Food Policy 138 (2026) 103014

Contents lists available at ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

The impacts of nutrient- and health-optimal diets on the food system in Switzerland

Utkur Djanibekov [a,*], Albert von Ow [a], Alba Reguant-Closa [b], Daria Loginova [c], Cédric Furrer [b], Mélanie Douziech [b], Stefan Mann [d], Thomas Nemecek [b]

[a] Research Group Economic Modelling and Policy Analysis, Agroscope, Tänikon 1, Ettenhausen 8356, Switzerland
[b] Research Group Life Cycle Assessment, Agroscope, Reckenholzstrasse 191, Zurich 8046, Switzerland
[c] Seminar for Sociology SfS-HSG, University of St. Gallen, Müller-Friedberg-Strasse 8, St. Gallen 9000, Switzerland
[d] Research Group Socioeconomics, Agroscope, Tänikon 1, Ettenhausen 8356, Switzerland

ARTICLE INFO

Keywords:
Food system impact
Diet change
Healthy consumption
Trade-offs
Synergies
Mathematical programming

ABSTRACT

Current dietary choices deviate from the recommended diet and are unhealthy. Food consumption is interlinked with the food system, and improving dietary choices will have an impact on the food system. The objective of this study is to analyze the impact of nutrient- and health-optimized diets for an average Swiss consumer on the food system. We analyze three scenarios, including projected future diets and diets that optimize nutrient and health indices. We use the Swiss Sustainable Food System model, which is an ex-ante dynamic programming model. The model considers agricultural production, processing, trade, storage, and consumption stages of the food system. The results show that the projected future diet yields slightly better nutrient intake, but slightly fewer health benefits compared to current diets. Diets optimizing nutrient intake and health impacts yield substantial health benefits. Diets optimizing nutrient intake and health impacts increase the consumption of plant-based products by 55% and 78% respectively, in terms of calories, in contrast to the reference scenario, whereas they reduce the consumption of animal-based products by 35% and 43% respectively, in terms of calories. To meet the demand for these dietary shifts, agricultural production should change by increasing the area of crops producing plant-based foods and decreasing livestock numbers. Import dependency increases with diets designed to improve the health of the population. Environmental outcomes result in trade-offs, with greenhouse gas and nitrogen emissions decreasing, while water use and pesticide risks in surface water and semi-natural habitats increase.

1. Introduction

Globally, current dietary choices are sub-optimal from a health, nutrition, and environmental perspective. In general, the consumption of most food groups has increased (FAO, 2018), but the consumption of unhealthy foods outpaces that of healthy foods (GBD Collaborators, 2020). In the comparison of countries by income and socio-development status, unhealthy consumption remains the main risk factor for non-communicable diseases and deaths, regardless of wealth status (GBD Collaborators, 2020). Diets should comprise foods that are healthy, provide nutrients in sufficient quantity, and meet the energy requirements of the individual (Fanzo and Davis, 2019; WHO, 2003).

Food consumption habits are interlinked in the food system with agricultural production, trade, and environmental sustainability (Frehner et al., 2022; Paris et al., 2024). Agricultural production is an important source of rural income and employment, and it produces raw foods that are processed, retailed, and consumed by individuals. However, food production and consumption contribute to 30 % of all greenhouse gas emissions, use 70 % of freshwater, occupy 40 % of land, and lead to natural resource degradation (IPCC, 2019; Springmann et al., 2018; Tilman and Clark, 2014). A dietary change is essential to reducing environmental pollution (Paris et al., 2024). For example, substituting 10 % of calorie consumption from beef and processed meat with vegetables, fruits, nuts, legumes, and seafood can reduce greenhouse gas emissions from food consumption by 33 % (Stylianou et al., 2021). Nevertheless, improving diets could also result in negative

* Corresponding author.
E-mail addresses: utkur.djanibekov@agroscope.admin.ch (U. Djanibekov), albert.vonow@agroscope.admin.ch (A. von Ow), albareguantclosa@gmail.com (A. Reguant-Closa), daria.loginova@unisg.ch (D. Loginova), cedric.furrer@agroscope.admin.ch (C. Furrer), melanie.douziech@agroscope.admin.ch (M. Douziech), stefan.mann@agroscope.admin.ch (S. Mann), thomas.nemecek@agroscope.admin.ch (T. Nemecek).

https://doi.org/10.1016/j.foodpol.2025.103014
Received 13 June 2025; Received in revised form 17 November 2025; Accepted 21 November 2025
Available online 3 December 2025

outcomes. For instance, dietary changes that improve the health of consumers can deteriorate some environmental indicators, such as an increase in water use abroad, as de Lange et al. (2024) showed for Bangladesh. Recent study by the EAT-Lancet commission stated that changing a diet toward a recommended healthy diet can lead to social, economic and environmental trade-offs in the food system (Rockström et al., 2025). Therefore, due to synergies and trade-offs between different dimensions of the food system, the interlink between different actors and processes in the food system should be explicitly considered when developing dietary recommendations or introducing other interventions in the food system (Béné et al., 2019; Rockström et al., 2025).

Previous research has analyzed the impact of dietary recommendations, such as the EAT–Lancet diet or dietary recommendations developed by local government organizations, on health, economic, environmental, and social indicators. Some of these studies have focused on dietary recommendations that improve the health of the population by improving nutrient intake in diets (e.g., Horgan et al., 2016; Zhao et al., 2025). Other studies have analyzed the impacts of improving diets using health indices (e.g., Paris et al., 2024; Stylianou et al., 2021). They showed how these diets affect other elements of the food system and may lead to synergies and trade-offs.

The studies that analyzed the impacts of dietary changes used different approaches, such as life cycle assessment (e.g., Paris et al., 2024), a system dynamics model (e.g., Eker et al., 2019), value chain and footprint analyses (e.g., Kim et al., 2020; Li et al., 2024), and statistical estimations (Clark et al., 2019). However, these approaches may not provide information on optimal health outcomes for consumers because they lack behavioral responses and do not provide information on ex-ante changes in the studied system due to optimal dietary shifts. Studies that applied ex-ante optimization methods for analyzing dietary impacts considered the individual or household (e.g., Zhao et al., 2025), agricultural sector (e.g., Rieger et al., 2023; Springmann et al., 2018), and economy-wide (e.g., de Lange et al., 2024) models. Springmann et al. (2018) used an agricultural sector model at the global level, which includes food system settings, to understand the impacts of dietary changes toward guidelines and flexitarian diets on the environment. A few studies that used an ex-ante optimization model investigated the effects of dietary changes toward recommendations or due to import disruptions on the food system at the country level (e.g., Ferjani et al., 2018; von Ow et al., 2020). For example, von Ow et al. (2020) analyzed the impacts of the minimization of environmental outputs on the food system while considering changes in diets toward recommendations.

However, previous research did not identify the nutrient- and health-optimal diets within the food system's settings and constraints, which might restrict the supply of food products and lead to trade-offs as a result of these diets (Hirvonen et al., 2020). Optimizing diets to improve nutrient intake and health impacts using the ex-ante food system model allows for the simultaneous capturing of the multidimensional impacts of identified nutrient- and health-optimal diets on the food system, such as economic, environmental, and social impacts. Therefore, our contribution to this research stream is the application of an ex-ante food system model to analyze the various impacts of nutrient- and health-optimal diets to improve the health of the population on the food system.

Our case study is the Swiss food system. In Switzerland, the federal government has been promoting a nutritious, healthy, and sustainable diet within the Swiss Nutrition Strategy (FSVO, 2025). Based on this strategy, the Swiss Dietary Recommendations were developed.[1] The Swiss Dietary Recommendations takes a holistic approach by considering the consumption of nutritious and healthy foods, and environmental sustainability. The recommendation provides dietary guidelines based on the consumption of eight food groups, which are given as a range of consumption portions and food amounts. Nevertheless, the current diet of most of the Swiss population is suboptimal, deviating from the recommendations of experts for health improvement and disease risk reduction (Marques-Vidal et al., 2023; Schuh et al., 2018). Schuh et al. (2018) showed that over six out of ten surveyed participants failed to comply with at least three guidelines from food-specific groups. An unhealthy diet is the most important risk factor for non-communicable diseases, affecting over 2.3 million Swiss people aged 15 and over, amounting to 80 % of healthcare costs (FOPH, 2025). This trend is expected to further increase due to the aging of the Swiss population (Marques-Vidal et al., 2023).

In addition to health impacts, dietary changes affect other elements of the food system. For example, the availability of food products for consumers can increase their adherence to dietary recommendations (de Mestral et al., 2020). According to Goal 21 of the Legislative Planning of Switzerland, domestic agricultural production needs to ensure a secure supply of food to the population.[2] Adequate domestic production of food commodities for consumers is not guaranteed because Switzerland has insufficient agricultural areas and produces insufficient amounts of food to meet population demand. Therefore, the country is dependent on imports to provide about half of the food consumed in terms of calories (Agristat, 2024). Almost one third of the consumed calorie levels come from animal-based products (Agristat, 2024), which mostly originate from domestic livestock production. The food system also substantially affects the environment. The environmental impacts of food consumption in Switzerland account for 25 % of the total environmental impacts (Nathani et al., 2022). Globally, Swiss agricultural production has the third highest negative environmental externalities per calorie supplied, and its external costs for the environment and health amount to about 26 billion USD per year (Lucas et al., 2023).

The Swiss federal government aims to make the food system more sustainable and is developing Agricultural Policy 2030+.[3] The policy is a response to the parliamentary mandate and is based on a postulate report on the future direction of agricultural policy, which shows how agriculture and the food sector need to develop by 2050 (Federal Council, 2022). The postulate report states that agricultural policy must be further developed by strengthening its contribution to healthy and sustainable nutrition, and that in addition to agriculture, further development is needed in the downstream and consumption stages to make the food system more sustainable. Accordingly, Agricultural Policy 2030+ aims to take a holistic approach to the food system and includes all stakeholders in the value chain. The policy will focus on achieving guaranteed food security, reducing environmental footprints, and improving economic and social prospects in the future. The Swiss Dietary Recommendations will likely be considered in this policy when recommending policies for a more sustainable food system with dietary changes. However, the dietary recommendations are developed by focusing on nutritional, health, and environmental sustainability (Christen, 2025), while other elements of the food system are not explicitly considered. In this paper, we consider various elements of the food system in analyzing dietary shifts, which may help to better understand the different impacts of and possible barriers to implementing dietary recommendations and, accordingly, help to tailor policies.

The objective of this study is to analyze the impacts of nutrient- and health-optimal diets that improve the nutritional and health status of an average Swiss consumer on the food system. We assess three dietary change scenarios: (1) projected future food consumption based on interpolation from historical observations, (2) diet optimizing nutrient intake, and (3) diet maximizing health impacts. We analyze the impacts of nutrient- and health-optimal diets on the food system, including

[1] https://www.blv.admin.ch/blv/de/home/lebensmittel-und-ernaehrung/ernaehrung/empfehlungen-informationen/schweizer-ernaehrungsempfehlungen.html.

[2] https://www.bk.admin.ch/bk/de/home/dokumentation/fuehrungsunterstuetzung/legislaturplanung.html.

[3] https://www.blw.admin.ch/en/agricultural-policy-2030.

impacts on health, nutrient intake, agricultural production, trade, and the environment.

2. Methods

2.1. Overall structure of the model

We use the Swiss Sustainable Food System (SWISSfoodSys) model to analyze the impacts of the optimization of nutrient intake and health impacts of diets on the Swiss food system (Fig. 1). SWISSfoodSys is an ex-ante dynamic programming model that simulates the period from 2019 to 2050. We consider 2019 the initial year of the model to exclude the temporary impacts of COVID-19 on the food system.

The SWISSfoodSys model considers different stages of the food system: (1) agricultural production (crop and livestock), (2) processing (food, feed, and byproducts), (3) trade (export and import), (4) storage (compulsory and optional each year), and (5) consumption (dietary pattern, nutrient, and calorie intake, and health impacts).

Agricultural production includes 43 crop activities and 41 livestock categories. Crop production includes three production methods (conventional, organic, and pesticide reduced) and three regions (mountain, hill, and valley) of Switzerland. Furthermore, there are different livestock and milk production intensities. Livestock categories transition between different ages from newborn animals to older animals, for example, cattle that are between 1- and 2-years old transition over time to cattle that are over 2 years old. Crop and livestock production is interlinked through fodder crops given to livestock and manure used for growing crops. The total agricultural area in Switzerland is limited to the current total area. We assume that positive and negative effects on yields (e.g., breeding progress, climatic changes, and restrictions on pesticide use) balance each other out, so that yields per crop area and per livestock unit remain constant in the study period (2019–2050).

