# Life Cycle Assessment of Beef, Pork and Poultry

## Executive Summary

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# Executive Summary

The objective of the "Environmental Assessment of Beef, Pork and Poultry" research initiative was to create an environmental life cycle assessment (LCA) of cattle, pig and poultry (i.e. chicken) production in Switzerland and selected source countries for imports and to compare the environmental impacts of the different production systems. To this end, a product LCA of the Swiss cattle-, pig- and poultry-fattening systems up to the farm gate was created for a standard variant according to Proof of Ecological Performance (PEP), a PEP variant with high-animal-welfare husbandry (BTS/RAUS criteria, suckler-cow husbandry) and an organic variant, respectively. Table 1 gives an overview of the investigated systems. In each case, two foreign variants per livestock species were compared with Swiss production including all processes up to the delivery to point of sale. These consisted of production in Germany and Brazil for beef, in Germany and Denmark for pork, and in France and Brazil for chicken.

**Table 1: Overview of the investigated systems**

| Cattle-Fattening Systems | Pig-Fattening Systems | Poultry-Fattening Systems |
|---|---|---|
| Bull-Fattening PEP Switz. | Pig-Fattening PEP Switz. | Poultry-Fattening PEP BTS Switz. |
| Suckler-Cow System PEP Switz. | Pig-Fattening PEPetho[1] Switz. | Poultry-Fattening PEP BTS RAUS Switz. |
| Org. Suckler-Cow System Switz. | Org. Pig-Fattening Switz. | Org. Poultry-Fattening Switz. |
| Org. Heavy-Livestock Fattening Switz. | - | - |
| Bull-Fattening Germany | Pig-Fattening Germany | Poultry-Fattening France |
| Cattle-Fattening Brazil | Pig-Fattening Denmark | Poultry-Fattening Brazil |

[1] 'etho' meets the requirements of the BTS (= particularly animal-friendly housing) and RAUS (= regular access to outdoor facilities) regulations (Etho programmes)

The results highlight the environmental impacts of meat production and provide reference points for both optimisations in Swiss agriculture and measures in the supply chain of the Swiss 'Coop' supermarket chain. The research initiative was carried out and financed by Agroscope Reckenholz-Tänikon Research Station ART (Life Cycle Assessment Research Group) together with Coop, and ran from June 2010 to September 2012.

**Methodology applied**

The LCAs were calculated by means of the SALCA (Swiss Agricultural Life Cycle Assessment) method developed by ART. Said method comprises the environmental impacts which are relevant for agriculture in a midpoint impact assessment. The environmental impacts of non-renewable-energy demand, global-warming potential, ozone formation, demand for phosphorus and potassium resources, competition for land, competition for arable land, deforestation, water use (blue water), eutrophication, acidification, ecotoxicity and human toxicity were analysed. Comparisons were made on both the agricultural and 'delivery to point of sale' levels, with the results of the former referring to kg live weight and those of the latter to kg ready-to-sell meat as the functional unit. 'Ready-to-sell meat' is defined as packaged meat intended for human consumption upon delivery to the sales point (kg net weight). The impact category 'biodiversity' was analysed for the cattle-fattening systems (farm level) in Switzerland. Further environmental impacts such as soil quality, smell and noise were not taken into account. Moreover, the use of medication and other non-environment-related aspects such as animal welfare, landscape aesthetics and economic factors did not form part of the study.

The calculated animal-production systems for Swiss cattle- and pig fattening stem from the 'Life Cycle Assessment – Farm Accountancy Data Network' (LCA-FADN) project's model farms. Earlier studies showed a very high variability between commercial farms, with the variability between farms of the same

