

# How cows compete with human nutrition – assessing feed-food and land-use competition of Swiss dairy production

Ineichen S.<sup>1</sup>, Zumwald J.<sup>2</sup>, Nemecek T.<sup>2</sup> and Reidy B.<sup>1</sup>

<sup>1</sup>Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences HAFL, 3052 Zollikofen, Switzerland; <sup>2</sup>Agroscope, Agroecology and Environment, Life Cycle Assessment Research Group, 8046 Zurich, Switzerland

## Abstract

Ruminants are able to convert feed sources not directly usable by humans into valuable human-edible food. If, however, ruminants are fed with feedstuff that could have been consumed directly as food by humans (i.e. cereals), or which were produced on land that could be used to grow arable crops for direct human consumption, competition arises between feed production for ruminants and food production for humans. We developed and applied two different methods to assess feed-food and land-use competition on Swiss dairy farms. Depending on the amount and type of concentrate used, limited feed-food competition was found. All farms showed a larger edible output (in terms of milk and meat) than input (in terms of feedstuffs). Contrastingly, strong competition for land-use was found, as most farms (depending on the proportion of arable land) could have produced more edible energy and protein, if the land had been used instead for direct human food production.

**Keywords:** feed-food competition, land-use competition, by-products, dairy production

## Introduction

Ruminants are able to convert fibre-rich feed sources into valuable human-edible food. This unique ability of ruminants may be relevant for ensuring future global food demands, as decreasing arable land area meets an ever-growing world population. Having scarce resources such as land and therefore feedstuffs in mind, ruminants need to convert feed into food (as milk and meat) efficiently. A higher feed conversion efficiency can be achieved by feeding more concentrated feedstuffs (meaning higher density of energy or protein content per kg of dry matter). However, many of these concentrate feeds would also be suitable for direct human consumption (e.g. wheat or soybeans). If the potential human edibility of feeds is being considered, ruminants may directly compete with human nutrition (CAST, 1999) or indirectly, when feed is being produced on land that would be suitable for crop production as well (Van Zanten *et al.*, 2016). In this paper, we combined two existing methods to quantify feed-food and land-use competition on Swiss dairy farms.

## Materials and methods

Twenty-five dairy farms, located on the Swiss Central Plateau as well as in mountainous regions, were chosen. They depict a variety of traits (climate zone, milk yield, organic/conventional, feeding strategy, arability of the land used) that may be suitable to explain differences in the degree of competition between feed/food and land use respectively. The farms managed 33 ( $\pm 16$ ) ha land and held 46 ( $\pm 26$ ) cows. All farm-specific data (feed consumed by cows, yields per hectare, purchased feeds, milk production, replacement rates, etc.) were collected on farm by individual interviews during 2018. The system boundaries were set at the farm gate, meaning all animals, feeds and land area necessary to produce the milk and sustain the herd were included. Land area or animals kept on farm that were neither producing milk nor rearing were excluded. Surplus calves were counted as meat output (75 kg live weight) as well as culled cows (individual farms mean cows live weight). Boneless meat yield of calves was set at 410 g kg<sup>-1</sup> of live weight, for culled cows at 310 g kg<sup>-1</sup> of live weight. Protein content was assumed to be at 32, 170 and 190 g kg<sup>-1</sup> for milk, veal and beef respectively. All calculations were conducted for protein

(with quality correction by the digestible indispensable amino acid score (DIAAS), FAO 2013) as well as energy. In this paper we focus on protein, as animal products usually contribute more to protein than energy demands of humans. Most findings were equivalent for both nutritional aspects but differed only numerically.

Feed-food competition is being expressed as the ratio of all human edible feeds (numerator) divided by all edible products (milk and meat, denominator) as proposed by Wilkinson (2011). Values below one indicate that there was more human edible food produced than consumed by the dairy system and vice versa. Edibility of feedstuffs was assumed to be 'low', meaning a poor recovery rate of human-edible energy and protein from feeds according to Ertl *et al.* (2015).

