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D7.1 Current and Future Diets

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Project title: Gap resolutIon in sAfety, NuTritional, alLergenicity and Environmental assessments to promote Alternative Protein utilization and the dietary Shift

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Executive Summary

This document contains a description of current diets across Europe and a plan to compose future diets with alternative protein derived foods for four regions in Europe (Deliverable 7.1). The report consists of two main sections namely *Current diets* and *Future diets*. This deliverable is part of a set of four deliverables related to WP7.

The section *Current diets* addresses the methodology to estimate the current food consumption of the European population and evaluate its nutritional adequacy and quality, and environmental sustainability. Nationally-representative dietary surveys from 28 European countries were used as input to calculate food consumption and related nutrient intakes and environmental impacts. Results are presented for four European regions (i.e. North, South, West, and East). Overall, dairy products were the most consumed animal-based food, followed by meat, fish and seafood, and eggs. Comparing regions showed that Northern Europe had the highest dairy consumption, Eastern Europe consumed the highest amounts of meat and eggs, and Southern Europe consumed most fish and seafood. Nutritional assessment showed that mean protein intake was comparable between regions and exceeded the average protein requirement. Animal protein contributed 64-72% to total protein intake, which was mostly derived from meat and dairy products. Environmental assessment showed that absolute diet-related greenhouse gas emissions and land use were lower in Southern Europe compared to the other regions. Meat consumption contributed highest to greenhouse gas emissions and land use. Overall, differences in environmental impacts between regions were smaller for energy-standardized values compared to absolute values.

Based on the current diets consumed by the European population, future diets with alternative protein derived foods will be composed for four regions in Europe. The section *Future diets* describes a number of dietary scenarios that will be created. The scenarios include (1) complying to the dietary guidelines, (2) lowering animal-based protein foods, (3) replacing animal-based protein foods with alternative protein foods based on a 50/50 ratio, and (4) replacing animal-based protein foods with alternative protein foods based on a 30/70 ratio. Furthermore, the section sets out the different data sources needed for composing these future diets based on current diets. Future diets will be evaluated on their nutritional and environmental properties in the next stage of this project. Results will be presented in Deliverable 7.3 (M42).

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List of Acronyms

BMI	Body Mass Index
DRV	Dietary reference value
EFSA	European Food Safety Authority
EuroFIR	European Food Information Resource
GHG	Greenhouse gas
LCA	Life cycle assessment
MRI	Max Rubner-Institut
MRV	Maximum recommended value
NEVO	Dutch Food Composition Database
NRF	Nutrient Rich Foods
SHARP-ID	SHARP Indicators Database
WP	Work Package

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Set up of the deliverable

Deliverable 7.1 is part of a set of four deliverables related to WP7. The aim of WP7 is to assess the impacts of the foreseen dietary shifts using alternative protein derived foods on human health and the environment, and compare these with current, observed diets. Eventually, we wish to optimise the dietary shifts while complying with health and environmental requirements but also accounting for consumer preferences and costs.

This deliverable includes (1) a description of current diets across Europe, and (2) a plan to compose future diets with alternative protein derived foods for four regions in Europe. The methodology and results of the current diets are described in section 1. The rationale and planning to derive future diets are described in the section 2.

1. Current diets

As a first step in WP7.1, the current food consumption of the European population was defined and evaluated for its nutritional adequacy and quality, and environmental sustainability. Based on nationally-representative dietary surveys from 28 European countries, we calculated the current diet and related nutrient intakes and environmental impacts per country and region. All countries and regions were compared and evaluated, allowing to identify region-specific nutrient gaps and environmental challenges. In the following sections, the methodology and results are provided.

Methodology

Study population and dietary data

Individual-level food consumption data were obtained from nationally-representative dietary surveys, available from the European Food Safety Authority (EFSA) Comprehensive European Food Consumption Database [1]. This database is part of the EU Menu project that aims to increase the availability of high-quality, detailed, and harmonized food consumption data across Europe [2]. From the 29 European countries included in the database, 28 European countries for which dietary information for the adult population (aged 18-64 years) was available, were selected for our study (**Appendix, Table A1**).

Detailed information concerning the methodologies and protocols used for the dietary surveys can be retrieved from the original publications of each country, accessible through the EFSA database [1]. In short, individual-level food consumption data were collected by all participating European countries, preferably according to the EU Menu methodology [2], and provided to EFSA. Data were obtained between 2000 and 2021 for 1-7 days by means of (web-based) food records or 24-hours / 48-hours dietary recalls (**Appendix, Table A1**). All food items were classified for each country according to the FoodEx2 classification system developed by EFSA [3]. We requested and received the food consumption data via EFSA with permission from the countries. Particularly, the authors of the dietary surveys of Bosnia and Herzegovina [4], Montenegro [5], and Serbia [6] provided their consent for the use of the data.

Food consumption data were linked with detailed information on nutrient composition per food item, using the Dutch Food Composition Database (NEVO) [7]. This database was selected due to its comprehensive inclusion of macro- and micronutrients and representativeness of the European context. Moreover, the database was recently extended with information on amino acid profiles, which is especially of interest to our study and missing in (almost) all food composition tables in Europe.

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Two previously used linkages were combined and evaluated [8–10], and remaining food items were matched to the NEVO code that most closely resembled the seventh level of the FoodEx2 classification based on nutritional value and/or ingredient composition. All coding was done by two researchers and checked by a research dietician.

Nutritional adequacy and quality

Nutritional adequacy of the diets was defined by the fulfilment of a set of nutrient recommendations relevant for the European population and important when limiting the consumption of animal-based foods. The population prevalence of inadequate intake of nutrients of the diets was estimated using dietary reference values (DRVs) and maximum recommended values (MRVs). DRVs were derived from EFSA [11]. MRVs were not available from EFSA and, therefore, derived from the World Health Organisation [12, 13] and Food and Agriculture Organisation [14]. Nutritional quality of the diets was assessed with the Nutrient Rich Foods (NRF) index [15, 16]. The NRF algorithm was calculated as the unweighted sum of percentage DRVs for nutrients to encourage minus the sum of percentage MRVs for nutrients to limit. In the present study, the NRF15.3 was used to capture as many nutrients that are potentially relevant to the European population. The NRF15.3 includes fifteen nutrients for which intake should be promoted (protein, mono-unsaturated fatty acids, dietary fibre, calcium, iron, potassium, zinc, vitamins A, D, E, C, B1, B2, B12, and folate) and three nutrients for which intake should be limited (saturated fat, added sugar, and sodium).

