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How to supply food for the Swiss population in an environmentally optimal way by using domestic production resources best?

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Abstract
The environmental impacts of nutrition can be reduced at both the production and consumption stages. We investigated how a diet associated with the lowest possible environmental impacts might look like for the Swiss population. The DSS-ESSA model system, built to simulate the Swiss food supply including imports and exports, was extended by including detailed nutritional requirements and LCA indicators for environmental impacts. The environmental impacts of the diet could be reduced by over 50% in the optimized scenarios, mainly by reducing feed imports, food imports and animal production impacts. The composition of the average diet would change significantly: drop in the proportion of meat (-70%) and larger proportions of grains or potatoes (+35%) as well as legumes including peanuts (20% of protein supply), whilst milk consumption levels would remain constant.

Keywords: *Food supply, environmental impact, optimization model*

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1. Introduction

Food production is associated with significant environmental impacts. Opportunities for reducing them exist at both the production and consumption stages. On behalf of the Swiss Federal Office for Agriculture (FOAG), Agroscope investigated how a diet associated with the lowest possible environmental impacts might look like for the Swiss population. The following issues were studied:

- To what extent could the environmental impacts be reduced?
- What would a needs-based diet for the Swiss population coupled with a reduction in environmental impacts look like?
- How would this alter agricultural production in Switzerland?
- Which consequences for imports and the degree of self-sufficiency are to be expected?

2. Material and methods

For this analysis, the DSS-ESSA model system was used. This decision support system and linear programming model simulates the Swiss food supply, including agricultural production, food processing, external trade and food stock management. Originally, it has been built to identify the optimal allocation of the available resources in scenarios of serious food supply crisis (Fig. 1). Detailed nutritional requirements and indicators for environmental impacts based on LCA methodology were integrated into the model. ReCiPe 2008 methodology (hierarchist, Goedkoop et al., 2009) was used as the default environmental indicator for the target function in the optimization. Five scenarios were analysed: The **Reference** scenario represents the current situation. In all other scenarios the environmental impact (ReCiPe) was minimised, by setting different constraints: in **Min ReCiPe** the nutritional requirements must be fulfilled. In the **FP** scenario, the nutritional recommendations according to the Swiss food pyramid were to be respected. The same applied in **FP/Cal**, but in addition, the energy intake had to be reduced to the recommended level in addition, i.e. by 10% compared to the other scenarios. Finally, in the **FoodWaste** scenario, all preventable food waste during consumption was avoided. In addition, the following conditions were to be met in all scenarios: 1) the whole agricultural area and arable land in Switzerland had to be used for food production, 2) food exports were kept constant at current levels, and 3) current deviations from nutritional recommendations were tolerated, but no further increase was allowed. The detailed description of the model and the full results are reported by Zimmermann et al. (2017).

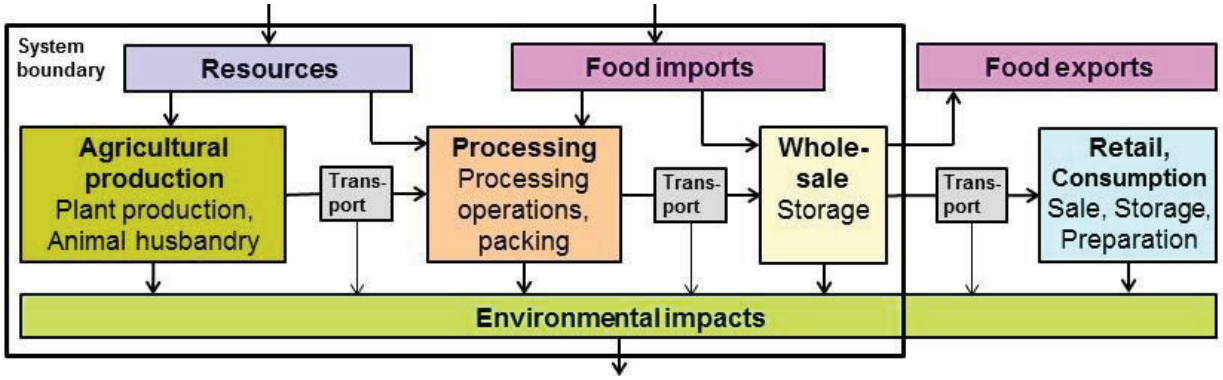

Fig. 1: Food-supply system under consideration.