Monetary costs and revenues are calculated only at the agricultural production stage of the SWISSfoodSys model. The cultivation of crops and rearing livestock relies on the employment of farm household members and hired labor. Livestock categories produce raw products and manure for fertilizing crops, and crops produce raw products and seeds for crop cultivation. Raw crop and livestock products can be either used at the agricultural production stage, exported, stored, or processed. Raw and processed products can also be imported from abroad, especially products that are insufficiently or not produced in Switzerland. The model's processing stage includes 127 products, which include feed given to livestock and products exported, supplied to consumers, and stored for the next periods.

The trade stage of commodities includes the import and export of raw and processed products. Some imported raw products are processed in Switzerland and can be exported abroad. Processed, imported, and stored products can be supplied as food for consumption. We consider 78 food products that are supplied through domestic production and imports. We split the flour and bread of wheat, rye, and spelt into refined and whole-grain foods. Barley grains and oat flakes are considered whole-grain foods, whereas rice, pasta, and pastries are assumed to be refined grain foods. We assume the actual (i.e., observed) consumption, import, and export quantities of whole grains to be 17.5 % and refined grains to be 82.5 %, which are based on the consumption quantities of whole and refined grains in Switzerland, as reported by von Blumenthal et al. (2025). We assume an overall Swiss population of 8.54 million people in 2019 as consumers. Using the population growth rate, we assume that the population will increase over time and reach 10.40 million by 2050 (FSO, 2020a). We do not consider policy, technological, and other exogenous changes over time, except for the population growth rate.

The SWISSfoodSys model results can provide economic (e.g., production quantities), social (e.g., farm employment), environmental (e.g., greenhouse gas emissions, water use, nitrogen emissions, and pesticide applications), and political (e.g., food waste and food self-sufficiency) outputs. The main equations of the model are given in Supplementary Material A. The SWISSfoodSys model is programmed in the General Algebraic Modeling System (GAMS), and its codes are provided by Djanibekov and von Ow (2025).

2.2. Nutrition and health indicators

In the SWISSfoodSys model, we assume the food consumption of an average Swiss consumer. Food consumption considers lower and upper constraints for the number of food portions of actual (i.e., observed)

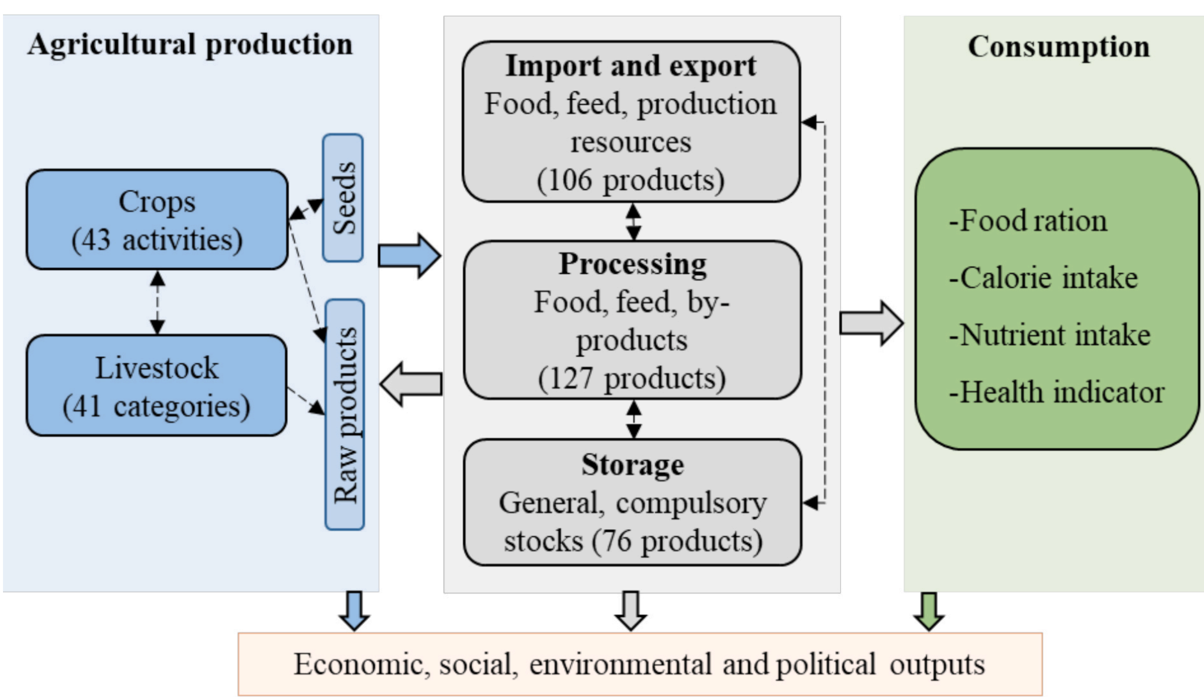

Fig. 1. Schematic view of the Swiss Sustainable Food System (SWISSfoodSys) model.

consumption. The upper and lower limits of the consumption of food portions are derived based on deviations from the actual consumption of food products. We model the impacts of food consumption on the health of the Swiss population using the Health Nutritional Index (HENI), as described by Stylianou et al. (2021), and based on epidemiological data from the Global Burden of Disease study (GBD Collaborators, 2020). In the model, 15 dietary risk factors are considered for the HENI analysis using Swiss-specific dietary risk factors from Ernstoff et al. (2020). This index uses the micro-disability adjusted life years (μDALYs), which is a measure expressed in the number of minutes lost due to ill health, disability, or early death as a result of unhealthy diets (GBD Collaborators, 2020; Stylianou et al., 2021). We multiply μDALY by –0.53 to convert μDALY into the HENI score, with one positive point of HENI corresponding to one minute of healthy life gained from healthy food consumption, while one negative point of HENI corresponds to one minute of healthy life lost due to unhealthy diets. The HENI score is calculated per food product.

We also calculate the nutrient density of foods and diets using the Nutrient Rich Food Index 10.3 (NRF10.3; Drewnowski et al., 2021; Fulgoni et al., 2009). The NRF10.3 index includes 10 nutrients to encourage (i.e., qualifying nutrients) and 3 nutrients to limit (i.e., disqualifying nutrients) food consumption. For the analysis at the diet level, we apply capping at the maximum level of consumption of qualifying nutrients, because the increase in the consumption of qualifying nutrients above the recommendation does not lead to an increase in the nutritional quality of a diet. At the diet level, we assume that disqualifying nutrients are considered only when they exceed their highest level of consumption recommendations. Nutrient recommendations are based on the daily nutrient intake of average male and female adults in Switzerland (FSVO, 2023a). The values of the recommended daily intake of nutrients and dietary risk factors are given in Tables A and B, respectively, in Supplementary Material B.

We also assume upper and lower limits of calorie requirements of 2,280 and 2,380 kcal/capita/day, respectively. We do not consider nutritional or food supplements that can increase the nutrient intake and health of a population. Table 1 presents the main assumptions of the model on dietary patterns.

2.3. Life cycle assessment and environmental impacts

All stages of the food system in the SWISSfoodSys model cause environmental impacts. These environmental impacts in the food system are calculated using a life cycle assessment approach (Nemecek et al., 2024) and obtained from the literature (e.g., Dueri and Mack, 2024; Korkaric et al., 2023). Life cycle inventories are generated for agricultural activities and food, feed, and byproducts using the Swiss Agricultural Life Cycle Assessment (SALCA) model. To cover the environmental impacts of imports, we collect life cycle inventories from existing databases: ecoinvent (Wernet et al., 2016), Agribalyse (Koch and Salou, 2016), AgriFootprint (van Paassen et al., 2019), World Food LCA database (Nemecek et al., 2019), and the SALCA databases (Gaillard and Nemecek, 2009). For imports, we consider a mix of countries of origin and related means of transportation. To calculate the environmental impacts of life cycle inventories, we use the SALCA v2.01 method (Douziech et al., 2024). In this study, we model greenhouse gas and nitrogen emissions, water use, and pesticide risk indicators. We calculate greenhouse gas emissions and water use for agricultural production, processing, and cooking in Switzerland, as well as for imported and exported products. Pesticide risks are calculated for groundwater, surface water, and semi-natural habitats from domestic crop production, in which pesticide risks are produced from crops grown on different production methods (conventional, organic, and pesticide reduced) and in three regions (mountain, hill, and valley). Nitrogen emissions are calculated for domestic agricultural production by considering the nitrogen application for crops. The model also includes food waste from food processing and household consumption (Beretta, 2018). We assume that there are no technological changes affecting the environmental output and production efficiency of the food system.

Table 1
Main assumptions related to diets.

Consumption variables	Description
Food portions	Upper and lower boundary of portions of food groups
Lower boundary of calorie intake	2,280 kcal/capita/day
Upper boundary of calorie intake	2,380 kcal/capita/day
μDALYs	Micro-disability adjusted life years, which includes 15 dietary risk factors
Health Nutritional Index (HENI)	Positive values show the minutes of healthy life gained from healthy food consumption and negative values show the minutes of healthy life lost from unhealthy food consumption
Nutrient Rich Food index (NRF10.3)	Ten qualifying nutrients: protein, fiber, vitamins A, C and E, potassium, calcium, magnesium, iron, and iodine Three disqualifying nutrients: sugar, saturated fats, and sodium

2.4. Scenarios

We analyze with the SWISSfoodSys model the impacts of nutrient- and health-optimized diets, including diets improving health, such as optimal nutrient intake and optimal impacts on the health of the average Swiss consumer. In addition, we analyze the impacts of projected changes in the consumption of food products based on interpolations from historical observations. We simulate separate diets that optimize nutrient and health impacts to observe the differences in their impacts on health and the food system. The study does not model specific diets, such as vegetarian and vegan diets. The model initially simulates the reference scenario with the current actual food consumption patterns of the average Swiss consumer. To analyze the impact scenarios, we compare them with the reference scenario. We simulate the following three scenarios (Table 2):

- The *Projection scenario* analyzes the impact of possible future changes in food consumption on the food system. This scenario is simulated to observe how the expected future diet might change from the current diet in the reference scenario and to analyze the impacts on the health of the consumer and the performance of the food system. We assume that the future diet will be based on estimated trends from the historically observed actual consumption of food products (Loginova and Mann, 2024a, b; Mann and Loginova, 2023). Food consumption projections until 2050 for each food are based on observations of food consumption of 78 foods by 46,456 households in Switzerland over the years 1990–2017 (FSO, 2022). To forecast the food consumption of an average consumer, we employ a 3-step procedure: we (1) assess linear models for growth in consumption of each food, (2) extrapolate the estimated trends for each food, and (3) transform growth in consumption back to consumption in levels. In this scenario, we assume that the maximum and minimum quantities of food portions and calories are not constrained; instead, the

Table 2
Summary description of scenarios.

Scenarios	Description
Reference	Current average quantity of food consumption.
Projection	Consumption of food products based on the estimated projection of historical observation of food consumption.
MaxNutrient	Optimization of nutrient consumption (nutrient density) level of the population using the Nutrient Rich Food Index 10.3 (NRF10.3).
MaxHealth	Optimization of health of the population from diets using the Health Nutritional Index (HENI).

consumption of food products, portions, and calories follows the projection amount.

- The *MaxNutrient scenario* identifies the consumption quantity of food products to improve the nutrient density of the diet by having an optimal level of nutrient intake. To model the optimal level of nutrient intake at the diet level, we maximize the NRF10.3 index over the modeled period of 2019–2050, considering the summed difference between 10 qualifying nutrients that positively contribute to a nutritious diet and 3 disqualifying nutrients that negatively contribute to a nutritious diet. We cap the maximum consumption level of qualifying nutrients to limit the effect of nutrient intake above the recommendation. We assume a threshold for disqualifying nutrients at a diet level, and these nutrients are accounted for when they exceed the highest level of consumption recommendations (for a detailed description of the index, see Section 2.2). We also consider the maximum and minimum quantities of food portions and calories consumption amount.
- The *MaxHealth scenario* maximizes the health of a consumer affected by the consumption of food products based on the HENI. We assume that the consumer will optimize her/his consumption pattern and select food products that will lead to the maximum positive health impacts considering the food system settings. In this scenario, to find the optimal value of HENI, we maximize the summed difference between the consumed food products that have positive and negative impacts on HENI over the modeled period. The positive value of HENI shows a healthy life gained from a diet, while the negative value shows a healthy life lost due to an unhealthy diet. Similar to the MaxNutrient scenario, the maximum and minimum quantities of food portions and calorie consumption amounts are included.