type often being greater than that between different farm types. Since – owing to this high variability – the available sample of real farms was too small to represent overall Swiss production, model farms were used for the analysis of Swiss animal-production systems. Based on Farm Accountancy Data Network (FADN) data, these model farms depict average farms for all of Switzerland's important farm types, taking account of farming method and region. The production data for modelling the Swiss cattle- and pig-fattening systems are based on the years 2003-2005, whilst supplementary information stems from the 2006 'Profit Margin' catalogue. The model farms were also used for analysing biodiversity in the Swiss cattle-fattening sector. A comparison of the model farms with the real farms confirmed that each model farm did a good job of representing an average farm.
2010 data of the meat processing company Bell on poultry production for the Swiss supermarket chain 'Coop' was available for assessing the state of the poultry-fattening industry in Switzerland. Because the foreign systems for all livestock species were for the most part modelled on the basis of details from the literature, the reference period varies from around 2000 to 2009, depending on the availability of data. For the downstream processes, data from Bell, the Swiss Coop chain and livestock- and meat-trading businesses from the years 2009 and 2010 were used.
Since the low number of farms studied meant that no significance tests could be performed, the doubled standard deviation was used in each case to gauge the differences between the systems. Differences were only assumed if the intervals of the doubled standard deviation between two systems did not overlap.

**Results**
In all of the systems examined, agricultural production was dominating the environmental impacts. Here, the cultivation and production methods employed, rather than the place of production, were decisive. **How** saleable meat is produced, rather than **where**, is therefore the key factor for its environmental impacts.
Within the downstream processes, the slaughtering, processing and packaging processes accounted for the largest proportion of environmental impacts. Particularly in the spheres of water and energy consumption and packaging materials, where the downstream processes made an appreciable contribution to environmental impacts, improvements such as more-resource-efficient technologies or a switch to renewable energies could bring advantages. For imported meat, transport routes played a relatively minor role only. An exception to this is air transport, which significantly increases certain environmental impacts (especially non-renewable energy demand, global warming potential and human toxicity). The efficiency of a system over the entire production chain was substantially determined by its yield and losses over the various stages. Owing to the great importance of livestock production in the case of all environmental impacts, the yield or losses in the processes downstream from agriculture was a very important factor for the environmental impacts on the 'point of sale' level, with the losses arising at the agricultural level, e.g. during the production of the fodder (harvest and preservation) or on the pasture, also playing a role.

Crucial factors for the environmental impact of livestock production on the agricultural level were **system design**, the **efficiency of the system** and **feeding**. With efficiency, feed conversion in particular played an important role, whilst with feeding both the composition and production of the feedstuffs were crucial.
In organic farming, the ban of mineral fertilisers and pesticides had a positive effect on various environmental-impact categories. The demand for phosphorus and potassium resources was significantly lower for all livestock species in the case of organic production, as were terrestrial and aquatic ecotoxicity (see Figs. 1, 3 and 5). By contrast, the lower yields in organic farming exerted a negative influence, resulting in a higher environmental impact per kg feedstuff used, which, owing to the key influence of the latter's production significantly affected the environmental impacts per kg of meat (especially in the case of monogastrics).

*Monogastrics (Pig and poultry production)*
In terms of system design, for pork and poultry there were no essential differences between the individual variants; production is highly standardised in all of the assessed countries. Only the systems with etho-programmes differed in certain respects from conventional PEP production. With poultry, etho-production

uses slower-growing hybrids that are adapted to the prescribed longer fattening period and the use of an outdoor area. Animals reared in an animal-friendly manner have a lower feed-conversion rate and consequently higher environmental impacts per product unit (Figure 5). With pig production, by contrast, animal performance was on a similar level in all systems, with the result that the environmental impacts of etho-production hardly differed from those of PEP production here (Figure 3). Only the outdoor area in the etho-production system led to higher ammonia emissions.

For the monogastrics, feed, and especially feed conversion, were critical aspects of a system's efficiency. The better the feed conversion of the animals, the less feedstuffs required for growth, and the lower the environmental impacts from feedstuff cultivation per product unit. Feedstuff production (i.e. cultivation, processing, transport, etc.) also accounted for the highest percentage of environmental impacts per kg of meat. Bearing in mind environmental criteria when composing rations as well as environmentally optimising feedstuff cultivation itself are important measures for reducing environmental impacts in the poultry- and pig-production sectors. Here, special attention must be paid to the use of soya, since a considerable percentage of the soya traded worldwide is grown on land obtained over the last few decades by clearing rainforest and converting species-rich savannah to agriculture. This land conversion leads to massive environmental impacts which above all have repercussions for the categories of global warming potential (release of $CO_2$ through slash-and-burn and humus depletion) and ozone formation potential. The systematic implementation of programmes for the production and trading of soya certified as 'deforestation-free' and the use of such feedstuff can make an important contribution to improving the environmental impacts of meat production.