Environmental sustainability

Diet-related environmental impacts were calculated using the SHARP Indicators Database (SHARP-ID) [17], which includes estimates of European average greenhouse gas (GHG) emissions and land use of food items. The SHARP-ID was developed as part of the EU-financed SUSFANS project (H2020-SFS-2014-2, Grant 633692). In short, attributional life cycle assessment (LCA) was applied to quantify the environmental impacts throughout the entire life cycle of a food product, including primary production, primary packaging, transport, food losses and waste, and food preparations at home. Due to limited availability of data, industrial food processing, storage, and transport from retail to home were not included. To divide environmental impact between a product and its co-products, economic allocation was used for all foods, expect for animal-sourced foods where nitrogen allocation was applied. LCA data were adjusted for consumption amount using available conversion factors for production, edible portion, cooking losses and gains, and food losses and waste. LCA data were available for 957 FoodEx2 coded foods, based on 182 primary food products, that are relevant to food consumption in four European countries (Denmark, Czech Republic, Italy, and France).

To extend the LCA data to food items consumed in the remaining European countries, extrapolations were carried out. Missing values were preferably supplemented with estimates for similar food items, comparable in production method and/or ingredient composition. Alternatively, the mean value of the same (and if not available higher) level of the FoodEx2 classification was used. For instance, *preserved tomatoes not concentrated* (level 4) was extrapolated with the mean value of all items in that specific subgroup, while *rice chips* (level 5) was extrapolated with the mean value of the higher subgroup *chips/crisps* (level 4). Furthermore, recipes were created for composite dishes based on a combination of food items if no suitable alternative was available. For instance, *beans, meat, and vegetables meal* was extrapolated with 1/3 *legumes based dishes*, 1/3 *mammals and birds meat*, and 1/3 *vegetables and vegetable products*. All extrapolations were done and checked by a team of two researchers.

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Demographic and anthropometric characteristics

Information on demographic and anthropometric characteristics of participants of the dietary surveys were delivered by EFSA with permission from the countries. Data were available on age, sex, educational level, special condition, body weight, and height. Age was categorized in three categories (18-34 years, 35-49 years, and 50-64 years) and educational level was coded as low (no till lower secondary education), medium (upper secondary or post-secondary education), or high (university to post-university education). Body Mass Index (BMI) was calculated by dividing body weight by height squared (kg/m^2) and participants were categorized as underweight, normal weight, overweight, or obese based on BMI cut-off values of the World Health Organisation [18]. In statistical analyses, lactating or pregnant participants were excluded.

Statistical analysis

Countries were assigned to one of the four European regions (i.e. North, South, West, and East) (**Table 1**). Demographic and anthropometric characteristics of the study population were generated for each country and region. Continuous variables were expressed as means with SDs and categorical variables as counts with percentages. For all participants in the dietary surveys, daily food and beverage consumption, nutritional adequacy and quality, and GHG emissions and land use of the diet were calculated. Since energy intake varies considerably between countries, food and beverage consumption were standardized for total energy intake and expressed per 2000 kcal. Both absolute and energy-standardized GHG emissions and land use were presented to show the influence of varying energy intakes on environmental impacts. Means with SDs were generated for each country and region. In the current report, results are presented for each of the four European regions stratified by sex. A scientific paper with more detailed results on all countries is in process, which will also contain more information on nutritional adequacy and quality.

Table 1. Country division in European regions.

European regions			
North (5)	**South (5)**	**West (7)**	**East (11)**
Denmark	Cyprus	Austria	Bosnia and Herzegovina
Estonia	Greece	Belgium	Bulgaria
Finland	Italy	France	Croatia
Latvia	Portugal	Germany	Czechia
Sweden	Spain	Ireland	Hungary
		Netherlands	Montenegro
		United Kingdom	Poland
			Romania
			Serbia
			Slovakia
			Slovenia

Results

Baseline characteristics

Of the 48,228 participants in the national dietary surveys and included in the analyses, the majority originated from Western Europe (n = 19,835, 41%), followed by Eastern Europe (n = 14,041, 29%) and Northern Europe (n = 7663, 16%), and the lowest number of participants were located in Southern

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Table 2. Baseline characteristics of the study population stratified for European region.

	North		South		West		East	
Characteristics[1]	Mean / n	SD / %	Mean / n	SD / %	Mean / n	SD / %	Mean / n	SD / %
Population	7663		6689		19,835		14,041	
Sex								
Males	3321	43.3	3171	47.4	8799	44.4	6818	48.6
Females	4342	56.7	3518	52.6	11036	55.6	7223	51.4
Age (years)	42.5	13.3	42.2	13.0	41.5	13.0	40.5	13.0
Age category								
18-34 years	2397	31.3	2136	31.9	5687	31.8	5294	37.7
35-49 years	2589	33.8	2331	34.8	6712	37.6	4574	32.6
50-64 years	2677	34.9	2222	33.2	5457	30.6	4173	29.7
BMI (kg/m^2)	26.0	4.9	26.0	5.0	26.0	4.6	25.7	5.0
Weight status								
Under weight	148	1.9	138	2.1	313	1.6	325	2.3
Normal weight	3597	46.9	3152	47.1	7734	39.0	6571	46.8
Overweight	2580	33.7	2195	32.8	8865	44.7	4968	35.4
Obese	1338	17.5	1204	18.0	2923	14.7	2177	15.5
Educational level								
Unspecified	4349	56.8	2592	38.8	16,375	82.6	7750	55.2
Low	269	3.5	1746	26.1	226	1.1	2195	15.6
Medium	1659	21.6	1181	17.7	1293	6.5	2031	14.5
High	1386	18.1	1170	17.5	1941	9.8	2065	14.7

[1] Continuous variables are presented as means with SDs and categorical variables are presented as counts with percentages.

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Europe (n = 6689, 14%) (**Table 2**). Age and sex distributions were comparable between regions, with a mean age ranging between 40.5-42.5 years and 43-49% of the population being male. Distribution of weight status varied slightly between regions; 59.4% of the Western European population was overweight or obese, whereas overweight and obesity combined was less prevalent in Northern Europe (51.2%), Eastern Europe (50.9%), and Southern Europe (50.8%). Interestingly, the proportion of obese participants was lowest in Western Europe (14.7%) and highest in Southern Europe (18.0%). Information on educational level was unavailable for the majority of the study population (64%), and therefore insufficient to compare regions.

Food consumption

Figure 1 and 2 show the energy-standardized consumption of food and beverage groups in four European regions stratified by sex. Consumption of animal-based foods (i.e. meat, fish and seafood, other protein sources, eggs, dairy products, and animal fats) varied markedly between regions (**Figure 1**). Dairy products were the most consumed animal-based food in all regions, except for Eastern European males who consumed more meat products. Northern Europe had the highest dairy consumption with mean intakes of 332.9 and 303.4 g/day for females and males, respectively, followed by Southern Europe (330.6 and 241.8 g/day), Western Europe (263.9 and 213.9 g/day), and Eastern Europe (209.9 and 170.1 g/day). In all regions, milk contributed most to dairy consumption, while yoghurt, cheese, and cream and dessert were less consumed. Mean consumption of meat ranged between 124.9-155.3 and 146.4-185.3 g/day for females and males, respectively, across regions, with Eastern Europe reporting the highest amounts and Western Europe the lowest amounts. Meat consumption mainly consisted of red meat, closely followed by processed meat, and the lowest consumption was found for white meat. Exceptions were the Southern European population who consumed more white meat than processed meat, and the Southern European males and Eastern European females who consumed more non-ruminant red meat than ruminant red meat. Mean consumption of fish and seafood ranged between 20.9-51.0 and 17.4-49.0 g/day for females and males, respectively, across regions, with the highest consumption in Southern Europe and lowest consumption in Eastern Europe. On the contrary, the Eastern European population consumed the highest amounts of eggs (29.6 and 32.5 g/day), whereas the consumption was lowest in Western Europe (19.8 and 19.7 g/day). Other protein sources, including amphibians, reptiles, snails, and insects, were on average not to minorly consumed in all regions (<0.1 g/day).