For simplicity in interpreting the results and to capture the dynamics of adjustments in the food system and food consumption projections, we present the scenario results of the last modeled period, that is, 2050. For simplicity to present the model results, we aggregate food products, crops and livestock categories into food, crop and livestock groups (see Tables C1–C3 in Supplementary Material B).

The model is validated by comparing the results of the reference scenario on consumption, crop area, and livestock number against their values in the actual observed situation in 2019, which is the input data used for the SWISSfoodSys model as described in Section 2.5 (see Tables D1–D3 in Supplementary Material B). The difference between the reference scenario and the actual situation is negligible for most of the activities and products.

2.5. Data sources

The SWISSfoodSys model uses statistical data on crop areas and livestock numbers (FOAG, 2020), foreign trade (FOCBS, 2020), domestic production and consumption (Agristat, 2020), and economic yields and costs (FSO, 2020b). Food consumption data used to derive the food portion constraints are based on the actual consumption of food products of an average Swiss adult in 2019 (Agristat, 2020). Specific technical data (e.g., farm labor force needed, feeding restrictions, and food processing factors) have been taken from agricultural databases (e.g., Agridea, 2020; Agristat, 2020; Agroscope, 2021) and food industry reports (e.g., Agristat et al., 2020). Most of the data used for the SWISSfoodSys model are based on 2019—that is, a year before the COVID-19 pandemic started.

Furthermore, the model uses data on environmental impacts calculated with the SALCA method (Nemecek et al., 2024) and from other life cycle inventory databases (Koch and Salou, 2016; Nemecek et al., 2019; Van Paassen et al., 2019; Wernet et al., 2016). The data on pesticide risk scores are based on studies by Dueri and Mack (2024) and Korkaric et al. (2023). Projected food consumption information is obtained from Loginova and Mann (2024a, b) and Mann and Loginova (2023). These studies used the food consumption database from FSO (2022), consisting of 20 million observations from 46,456 households in Switzerland over the years 1990–2017. This dataset considers the consumption of food at home and does not consider the consumption of food away from home (e.g., restaurant and cafeteria food). Information on the nutritional composition of food products is from FSVO (2023b), and the dietary risk factors for the Swiss population used for the HENI calculations are based on Ernstoff et al. (2020).

The data used for this study, except NRF10.3 and the HENI values and environmental impacts, are available at von Ow and Djanibekov (2025). The data on NRF10.3 and the HENI values and environmental impacts are available at sources as mentioned in sections 2.2 and 2.3, respectively.

3. Results

3.1. Health and nutrients

In the reference and Projection scenarios, the largest quantity of calories in a diet stems from refined grain products and sweets and sweetened beverages, such as sugar, honey, chocolate, ice cream, soft drinks, and other sugar products (Fig. 2). Consumption of calories of meat and dairy products, cooking oil, and alcoholic beverages is also high. Considering the projected consumption pattern (Projection scenario), the main difference from the reference scenario lies in an increased consumption of sweets, meat, and dairy products and a decreased consumption of refined grain products. As a result of these dietary changes, the total consumed daily calories are projected to be slightly higher than in the reference scenario.

Diets in the MaxNutrient and MaxHealth scenarios have a similar trend in the consumption increase of vegetables, fruits, grains, potatoes, and nuts because these foods are nutritious and positively affect nutrient intake and health impacts. In the MaxHealth scenario, consumption of whole grains is the largest among the scenarios, as they substantially contribute to improving health, whereas refined grains are not consumed due to their almost zero health benefits. In this scenario, the consumption of sweets, sweetened beverages, fruit juices, alcoholic beverages, and meat products is almost zero. Sweets, sweetened beverages and fruit juices have low health benefits but high calorie content, and thus their consumption is reduced to consume foods with higher health benefits per calorie level. Alcoholic beverages and meat products are consumed in negligible quantities due to their negative impacts on health. Red meat is consumed in small quantities to meet the calorie consumption constraint and food portion constraint on meat products and other protein sources, whereas poultry is not consumed. In the MaxNutrient scenario, the share of refined grain and dairy products in diets is larger than in the MaxHealth scenario because dairy products provide large amounts of calcium, and refined grain products are mainly consumed to fulfill calorie requirements in the MaxNutrient scenario.

When comparing the diets in the MaxNutrient and MaxHealth scenarios with the Swiss Dietary Recommendations, then they substantially differ from the recommendation (Table E in Supplementary Material B). These diets have larger consumption of grain products and potatoes, protein sources, particularly fish and meat alternatives, nuts, and oils, especially cooking oil. They have lower consumption of portions of meat, sweets and sweetened beverages than the recommendation.

The impacts of diets in the reference and Projection scenarios on health (i.e., HENI index) are similar (Fig. 3). Large positive health benefits come from the consumption of fruits, followed by nuts, grains, and vegetables. Future projected diets result in larger health benefits from fruits and nuts but lower health benefits from vegetables and grains than in the reference. These diets also include large quantities of unhealthy foods, such as alcoholic beverages and meat products, whose projected consumption is expected to increase. The overall health impacts for an individual are positive, amounting to 19.1 and 18.9 min/capita/day of healthy life gained for the reference and Projection scenarios, respectively.

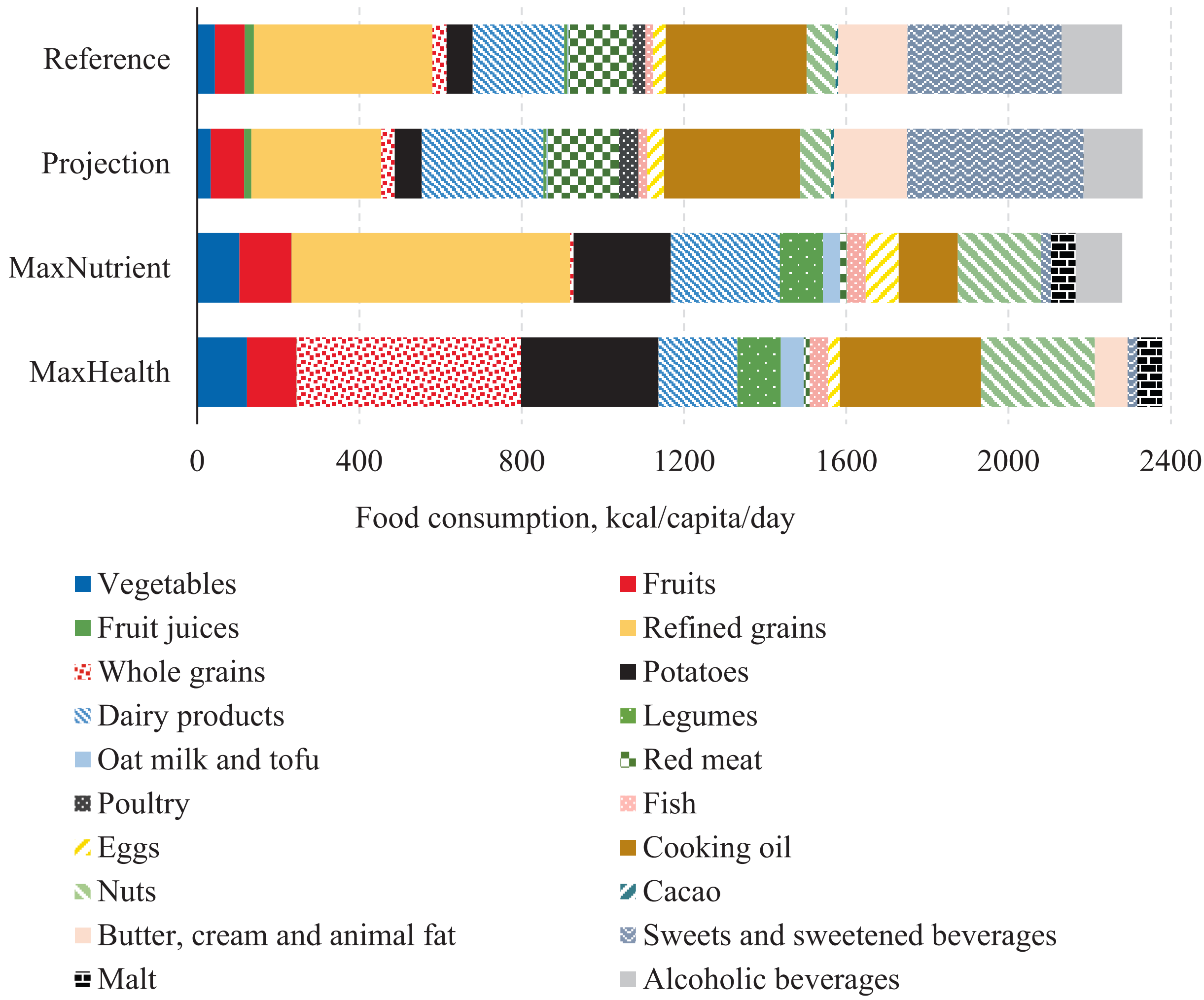

Fig. 2. Food calorie consumption in the reference, Projection, MaxNutrient, and MaxHealth scenarios. Note: MaxNutrient is the Nutrient Rich Food Index (NRF10.3) maximization scenario. MaxHealth is the Health Nutritional Index (HENI) maximization scenario. Food waste is subtracted in the calculation of food calorie consumption.

The health benefit of the MaxNutrient scenario diet is 63.5 min/capita/day of healthy life gained. The quantity of some foods in diets that have positive health effects, such as dairy products and cooking oil, is reduced. The negative effect of the diet optimizing nutrient intake on health is 5.6 min/capita/day of healthy life lost, which comes from the intake of alcoholic beverages and meat products, although their values are lower than in the reference and Projection scenarios. The net health impact of the diet is 57.9 min/capita/day of healthy life gained.

The positive health impacts of the MaxHealth scenario are substantially larger than those of the other simulated scenarios. The large share of health benefits comes from the increased consumption of whole-grain products and nuts, followed by fruits and vegetables. Drinking alcoholic beverages and eating meat products increase the risks related to a diet; thus, their consumption is close to zero. In the MaxHealth scenario, the HENI value is 374 %, 379 %, and 57 % larger than in the reference, Projection, and MaxNutrient scenarios, respectively.

Consumption of potassium, iodine, iron, magnesium, vitamin C, calcium, and fiber is below the optimum in the reference scenario (Fig. 4). Saturated fats and sugar exceed the maximum recommended quantities and have negative effects on nutrition. In the projected food consumption scenario (i.e., Projection), the intake of some nutrients is slightly better compared to the reference scenario. Consumption of potassium, calcium, magnesium, iron, and iodine increases in this scenario in comparison to the reference scenario. However, the amounts of sugar and saturated fats in the diet are also projected to increase, and the intake of fiber slightly decreases.

The MaxNutrient scenario captures the nutrient adequacy of the diet, optimizing nutrient intake (i.e., the NRF10.3 index). Here, the amount of all qualifying nutrients in the diets reaches the recommended level. In addition, the consumption of disqualifying nutrients is lower than the maximum recommended consumption levels; accordingly, they do not negatively affect the diet and are shown as zero in Fig. 4. In the MaxHealth scenario, which optimizes health impact, the intake of nutrients is also substantially improved, in contrast to the reference and Projection scenarios. However, iodine and calcium do not reach the recommended amounts.