*Cattle fattening*

For cattle fattening, other parameters were decisive than was the case for the monogastrics. In terms of system design, there are two fundamentally different systems: bull fattening and suckler-cow husbandry. Since in bull fattening the animals stem from milk production, a majority of the environmental impacts of the mother animal are attributed to milk production. By contrast, with the suckler-cow system the total environmental impact of the suckler cow is ascribed to meat production. Because of this, the environmental impacts from suckler-cow husbandry increased in many categories (see Figure 1). This difference was especially clear for the environmental impacts global warming potential and ozone formation. The most important contribution to these environmental impacts is made by enteric methane formation in the digestive systems of ruminants, which carries particular weight owing to the full inclusion of the mother cow in the suckler-cow systems. The suckler-cow systems also tended to have higher values for the environmental impact of non-renewable energy demand than did bull fattening systems. The difference was not as clear-cut as for the environmental impacts global warming potential and ozone formation, however, since the suckler cows were kept more extensively.

With ruminants such as cattle, environmental optimisation via feed is more complex than with monogastrics. Although the principle 'the higher the growth rate of the fattening animals, the more efficient the system' also applies here, concentrated feed must be used in order to achieve very high growth rates, which cancels out a key advantage of the ruminants, viz. the use of grassland without direct food competition with humans. In addition, the use of concentrates has an adverse effect in a number of other environmental categories, such as resource and energy demand, or ecotoxicity. Although grass-based feed results overall in a higher land requirement, this is primarily for grassland, with different potential uses than arable land.

The conflict between intensive production and the preservation of species diversity was apparent in the biodiversity analysis for the Swiss beef-production systems. Production methods with a high proportion of feed from arable crops exhibited a lower biodiversity potential with a high surface-area productivity, whilst the production of beef on land with a high biodiversity potential was only achieved with a low surface-area productivity. Clearly defined goals are therefore important when designing beef-production systems. If biodiversity is an important aim, care must be taken to identify land that is valuable for biodiversity and to manage it extensively.

Generally speaking, when defining measures for the improvement of meat production, it is important that the systems be viewed in their entirety, as there is otherwise the danger that improvements in one area will lead to worsening in another.

**Discussion of the Data and Methodology**

The present study highlights the environmental impacts associated with the production of 1 kg of ready-to-sell meat.

The data for the Swiss cattle- and pig-fattening systems are based on model farms, whilst the poultry-fattening systems as well as the foreign cattle- and pig-fattening systems were designed on the basis of data from the literature and from expert statements. Consequently, modelled systems rather than actual working farms were studied. This means that the large variability between individual farms that prevails in practice is not portrayed. As a result, the statements made in this study always refer to the average situation, and may not be applied to individual farms.

Since the number of model farms studied was too low for significance tests to be used, the significance of the differences could not be assessed. The doubled standard deviation used instead, however, provides evidence of the significance of the calculated differences.

**Outlook**

This study takes into account the environmental aspects of meat production. It has allowed us to gain valuable knowledge and define starting points for improvement measures. The sustainable growth of the investigated systems requires the consideration of economic and social factors in addition to the ecological aspects. In addition, the consumption phase (including in particular food preparation and food wastage in the home) and disposal processes must be included in the analyses. In addition, the optimisation of beef production must be approached via an overall analysis of cattle production (milk and meat).

