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# Freshwater use in livestock production—To be used for food crops or livestock feed?

Ylva Ran[a,b,*], Corina E. van Middelaar[a], Mats Lannerstad[c,1], Mario Herrero[d], Imke J.M. de Boer[a]

[a] Animal Production Systems Group, Wageningen University, PO Box 338, 6700 AH Wageningen, The Netherlands
[b] Stockholm Environment Institute, Linnégatan 87D, 115 23 Stockholm, Sweden
[c] International Livestock Research Institute, PO Box 30709, 00100 Nairobi, Kenya
[d] Commonwealth Scientific and Industrial Research Organization, Bioscience Precinct Carmody RD, St. Lucia, 4067, Queensland, Australia

## ABSTRACT

Current approaches to estimate freshwater use in livestock production systems generally fail to consider the competition for water resources with alternative uses, such as production of food crops food or other ecosystem services. This article presents a new method to account for the competition for freshwater use between food crops and animal feed, while assessing freshwater use in livestock production systems. The developed water use ratio (WUR) is defined as the maximum amount of human digestible protein (HDP) derived from food crops from the consumptive water use (CWU) appropriated to produce 1 kg of animal-source food (ASF) over the amount of HDP in that 1 kg of ASF. The CWU for livestock production is first categorized according to the land over which it is consumed, based on the suitability of that land to produce food crops. Then, the method assesses food-feed competition by determining the amount of HDP that could have been produced from food crops, using the same CWU currently used to produce ASF. The method enables identification of livestock production systems that contribute to global food supply without competing significantly over water resources with food production, based on their CWU. Three beef production systems in Uruguay are used to illustrate the method. During the backgrounding and the finishing stages, which are analyzed in this study, cattle can be kept on natural pasture (NP), seeded pasture (SP) or in feedlots (FL). The following three systems were analysed: i) NP-NP, ii) SP-SP and iii) SP-FL. Results show that the NP-NP system uses the largest amount of water per kg of beef output. However, results also show that the SP-SP and SP-FL systems can potentially produce more HDP by growing food crops than by producing beef. Based on the traditional measure for water productivity, i.e. the quantity of CWU per kilo of beef produced, we would conclude that the NP-NP system is least efficient, whereas based on the WUR the NP-NP system is the only system producing HDP more efficiently than food crops. Sustainable intensification not only implies improving agriculture and livestock productivity per unit of resource used, but also improving the number of human beings nourished. Results from this study illustrate the importance of considering competition and trade-offs with other uses when evaluating water use efficiency of livestock systems to promote sustainable intensification.

## 1. Introduction

A growing world population, estimated to reach nine billion people by 2050, is increasing the pressure on global agricultural production to ensure food security for all. Between 2005 and 2050 the demand for meat and milk products is projected to increase by around 70–80% and the demand for crop protein by 100–120% (Tilman et al., 2011; Alexandratos and Bruinsma, 2012).

Livestock production requires large amounts of natural resources, including water and land, and the expected rising demand for animal sourced foods (ASF) can potentially amplify environmental impacts related to livestock (Delgado et al., 1999; Godfray et al., 2010; Bouwman et al., 2013; Westhoek et al., 2014; Herrero et al., 2015).

At present, the global livestock sector uses about 75% of all agricultural land (Foley et al., 2011), and is responsible for about 30% of global agricultural water requirements, including rain and irrigation water used for production of feed and withdrawals for animal husbandry (Mekonnen and Hoekstra, 2012). At current productivity levels, the expected rise in demand for animal products will result in a doubling of the land and freshwater requirement, increasing the water

* Corresponding author at: Stockholm Environment Institute, Linnégatan 87D, 115 23 Stockholm, Sweden.
*E-mail addresses:* ylva.ran@sei-international.org (Y. Ran), research@lannerstad.com (M. Lannerstad).
[1] Present address: Welanders väg, 7, 112 50 Stockholm, Sweden.

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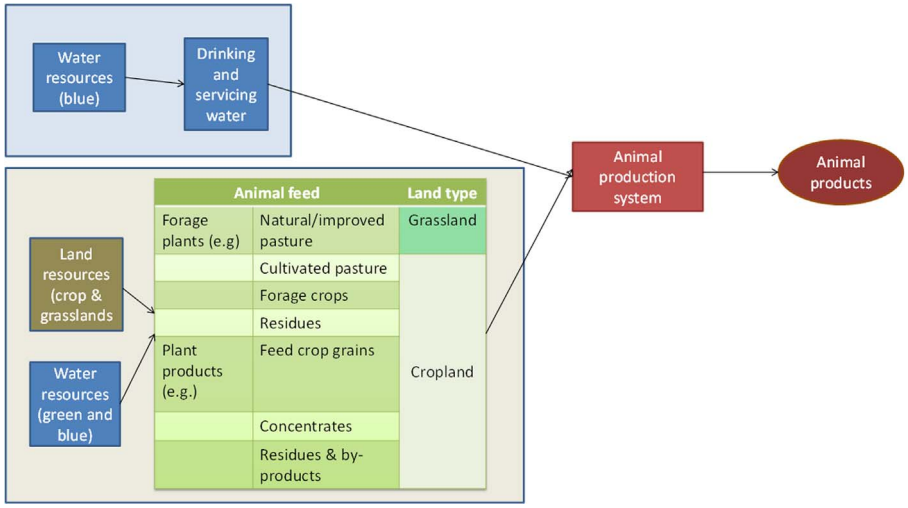