Land-use competition was assessed according to Van Zanten *et al.* (2016) by quantifying the land area occupied by dairy production and assessing its suitability for the production of arable crops for direct human consumption. In opposition to Van Zanten *et al.* (2016) four different crop rotations were defined to maximize protein (or energy) output for 'favourable' or 'less favourable' climatic conditions. Poor soil quality leads to a reduction in the potential yield per ha.

## Results and discussion

The annual milk yield was 7616 ( $\pm 1,636$ ) kg energy corrected milk (ECM) per cow. The mean annual diet of cows consisted of 78% ( $\pm 16\%$ ) grass (pasture, fresh cut, silage or hay), 10% ( $\pm 10\%$ ) corn (silage or dried), 10% ( $\pm 7\%$ ) concentrates and 2% ( $\pm 2\%$ ) of other feeds (such as sugar beet pulp or straw). Concentrate feed intensity was at 123 ( $\pm 71$ ) g kg<sup>-1</sup> ECM, where concentrate was defined as all feeds with a crude fibre content below 120 g kg<sup>-1</sup> dry matter.

Feed-food competition was below one for all farms, meaning that more edible protein and energy was produced than was fed to the cows (Figure 1). Competition was low for farms feeding exclusively grass (fresh cut, pasture, hay or silage). Feed-food competition may be reduced on all farms by replacing food crops by co-products as well as increasing overall productivity. Except for farms in the mountain area, land-use competition was generally greater than one, an indication that more food could have been produced with arable crops for direct human consumption. The degree of land-use competition depends on the share of arable land as well as the type and origin of bought feeds. The land-use competition may be decreased by using the less-favourable land area for dairy production as well as by improving the feed conversion ratio.

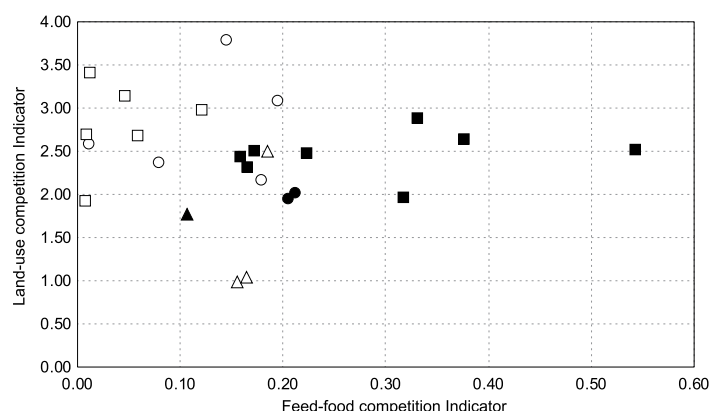


Figure 1. Feed-food and land-use competition for 25 Swiss dairy farms located in the Valley- (■, □), Hill- (●, ○) and Mountain-Zone (▲, △), open symbols refer to milk yield of <8,000 kg energy corrected milk (ECM) cow<sup>-1</sup>, filled symbols to a milk yield of >8,000 kg ECM cow<sup>-1</sup>.

## Conclusions

Feed-food and land-use competition indicators are not correlated and deliver a complementary and holistic view on the feed-food competition. Improving overall productivity decreases feed-food as well as land-use competition if animal's diets remain constant.

## References

- CAST (1999) *Animal agriculture and global food supply*. Task Force Report No. 135, Council for Agricultural Science and Technology, USA, 92 pp.
- Ertl P., Klocker H., Hörtenhuber S., Knaus W. and Zollitsch W. (2015) The net contribution of dairy production to human food supply: the case of Austrian dairy farms. *Agricultural Systems* 137, 119-125.
- FAO (2013) Dietary protein quality evaluation in human nutrition. In: *FAO Food and Nutrition Paper*, Rome; Italy, 79 pp.
- Van Zanten H.H.E., Mollenhorst H., Klootwijk C.W. Van Middelaar C.E. and De Boer I.J.M. (2016) Global food supply: Land use efficiency of livestock systems. *International Journal of Life Cycle Assessment* 21(5), 747-758.
- Wilkinson J. (2011) Re-defining efficiency of feed use by livestock. *Animal* 5(7), 1014-1022.