The analysis of primary farm networks is important for further improvements in the animal-production systems. Such networks enable us to derive the relevant success factors from best-practice farms, allowing us to develop optimised production systems from the latter (eco design). Since we have worked very little with real farm networks to date, significant research potential still exists here. By exploiting this potential and making use of the measures proposed in this study, the environmental impacts of meat production can be appreciably improved.

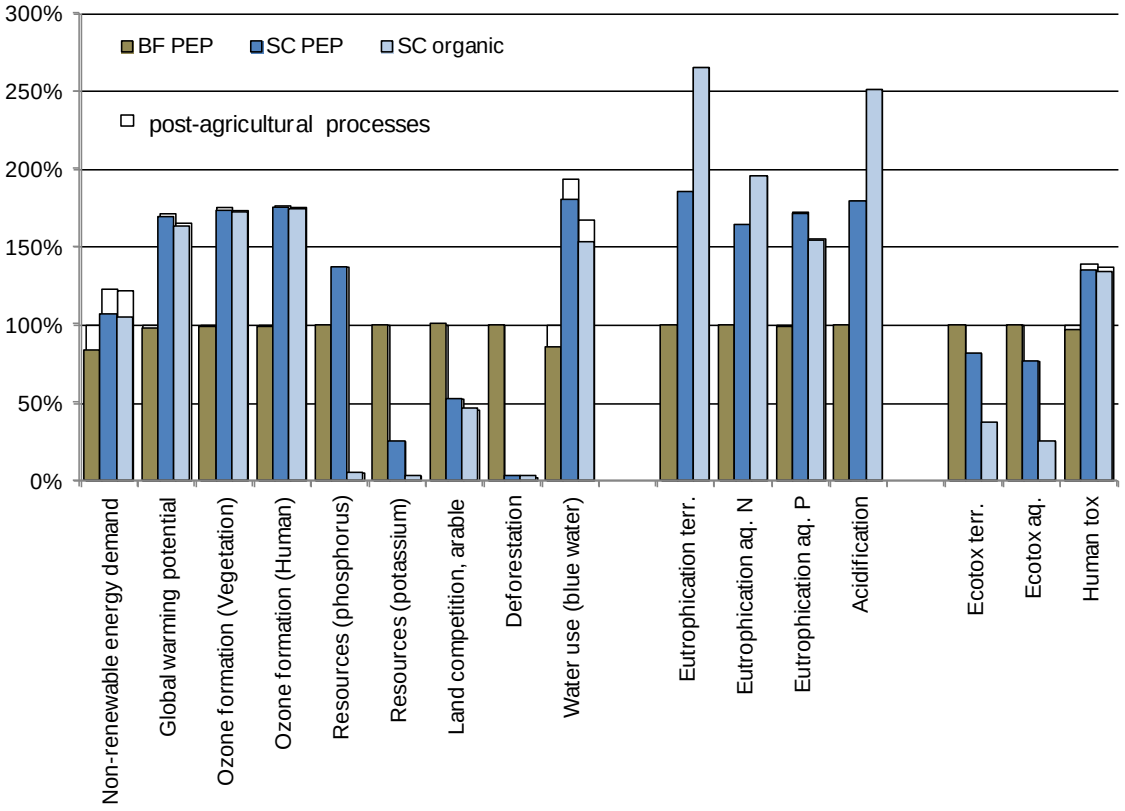


*Figure 1: Environmental impacts per kg ready-to-sell meat of the examined systems 'Beef production Switzerland' ('point of sale' level). The graphic shows the relevant differences between the examined systems per environmental impact, with respect to the 'Bull fattening' (BF) PEP reference system (= 100%). Because the environmental impacts were not weighted, the absolute height of the bars does not say anything about the significance of an individual environmental impact. SC = Suckler cow.*