**Fig. 1.** Conceptual flow chart of land and water resource requirement in livestock production. [Single column.]

resource use competition (Rockström and Barron, 2007; Rockström et al., 2007). An amplified water use for livestock and crop production can, in turn, locally increase the risk of water stress (Ridoutt and Pfister, 2010). At present, > 1.2 billion people already suffer conditions of physical water scarcity (Molden, 2007).

Livestock require water for e.g. drinking and cleaning services, and for the cultivation of feed crops or for grass growth (Figs. 1 and 2). In this paper, we focus on consumptive water use (CWU), which refers to water that is withdrawn from a watershed, and not discharged to the same watershed because it evaporates, is embodied in plants or animals, or is discharged to a different watershed (Falkenmark and Lannerstad, 2005). As a general rule, > 98% of the total CWU in livestock production can be attributed to evapotranspiration from feed crops and pastures. Only 2–8% of livestock CWU is drinking, servicing and feed-mixing water (Steinfeld et al., 2006; Mekonnen and Hoekstra, 2012; De Boer et al., 2013).

To acknowledge the importance of both soil moisture and water withdrawals from water bodies, water resources can be divided into green water, which refers to soil moisture available to plant growth, and blue water, which refers to liquid water in water bodies, as rivers, lakes and aquifers (Falkenmark, 1995). Green and blue water resources, however, are interchangeable states, and water can shift from one state to the other, and back. Green water use does not only affect the availability of soil moisture, but could also affect the availability of blue water, since part of the soil moisture, if unused, could drain out of the soil and re-charge water bodies as blue water. Thus, both green and blue water uses may ultimately alter water availability in the landscape in different ways, impacting local ecosystem functioning and, should therefore both be considered in water use assessments (Milà i Canals et al., 2009).

As illustrated in Fig. 1, livestock products, e.g. beef meat, can be produced in a variety of production systems that use a wide range of different feeds, which in turn can be grown using different natural resources and management practices. The use of water resources, and primarily green water, is tightly connected to the land that is used by a particular livestock production system. Green water is directly linked to a specific area, available as soil moisture for plant growth, while blue water is linked to water bodies, thus the ability in the landscape to store liquid water. Since the majority of water consumption in livestock systems relates to the cultivation of feed, water resource use and land use should be considered together, rather than separately (Ran et al., 2016).

Animal feed can be produced on grasslands such as natural pastures (grazing livestock) and cropland (all livestock). Grasslands, especially natural pastures, require primarily green water. However some pastures are irrigated, thus using additional blue water resources, and some are even cultivated and occupy land suitable as cropland. All animal feed crops require cropland for growth, however, some feed crops are rainfed, and thus depend entirely on green water, while others require irrigation water depend on both green and blue water.

To prevent unsustainable use and management of water resources, there is a need to describe the linkages between livestock production and freshwater use. Understanding and quantification of these links is imperative in order to increase water productivity in livestock production, and to identify trade-offs and synergies between livestock production and other competing water uses, such as food crop production. The focus on increased feed efficiency for livestock to improve resource use efficiencies, and changing consumer preferences towards more pork and poultry products, has led to a larger share of human edible plant material in animal feed (De Vries and De Boer, 2010; Eisler et al., 2014). An increased use of high quality croplands to cultivate animal feed, in preference to food crops, will further proliferate resource use competition between food and feed production.

Current estimates of both water and land resource use by livestock

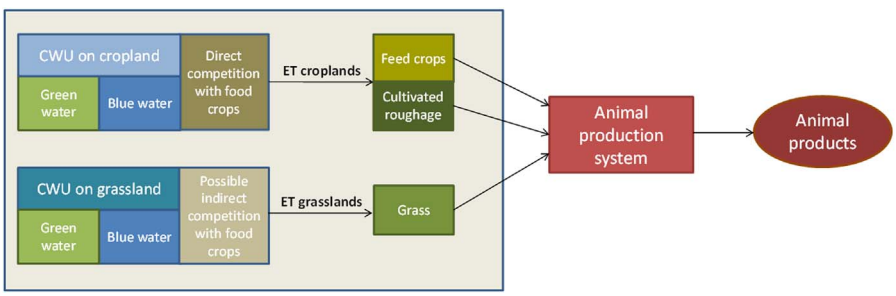


**Fig. 2.** Water use in livestock production categorized, considering differences by feed composition for different animal type and production systems and possible trade-offs between feed and food crops. [Single column.]