Considering plant-based foods (i.e. grains, starchy root and tubers, vegetables, fruit, legumes, nuts and seeds, vegetable oils and fats, meat and dairy imitates), grains were the most consumed plant-based food in all regions, except for Northern and Southern European females who consumed slightly more fruit and vegetables and only vegetables, respectively (**Figure 1**). Although refined grains contributed largely to the total grain consumption in all regions, the refined to whole grain ratio was largest for Southern Europe (11:1 and 17:1) and smallest for Northern Europe (2:1 and 2:1). Mean fruit and vegetable consumption ranged between 92.3-215.5 g/day and 147.9 – 246.6 g/day across regions, respectively. Northern European females (215.5 g/day) and Southern European males (146.6 g/day) consumed the highest amounts of fruits, whereas Southern European females and males consumed the highest amounts of vegetables (246.6 and 212.4 g/day). Consumption of both fruit and vegetables was lowest in Western Europe. Legumes (6.7-13.5 g/day), nuts and seeds (2.9-4.9 g/day), and meat and dairy imitates (0.7-13.1 g/day) were on average only minorly consumed in all regions, with higher intakes for females compared to males.

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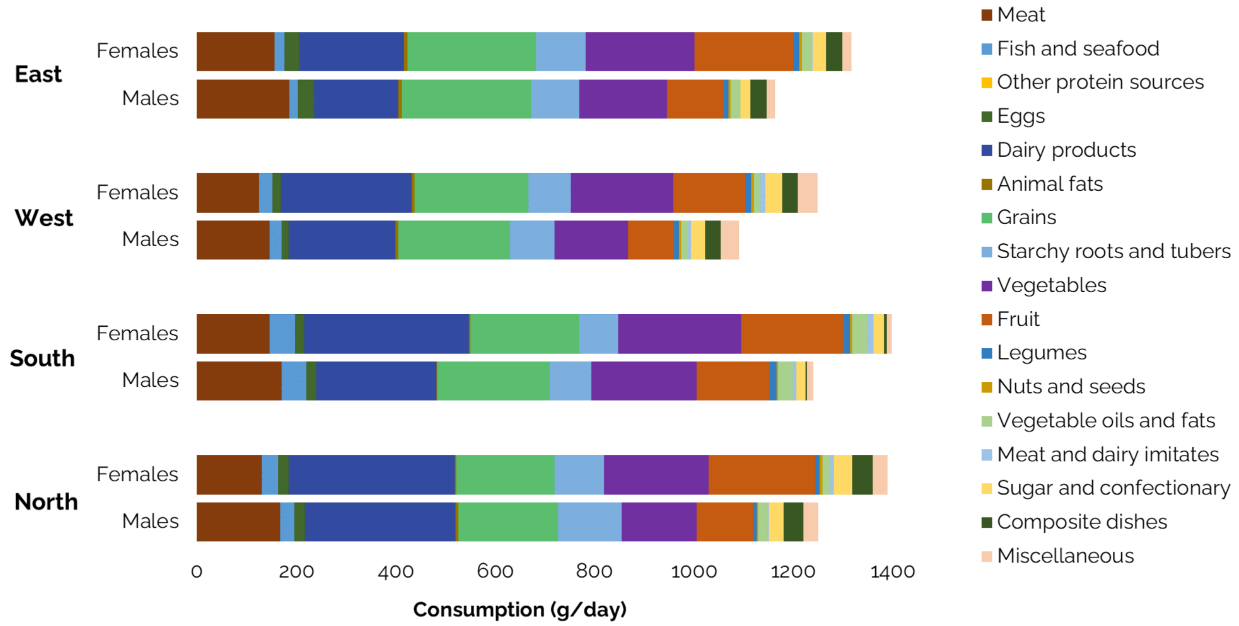

Figure 1. Mean consumption of food groups in four European regions stratified by sex. Values are standardized for total energy intake of the diet and expressed per 2000 kcal. Other protein sources include amphibians, reptiles, snails, and insects.

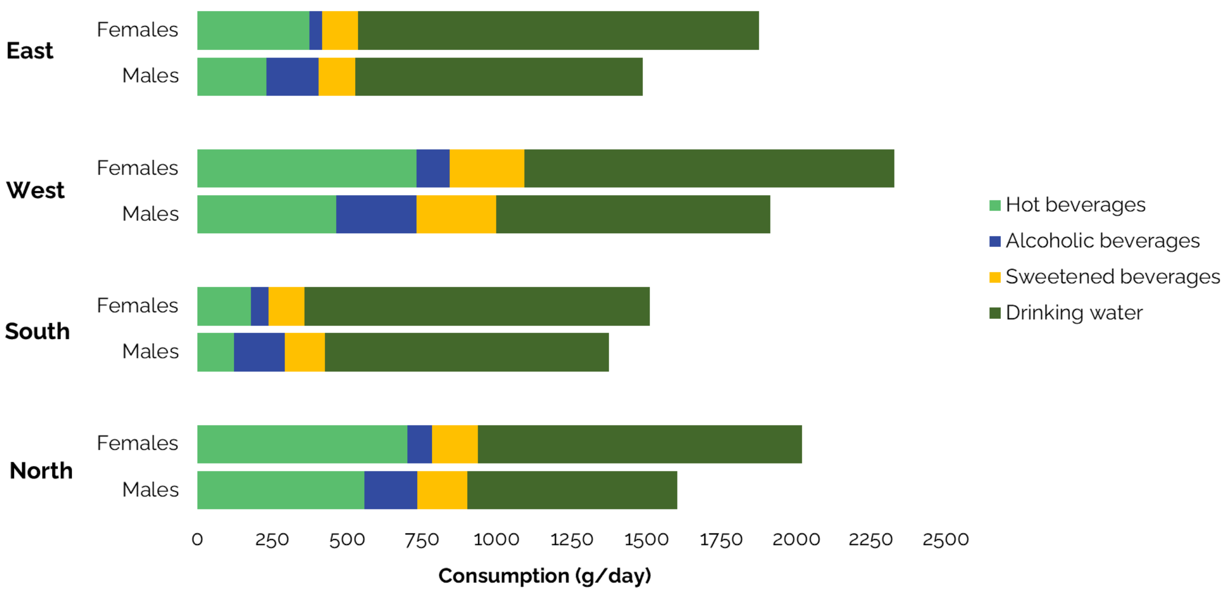

Figure 2. Mean consumption of beverage groups in four European regions stratified by sex. Values are standardized for total energy intake of the diet and expressed per 2000 kcal.

