Environmental impacts of scenarios for food provision in Switzerland

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ABSTRACT
This study evaluates and compares the environmental impact of food provision for the average consumption in Switzerland with 6 different scenarios, per person and year. Furthermore, the environmental impact of the recommendation for a sustainable and healthy food intake is assessed. The full environmental impacts are assessed with the ecological scarcity method 2013. Additionally, the global warming potential is evaluated (IPCC GWP 100a, incl. RFI). The lower the share of animal-based food in the diet is, the lower the environmental impacts are. The provision of "meat and fish" and "animal products" is most relevant to explain the differences in the overall environmental impact between the food scenarios.

Keywords: food provision, diet, vegan, ovo-lacto-vegetarian, ovo-lacto-pescetarian, flexitarian.

1. Introduction

This study has been commissioned by the WWF Switzerland to provide guidance to consumers in terms of the environmental impact of different food consumption scenarios (Jungbluth, Eggenberger et al. 2016).

There are different options to determine the amount of food production of a specific nutrition type. The environmental impacts of food consumption in Switzerland were already investigated from different starting points (Figure 1), such as: top-down splitting the overall environmental impacts to different consumption areas in an input-output analysis (Jungbluth, Nathani et al. 2011), food availability on the Swiss market (SBV market availability, Jungbluth, Itten et al. 2012; Schweizerischer Bauernverband 2013), data for large distributors such as supermarkets (MIGROS, Jungbluth 2011) or canteens (SV Group, Jungbluth, Keller et al. 2015), data from the Swiss BFS household budget surveys on food purchases (BfS 2012; Saner, Beretta et al. 2015; Jungbluth, Eggenberger et al. 2016), meals consumed (Jungbluth, Keller et al. 2015), nutritional recommendations (Brunner and Casetti 2014; Eggenberger and Jungbluth 2015).

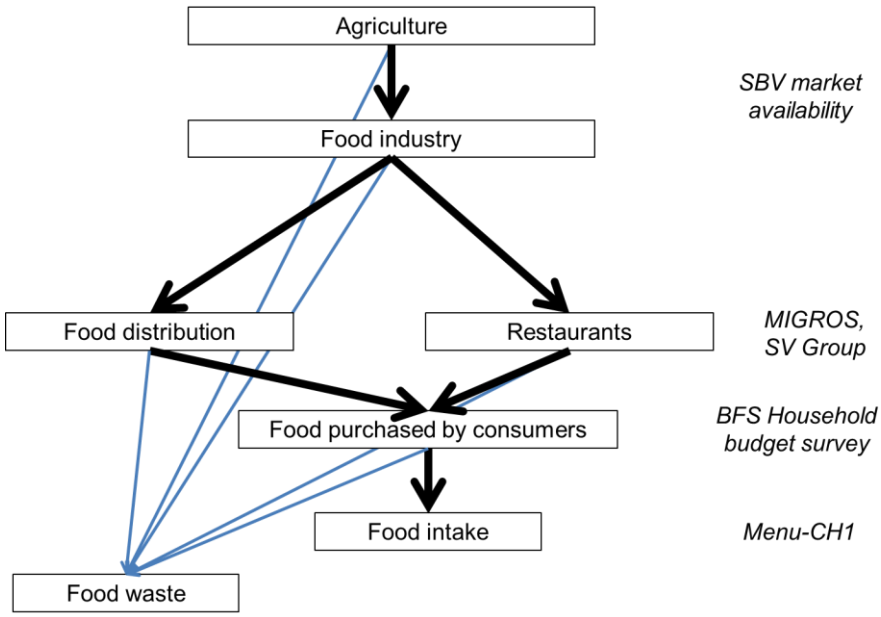

Figure 1: Food flows (black arrows) and different points of investigation to estimate the environmental impact. Food waste flows are shown with blue arrows.

The commissioner proposed 7 different diet styles, predefining their labelling and some basic characteristics. Further information on food provision per diet type and the environmental impacts was then elaborated by ESU-services. The information available on the amount of food produced for

the Swiss market in 2012 (Schweizerischer Bauernverband 2013) was used in this study to assess the average provision. Various studies and dietary recommendations were used in order to determine the production of food per specific nutrition type (Taylor 2000; USDA and USDH 2010; Meier and Christen 2013; Schweizerischer Bauernverband 2013; Leitzmann 2014; SGE 2014; van Dooren, Marinussen et al. 2014). The final report has been used for an article in the quarterly WWF member magazine.