3.2. Agriculture

Switzerland's agricultural activities are adjusted to capture the shift in the population's diets. The land use pattern in the MaxNutrient and MaxHealth scenarios substantially differs from that of the reference and Projection scenarios (Fig. 5). In the reference and Projection scenarios, grains, silage maize, and rapeseed occupy the largest crop areas, and the difference in land use areas between these scenarios is minor. In the MaxNutrient and MaxHealth scenarios, the cultivation areas of sugar beet, silage maize, rapeseed, and triticale substantially decrease, while the areas of vegetables, fruits, potatoes, soya, legumes, and barley increase. As nutrient- and health-optimizing diets differ, they also lead to differences in land use patterns. For instance, in the MaxNutrient

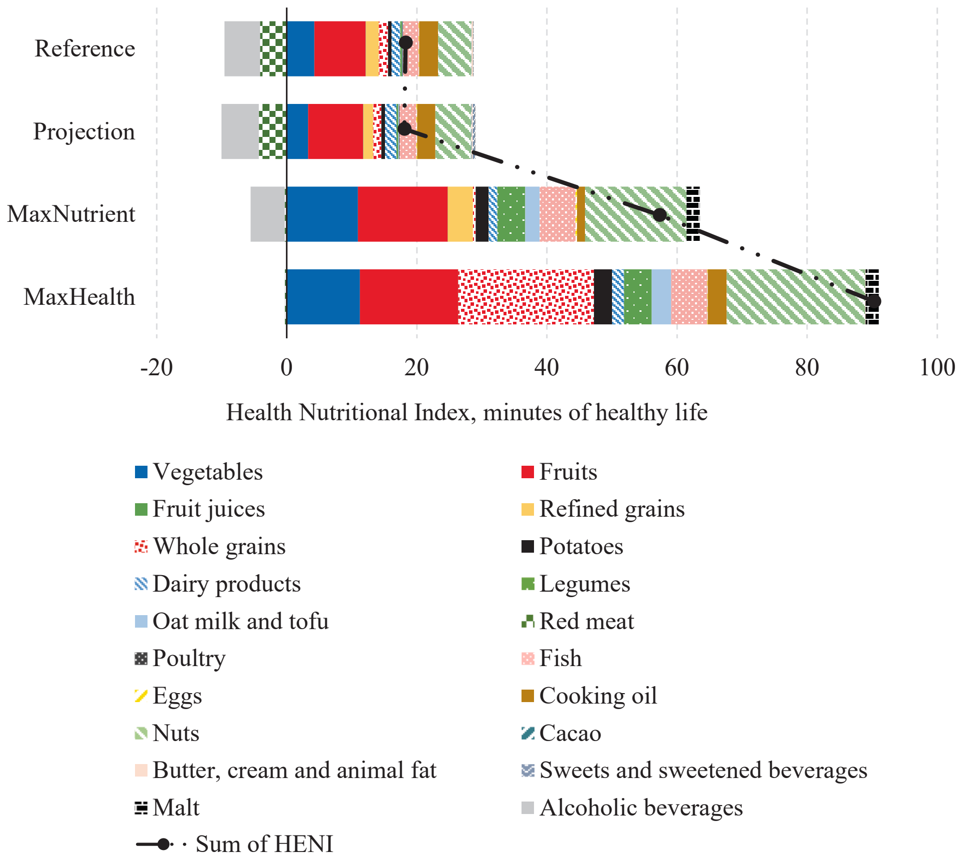

Fig. 3. Impacts of food consumption on the Health Nutritional Index (HENI) in terms of minutes of healthy life gained or lost in the reference, Projection, MaxNutrient, and MaxHealth scenarios. Note: MaxNutrient is the Nutrient Rich Food Index (NRF10.3) maximization scenario. MaxHealth is the HENI maximization scenario. Positive values of HENI reflect the minutes of a healthy life gained from food consumption. Negative values of HENI reflect the minutes of a healthy life lost from food consumption. The sum of HENI is the difference between the positive and negative health impacts of foods. Food waste is subtracted in the calculation of the impact of food consumption on HENI.

scenario, the areas of beans and peas and grain maize increase due to their nutrient values and accordingly increase in consumption (see Section 3.1). By contrast, in the MaxHealth scenario, due to their lower health benefits, the areas of beans and peas and grain maize reduce, while the area of wheat increases with the increase of consumption of whole-grain products. In these scenarios, the total crop area expands to pasture and meadow areas due to less consumption of animal-based products. Instead of a reduced production of livestock feed, the crop areas for human consumption increase.

Dairy cows and other cattle have the largest number of livestock units in all scenarios (Fig. 6). In the Projection scenario, the livestock unit number does not differ from the reference scenario for most livestock categories; only the numbers of broilers and laying hens are lower. Shifting diets toward optimizing nutrient intake and health impacts results in a large decrease in the number of livestock by 47 % and 42 % in the MaxNutrient and MaxHealth scenarios, respectively. With the exception of fish consumption, dietary changes substantially decrease meat consumption (see Section 3.1), which in turn reduces the number of livestock and the domestic production, import, and export of meat products (see Tables F–H in Supplementary Material B). However, large numbers of livestock are maintained, as its products are still consumed and exported.

3.3. Domestic production, export, and import

Fig. 7 shows the domestic production, consumption, import, and export of food products in terms of calories before subtracting food waste during the consumption and processing of foods. In the reference scenario, 6,072, 10,890, 2,156, and 6,885 billion calories of food products are produced, consumed, exported, and imported in Switzerland, respectively, before subtracting the food waste. Considering that in the reference scenario, the consumption of daily per capita calories before subtracting the food waste is 2,869 kcal/capita/day, then the produced domestically, consumed, exported, and imported calories correspond to daily per capita food calorie fulfillment of 56 %, 100 %, 20 %, and 63 %, respectively. In the Projection scenario, the import and export of food calories slightly decrease due to the minor increase of domestic production and consumption of calories to meet the future demand of food calories.

The MaxNutrient scenario (i.e., a diet with nutrient adequacy) leads to a substantial decrease in domestic production and exports of foods in terms of calories. These reductions are because diet increases consumption of pasta for calorie fulfillment, which includes import of durum wheat to process into pasta. The domestic production of calories reduces due to the production of foods that are low in calories but high in nutrients. Therefore, the imports of calories increase because not all foods can be produced domestically to have the optimal nutrient intake. The consumption of calories is the same as in the reference scenario if we remove food waste from consumption.

In the MaxHealth scenario, to have the highest positive effect of a diet on the health index (i.e., HENI value), consumption of calories increases before subtracting food waste due mainly to the increase in consumption of whole grains, potatoes, nuts, fruits, vegetables, and legumes. Imports of calories increase, as domestic production is insufficient to ensure the optimal health of the population from consumption. The main increase is observed in the imports of whole grains, potatoes,

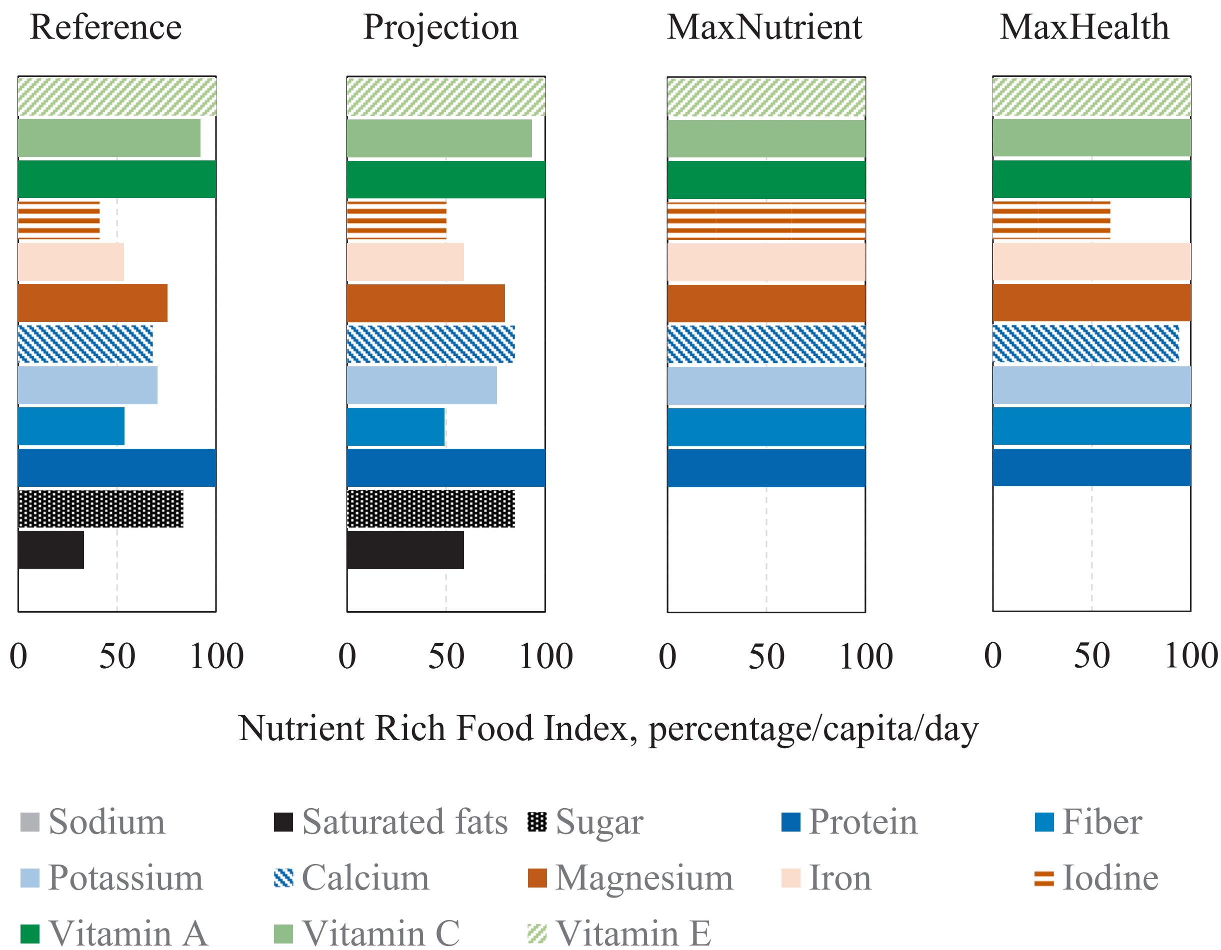

Fig. 4. Consumption of nutrients according to the Nutrient Rich Food Index (NRF10.3) in the reference, Projection, MaxNutrient, and MaxHealth scenarios. Note: MaxNutrient is the Nutrient Rich Food Index (NRF10.3) maximization scenario. MaxHealth is the Health Nutritional Index (HENI) maximization scenario. Values of sodium, saturated fats, and sugar (i.e., disqualifying nutrients) that are above 0% show higher consumption amounts of disqualifying nutrients than their maximum recommended values. The remaining nutrients are qualifying nutrients, where 100% of each qualifying nutrient is the maximum recommended consumption level, while below 100% is the case where the consumption of this nutrient can be further increased. Food waste is subtracted in the calculation of the consumption of nutrients.

nuts, fruits, vegetables, legumes, and fish (see Table F in Supplementary Material B). A higher share of domestically produced foods is consumed in Switzerland, and exports of food products are lower by 17 % than in the reference scenario.

The model results for import, export, domestic production, and consumption by products and calories are given in Tables F–I in Supplementary Material B.

3.4. Environmental impacts

In all scenarios, agricultural greenhouse gas emissions become lower than in the reference scenario (Table 3). Domestic agricultural greenhouse gas emissions are reduced by 36 % and 30 % in the MaxNutrient and MaxHealth scenarios, respectively, primarily due to the reduction in livestock numbers. In the MaxNutrient scenario, GHG emissions from imports increase due to imports of foods with high GHG emissions (see Section 3.3 and Table M in Supplementary Material B). Emissions from exports are reduced because of a decrease in the export quantity of food. An increased amount of cooking potatoes, vegetables, and fish increases greenhouse gas emissions from cooking in the MaxNutrient and MaxHealth scenarios.

The total water use increases in the Projection, MaxNutrient, and MaxHealth scenarios. Imports of products substantially increase water use, even though the import of food calories does not increase that much. Due to irrigation, large amounts of water are used to produce certain imported products, such as vegetables and fruits. In relative terms, food cooking results in the largest increase in water use due to dietary changes, especially water use for preparing meals with potatoes, vegetables, and flour. Water use for domestic agricultural production is lower in the Projection, MaxNutrient, and MaxHealth diets than in the reference diet, mainly due to fewer livestock; however, the absolute decrease is insufficient to address the increase in water use from imports. Tables J–O in Supplementary Material B show the model results for greenhouse gas emissions and water use in crop cultivation, livestock rearing, processing, import, export, and food cooking.

