by lactating cows (91% of the water footprint). The data show that, on average, there was a consumption of 14.28 ± 0.99 m^3 of water/animal/year in the evaluated farms, which only represented 0.4% of the WF, which was in line with the range of 0.3 to 1.6% reported by Naranjo et al. (2020) in the United States of America or lower than the world average of 1.1% (Mekonnen and Hoekstra, 2012) and the 3.75 ± 2% reported by Ibidhi and Salem (2020) in Tunisia. On the other hand, Yalta et al. (2021) in the Peruvian Amazonian reported a drinking WF from 1.9 to 5.12% of the total WF. The water used for general services (barn cleaning, udder cleaning and milking equipment, among others) was 128 ± 11.31 m^3/farm/year.

The results of this study show that 99.4% of the WF of milk production corresponds to feed production. Regarding the use or origin of the water resource, 60% corresponds to green water, and 30% to blue water. For the origin of the water source, 99% of blue water was from the water used in the farm for irrigation (corn forage production) and drinking water. In general, 63% of the WF was imported via the green water principally. In general, WF of milk production (0.664 ± 0.055 m^3/kg FPCM) was similar to the average WF of a mixed dairy system (0.95 m^3/kg milk; Mekonnen and Hoekstra, 2012). However, this WF is lower than reported in Tunisia (1.36 ± 0.14 m^3/kg FPCM; Ibidhi and Salem, 2020), in Algeria (1.96 to 2.15 m^3/kg of milk; Yerou et al., 2021) or the worldwide average (1.02 m^3/kg milk; Mekonnen and Hoekstra, 2012). Other works in Peru showed a big variation of WF for milk production but with different levels of milk production and feed supply. Sultana et al. (2014) reported a WF of 1.5 to 2.5 m^3/kg of milk corrected for energy in dairy farms in the Andes. While, in the Peruvian Amazon, Yalta et al. (2021), the estimated WF was from 0.74 to 1.82 m^3/kg milk. Scenario studies are needed in order to identify strategies reducing WF of milk in arid environments. This is more important as the increase in the consumption of animal products worldwide is likely to put further pressure on freshwater resources.

Table 1. Water footprint of dairy farms in the Peruvian coast, m^3/kg FPCM[a]

		Green	Blue	Grey	Total
Average					
	Feed	0.402	0.195	0.063	0.660
	Drink		0.003		0.003
	Service			0.001	0.001
	Total	0.402	0.198	0.064	0.664
Standard deviation					
	Feed	0.040	0.021	0.006	0.054
	Drink		0.000		0.000
	Service			0.000	0.000
	Total	0.040	0.021	0.006	0.055

[a]FPCM: Fat and protein corrected milk (kg/yr) = Milk yield (kg/yr) x (0.1226 x Milk fat (%) + 0.0776 x Milk protein (%) + 0.2534) (IDF, 2010)

Conclusion

Feed production was the main cause of water consumption, which shows the possibility of reducing the WF of these systems by prioritizing and optimizing water consumption by crops. Similarly, the importation of water is another source of opportunity since it represents up to 63% of the water footprint, where prioritizing local resources could decrease it. However, more research on the WF of these systems in arid zones is necessary.

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