2. Goal and Scope

This study evaluates and compares the environmental impact of the food provision for the average diet and for 6 different food provision scenarios in Switzerland, per person and year in a life cycle assessment (LCA). The starting point is the average availability of food products on the Swiss market. From this starting point, the following six scenarios are estimated: vegan, ovo-lacto-vegetarian, ovo-lacto-pescetarian, flexitarian, protein-oriented, meat-oriented. Furthermore, the impacts of just providing the food as recommended by the SGE (2014) for a sustainable and healthy diet is used as an eighth scenario (FOODprints®). In this last scenario, food losses in the life cycle are not accounted for.

The analysis includes the full life cycle of the food products until they are purchased in the supermarket. Transport to home and preparation are not included in this study. As far as data is available, conventionally produced consumption goods are included and compared. Organically cultivated food is not included in the framework of this study. For vegetable cultivation, the share of greenhouse cultivation is estimated. Switzerland is set as origin of food products whenever possible. Transport is estimated with average distances. Food losses in the life cycle are included in the data available for the food supply. Food losses in agriculture are roughly assessed (Schweizerischer Bauernverband 2013).

Health aspects are only considered in the recommendations of SGE for a sustainable and healthy diet but they are not a general focus of this study. Therefore, different scenarios for food supply are not necessarily comparable from a nutritional point of view. There might be certain health problems associated with the different scenarios. Also, the present consumption patterns of e.g. alcohol or sugar might not be healthy. Furthermore, individual demand for nutrients depends on e.g. age, health, gender, type of work or pregnancy and thus individual food intake patterns might be quite variable.

The total environmental impacts are assessed with the Ecological Scarcity Method 2013 and are presented as eco-points (Frischknecht, Büsser Knöpfel et al. 2013). Furthermore, the greenhouse gas potential is also evaluated (IPCC GWP 100a, IPCC 2013). The higher effect of greenhouse gas emissions by airplanes is included in this assessment with an RFI[1] factor (Jungbluth 2013).

3. Life Cycle Inventory (LCI)

The starting point is the amount of food available for the Swiss market in 2012 (Schweizerischer Bauernverband 2013). It includes the production in Switzerland and the balance of imports and exports. This information is complemented with additional statistics, for example data on beverage consumption. The values are then related to a single person in order to assess the environmental impact per year and person. This scenario corresponds to the Swiss average diet as it was estimated by the commissioner with a weekly consumption of 1kg of meat, 21 portions of milk products and 3 to 4 eggs.

Based on this average market availability, 6 different diet scenarios are estimated as shown in Table 1. The deviation is based on different studies for dietary recommendations and pre-defined values by the commissioner. The scenarios only model a change in protein intake. Other factors, for

[1] Radiative Forcing Index

example the provision of alcohol and mineral water, were not changed in comparison to the Swiss average scenario. The included amount of food provision is considerably higher than the finally eaten amount of food because food losses occurring at various points within the life cycle are included.

Additionally, the FOODprints® scenario is investigated. It refers to recommendations for a sustainable and healthy diet by the Swiss Society for Nutrition (Schweizerische Gesellschaft für Ernährung, SGE 2014). This "ideal" scenario is based on intake recommendations and does not consider food losses along the product life cycle. Therefore, it shows a lower amount of food produced and calorie intake. This scenario does not include any products transported by plane or cultivated in a heated greenhouse. Unhealthy food products such as alcoholic beverages and sweets are considerably reduced. Mineral water is fully replaced by tap water.

Table 1: Market availability (2012) and derived assumptions per diet and food product group. The FOODprints® scenario refers to the actually consumed amount of food.

