SPATIALIZED LIFE CYCLE WATER FOOTPRINTING OF U.S. MILK

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ABSTRACT

Dairy production in the US at the national scale is a distributed production system that entails great geographic diversity with respect to inputs and outputs. Milk therefore represents an interesting case study to develop and test spatialized life cycle approaches for both inventory and impact assessment.

The study is to be used by the U.S. dairy industry to create a baseline of water footprint, helping that industry and its constituent milk producers to identify areas to target for improvement, explore the changes in impact associated with new management scenarios, and document those improvements.

The result showed that water stress is 146 liters in competition per kg milk consumed and 121 liter in competition per kg milk at farm gate (water consumption is 225 liters per kg milk consumed and 181 liters of water consumed per kg milk at farm gate).

INTRODUCTION

Building upon work in progress within the UNEP-SETAC Life Cycle Initiative on water footprinting, a framework has been developed by Quantis which integrates a comprehensive state-of-the-science compilation of methods, addressing major issues related to water use in LCA, of which a large part is described in this report.

The study is to be used by the U.S. dairy industry to create a baseline of water footprint, helping that industry and its constituent milk producers to identify areas for improvement, explore the changes in impact associated with new management scenarios, and document those improvements. The study is the outgrowth of a January 2009 commitment by the

Innovation Center for U.S. Dairy (representing about 80% of the dairy industry) to reduce greenhouse gas (GHG) emissions of fluid milk by 25% by 2020.

The following report first outlines the methods and indicators used to evaluate the water stress impact of milk production in the U.S. A detailed description of modeled inventory data is provided. Results at the regional and national level are then presented based on 12 main feed crops.

METHODS

Functional unit and allocation

The overall functional unit for environmental impacts across the milk life cycle is one kilogram of fat and protein corrected milk (kg FPCM) consumed in the United States (U.S.). This is consistent with the previous carbon footprint conducted by the University of Arkansas (Thoma et al. 2013).

An intermediate, but equally relevant, functional unit is one kg of FPCM produced, i.e., up to the point at which milk leaves the farm gate. Therefore, we present results per kilogram of at the farm gate as well as per kilogram consumed. The term 'kg milk' is used to indicate 'kg FPCM at farm gate', when in the context of the field and dairy farm, and 'kg FPCM consumed' when in the context of the overall life cycle. Major differences between milk at the farm gate and milk consumed include the allocation to cream (19.8%) and losses at retail and consumer stages (12% and 20%, respectively) as defined in (Thoma et al. 2013). These losses require that more than 1 kg milk be produced in order for 1 kg to be consumed. Therefore, values at farm gate cannot be directly extracted from the overall life cycle, and hence the value of presenting the analysis from both perspectives.

General assessment framework for impact assessment

The framework used in this study, which includes the most up to date water impact assessment methods, is presented shown in Figure 1. Note that this framework focuses on blue water, which is consistent with current developments in the ISO framework, as green water is not extracted by users. Water quality, with respect to freshwater and marine eutrophication, is accounted for in terms of pollution impacts, rather than the conceptual grey water (a volume required to dilute a pollutant)..

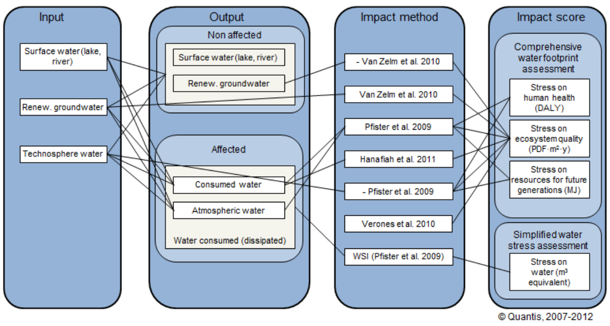

Figure 1 General framework for water stress impact assessment for feed production and on farm water use (grey water not included in the water use part of the study)

A matrix approach was developed to provide the spatialized water stress impact of U.S. milk production (Anne Asselin-Balençon, 2012). The water stress impact allows water use to be related to competition, which allows the analysis to distinguish between water use in water-rich or water-stressed areas. The unit for the water stress analysis is liters of water in competition.