The differential effects on pesticide risk indicators for groundwater, surface water, and semi-natural habitats relate only to domestic agricultural production, as each crop has a different impact of pesticide applications on these indicators. An increase in grapevine area leads to slightly higher pesticide risks in the Projection scenario compared to the reference scenario. Diets in the MaxNutrient and MaxHealth scenarios result in higher pesticide risk in surface water and semi-natural habitats than in the reference scenario because the area of crops that have a higher surface water and semi-natural habitat pesticide risk is increased. In the MaxHealth scenario, pesticide risk also increases in groundwater, while it reduces in the MaxNutrient scenario. The surface water pesticide risk increases the most—by 45 % and 127 % in the MaxNutrient and MaxHealth scenarios, respectively. An area increase in vegetables, fruits,

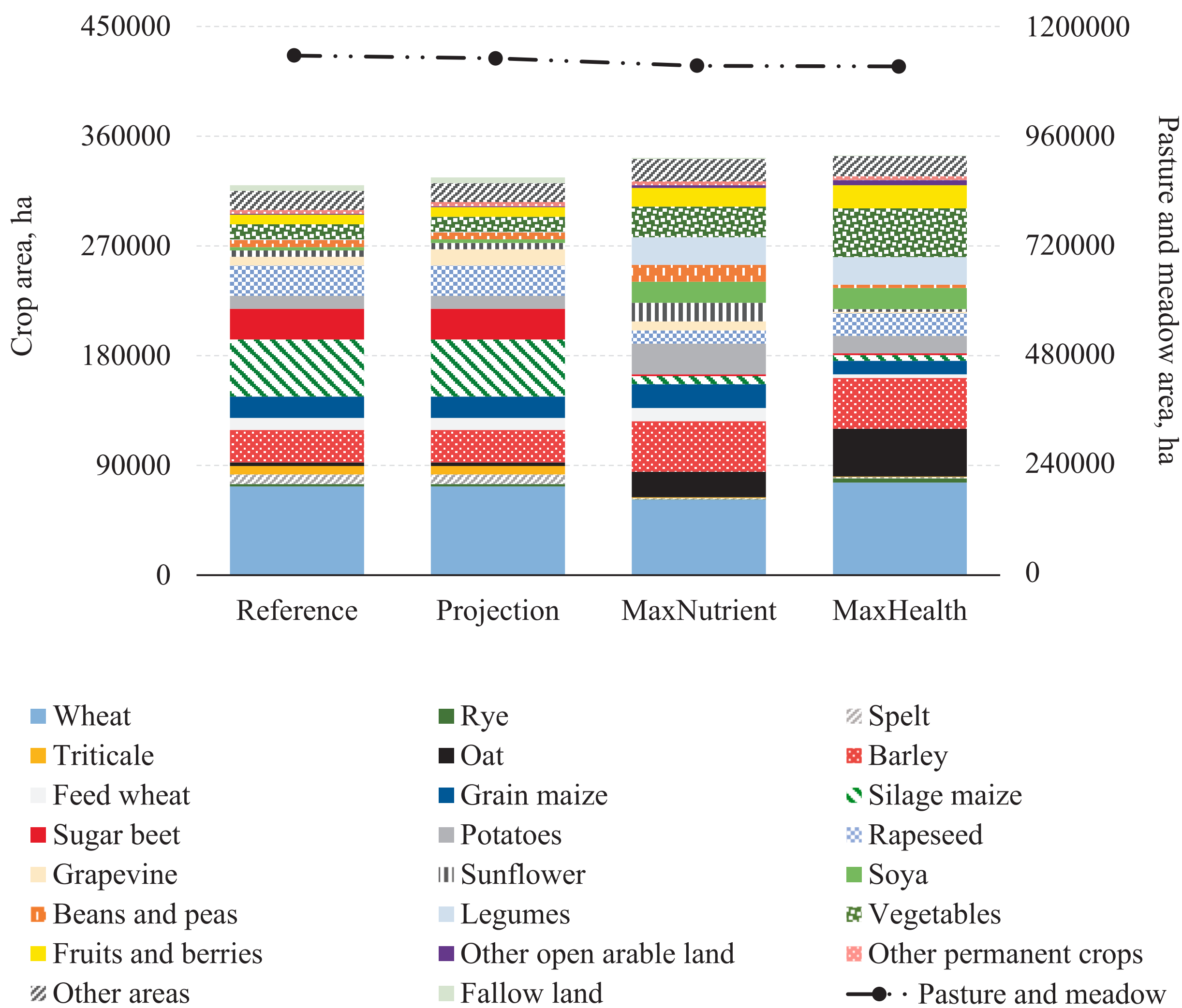

Fig. 5. Agricultural land use area in the reference, Projection, MaxNutrient, and MaxHealth scenarios. Note: MaxNutrient is the Nutrient Rich Food Index (NRF10.3) maximization scenario. MaxHealth is the Health Nutritional Index (HENI) maximization scenario.

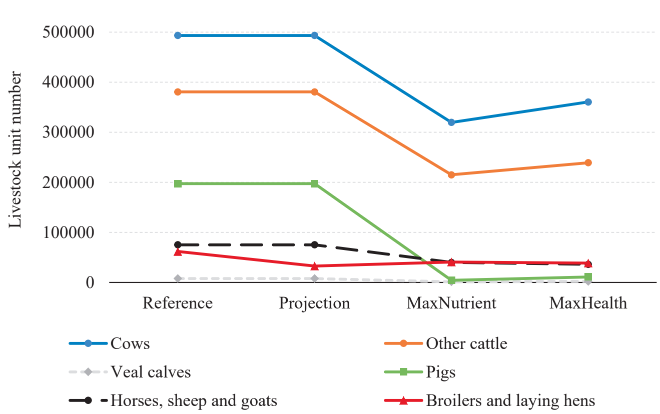

Fig. 6. Livestock unit number in the reference, Projection, MaxNutrient, and MaxHealth scenarios. Note: MaxNutrient is the Nutrient Rich Food Index (NRF10.3) maximization scenario. MaxHealth is the Health Nutritional Index (HENI) maximization scenario. Other cattle includes livestock, such as beef, calves, and heifers, for breeding and rearing calves, both males and females of different ages.

potatoes, and legumes increases the most pesticide risk (see Table P in Supplementary Material B).

Nitrogen surpluses that lead to nitrogen emissions such as ammonia, nitrate, and nitrous oxide, from domestic agricultural production are lower in all scenarios than in the reference scenario, primarily because of a decrease in livestock numbers and a change in cropping patterns.

4. Discussion and policy implications

4.1. Nutrient- and health-optimal diets

Improving diets is important for improving human health and reducing non-communicable diseases (GBD Collaborators, 2020). We show that current diets are sub-optimal, do not have many health benefits, and lack an optimal quantity of nutrients. Projected future food consumption patterns will change only slightly from current diets. The state of current and projected diets necessitates changes to improve the nutritional and health statuses of the population. Our study can inform policymakers who seek to develop recommendations to improve diets.

Diets optimizing nutrient intake and health impacts bring substantial benefits to the health of the population. We show that the HENI value increases from 19.1 min/capita/day of healthy life gained in the reference scenario to 57.9 and 90.7 min/capita/day of healthy life gained with diets in the MaxNutrient and MaxHealth scenarios, respectively. These diets require substantial shifts from meat products to plant-based ones. Particularly, these diets lead to an increase in the consumption of vegetables, fruits, plant-based alternatives, whole grains, and potatoes. Although red meat has negative impacts on health, it is still consumed in

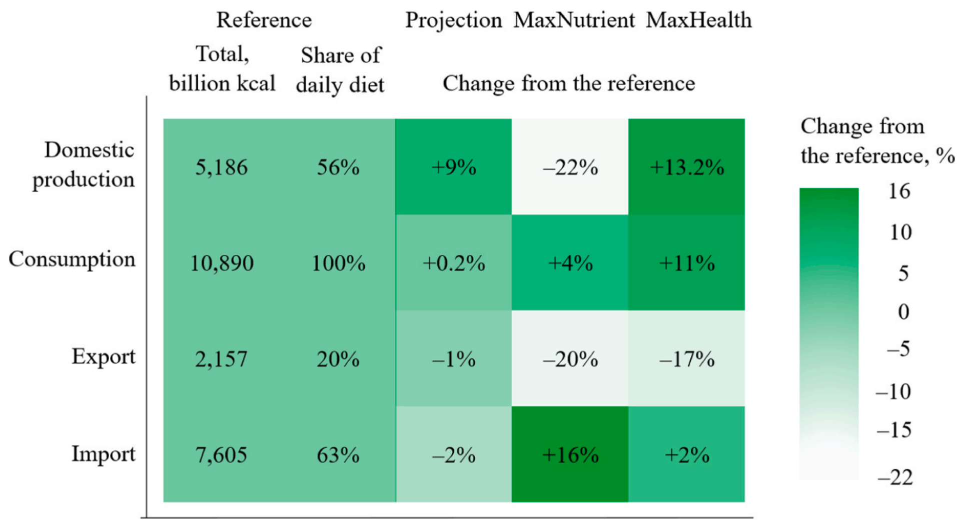

Fig. 7. Domestic production, consumption, export, and import of food products in terms of calories before subtracting the food waste in the reference, Projection, MaxNutrient, and MaxHealth scenarios. Note: MaxNutrient is the Nutrient Rich Food Index (NRF10.3) maximization scenario. MaxHealth is the Health Nutritional Index (HENI) maximization scenario. Column on share of daily diet in the reference scenario shows the daily per capita calorie consumption fulfillment before subtracting food waste.

Table 3
Greenhouse gas emissions, water use, pesticide risk, and nitrogen emissions in the reference, Projection, MaxNutrient, and MaxHealth scenarios.

Environmental indicators	Reference, value	Projection, % change	MaxNutrient, % change	MaxHealth, % change
Greenhouse gas emissions, ktCO$_2$e				
- Agricultural production	6,196	−0.1	−36	−30
- Import	9,729	18	8	−10
- Export	2,857	0.3	–6	−0.4
- Processing	1,239	6	–8	−9
- Food cooking	332	–5	82	82
- Total	14,639	12	−7	−18
Water use, million m^3				
- Agricultural production	73	−1	−34	−20
- Import	550	12	56	15
- Export	105	1	−14	−9
- Processing	17	16	51	76
- Food cooking	20	−3	83	98
- Total	556	12	58	20
Pesticide risk from agricultural production, million value				
- Surface water	1,440	0.2	45	127
- Groundwater	10	1	−2	22
- Semi-natural habitat	604	1	3	30
Nitrogen emissions from agricultural production, kt nitrogen	97	−0.5	−23	−23

Note: MaxNutrient is the Nutrient Rich Food Index (NRF10.3) maximization scenario. MaxHealth is the Health Nutritional Index (HENI) maximization scenario. Nitrogen emissions include emissions from ammonia, nitrous oxide, and nitrate. The export values of greenhouse gas emissions and water use are subtracted from their summed impacts because these environmental impacts are assumed to be exported through the products consumed abroad and are not included in the diet of the Swiss population.

small quantities due to its calorie content and food system constraints, whereas poultry is not consumed at all. Previous literature has reported similar outcomes (e.g., Kim et al., 2019; Laundry and Ward, 2024; Paris et al., 2024). For example, de Lange et al. (2024) showed that a reduction in meat consumption and substituting it with plant-based foods can offer substantial health improvements. The EAT-Lancet diet recommends substantial reduction of meat consumption in most parts of the world and instead increase consumption of plant-based products (Rockström et al., 2025). Therefore, Switzerland's dietary recommendations need to consider a shift from meat products toward more plant-based foods, which can improve health even with marginal dietary changes. This corresponds to the diet of the Swiss Dietary Recommendations, which recommends lower consumption amounts of meat products and an increase in portions of vegetables, fruits, and other plant-based foods than it is currently consumed (SSN and FSVO, 2024). However, the diets in the MaxNutrient and MaxHealth scenarios differ from the Swiss Dietary Recommendations, in terms of consumption of some foods. These diets lead to larger consumption of grain products and potatoes, protein sources, particularly fish and meat alternatives, and nuts, than in the recommendation. Some food products are consumed negligibly such as meat, while the Swiss Dietary Recommendations suggests consuming one portion of protein sources a day, which can be one portion of meat. Therefore, to have the nutrient- and health-optimal diets the Swiss Dietary Recommendations might consider further increase in consumption of portions of whole-grain products, fish, legumes, meat alternatives and nuts, while consider further decrease in consumption of meat.

We also show that a diet optimizing nutrient intake leads to different dietary patterns, health impacts, and nutrient intake than a diet optimizing health impacts, even though this difference is smaller than the difference from the reference diet. The most nutrient-rich diet (i.e., the MaxNutrient scenario) improves health in contrast to the reference scenario but has lower health benefits than the scenario optimizing the health impacts (i.e., the MaxHealth scenario; e.g., Cardinaals et al., 2024). The same holds for the healthiest diet (i.e., the MaxHealth scenario), which does not reach the recommended amounts of calcium and iodine. Iodine intake is currently deficient in the Swiss population. Hence, having diets that lead to an optimal health outcome will not improve this situation, as additional strategies are required to improve iodine intake, for example, the more widespread use of iodized salt in food products instead of unfortified salts (Andersson and Herter-Aeberli, 2019).