Food product group	**Unit**	**Average 2012**	**Vegan**	**Ovo-lacto-Vege-tarian**	**Ovo-lacto-Pesce-tarian**	**Flexi-tarian**	**Protein-oriented**	**Meat-oriented**	**FOOD prints®**
Vegetables	kg	107	200	133	133	120	53	53	131
Fruits	kg	61	76	76	76	68	30	30	75
Grain Products	kg	171	171	171	171	171	171	171	111
Eggs and Honey	kg	13	0	16	16	12	33	20	9
Milk, Milk Products	kg	144	0	144	144	144	203	144	155
Meat	kg	50	0	0	0	16	78	104	13
Fish	kg	8	0	0	14	4	8	8	3
Meat alternatives and soy milk	kg	0	159	16	14	8	0	0	11
Fats and Oils	kg	30	30	30	30	30	30	30	11
Pulses	kg	1	8	4	4	3	1	0	5
Nuts	kg	4	13	13	11	8	4	2	9
Non-alcoholic beverages, without tap water	kg	215	215	215	215	215	215	215	34
Alcoholic beverages	kg	94	94	94	94	94	94	94	31
Total (without beverages)	**kg**	**587**	**657**	**602**	**612**	**582**	**610**	**562**	**533**
Calories (without beverages)	kcal/d	3227	2980	3288	3285	3202	3538	3292	2571
Proteins	g/d	101	173	90	94	90	147	121	77

The average amount of food available on the Swiss market is set to 600 kg per year and person, beverages not included. This amount is decisively higher than the finally consumed food because various food losses occur within the product life cycle. The following assumptions were made for the different food provision scenarios:

Based on the average scenario and as compensation for the complete abstinence from meat and fish, the amount of meat alternatives, pulses and nuts was increased for the ovo-lacto-vegetarian and the vegan scenario. The increase corresponds to the conversion factors such as they are applied in van Dooren et al. (2014) between the average Dutch consumption and the vegetarian and vegan diet. Therefore, the protein supply is considered to be sufficient in all scenarios.

For the amount of vegetables in the vegan scenario, the respective amount in the ovo-lacto-vegetarian scenario was multiplied by factor 1.5. The provision of fruits was not modified. These estimations are oriented towards the dietary recommendations for the vegan diet, as they are stated in van Dooren (2014, factor 2) and in USDA (2010, no increase). Furthermore, soy milk substitutes the amount of milk and milk products consumed in the average scenario (see van Dooren, Marinussen et al. 2014).

For the ovo-lacto-vegetarian scenario, the amount of vegetables and fruits consumed in the average diet was increased by 25 percent (mean value between vegan and average diet). The flexitarian scenario is calculated as the mean values of the average and the ovo-lacto-vegetarian scenario.

For the protein- and meat-oriented scenarios, the amount of animal products was increased to the values defined by the commissioner. In contrary, the amount of vegetables and fruits is only half of the consumed amount in the average scenario, because a compensation of the higher values in meat and milk product consumption is assumed.

The amount of grain products is set the same for all diet scenarios. The same is true for oils and fats, as well as for alcoholic and non-alcoholic beverages (except FOODprints®). Tap water is not included in Table 1, but taken into account in the life cycle inventory analysis.

Table 2 provides further information on the food products included in the life cycle inventory analysis per food product group. The modelling of the LCI is based on the assumptions for food product groups shown in Table 1. For the LCI, more detailed data is used. Each food product group is allocated to single food products as they are shown in the middle column (for example division of the overall amount of meat in beef, veal, pork and poultry). The inventory analysis is based on data of the ecoinvent database (ecoinvent Centre 2010; LC-inventories 2016) and data of the ESU-database (ESU 2016; Jungbluth, Keller et al. 2016). In the LCIA, the various food product groups are limited to a reduced number of food categories, what allows an easier interpretation of the results at a later stage (right column).

Table 2: Food product groups, the included food products and the respective food category in LCIA

Food product group	Included food products	Food category in LCIA
Vegetables	Diverse sorts of vegetables, white mushrooms, herbs	Vegetables and Fruits
Fruits	Diverse sorts of fruits	Vegetables and Fruits
Grain Products	Bread, flour, grain, rice, potatoes, sugar, biscuits	Grain Products
Eggs and Honey	Eggs, Honey	Animal Products
Milk, Milk products	Milk, cheese, yoghurt, cream, whey protein powder	Animal Products
Meat	Diverse sorts of meat such as beef, veal, pork, poultry	Meat and Fish
Fish	Fish, mollusk, crustaceans	Meat and Fish
Meat alternatives and soy milk	Tofu, quorn, soy milk	Vegetable Proteins
Fats and Oils	Diverse sorts of vegetable oils, margarine, butter, chocolate	Fats and Oils
Pulses	Pulses such as lentils	Vegetable Proteins
Nuts	Nuts such as almonds	Vegetable Proteins
Non-alcoholic beverages, without tap water	Coffee, tea, fruit juices, soda, mineral water	Beverages
---	Tap Water	Beverages
Alcoholic beverages	Beer, wine, liquors	Beverages

4. Life Cycle Impact Assessment (LCIA)

Figure 2 shows that the environmental impact of the average food consumption scenario amounts to about 5 million eco-points per person and year. This figure is comparable to the results calculated with an input-output analysis for Switzerland (Jungbluth, Nathani et al. 2011).