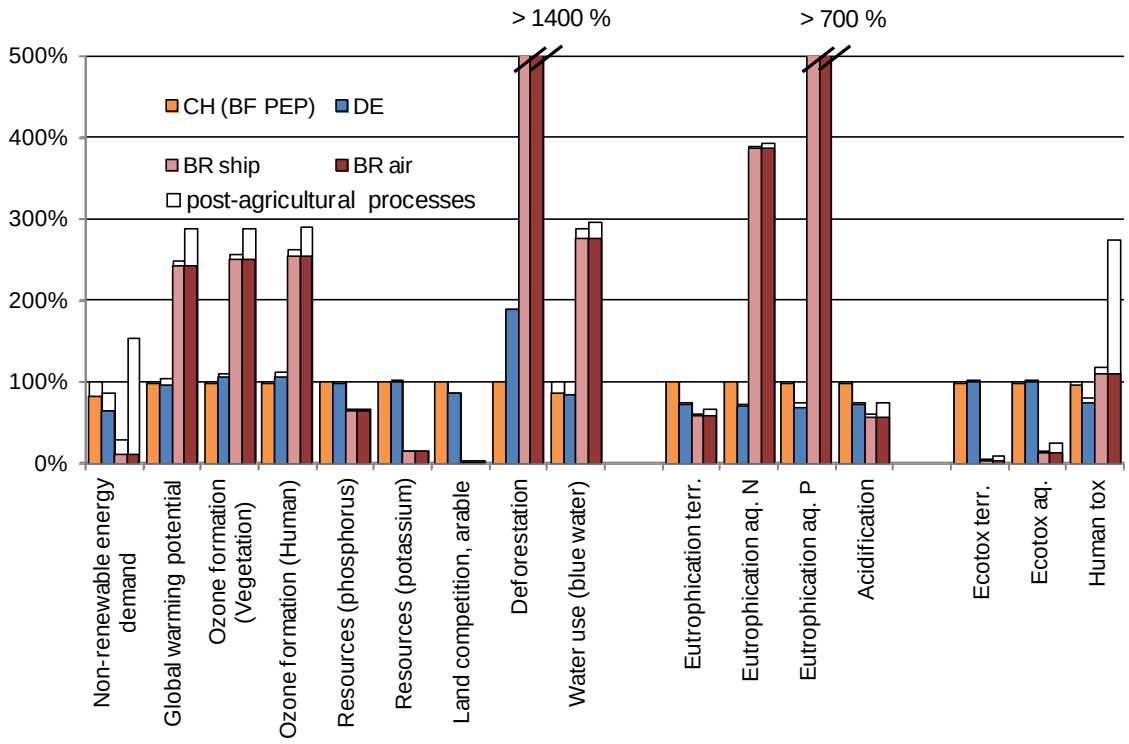


*Figure 2: Environmental impacts per kg ready-to-sell meat of the examined systems Beef production Switzerland (CH, BF PEP), Germany (DE) and Brazil (BR, transported either by ship or aircraft) ('point of sale' level). The graphic shows the relevant differences between the examined systems per environmental impact, with respect to the Swiss reference system in each case ('Bull fattening', BF PEP) (= 100%). Because the environmental impacts were not weighted, the absolute height of the bars does not say anything about the significance of an individual environmental impact.*