Mean consumption of sugar and confectionary ranged between 21.5-37.5 and 18.1-30.6 g/day for females and males, respectively, across regions, with the highest consumption in Northern Europe and lowest in Southern Europe (**Figure 1**). Interestingly, the Western European population consumed on average considerably higher amounts of sugar sweetened beverages (248.6 and 265.4 g/day) compared to the other regions (**Figure 2**). Mean consumption of hot beverages was approximately 2-

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3 times higher in Northern and Western Europe compared to Eastern and Southern Europe, respectively.

Protein intake and adequacy

Mean daily protein intake differed only slightly across European regions, ranging between 1.07-1.11 g/kg body weight (**Figure 3**). In all regions, the mean daily protein intake exceeded the average protein requirement of 0.66 g/kg body weight. Nonetheless, 9-18% of the total study population did not meet the protein requirements. Protein inadequacy (i.e. protein intake <0.66 g/kg body weight) was more prevalent in Western Europe (18%) and Eastern Europe (17%) compared to Northern Europe (14%) and Southern Europe (10%).

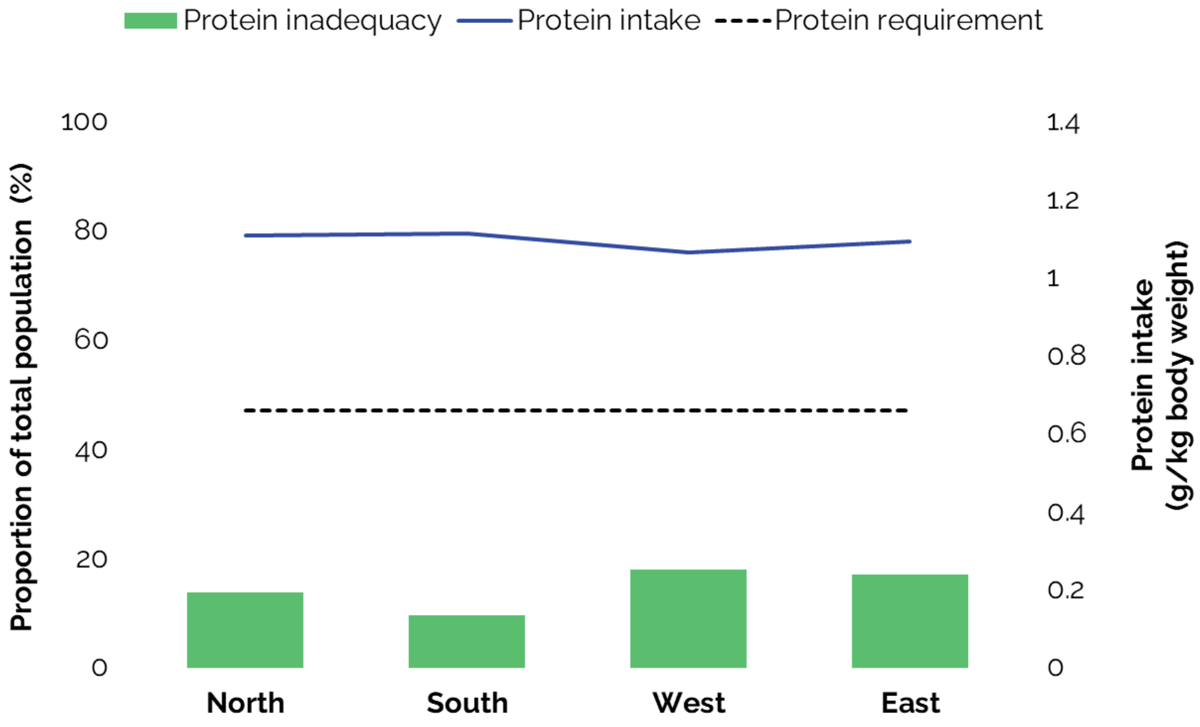

Figure 3. Mean daily protein intake in four European regions compared to the average protein requirement (0.66 g/kg body weight), including the proportion of participants with inadequate protein intake (<0.66 g/kg body weight).

Animal protein contributed more to the total protein intake than plant protein in all regions, ranging between 64-70% and 65-72% for females and males, respectively (**Figure 4**). In Southern Europe and Northern Europe, the contribution of animal protein was slightly higher compared to Western Europe and Eastern Europe. More than one third of the total protein intake was related to meat consumption (30-42%), which was higher for males compared to females (**Figure 5**). Grains and dairy products contributed 18-26% and 12-23%, respectively, to the total protein intake. The Northern European population had a higher protein intake from dairy products compared to grains, whereas this was reversed for the other regions.

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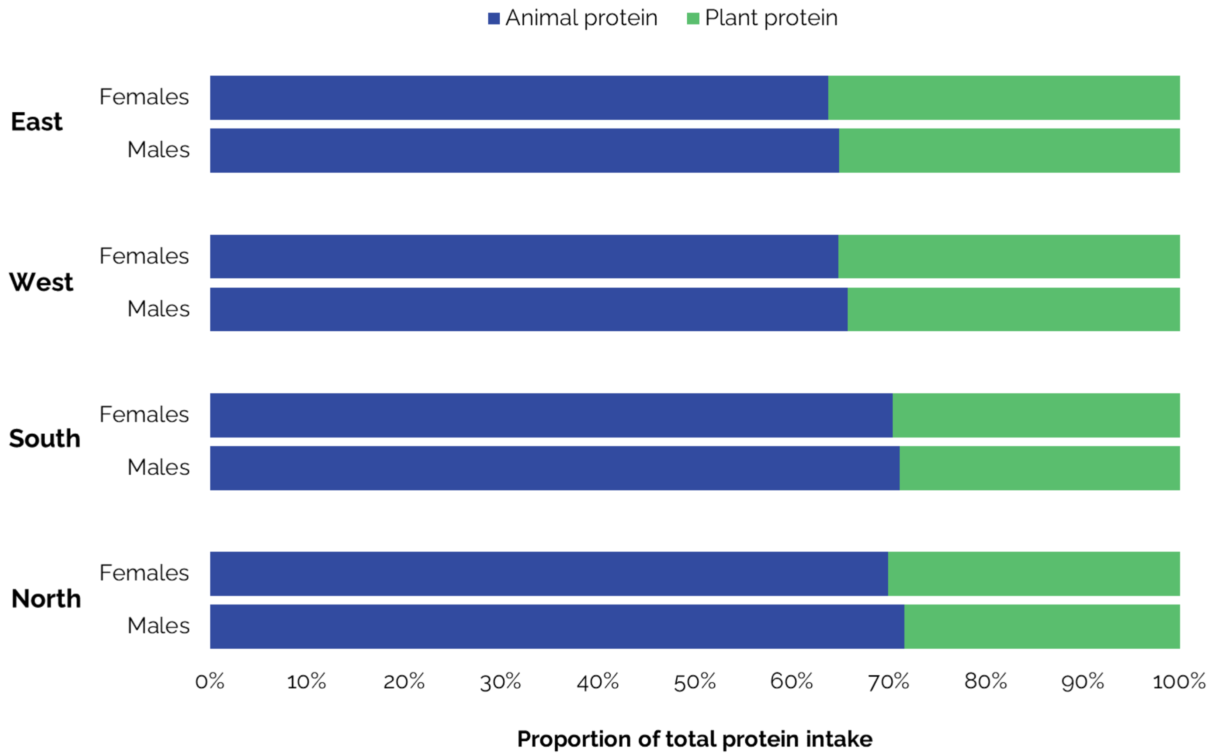

Figure 4. Contribution of animal and plant protein to the total protein intake in four European regions stratified by sex.