The FOODprints®-scenario causes a low environmental impact but cannot be fully compared to the other diet styles because only the food intake is considered. Regarding the food provision scenarios, the food provision for the vegan diet scenario causes the lowest environmental impacts. The highest impacts are calculated for the scenarios “protein-oriented” and “meat-oriented”. The impacts caused by the product groups “meat and fish” and “animal products” are most relevant and explain the main differences in the overall environmental impact between the different food scenarios (see Figure 2).

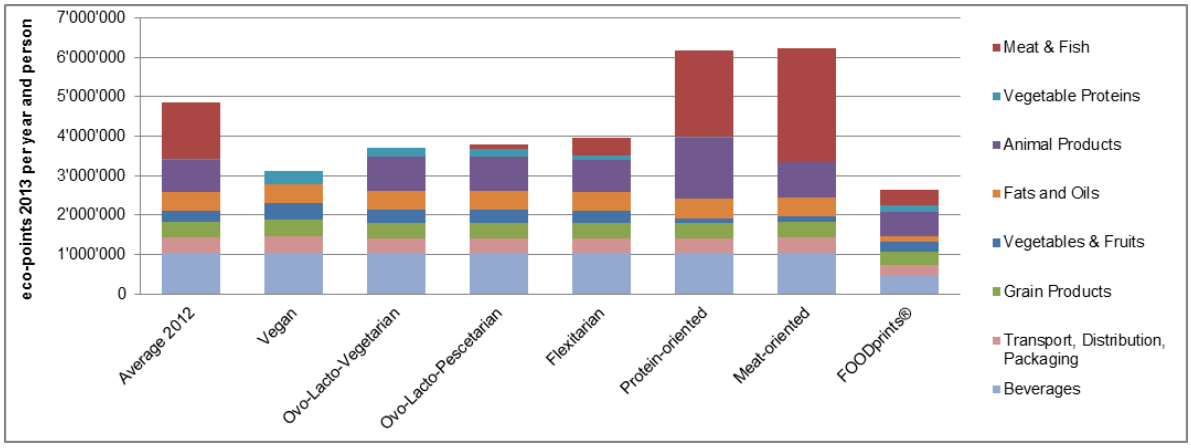

Figure 2: Environmental impacts of different dietary scenarios split per food product groups (eco-points per year and person).

The same statements made for the environmental impact (Figure 2) are also true for the results regarding the global warming potential as shown in Figure 3. The pattern is very similar and only small differences are identifiable for the global warming potential compared to the total environmental impacts. The share of animal products (mainly milk products) is higher than in the total environmental impact because the methane produced by cattle has a higher relative impact. In addition, the emission of greenhouse gases in transport has a bigger share in the global warming potential than it has in the total environmental impacts.