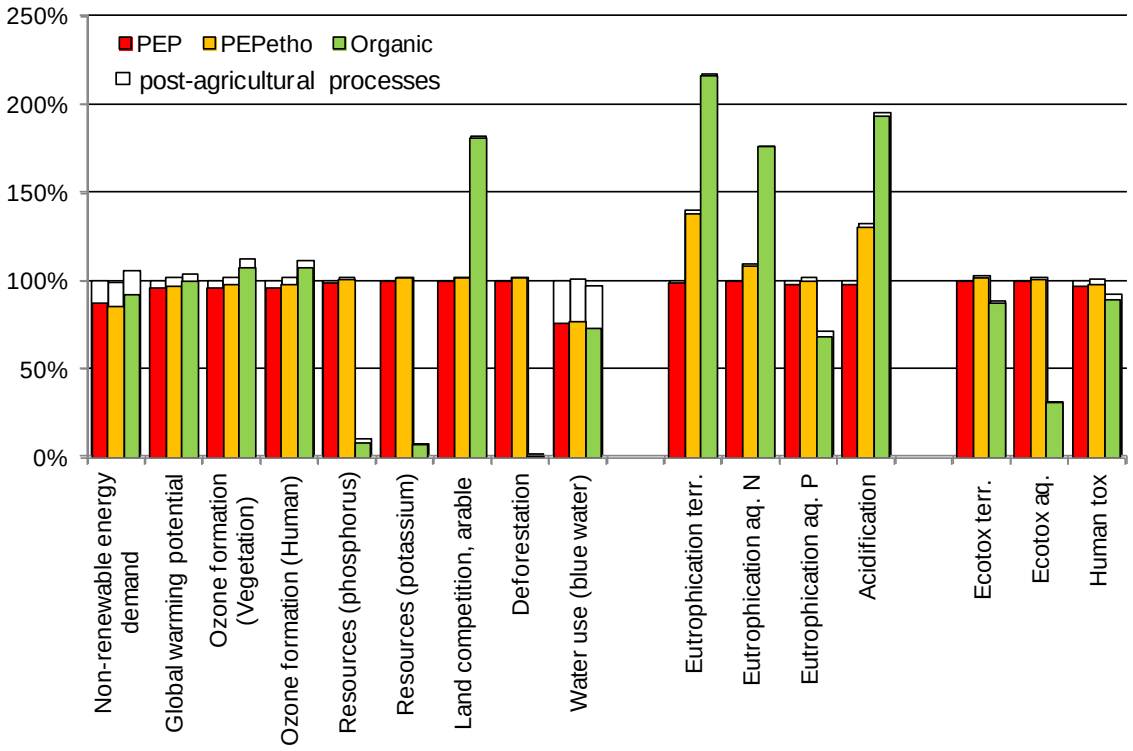


*Figure 3: Environmental impacts per kg ready-to-sell meat of the examined systems 'Pork production Switzerland' ('point of sale' level). The graphic shows the relevant differences between the examined systems per environmental impact, with respect to the PEP reference system in each case (= 100%). Because the environmental impacts were not weighted, the absolute height of the bars does not say anything about the significance of an individual environmental impact. etho = Ethoprogramme (a system geared to animal welfare).*