RESULTS AND DESCUSION

Dairy and agriculture are water intensive activities and water use and impacts can vary widely depending on region, crop irrigation and type of crop. Irrigation can account for up to 90% of water withdrawn from available sources. Furthermore, of these irrigation withdrawals, approximately 15% to 35% of worldwide are estimated to be unsustainable. As competition for water resources from other sectors continues to increase, there is a demand for agriculture and dairy industries to improve efficiency of water use. On a dairy farm, water use is mainly associated with irrigation, accounting for up to 90% of on farm water use. Water consumption is 225 liters per kg milk consumed and 181 liters of water consumed per kg milk at farm gate). This water consumed is then combined with the water stress index to deliver the volume of water in competition (Figure 2). Water stress impacts due to milk production at the farm gate are spatially differentiated by region.

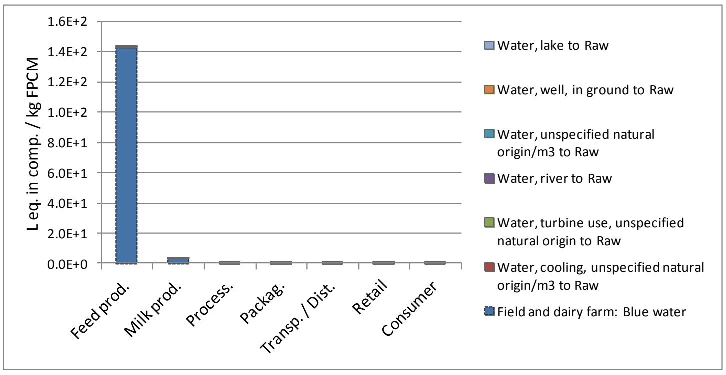

Figure 2 Water stress impact contribution from all stages of the life cycle to national average, combining spatial and nonspatial components

Because a large fraction of milk production takes place in western regions, where many crops also are irrigated, production of milk in those regions will induce water consumption for crops produced locally or regionally, leading to a national average of 121 liters of water consumed for crop production per kg milk produced at farm gate and 146 liters in competition per kg milk consumed.

Figure 3 shows water stress, freshwater and marine eutrophication impacts per kg FPCM, of milk produced in each watershed. Water stress is most significant in the western portion of the country, while overall freshwater eutrophication tends to be higher in the Midwest and East. However, when restricting impacts to areas with phosphorus concentration higher than 100 µg/L– the highest impacts are induced in the California, Missouri, and Upper Mississippi water basins. Variation in marine eutrophication due to nitrogen compounds is reduced relative to the other impacts.

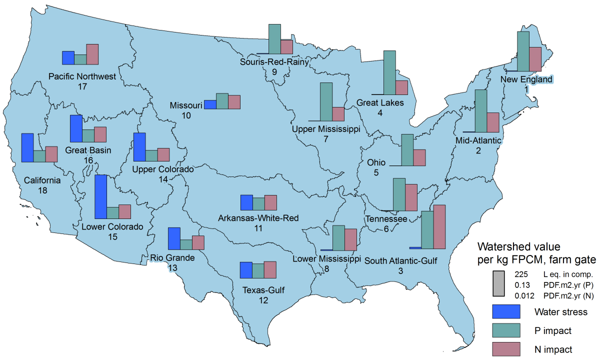

Figure 3 Comparison of watershed-level impacts for water stress, freshwater eutrophication, and marine eutrophication from field and dairy farm

CONCLUSIONS

The water footprint is becoming a more relevant group of impact categories that deserve to be studied in further details since these impacts show very important variation across the country. Water is a local issue impacted by both water supply and watershed characteristics. Water quality and quantity issues are closely linked as the quantity of a stream flow will heavily influence the inherent water quality. For the spatialized assessment of on farm water stress impact, the following key lessons can be drawn:

- Feed production dominates the water stress impact for feed and milk production, therefore source of feed matters to the water footprint of milk production.
- Water stress impact (based on the water stress of the region) varies widely by location.
- Water stress impact of milk production is dominated by a few regions with a combination of high water stress (high irrigation water use) and high crop production.
- Alfalfa hay and silage, grass hay and silage are mainly locally produced and consumed; they are dominant water users in water stressed regions.

The results of the current water stress assessment of milk production in the U.S. reveal certain possible approaches to reduce the milk water footprint:

- Improve supply chain of feed sourcing and supply
- Improve feed ration management and feed conversion efficiency
- Improve efficiency of irrigation techniques
- Improve reuse and recycling of on farm water use

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