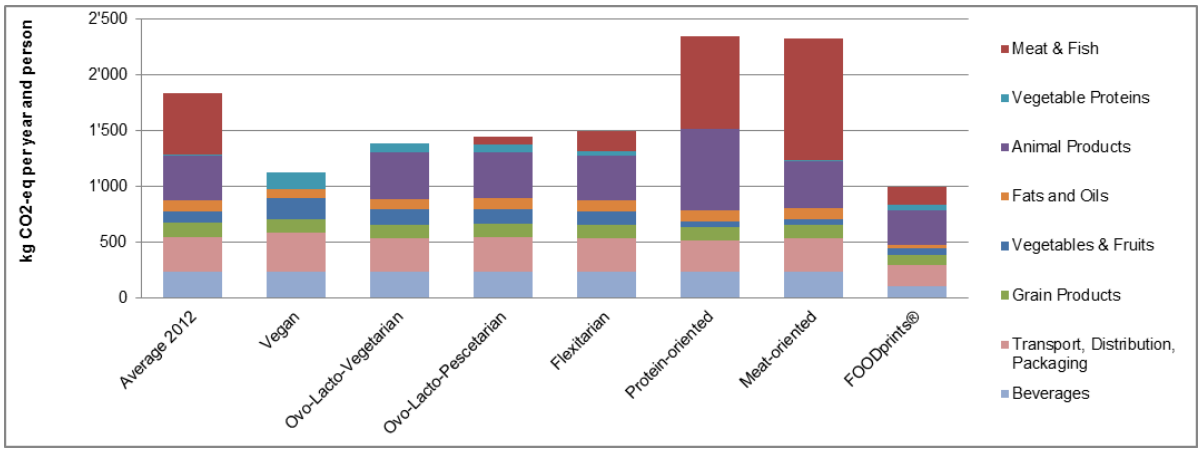

Figure 3: Global warming potential of the different dietary scenarios, split per food product group (kg CO2-eq per year and person)

The analysis of shares of the different environmental impact categories is presented in Figure 4. The impact categories “heavy metals into soil” and “main air pollutants” and “particulate matter” show the highest variability regarding their influence on the overall impact. “Heavy metals into soil” play a more important role in the vegetable based food provision scenarios. The environmental impact of this impact category is predominantly caused by the fertilizer and pesticide usage in coffee and wine production. However, as the absolute amount of coffee and wine provision is defined the same for all scenarios (except FOODprints®), differences in the share of that impact category are mainly explained by the lower overall impact of vegetable based food provision scenarios. In contrary, the food provision scenarios rather based on animal products show a higher share in main air pollutants and particulate matter. This is caused by the ammonia and nitrogen oxides emissions in livestock breeding. The share of the other impact categories does not vary between the different scenarios in a relevant way.

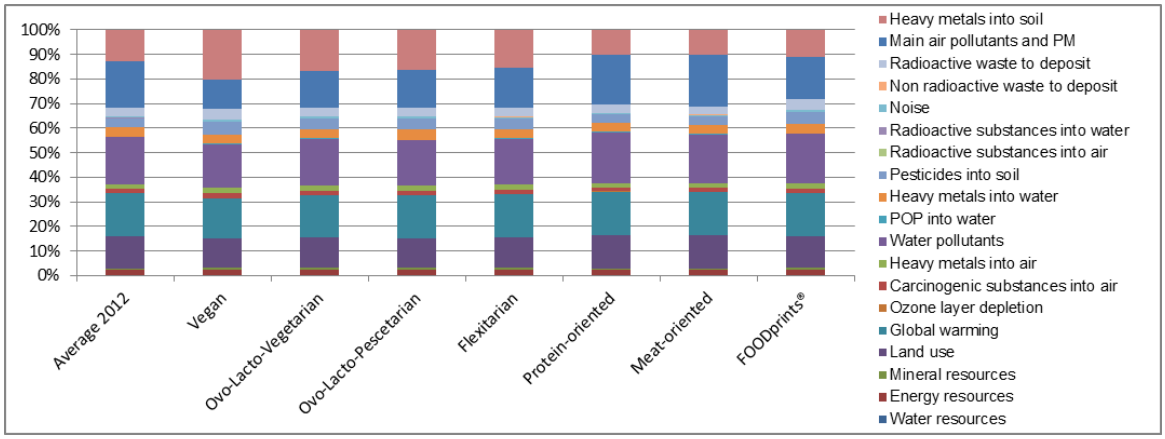

Figure 4: Environmental impact of the different scenarios, split per impact categories of the Ecological Scarcity method 2013

5. Interpretation

The results confirm the important role of meat and fish provision concerning the environmental impact of diets in Switzerland. Vegetable proteins in the meat-reduced diets cause a lower environmental impact. This is even true for the vegan diet scenario, which is characterized by an increased amount of consumed vegetable proteins in order to substitute meat, fish and other animal products such as milk and eggs. The impact of other animal products is to be highlighted as well when addressing reduction potentials of environmental impacts. After meat and fish, this food product group is the second most important source of the environmental impact of diets.

For all scenarios, the same amount of beverages was assumed (except FOODprints®). Therefore, this food product group does not influence the differences between the diet scenarios. Nevertheless, the beverage provision has to be considered when assessing environmental impact reduction potentials. On average, almost a quarter of the total impact is caused by beverages (particularly wine and coffee).