In the context of the Swiss Dietary Recommendations, it suggests a certain range of food consumption quantity, but it lacks information on nutrient intake and health outcomes if different quantities of food products are consumed within this range (SSN and FSVO, 2024). An addition to the current dietary recommendation can be the optimization of both nutrient intake and health impacts. Moreover, presenting dietary recommendations with information on the change in health impacts and nutrient intake levels of different recommended food portions can help consumers select nutrient dense and a healthy diet, while meeting their taste preferences and budget.

4.2. Agricultural production and trade

Swiss Agricultural Policy 2030+ is under development, and it will consider a holistic approach to food systems by taking into account all stakeholders in the value chain, from farmers to processors and consumers. The policy will focus on areas such as improving the socio-economic prospects of agriculture and the agri-food sector, domestic food self-sufficiency, and environmental impacts. The intersection of diets and food systems forms the foundation of health, economic growth, and sustainability outcomes for society (Fanzo and Davis, 2019).

We show that the interlink between demand and supply leads to the impact of dietary changes that extend beyond the consumer level to the food system. Improving diets requires an increase in the supply of healthy foods. If consumers and policymakers want the healthiest (i.e., MaxHealth scenario) and nutrient adequate (i.e., MaxNutrient scenario) diets, the domestic production of foods such as vegetables, fruits, grains, potatoes, legumes, oat milk and tofu, and nuts need to increase substantially, whereas the production of animal-based foods, sweets and sweetened and alcoholic beverages need to reduce substantially. The domestic production of red meat reduces by 85 % and 87 % in the MaxNutrient and MaxHealth scenarios respectively, and production of poultry by 92 % in both scenarios. For large changes in domestic production of foods, the land use pattern must change from the reference and Projection scenarios, particularly increasing the cultivation areas of vegetables, fruits, oats, legumes, and soya by reducing the animal feed area and livestock number. Von Ow et al. (2020) showed that increasing the consumption of plant-based foods in Switzerland requires a substantial increase in crop areas at the expense of reducing livestock numbers. Similarly, in a study of European Union countries, Rieger et al. (2023) showed that improving a diet reduces livestock numbers and increases the cultivation area of vegetables and fruits.

To have substantial land use changes in Switzerland may require changes in domestic agricultural policies, such as adjustments of direct payments for food crop cultivation. Currently, about 0.6 billion Swiss francs are given as direct payments to livestock farmers, and about 2.3 billion Swiss francs for crop production (Agristat, 2024). Healthy diets lead to a total reduction in livestock unit numbers by 49 % and 43 % in MaxNutrient and MaxHealth scenarios, respectively. To increase the crop cultivation areas used for human food production, direct payments for livestock production must decrease, while those for plant-based foods must increase. Thus, the incomes of livestock farmers can be reduced by having fewer direct payments and less consumer demand for animal-based foods, which might also reduce total agricultural incomes. According to Pais et al. (2020), European countries can experience economic losses with a reduction in meat consumption and production due to the large share in income generation of the livestock sector in the economy. In addition, as most feed crop areas will be used for growing crops for human consumption, the reduction of livestock farmers will occur. Additional measures to support the incomes and existence of livestock farming are needed, such as improvements in livestock management (e.g., feeding, breeding, and manure management), integration of crops into livestock systems (Jaisli and Brunori, 2024), and production of high-quality meat products that are efficient in resource use and have minimal health impacts.

Agricultural production changes alone will not be sufficient to support healthy diets for consumers. Switzerland's international trade of food commodities will also need to change. In the case of Switzerland, a special importance is the import flow of products, because the country does not produce sufficient food to meet its demand and relies on the import of food products. The change in diets toward healthy diets further increases dependency on food imports. In the current study, we assume the continuous availability of food imports and exogenous prices. Large-scale dietary changes will lead to adjustments in domestic markets and international trade. For example, Gatto et al. (2023) showed that dietary shifts affect domestic markets and international trade and consequently food prices. Prices for highly demanded products will increase, while the opposite holds for products with reduced demand. In addition, the food supply could be disproportionate compared to demand shifts (Spiker et al., 2023). Changes in the domestic prices of products will also change export and import volumes. Such market and trade changes will influence the purchasing basket of consumers, which in turn may again change the dietary pattern of consumers and deviate from the optimal nutrient intake and health impact diets that our study derived. Therefore, dietary changes should account for capacity for domestic production and possible changes in domestic markets and international trade, which may put pressure on the economy, food security, and health of the population (Ferjani et al., 2018; Gatto et al., 2023).

4.3. Environment

Policies that aim for diet improvement, such as the Swiss Nutrition Strategy (FSVO, 2025), also target environmental sustainability. In addition, the Swiss government has set goals for several environmental impacts. For instance, the Agriculture and Food Climate Strategy 2050, which is used to develop Agricultural Policy 2030+, aims to reduce agricultural greenhouse gas emissions by 40 % and per capita greenhouse gas emissions from consumption by two-thirds by 2050 compared to 1990 levels (FOAG et al., 2025). Agricultural nitrogen emissions are also planned to be reduced by 30 % compared to 1990 levels (FOEN, 2022). In addition, agricultural pesticide risks are planned to be halved by 2027 compared to the 2012/2015 levels (Dueri and Mack, 2024). Environmental policies also need to consider the dietary change of the population, as it can substantially alter the environmental impacts.

Our study shows that changes toward nutrient- and health-optimal diets reduce domestic agricultural greenhouse gas emissions, water use and nitrogen emissions because of the shift from animal-based foods to plant-based ones. This is particularly attributed to a large decrease in red meat and poultry consumption, which in addition to improving health also substantially reduces the livestock number and as a result reduces greenhouse gas emissions, water use and nitrogen emissions from agricultural production. The Swiss Dietary Recommendations also suggests moderate consumption of meat to have decrease in environmental impacts (SSN and FSVO, 2024). Similarly, in the case of Switzerland, Frehner et al. (2022) showed that changes toward plant-based diets improve diet quality and reduce environmental impacts. However, in our study, some environmental impacts become worse with diets improving health. We show that pesticide risks increase due to the area increase in vegetables, fruits, and legumes. In addition, water use in the food system increases. Springmann et al. (2018) also reported that changing diets by replacing animal-based foods with plant-based can contribute to climate change mitigation, but other environmental impacts might worsen such as increase in freshwater use.

Changes in environmental impacts also occur abroad and have spillover effects in countries that export to Switzerland. For example, we show that an increase in imports leads to an increase in water use abroad, which can put pressure on water availability in that country. Similarly, in the case of Bangladesh, de Lange et al. (2024) showed that improving the diet towards recommendations increases water use abroad due to the import of more water-intensive food products. To navigate trade-offs and produce synergies, the domain-specific measures in the food system are needed (Rockström et al., 2025). Accordingly, future environmental policies focusing on the food system need to consider potential synergies, especially externalities in the food system that occur domestically and abroad due to dietary changes and develop measures along the food system to manage the trade-offs.

4.4. Limitations and future research

Our study contributes to the research by developing a food system model to analyze the impacts of diets that optimize nutrient intake and health impacts on the food system. However, the SWISSfoodSys model has several limitations and potential for further improvement. For example, we use the NRF10.3 and HENI indices as nutrient intake and health impact indices for measuring nutrient- and health-optimal diets, respectively, which are among the many approaches that have their own calculation assumptions (Tharrey et al., 2017; Ali et al., 2022). For instance, the HENI index of a diet has limitations due to the linearity of dietary risk factors, missing behavioral and metabolic risk factors and nutrient density, and failing to include ultra-processed foods (Ortenzi et al., 2023; Weidema and Stylianou, 2020) or consider excess consumption of calories that leads to obesity. Other health impact indexes that address these limitations are needed. Future research also needs to consider the possibility of mixing different foods and different cooking methods that can influence the health of consumers, as well as nutritional and food supplements that may increase nutrient intake and health impacts.

In addition, we consider the impacts of dietary shifts of an average Swiss consumer in line with different food consumption recommendations (e.g., the Swiss Dietary Recommendations). However, dietary changes and their impact on health can differ for various consumers, depending on their age, gender, and other characteristics. Dietary shifts will need to consider different demographic groups of consumers (e.g., Loginova and Mann, 2024b) and cultural differences across areas of cantons of Switzerland. Dietary changes should also account for affordability, satiety, and consumers' cultural perceptions (Steenson and Buttriss, 2021).

Further research should also focus on policies that are effective in promoting healthy, economically, and environmentally sustainable diets in Switzerland. A range of different measures are required to promote changes in diets toward more healthy foods, accounting for the benefits and costs of multiple actors in the food system. Additional policies can be focused on supporting pesticide-free organic or non-organic farming, extension services for farmers (Finger and Möhring, 2024), designing appropriate food labels for consumers (Hosni et al., 2024), and strategies promoting sustainable production practices abroad.

Furthermore, our modeling approach uses deterministic model calculations and assumes exogeneous prices and no future developments except population growth. Actors in the food system may also have different objectives, such as maximizing agricultural and processing incomes, increasing net trade returns, minimizing environmental pollution, and maximizing the health of consumers, where these objectives can conflict with different actors. Therefore, future research on analyzing the food system should include methodological improvements by assessing uncertainties (Li et al., 2024), market responses (Rieger et al., 2023) and technological developments (Herrero et al., 2020), and using a multi-objective optimization model that considers the various objective functions of actors in the food system (Rohmer et al., 2019).

5. Conclusion

The study highlights the importance of identifying nutrient- and health-optimal diets from the food system's perspective. We show that the food consumption pattern of diets optimizing nutrient adequacy and health impacts substantially differs from current diets. These diets imply a substantial increase in the consumption of plant-based products, while the consumption of animal-based products, sweets, and sweetened beverages is reduced. Moreover, a diet that targets optimal nutrient intake differs from one aimed at the highest health outcomes, resulting in differences in nutrient intake levels and health impacts, although this difference is smaller than the changes from the reference diet.

Our study also suggests that the impacts of dietary shifts go beyond the consumer level and influence the food system, leading to various synergies and trade-offs. For example, agriculture will need to shift large areas to food crop production to have diets that optimize nutrient intake and health impact while reducing the areas of feed crops and the number of livestock. The imports of food also increase because domestic production does not produce sufficient food to meet the diet's objectives. In addition, the impacts of nutrient- and health-optimal diets on environmental indicators differ, with a reduction in the overall emissions of greenhouse gases and nitrogen and an increase in surface water and semi-natural habitats of pesticide risks and water use. Due to the change in the import of commodities, environmental effects have spillover effects abroad.

This study has important policy implications for countries aiming to improve population diets and the performance of the overall food system. First, the food consumption recommendations should consider that to have a healthy diet, substantial shifts from consumption, production, and trade of animal-based foods to plant-based foods will be required. Second, when building dietary recommendations, considering the nutrient- and health-optimal diets within the food system context can help identify the healthiest diet and understand the feasibility of achieving a dietary shift and possible changes in other stages of the food system. Instruments for increasing synergies and reducing the trade-offs of dietary shifts should be developed when proposing large-scale changes in the food system.

CRediT authorship contribution statement

Utkur Djanibekov: Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Albert von Ow:** Writing – original draft, Methodology, Investigation, Formal analysis. **Alba Reguant-Closa:** Writing – original draft, Formal analysis, Investigation. **Daria Loginova:** Writing – review & editing, Investigation, Data Curation. **Cédric Furrer:** Writing – original draft, Investigation, Data curation. **Mélanie Douziech:** Writing – review & editing, Investigation, Data Curation. **Stefan Mann:** Writing – review & editing, Investigation, Data Curation. **Thomas Nemecek:** Writing – review & editing, Investigation, Data Curation.

Acknowledgements

We would like to thank the anonymous reviewers and Prof. Roberta Sonnino for their valuable comments on improving the manuscript. We would also like to thank Dr. Gabriele Mack and Dr. Nadja El Benni for their feedback on an earlier version of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodpol.2025.103014.