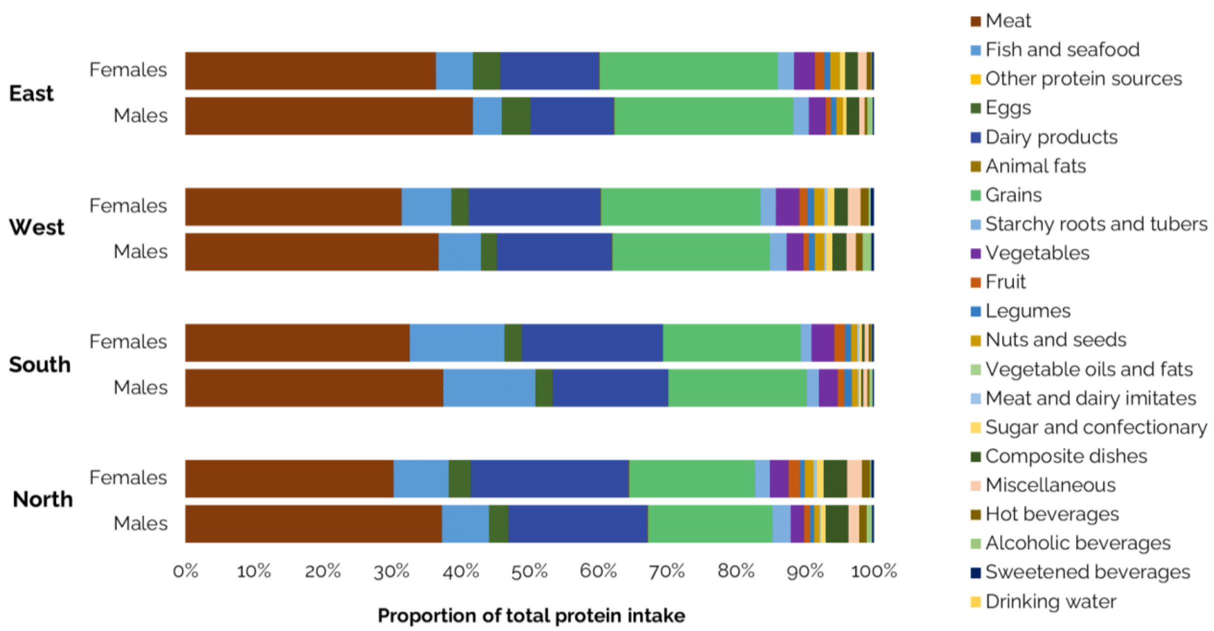

Figure 5. Contribution of food and beverage groups to the total protein intake in four European regions stratified by sex. Other protein sources include amphibians, reptiles, snails, and insects.

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Environmental sustainability

Absolute and energy-standardized diet-related GHG emissions and land use in four European regions stratified by sex are presented in **Figure 6 and 8**. Mean absolute GHG emissions ranged between 4.3-5.1 and 5.8-7.0 kg CO_2-eq/day for females and males, respectively, across regions, with markedly lower emissions for Southern Europe compared to the other regions (**Figure 6**). More than one third of the absolute diet-related GHG emissions were related to meat consumption (33-48%), which was higher for males compared to females (**Figure 7**). Dairy products and grains contributed 12-21% and 6-14%, respectively, to the absolute diet-related GHG emissions. Mean absolute land use ranged between 5.4-6.3 and 7.6-9.5 m^2/day for females and males, respectively, across regions (**Figure 8**). Again, diets of the Southern European population used the lowest amount of land, whereas the other regions differed less. In all regions, meat contributed to approximately half of the absolute diet-related land use (44-58%), followed by grains (10-18%) and dairy products (8-16%) (**Figure 9**).

For males, absolute environmental impacts were higher than energy-standardized environmental impacts, whereas the reverse holds for females (**Figure 6 and 8**). Exceptions were Southern European males who reported slightly lower absolute GHG emissions and land use. Overall, differences in environmental impacts between regions and sex were smaller for energy-standardized values compared to absolute values.

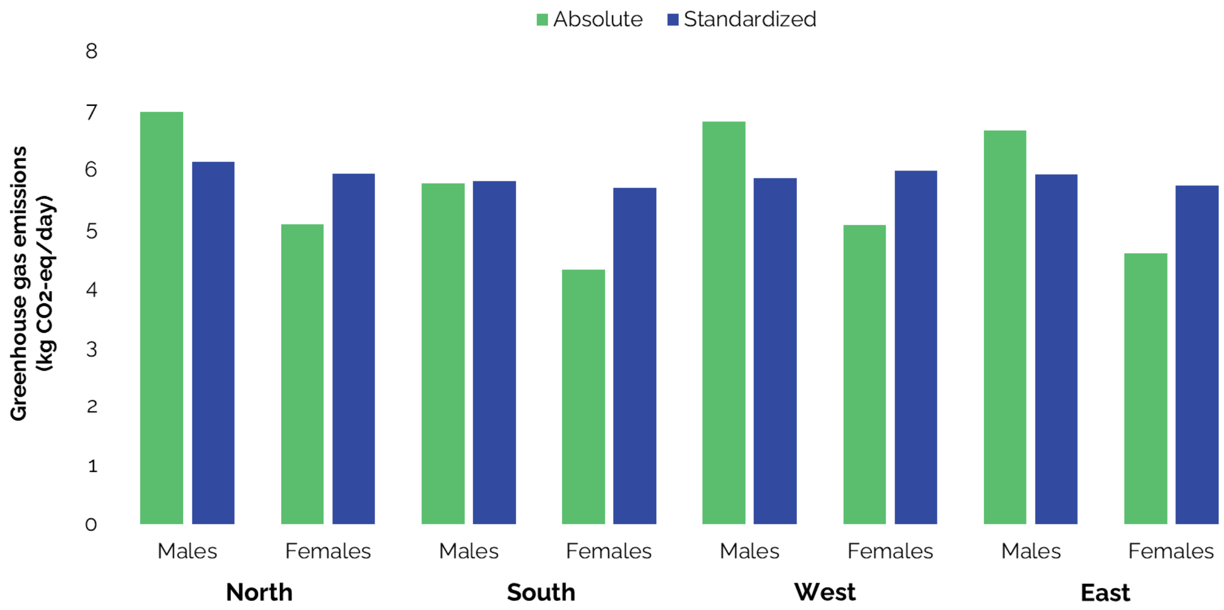

Figure 6. Mean absolute and energy-standardized diet-related greenhouse gas emissions in four European regions stratified by sex. Standardized values are expressed per 2000 kcal.