Figure 5 provides an overview on the results of the studies conducted so far in Switzerland and includes some of the results obtained in the study at hand ("market availability", "scenario, availability, vegan", "scenario, availability, meat oriented", "scenario, intake recommendation, FOODprints®"). The results depend on the starting point of the analysis. The highest environmental impacts are those obtained with the top-down approach (input-output-analysis) (Jungbluth, Eggenberger et al. 2016)followed by the modelling of the food availability presented here. If impacts are calculated based on recommended diets, the amounts of food are much lower than the real market availability. This can be explained by food waste in different stages of production and by a possible overconsumption. Estimates based on nutritional recommendations also tend to underestimate the impacts because they seem to omit parts of frequently consumed food (e.g. alcohol or sweets). Hence, there are huge differences between the impact results when considering different starting points in terms of the amount of food included.

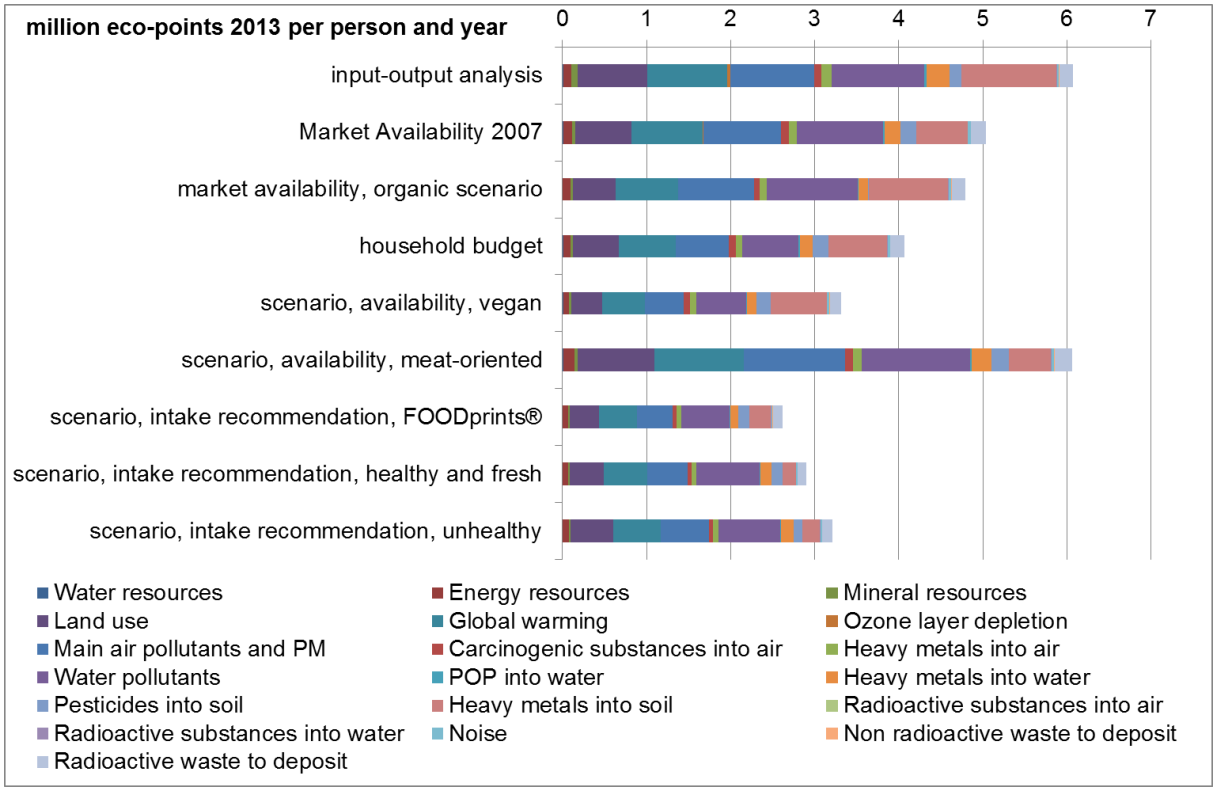

Figure 5: Environmental impacts of food consumption calculated for Switzerland (eco-points per person per year. Calculation is conducted with different statistics, accounting methods and scenarios.

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