References

Agridea, 2020. Deckungsbeiträge 2020. Landwirtschaftliche Beratungszentrale. Agridea, Lindau https://www.agridea.ch/ (accessed 14 October 2022).
Agristat, 2020. Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2019. Kapitel 7: Nahrungsmittelbilanz. https://www.sbv-usp.ch/de/services/agristat-statistik-der-schweizer-landwirtschaft/statistische-erhebungen-und-schaetzungen-ses (accessed 14 October 2022).
Agristat, 2024. Agristat – Swiss agriculture in figures. Swiss Farmers' Union, Brugg https://www.sbv-usp.ch/en/services/agristat-swiss-agriculture-in-figures (accessed 10 January 2025).
Agristat, TSM, SMP, SCM, BO Milch, 2020. Milchstatistik der Schweiz 2019. https://www.sbv-usp.ch/de/services/agristat-statistik-der-schweizer-landwirtschaft/milchstatistik-der-schweiz-mista (accessed 14 October 2022).
Agroscope, 2021. Fütterungsempfehlungen für Wiederkäuer (Grünes Buch). Agroscope, Posieux https://www.agroscope.ch/gruenes-buch (accessed 1 February 2022).
Ali, Z., Scheelbeek, P.F., Felix, J., Jallow, B., Palazzo, A., Segnon, A.C., Havlík, P., Prentice, A.M., Green, R., 2022. Adherence to EAT-Lancet dietary recommendations for health and sustainability in the Gambia. Environ. Res. Lett. 17, 104043. https://doi.org/10.1088/1748-9326/ac9326.

Andersson, M., Herter-Aeberli, I., 2019. Jodstatus in der Schweizer Bevölkerung. Schweizer Ernährungsbulletin 63–83. https://doi.org/10.24444/blv-2018-0111.

Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I.D., de Haan, S., Prager, S.D., Talsma, E. F., Khoury, C., 2019. When food systems meet sustainability – current narratives and implications for actions. World Dev. 113, 116–130. https://doi.org/10.1016/j.worlddev.2018.08.011.

Beretta, C., 2018. Environmental assessment of food losses and reduction potential in food value chains. Dissertation ETH No. 25648. https://doi.org/10.3929/ethz-b-000347342 (accessed 18 October).

Cardinaals, R.P.M., Verly Jr., E., Jolliet, O., Van Zanteen, H.H.E., Huppertz, T., 2024. The complementarity of nutrient density and disease burden for Nutritional Life Cycle Assessment. Front. Sustain. Food Syst. 8, 1304752. https://doi.org/10.3389/fsufs.2024.1304752.

Christen, A., 2025. Revision of the food-based dietary guidelines for Switzerland: Procedure handbook. Report Commissioned by Federal Food Safety and Veterinary Office FSVO. accessed 1 August 2025 Büro Für Ernährung Christen 25, pp. https://www.blv.admin.ch/blv/en/home/lebensmittel-und-ernaehrung/ernaehrung/empfehlungen-informationen/schweizer-ernaehrungsempfehlungen.html.

Clark, M.A., Springmann, M., Hill, J., Tilman, D., 2019. Multiple health and environmental impacts of foods. PNAS 116 (46), 23357–23362. https://doi.org/10.1073/pnas.1906908116.

De Lange, T., van Dijk, M., Kuiper, M., van Ziest, W.-J., Bartelings, H., Mizan, A., van Meijl, H., 2024. Socio-economic, environmental and health impacts of dietary transformation in Bangladesh. Environ. Res. Lett. 20, 014057. https://doi.org/10.1088/1748-9326/ada0ca.

de Mestral, C., Khalatbari-Soltani, S., Stringhini, S., Marques-Vidal, P., 2020. Perceived barriers to healthy eating and adherence to dietary guidelines: Nationwide study. Clin. Nutr. 39 (8), 2580–2585. https://doi.org/10.1016/j.clnu.2019.11.025.

Djanibekov, U., von Ow, A., 2025. Documentation of the Swiss Sustainable Food System (SWISSfoodSys) model: Version 1.0. Agroscope Science 214. https://doi.org/10.34776/as214e.

Douziech, M., Bystricky, M., Furrer, C., Gaillard, G., Lansche, J., Roesch, A., Nemecek, T., 2024. Recommended impact assessment method within Swiss Agricultural Life Cycle Assessment (SALCA): v2.01. Agroscope Science 183. https://doi.org/10.34776/as183e.

Drewnowski, A., Amanquah, D., Gavin-Smith, B., 2021. Perspective: how to develop Nutrient Profiling Models Intended for Global Use: a Manual. Advanced Nutrition 12 (3), 609–620. https://doi.org/10.1093/advances/nmab018.

Dueri, S., Mack, G., 2024. Modeling the implications of policy reforms on pesticide risk for Switzerland. Sci. Total Environ. 928, 172436. https://doi.org/10.1016/j.scitotenv.2024.172436.

Eker, S., Reese, G., Obersteiner, M., 2019. Modelling the drivers of a widespread shift to sustainable diets. Nat. Sustain. 2, 725–735. https://doi.org/10.1038/s41893-019-0331-1.

Ernstoff, A., Stylianou, K.S., Sahakian, M., Godin, L., Dauriat, A., Humbert, S., Erkman, S., Jolliet, O., 2020. Toward win–win policies for healthy and sustainable diets in Switzerland. Nutrients 12 (9), 2745. https://doi.org/10.3390/nu12092745.

Fanzo, J., Davis, C., 2019. Can diets be healthy, sustainable, and equitable? Curr. Obes. Rep. 8, 495–503. https://doi.org/10.1007/s13679-019-00362-0.

Food and Agriculture Organization of the United Nations (FAO), 2018. Nutrition and food systems: a report by the high level panel of experts on food security and nutrition of the committee on world food security. Food & Agriculture Organization, Rome, p. 150.

Federal Council, 2022. Zukünftige Ausrichtung der Agrarpolitik. Bericht des Bundesrates in Erfüllung der Postulate 20.3931 der WAK-S vom 20. August 2020 und 21.3015 der WAK-N vom 2. February 2021. https://www.parlament.ch/centers/eparl/curia/2020/20203931/Bericht%20BR%20D.pdf (accessed 4 September 2025).

Federal Food Safety and Veterinary Office (FSVO), 2023a. Dietary reference values for Switzerland. Federal Food Safety and Veterinary Office, Bern. https://www.blv.admin.ch/blv/de/home/lebensmittel-und-ernaehrung/ernaehrung/empfehlungen-informationen/naehrstoffe/naehrstoffzufuhr-dynamische-tabelle.html (accessed 1 February 2024).

Federal Office for Agriculture (FOAG), 2020. Agrarbericht 2020. Federal Office for Agriculture, Bern https://www.agrarbericht.ch/ (accessed 8 September 2022).

Federal Office for Customs and Border Security (FOCBS), 2020. Foreign trade statistics 2019 https://www.gate.ezv.admin.ch/swissimpex/ (accessed 3 September 2023).

Federal Office for the Environment (FOEN), 2022. Gewässer in der Schweiz. Federal Office for the Environment, Bern https://www.bafu.admin.ch/bafu/de/home/themen/wasser/publikationen-studien/publikationen-wasser/gewaesserbericht.html (accessed 15 September 2025).

Ferjani, A., Mann, S., Zimmermann, A., 2018. An evaluation of swiss agriculture's contribution to food security with decision support system for food security strategy. Br. Food J. 120 (9), 2116–2128. https://doi.org/10.1108/BFJ-12-2017-0709.

Finger, R., Möhring, N., 2024. The emergence of pesticide-free crop production systems in Europe. Nat. Plants 10, 360–366. https://doi.org/10.1038/s41477-024-01650-x.

Federal Office for Agriculture (FOAG), Federal Food Safety and Veterinary Office (FSVO), Federal Office for the Environment (FOEN), 2025. Klimastrategie Landwirtschaft und Ernährung 2050. Federal Office for Agriculture, Federal Food Safety and Veterinary Office, Federal Office for the Environment, Bern and Ittigen. https://www.blw.admin.ch/en/agriculture-and-food-climate-strategy-2050 (accessed 15 September 2025).

Federal Office of Public Health (FOPH), 2025. Facts and figures: Noncommunicable diseases. Bern, Switzerland. [updated 13.02.2025]. https://www.bag.admin.ch/bag/de/home/zahlen-und-statistiken/zahlen-fakten-nichtuebertragbare-krankheiten.html (accessed 20 March 2025).

Frehner, A., De Boer, I.J.M., Muller, A., Van Zanten, H.H.E., Schader, C., 2022. Consumer strategies toward a more sustainable food system: Insights from Switzerland. Am. J. Clin. Nutr. 115 (4), 1039–1047. https://doi.org/10.1093/ajcn/nqab401.

Federal Statistical Office (FSO), 2020b. Landwirtschaftliche Gesamtrechnung 2019. Federal Statistical Office, Neuchâtel https://www.bfs.admin.ch/asset/de/px-x-0704000000_121 (accessed 22 August 2022.

Federal Statistical Office (FSO), 2022. Household budget survey. Federal Statistical Office, Neuchâtel. https://www.bfs.admin.ch/bfs/en/home/statistics/economic-social-situation-population/surveys/hbs.html#:~:text=The%20purpose%20of%20the%20Household,conducted%20on%20a%20continuous%20basis (accessed 15 November 2023).

Federal Food Safety and Veterinary Office (FSVO), 2023b. The Swiss food composition database. Version V6.5, Federal Food Safety and Veterinary Office, Bern. https://kwk.blv.admin.ch/naehrstofftabelle-en/ (accessed 1 November 2023).

Federal Food Safety and Veterinary Office (FSVO), 2025. Swiss Nutrition Strategy 2025–2032. Federal Food Safety and Veterinary Office, Bern. https://www.blv.admin.ch/blv/de/home/das-blv/strategien/schweizer-ernaehrungsstrategie.html (accessed 1 April 2025).

Fulgoni III, V.L., Keast, D.R., Drewnowski, A., 2009. Development and validation of the nutrient-rich foods index: a tool to measure nutritional quality of foods. J Nutr. 139 (8), 1549–1554. https://doi.org/10.3945/jn.108.101360.

Gaillard, G., Nemecek, T., 2009. Swiss Agricultural Life Cycle Assessment (SALCA): An integrated environmental assessment concept for agriculture, in: Integrated Assessment of Agriculture and Sustainable Development, Setting the Agenda for Science and Policy. Egmond aan Zee, The Netherlands.

Gatto, K., M., van Meijl, H., 2023. Economic, social and environmental spillovers decrease the benefits of a global dietary shift. Nat. Food 4, 496–507. https://doi.org/10.1038/s43016-023-00769-y.

Global Burden of Disease (GBD) Collaborators, 2020. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet 396 (10258), 1223–1249. https://doi.org/10.1016/S0140-6736(20)30752-2.

Herrero, M., Thornton, P.K., Mason-D'Croz, D., Palmer, J., Benton, T.G., Bodirsky, B.L., Bogard, J.R., Hall, A., Lee, B., Nyborg, K., Pradhan, P., Bonnet, G., Bryan, B.A., Campbell, B.M., Christensen, S., Clark, M., Cook, M.T., de Boer, I.J.M., Downs, C., Dizee, K., Folberth, C., Godde, C.M., Gerber, J.S., Grundy, M., Havlik, P., Jarvis, A., King, R., Loboguerrero, A.M., Lopes, M.A., McIntyre, C.L., Naylor, R., Navarro, J., Obersteiner, M., Parodi, M., Peoples, M.B., Pikaar, I., Popp, A., Rockström, J., Robertson, M.J., Smith, P., Stehfest, E., Swain, S.M., Valin, H., van Wijk, M., van Zanten, H.H.E., Vermeulen, S., Vervoort, J., West, P.C., 2020. Innovation can accelerate the transition toward a sustainable food system. Nat. Food 1, 266–272. https://doi.org/10.1038/s43016-020-0074-1.

Hirvonen, K., Bai, Y., Headey, D., Masters, W.A., 2020. Affordability of the EAT–Lancet reference diet: a global analysis. Lancet Glob. Health 8, e59–e66. https://doi.org/10.1016/S2214-109X(19)30447-4.

Horgan, G.W., Perrin, A., Whybrow, S., Macdiarmid, J.I., 2016. Achieving dietary recommendations and reducing greenhouse gas emissions: Modelling diets to minimise the change from current intakes. Int. J. Behav. Nutr. Phys. Act. 13 (46). https://doi.org/10.1186/s12966-016-0370-1.

Hosni, H., Segovia, M., Zhao, S., Palma, M.A., Skevas, T., 2024. Improving consumer understanding of pesticide toxicity labels: Experimental evidence. Sci. Rep. 14, 17291. https://doi.org/10.1038/s41598-024-68288-9.