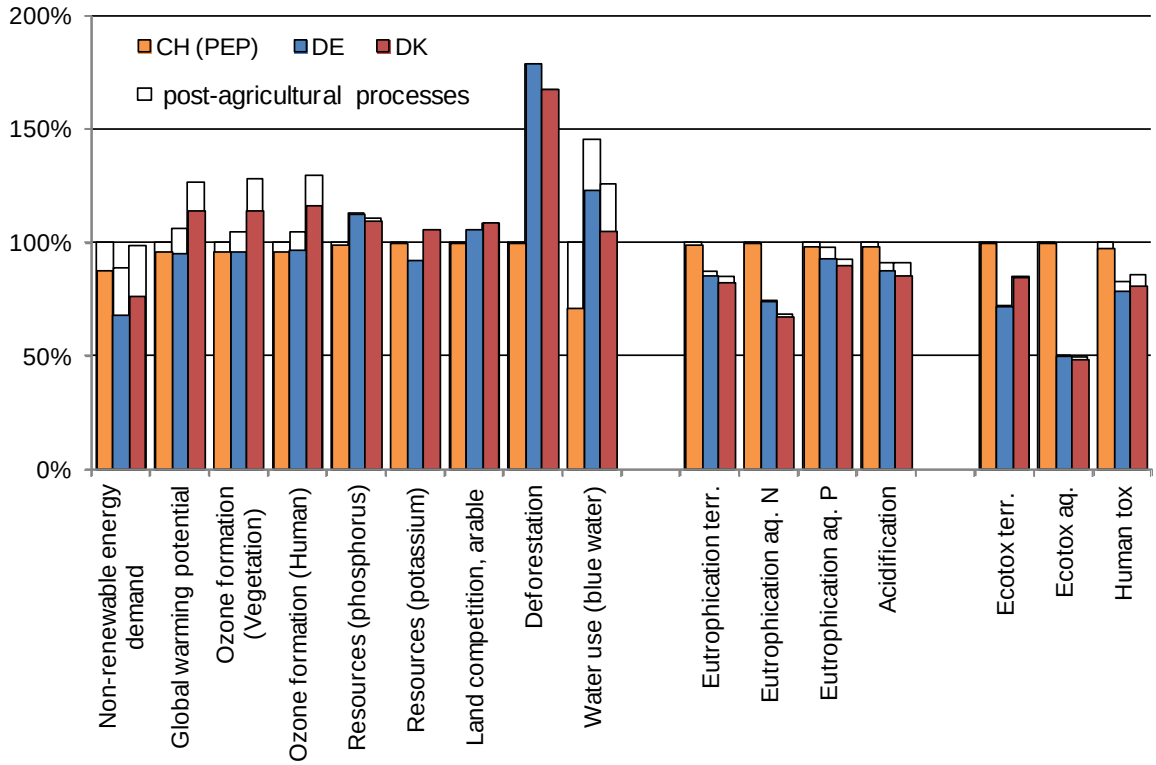


*Figure 4: Environmental impacts per kg ready-to-sell meat of the examined systems 'Pork production Switzerland' (CH, PEP), Germany (DE) and Denmark (DK) ('point of sale' level). The graphic shows the relevant differences between the examined systems per environmental impact, with respect to the Swiss (PEP) reference system in each case (= 100%). Because the environmental impacts were not weighted, the absolute height of the bars does not say anything about the significance of an individual environmental impact..*