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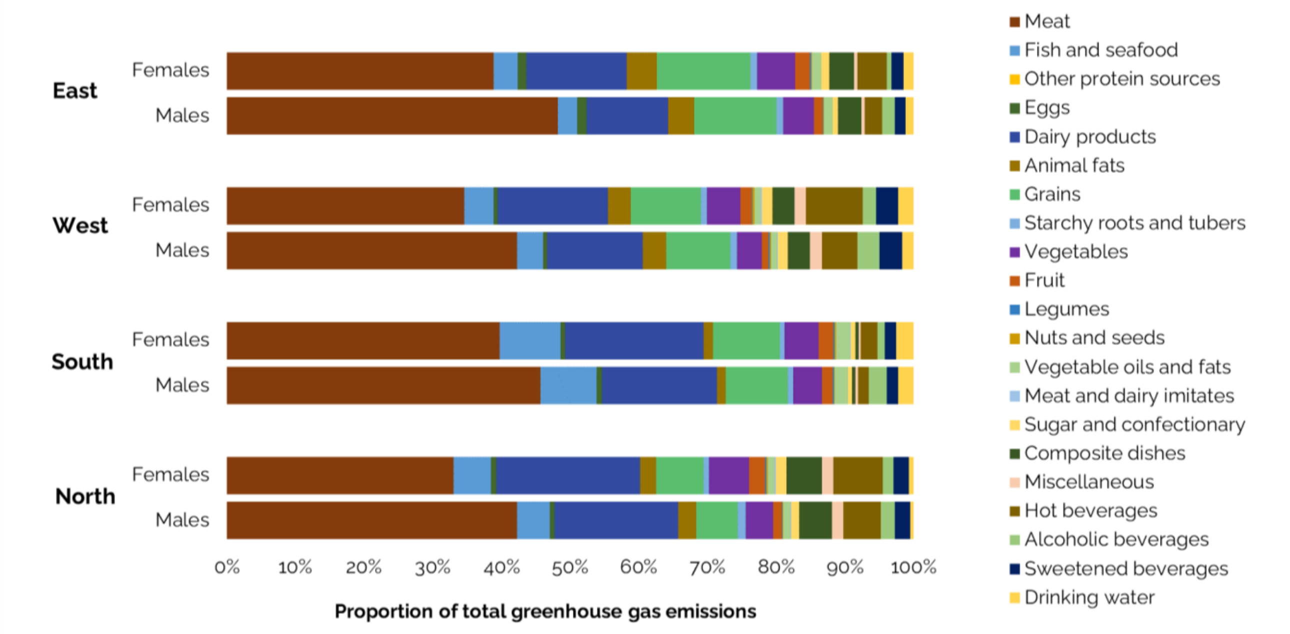

Figure 7. Contribution of food and beverage groups to the mean absolute diet-related greenhouse gas emissions in four European regions stratified by sex. Other protein sources include amphibians, reptiles, snails, and insects.

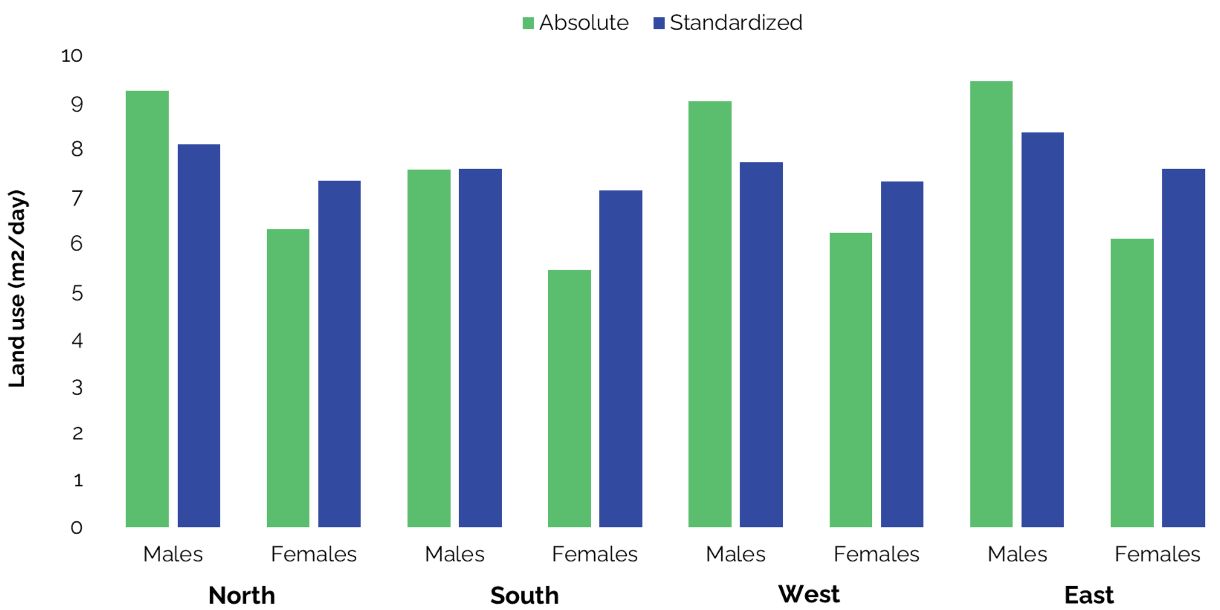

Figure 8. Mean absolute and energy-standardized diet-related land use in four European regions stratified by sex. Standardized values are expressed per 2000 kcal.