3. Results

Overall, it appears that the environmental impacts of diet can be reduced by more than 50% (Fig. 2); major improvements are possible for almost all environmental impacts. As regards deforestation, largely dispensing with certain imported products such as soya feedstuffs and cocoa even a 80% reduction could be achieved. Major reductions were also possible for the individual emissions (greenhouse gases and ammonia, -50%; nitrate and phosphorus, -35%). Owing to the higher proportions of milk and vegetables and the lower sugar consumption, compliance with the food pyramid recommendations (FP scenario) led to a smaller reduction in environmental impacts. By contrast, avoidance of food waste in the household yielded a more significant reduction.

The composition of the average diet changed significantly (Fig. 3). Key features of a resource-conserving diet of this sort were a significant drop in the proportion of meat (-70%) and a larger proportion of grains, potatoes or legumes (+35%) as well as nuts or oils (+50%), whilst milk consumption remained at the same level. This result can be explained by the major differences in environmental impacts between animal and plant foods, with milk nevertheless performing significantly more favourably than meat. By contrast, differences among plant foods are often relatively small. Thus, the replacement of potatoes by grains, or nuts by vegetable oils and grains had very little influence on total environmental impact. The optimized diet was closer to the nutritional recommendations than the current diet, especially due to lower meat and alcohol consumption, and its partial replacement of animal fats with vegetable oils and fats.

In line with the decrease in the proportion of meat in the diet, livestock populations – especially pig, fattening-poultry, suckler cow and fattening-cattle numbers – also fell sharply in the model results. Grassland was used for dairy farming, and the proportion of higher-yielding dairy cows increased as far as possible with a grassland-based feeding. Overall, animal populations – measured in livestock units – fell by almost half. A large proportion of the permanent grasslands was farmed extensively. The low-nutrient grass from these lands was fed to the rearing cattle, sheep and goats. The sharp reduction in livestock populations means that feed imports were largely eliminated. Arable land also continued to be used for forage cultivation, but to a significantly lower extent. Whereas a part of this land was used as temporary leys, which are important for a balanced crop rotation, significantly more grains for the human diet (+70%) were grown on arable land. There was also an increase in the area devoted to potatoes (+140%), vegetables (+100%; in the FP scenario, even +350%) and oilseed rape (+20%).

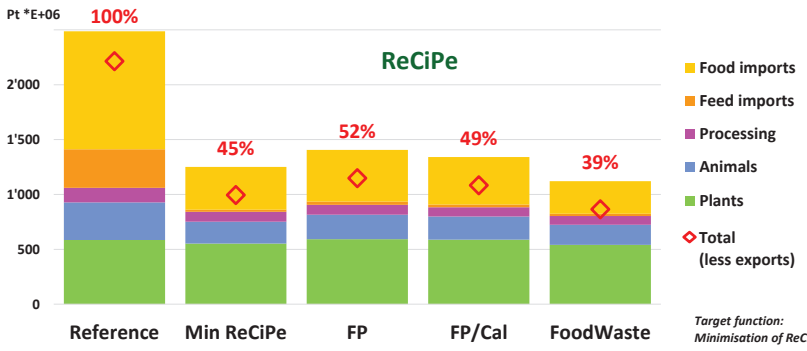

Fig. 2: Environmental impacts of food supply for the Swiss population in five scenarios (indicator ReCiPe 2008 endpoint, hierarchist).