Intergovernmental Panel on Climate Change (IPCC), 2019. Summary for policymakers, in: Shukla, P.R., Skea, J., Calvo Buendia, E., Masson-Delmotte, V., Pörtner, H.-O., Roberts, D.C., Zhai, P., Slade, R., Connors, S., van Diemen, R., Ferrat, M., Haughey, E., Luz, S., Neogi, S., Pathak, M., Petzold, J., Portugal Pereira, J., Vyas, P., Huntley, E., Kissick, K., Belkacemi, M., Malley, J., (eds), Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems. IPCC.

Jaisli, I., Brunori, G., 2024. Is there a future for livestock in a sustainable food system? Efficiency, sufficiency, and consistency strategies in the food-resource nexus. J. Agr. Food Res. 18, 101496. https://doi.org/10.1016/j.jafr.2024.101496.

Kim, H., Caulfield, L.E., Garcia-Larsen, V., Steffen, L.M., Coresh, J., Rebholz, C.M., 2019. Plant-based diets are associated with a lower risk of incident cardiovascular disease, cardiovascular disease mortality, and all-cause mortality in a general population of middle-aged adults. J. Am. Heart Assoc. 8 (16), e012865. https://doi.org/10.1161/JAHA.119.012865.

Kim, B.F., Santo, R.E., Scatterday, A.P., Fry, J.P., Synk, C.M., Cebron, S.R., Mekonnen, M. M., Hoekstra, A.Y., de Pee, S., Bloem, M.W., Neff, R.A., Nachman, K.E., 2020. Country-specific dietary shifts to mitigate climate and water crises. Global Environ. Change 62, 101926. https://doi.org/10.1016/j.gloenvcha.2019.05.010.

Koch, P., Salou, T., 2016. AGRIBALYSE®: Rapport Méthodologique –Version 1.3. https://doc.agribalyse.fr/documentation/les-donnees/documentation-complete.

Korkaric, M., Lehto, M., Poiger, T., de Baan, L., Mathis, M., Amman, L., Hanke, I., Balmer, M., Blom, J.F., 2023. Nationale Risikoindikatoren für Pflanzenschutzmittel. Weiterführende Analysen. Agroscope Science 1–48. https://doi.org/10.34776/as154g.

Laundry, M.J., Ward, C.P., 2024. Health benefits of a plant-based dietary pattern and implementation in healthcare and clinical practice. Am. J. Lifestyle Med. 18 (5), 657–665. https://doi.org/10.1177/15598276241237766.

Li, J., Gonzalez, W., Monterrosa, E., Gomez, M.I., Nicholson, C.F., 2024. Choice experiments and value-Chain modeling of attribute improvements to increase vegetable consumption in Kenya. Food Policy 127, 102682. https://doi.org/10.1016/j.foodpol.2024.102682.

Loginova, D., Mann, S., 2024a. Sweet home or battle of the sexes: who dominates food purchasing decisions? Humanit. Soc. Sci. Commun. 11, 261. https://doi.org/10.1057/s41599-024-02745-8.

Loginova, D., Mann, S., 2024b. Forecasting food trends using demographic pyramid, generational differentiation and SuperLearner. Humanit. Soc. Sci. Commun. 11, 1437. https://doi.org/10.1057/s41599-024-03890-w.

Lucas, E., Guo, M., Guillén-Gosálbez, G., 2023. Low-carbon diets can reduce global ecological and health costs. Nat. Food 4, 394–406. https://doi.org/10.1038/s43016-023-00749-2.

Mann, S., Loginova, D., 2023. Distinguishing inter- and pangenerational food trends. Agric. Food Econ. 11, 10. https://doi.org/10.1186/s40100-023-00252-z.

Marques-Vidal, P., Infanger, E., Baumer, B., Van der Horst, K., Lehmann, U., Bender, N., Pannen, S., Karavasiloglou, N., Rohrmann, S., El Maohub, Y., Speranza, C., Suggs, S., Alig, M., Sangin, S., Frei, S., Meier, M., 2023. Swiss dietary recommendations: Scientific background. Centre hospitalier universitaire vaudois CHUV, Lausanne, Report for Federal Food Safety and Veterinary Office.

Peyronne, J., 2022. Umwelt-Fussabdrücke der Schweiz: Entwicklung zwischen 2000 und 2018. Federal Office for the Environment FOEN, Bern, Switzerland, p. 128. https://www.bafu.admin.ch/bafu/de/home/themen/wirtschaft-konsum/konsum-und-produktion/ressourcenverbrauch.html.

Nemecek, T., Bengoa, X., Lansche, J., Roesch, A., Faist-Emmenegger, M., Rossi, V., Humbert, S., 2019. Methodological Guidelines for the Life Cycle Inventory of Agricultural Products. Lausanne and Zurich, Switzerland.

Nemecek, T., Roesch, T., Bystricky, M., Jeanneret, P., Lansche, J., Stüssi, M., Gaillard, G., 2024. Swiss Agricultural Life Cycle Assessment: a method to assess the emissions and environmental impacts of agricultural systems and products. Int. J. Life Cycle Assess. 29, 433–455. https://doi.org/10.1007/s11367-023-02255-w.

Ortenzi, F., McAuliffe, G.A., Leroy, F., Nordhagen, S., van Vliet, S., del Prado, A., Beal, T., 2023. Can we estimate the impact of small targeted dietary changes on human health and environmental sustainability? Environ. Impact Assess. Rev. 102, 107222. https://doi.org/10.1016/j.eiar.2023.107222.

Pais, D.F., Marques, A.C., Fuinhas, J.A., 2020. Reducing meat consumption to mitigate climate change and promote health: but is it good for the economy? Environ. Model Assess. 25, 793–807. https://doi.org/10.1007/s10666-020-09710-0.

Paris, J.M.G., Escobar, N., Falkenberg, T., Gupta, S., Heinzel, C., Junior, E.V., Jolliet, O., Borgemeister, C., Nöthlings, U., 2024. Optimised diets for achieving one Health: a pilot study in the Rhine-Ruhr Metropolis in Germany. Environ. Impact Assess. Rev. 106, 107529. https://doi.org/10.1016/j.eiar.2024.107529.

Rieger, J., Freund, F., Offermann, F., Geibel, I., Gocht, A., 2023. From fork to farm: Impacts of more sustainable diets in the EU-27 on the agricultural sector. J. Agric. Econ. 74 (3), 764–784. https://doi.org/10.1111/1477-9552.12530.

Rockström, J., Thilsted, S.H., Willet, W.C., Gordon, L.J., Herrero, M., Hicks, C.C., Mason-D'Croz, D., Rao, N., Springmann, M., Wright, E.C., Agustina, R., Bajaj, S., Bunge, A. C., Carducci, B., Conti, C., Covic, N., Fanzo, J., Forouhi, N.G., Gibson, M.F., Gu, X., Kebreab, E., Kremen, C., Laila, A., Laxminarayan, R., Marteau, T.M., Monteiro, C.A., Norberg, A., Njuki, J., Oliveira, T.D., Pan, W.-H., Rivera, J.A., Robinson, J.P.W., Sundiang, M., te Wierik, S., van Vuuren, D.P., Vermeulen, S., Webb, P., Alqodmani, L., Ambikapathi, R., Barnhill, A., Baudish, I., Beier, F., Beillouin, D., Beusen, A.H.W., Breier, J., Chemarin, C., Chepeliev, M., Clapp, J., de Vries, W., Pérez-Domínguez, I., Estrada-Carmona, N., Gerten, D., Golden, C.D., Jones, S.K., Jørgensen, P.S., Kozicka, M., Lotze-Campen, H., Maggi, F., Marzi, E., Mishra, A., Orduna-Cabrera, F., Popp, A., Schulte-Uebbing, L., Stehfest, E., Tang, F.H.M., Tsuchiya, K., Van Zanten, H.H.E., van Zeist, W.-J., Zhao, X., DeClerck, F., 2025. The EAT–Lancet Commission on healthy, sustainable, and just food systems. The Lancet 406 (10512), 1625–1700. https://doi.org/10.1016/S0140-6736(25)01201-2.

Rohmer, S.U.K., Gerdessen, J.C., Claassen, G.D.H., 2019. Sustainable supply chain design in the food system with dietary considerations: a multi-objective analysis. Eur. J. Oper. Res. 273 (3), 1149–1164. https://doi.org/10.1016/j.ejor.2018.09.006.

Schuh, D.S., Pellando, L.C., Guessous, I., Marques-Vidal, P., 2018. Trends and determinants of change in compliance to dietary guidelines in a swiss community-dwelling sample. Prev. Med. 111, 198–203. https://doi.org/10.1016/j.ypmed.2018.03.008.

Federal Statistical Office (FSO), 2020a. Growth of the permanent resident population in Switzerland. Federal Statistical Office, Neuchâtel. https://www.bfs.admin.ch/bfs/en/home/statistics/population/population-projections/national-projections.html (accessed 22 August 2022.

Spiker, M.R., Welling, J., Hertenstein, D., Mishra, S., Mishra, K., Hurley, K.M., Neff, R.A., Fanzo, J., Lee, B.Y., 2023. When increasing vegetable production may worsen food availability gaps: a simulation model in India. Food Policy 116, 102416. https://doi.org/10.1016/j.foodpol.2023.102416.

Springmann, M., Wiebe, K., Mason-D'Croz, D., Sulser, T.B., Rayner, M., Scarborough, P., 2018. Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail. Lancet Planet. Health. 2 (10), e451–e461.

Swiss Society for Nutrition (SSN), Federal Food Safety and Veterinary Office (FSVO), 2024. Swiss dietary recommendations. Swiss Society for Nutrition and Federal Food Safety and Veterinary Office, Bern. https://www.blv.admin.ch/blv/en/home/lebensmittel-und-ernaehrung/ernaehrung/empfehlungen-informationen/schweizer-ernaehrungsempfehlungen.html (accessed 1 August 2025).

Steenson, S., Buttriss, J.L., 2021. The challenges of defining a healthy and 'sustainable' diet. Nutr. Bull. 45, 1932–1936. https://doi.org/10.1111/nbu.12439.

Stylianou, K.S., Fulgoni, V.L., Jolliet, O., 2021. Small targeted dietary changes can yield substantial gains for human health and the environment. Nat. Food 2 (8), 616–627. https://doi.org/10.1038/s43016-021-00343-4.

Tharrey, M., Maillot, M., Azaïs-Braesco, V., Darmon, N., 2017. From the SAIN, LIM system to the SENS algorithm: a review of a French approach of nutrient profiling. Proc. Nutr. Soc. 76, 237–246. https://doi.org/10.1017/S0029665117000817.

Tilman, D., Clark, M., 2014. Global diets link environmental sustainability and human health. Nature 515, 518–522. https://doi.org/10.1038/nature13959.

van Paassen, M., Braconi, N., Kuling, L., Durlinger, B., Gual, P., 2019. Agri-footprint 5.0 Part 1: Methodology and basic principles. https://simapro.com/wp-content/uploads/2020/10/Agri-Footprint-5.0-Part-1-Methodology-and-basic-principles.pdf.

Von Blumenthal, F., Schönenberger, K.A., Huwiler, V.V., Stanga, Z., Pestoni, G., Faeh, D., 2025. Dietary fibre intake in the adult Swiss population: a comprehensive analysis of timing and sources. J. Nutr. Sci. 14, e27. https://doi.org/10.1017/jns.2025.6.

Von Ow, A., Djanibekov, U., 2025. The database of the Swiss Sustainable Food System (SWISSfoodSys) model. Zenodo. https://doi.org/10.5281/zenodo.17228994.

Von Ow, A., Waldvogel, T., Nemecek, T., 2020. Environmental optimization of the swiss population's diet using domestic production resources. J. Clean. Prod. 248, 119241. https://doi.org/10.1016/j.jclepro.2019.119241.

Weidema, B.P., Stylianou, K.S., 2020. Nutrition in the life cycle assessment of food–function or impact? Int. J. Life Cycle Assess. 25, 1210–1216. https://doi.org/10.1007/s11367-019-01658-y.

Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., Weidema, B., 2016. The ecoinvent database version 3 (Part I): Overview and methodology. Int. J. Life Cycle Assess. 21 (9), 1218–1230. https://doi.org/10.1007/s11367-016-1087-8.

World Health Organization (WHO), 2003. Diet, nutrition and the prevention of chronic diseases: Report of a joint WHO/FAO expert consultation. WHO technical report series 916. Geneva, 149 p.

Zhao, Y., Fan, L., Wilson, N.L.W., Valderrama, A.V., Wilde, P., 2025. Variations on the Thrifty Food Plan: Model diets that satisfy cost and nutrition constraints. Food Policy 130, 102781. https://doi.org/10.1016/j.foodpol.2024.102781.