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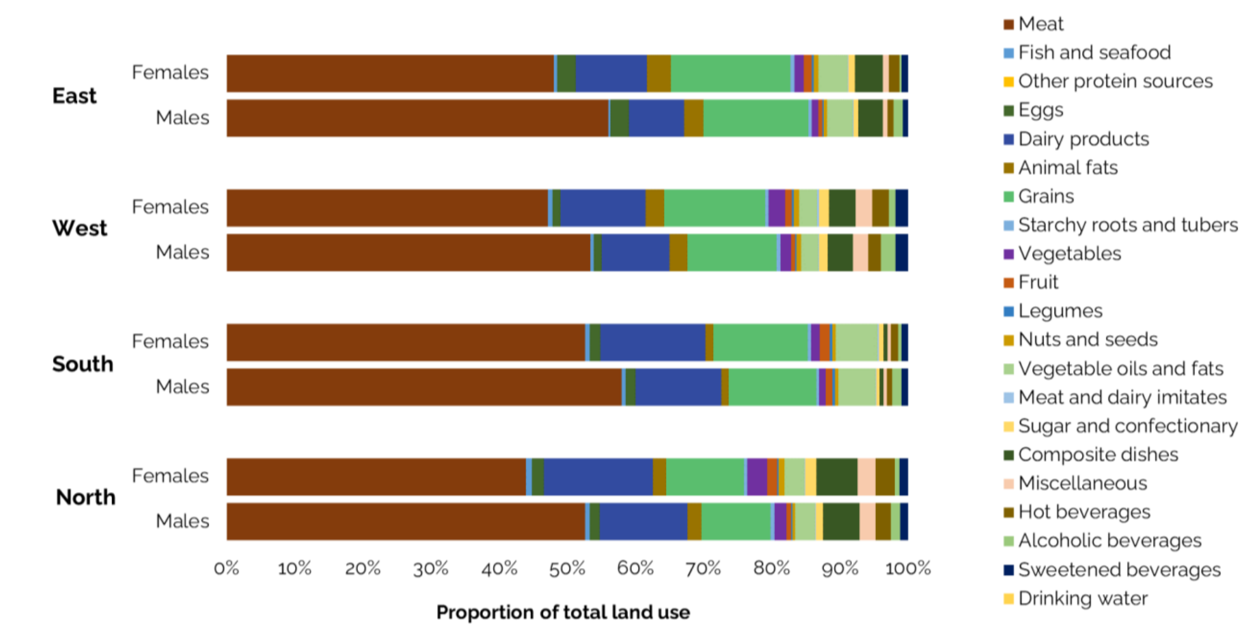

Figure 9. Contribution of food and beverage groups to the mean absolute diet-related land use in four European regions stratified by sex. Other protein sources include amphibians, reptiles, snails, and insects.

2. Future diets

As a second step in WP7.1, we aim to compose future diets with alternative protein derived foods for four regions in Europe. A number of different dietary scenarios will be created, starting from current diets and taking into consideration consumer preferences. All composed diets will be evaluated for diet quality and environmental sustainability. In the following sections, the rationale and planning are described.

Rationale

Country selection

In agreement with the consortium partners and stakeholder board of GIANT LEAPS, we have selected Finland, Italy, Germany, and Serbia to represent the North, South, West, and East regions of Europe. This selection was based on the availability of recent and high quality individual-level food consumption data, population size of the country to ensure inclusion of a larger and more diverse public, as well as representativeness of the diet for the entire region. The country selection was shared and discussed with the WP7 partners and the stakeholder board during a workshop in January 2023. Besides, the same countries will be included in the consumer surveys as part of WP1, allowing us to take region-specific consumer preferences into account when composing future diets.

Alternative protein derived foods

Since development stages widely vary between alternative protein sources, a distinction is made between three lists of sources within GIANT LEAPS (**Appendix, Table A2**). The *long list* represents more traditionally consumed sources, the *short list* contains the highest-potential sources for being newly or increasingly implemented in the European food chain, and the *exploratory list* consists of novel sources with many knowledge gaps that are still in process of EU Novel Food regulation. For composing future diets, we will initially focus on the GIANT LEAPS' *short list* as these sources will be used in WP2 to develop food prototypes as alternatives for animal-based foods (**Table 3**). The *long list* will additionally be included in WP7 during the diet modelling (Task 7.3) to assess the potential of (plant-based) traditional sources already on the market. In this stage, *short list* and *long list* protein sources will be evaluated and compared, and have the opportunity to be modelled into the optimized diets.

WP2 uses the alternative protein sources from the GIANT LEAPS' *short list* with the aim to develop healthy, sustainable, and tasty food prototypes as alternatives for meat, dairy products, culinary products, and eggs. Together with WP2 and WP4, these food items will be optimized for nutritional quality (including nutrient composition and digestibility) and sensory properties. This is to ensure that these foods are a good replacement for the intended animal-based products, providing the same (and preferably even more) beneficial nutrients and culinary experience. The newly developed alternative protein foods will be included in the future diets as replacement for traditionally consumed animal-based protein foods.

Table 3. List of alternative protein sources that will be included in the food prototypes and future diets.

Alternative protein sources	
Source	**Type**
Faba bean	Flour Concentrate Concentrate (deflavoured) Isolate
Lentil	Flour Concentrate Concentrate (deflavoured) Isolate
Chickpea	Flour Flour (deflavoured) Concentrate
Oat	Flour Concentrate (dry) Concentrate (wet)
Quinoa	Concentrate
Microalgae	Concentrate (green) Concentrate (yellow)
Rapeseed	Concentrate Isolate
Solein	Concentrate
Cricket	Flour

Information will be collected on the macro- and micronutrient composition, amino acid profile, and protein digestibility of the alternative protein sources. This will be done with chemical assays for nutrients and in vitro simulations for protein digestibility performed by WP2 and WP4, respectively,

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where possible. Missing data will be complemented with data from literature. A full list of nutrients that will be analysed and evaluated is provided in **Appendix, Table A3**. This list was composed in collaboration with the WP7 partners and an explanation on the inclusion of each nutrient is provided.

Additionally, LCA will be performed by WP5 to assess the environmental sustainability of the whole production and consumption chain of the developed alternative protein foods. Environmental impacts will be quantified for GHG emissions, land use, blue water consumption, and potentially eutrophication (depending on data availability). These indicators were selected based on the relatively large availability of supporting data, high usage in other studies, and coverage of different sustainability aspects. The selection was discussed and agreed upon with the consortium partners and stakeholder board.

Future dietary scenarios

Future diets will be composed for each of the four regions in Europe all represented by one country (i.e. Finland, Italy, Germany, and Serbia). Future diets will be derived from current diets to take into consideration cultural differences in consumption habits across regions. Input from the consumer surveys conducted in WP1 will be used to assure inclusion of preferred alternative protein sources and derived foods in the composed diets. A number of future dietary scenarios are created and will be evaluated (**Figure 10**). These scenarios were established based on interactions with the consortium partners and stakeholder board of GIANT LEAPS. Each scenario is explained in more detail in the following sections.