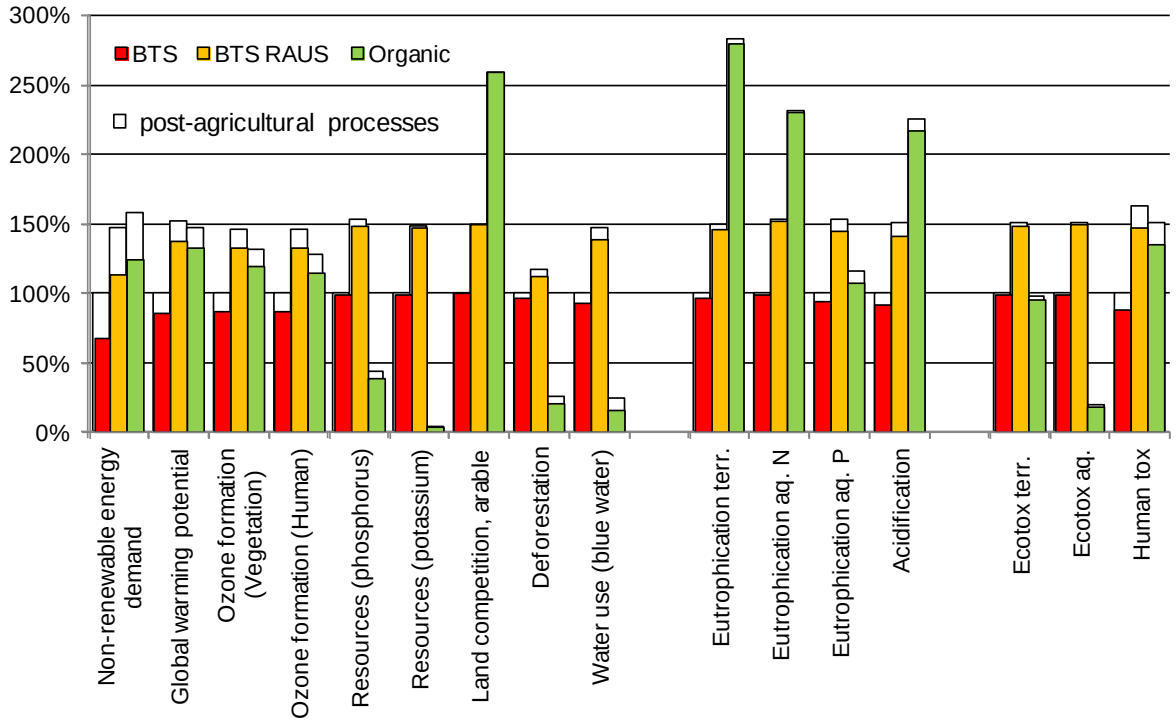


*Figure 5: Environmental impacts per kg ready-to-sell meat of the examined systems 'Poultry production Switzerland' ('point of sale' level). The graphic shows the relevant differences between the examined systems per environmental impact, with respect to the BTS reference system in each case (= 100%). Because the environmental impacts were not weighted, the absolute height of the bars does not say anything about the significance of an individual environmental impact.*

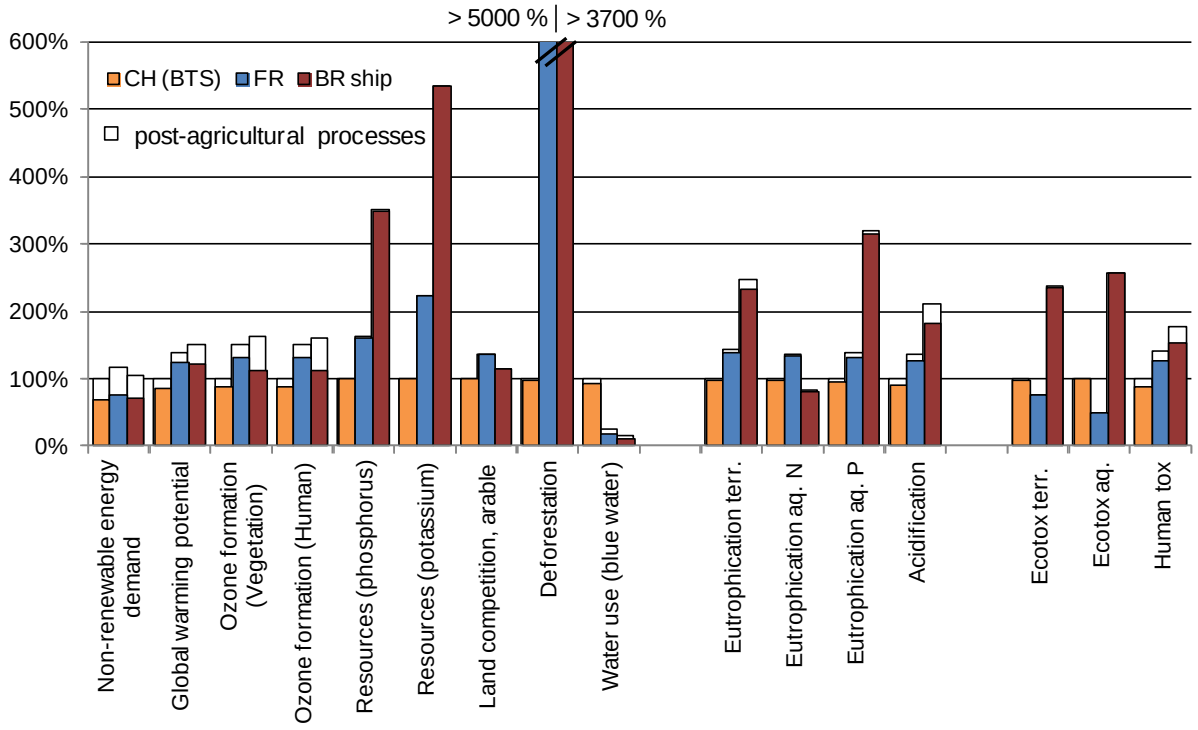


*Figure 6: Environmental impacts per kg ready-to-sell meat of the examined systems 'Poultry production Switzerland' (CH, BTS), France (FR) and Brazil (BR ship) ('point of sale' level). The graphic shows the relevant differences between the examined systems per environmental impact, with respect to the Swiss reference system (CH, BTS) in each case (= 100%). Because the environmental impacts were not weighted, the absolute height of the bars does not say anything about the significance of an individual environmental impact.*