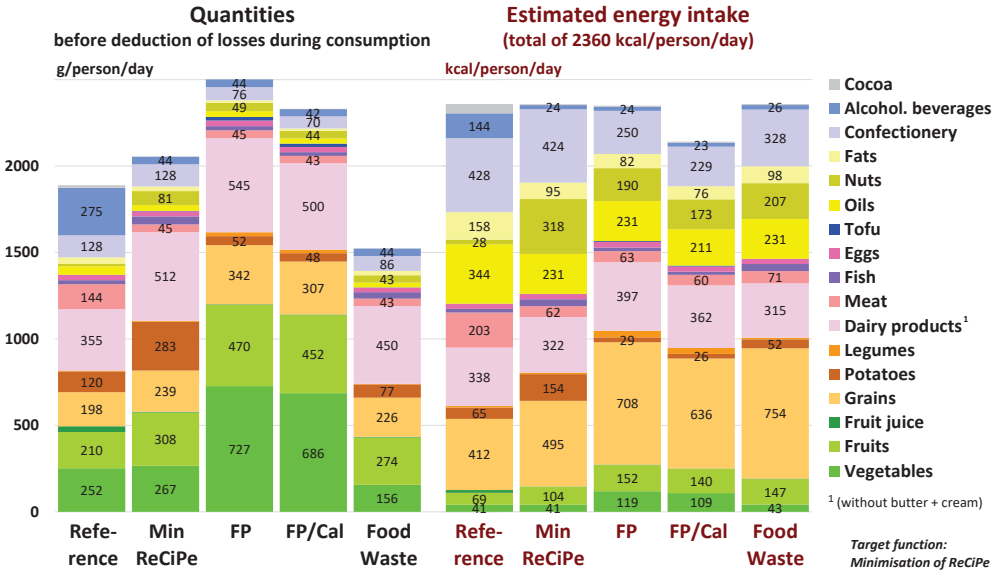

Figure 3: Average diet in the five scenarios.

Since the use of the domestic agricultural area was forced in all scenarios, mainly imports of food (-28% in calories) and feedstuffs (-85%) decreased. As a result, the percentage of domestically produced products, and hence the degree of self-sufficiency, increased significantly, from 61% to around 80%. The total environmental impacts of imported foods fell by around 70%, and those of foods produced in Switzerland – despite the higher amount of calories produced – by 20%.

4. Discussion

A sensitivity analysis showed that these results do not depend on the choice of LCIA method. A similar scale of percentage reduction to that of the ReCiPe indicator (-55%) was also achieved in the case of the minimisation of Impact World+ (-52%), Swiss Ecological Scarcity (-60%) and global warming potential (-61%). Dietary composition trends evolved in the same direction, but with differences for individual products.

In order to derive concrete measures for improvement, detailed investigations requiring a further expansion of the models and data sources used would have to be conducted. Moreover, it might also be necessary to consider economic aspects, depending on the issue examined.

5. Conclusions

A systematic focus on protection of the environment and resource conservation enabled the environmental impacts of the Swiss population's diet to be more than halved whilst maintaining the use of all of Switzerland's agricultural land, with unchanged exports and without an increase in existing deviations from dietary recommendations.

In order to achieve this, the average composition of the diet had to be changed substantially, involving on the one hand a significant increase in the consumption of (a) grains or potatoes, (b) nuts, and (c) fruits or vegetables, as well as the maintenance of dairy consumption in a predominantly unprocessed form; and on the other, a sharp reduction in meat and alcohol consumption, as well as a decrease in the consumption of edible oils, durum wheat products, rice, and processed dairy products. Sugar consumption would remain the same, or fall on the basis of the nutritional recommendations.

At the same time, production processes would need to be optimised, especially in terms of the feeding of cattle, who would essentially exploit the grassland yields. Concentrates would almost cease to be imported, and would only be cultivated domestically on a small scale.

An additional significant reduction in environmental impacts would be possible by avoiding food losses. Whilst losses at the production and processing stages are frequently inevitable, there exist greater reduction potentials at the consumption stage.

Synergy effects would accompany an environmentally optimised diet, since at the same time, it would largely meet current dietary recommendations. Furthermore, lower import levels would increase our degree of self-sufficiency, thereby reducing Swiss dependence on foreign sources.

All in all, the analysis shows that the current situation is far from the ideal of an environmentally friendly, resource-conserving food and feed production system, and that a great potential for improvement therefore exists.

References

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