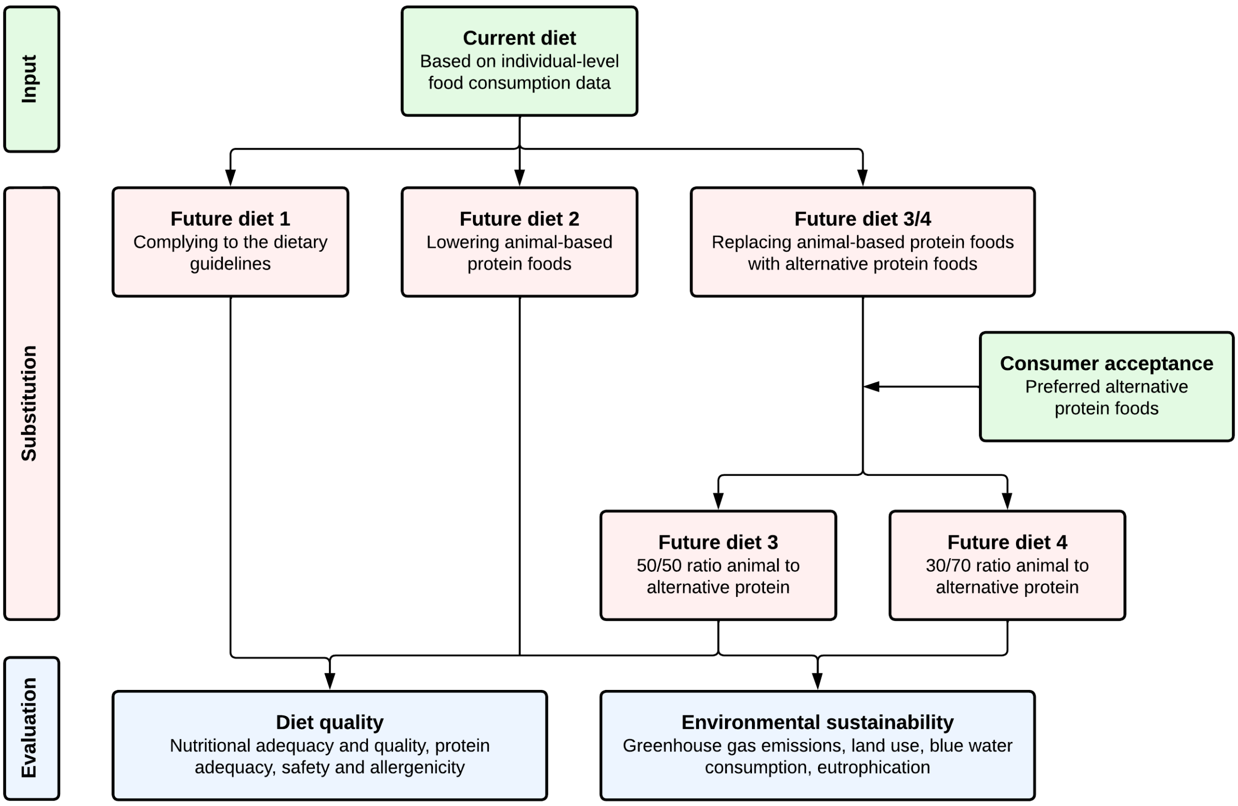

Figure 10. Schematic overview of the four dietary scenarios that will be composed based on current diets and evaluated for diet quality and environmental sustainability.

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In the first dietary scenario, current diets will be adjusted to comply with the dietary guidelines. A set of food-based dietary guidelines will be developed for Europe based on an inventory of current food-based dietary guidelines from the four selected countries. Reference values will be set for food groups that are important for non-communicable disease risk reduction. Such guidelines were previously published by Mertens et al. [19] and will be taken as a reference point. This dietary scenario will function as a healthy reference diet and, thereby, allows to evaluate the health gap of current and future diets. In addition, we will be able to assess the environmental sustainability of eating in line with the dietary guidelines.

The second dietary scenario will be developed to evaluate whether reducing the amount of animal-based protein foods in the diet will be sufficient in achieving environmental targets. The consumption of animal-based protein foods will be reduced (on food group level) to meet minimum protein recommendations set by EFSA [11, 20], corrected for protein quality. Animal-based food groups will be replaced with food groups that have a low protein content, such as fruits, vegetables, grains, vegetable oils and fats, sugar and confectionary, and beverages, based on current consumption ratios. To reflect realistic eating scenarios, substitutions will be carried out based on equal food weight (grams).

In both the third and fourth dietary scenarios, animal-based protein foods will be replaced with alternative protein derived food items. Currently, the European population consumes approximately 60-70% of dietary protein from animal sources, whereas plant sources only contribute 30-40% [21, 22]. Therefore, replacements will be done according to either a 50/50 or 30/70 percentage ratio of animal protein to alternative protein to reflect a realistic short-term scenario and more long-term scenario, respectively. Animal-based protein foods will be replaced by similarly used alternative protein foods. For instance, a hamburger will be replaced by a lentil-based burger and dairy yoghurt will be replaced by solein-based yoghurt. Again, substitutions will be carried out based on equal food weight (grams). Alternative protein foods will not be fortified with vitamins and minerals in the first place, but when nutrient deficiencies occur, the potential influence of fortification will be explored as an additional scenario.

Diet quality and environmental sustainability

The impacts of current diets and all composed future diets on diet quality and environmental sustainability will be estimated for each country, and compared between regions and dietary scenarios (**Figure 7**). Diet quality aspects will include nutritional adequacy and quality, and protein adequacy. Safety and allergenicity are other important health aspects that will be assessed for the future diets based on a selected set of indicators (which will be described in Deliverable 7.2). GHG emissions, land use, blue water consumption, and eutrophication will be calculated to assess the environmental impacts.

Nutritional adequacy and quality Nutritional adequacy and quality will be evaluated following a similar procedure as described in section 1. However, we aim to use standardized and harmonized national food composition tables representative of each region to calculate and compare the nutrient composition of the current and future diets, instead of the Dutch Food Composition Database. These tables will be provided by the European Food Information Resource (EuroFIR) and Max Rubner-Institut (MRI).

Protein adequacy Protein requirements of the human body are dependent on factors that influence the efficiency of protein use, which are often referred to as protein quality [21, 23]. Protein quality includes both the digestibility (i.e. the amount of protein that is absorbed by the body) and amino acid

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composition (i.e. the cellular bioavailability of the absorbed amino acids in relation to the body's needs) of a protein. As dietary proteins are extremely diverse, with large variations in digestibility and amino acid composition between different sources of proteins, protein quality may differ between diets that vary in ratios of animal to plant protein [24]. Therefore, it is relevant to consider protein quality when evaluating protein adequacy of future diets. Protein adequacy corrected for protein quality of the diets will be assessed following a three-step procedure that is described in more detail elsewhere [25].

Environmental sustainability Environmental sustainability will be assessed following a similar procedure as described in section 1. Additionally, the SHARP-ID will be extended with environmental impact data on the developed alternative protein foods collected by WP5, as described earlier. Furthermore, four environmental indicators will be added to the database, including blue water consumption, marine eutrophication, fresh water eutrophication, and terrestrial eutrophication. This will be done for all food items already in the database, as well as for the developed alternative protein food items. Data on these four indicators will be derived from the Dutch LCA food database [26], which includes estimates based on Dutch production and consumption practices. To adjust the LCA values to the European context, regression models will be used to estimate the values of the additional indicators based on the associations between GHG emissions and/or land use derived from the SHARP-ID and Dutch LCA food database for all consumed foods.

Planning

Unique about WP7 is that multiple sustainability aspects (i.e. nutritional quality, safety and allergenicity, environmental impact, and consumer acceptance) are coming together and will be integrated. This means that we intensively collaborate with all relevant WPs in GIANT LEAPS working on these different aspects. Over the last 12 months, we have invested a lot in establishing sustainable partnerships and effective communication with GIANT LEAPS partners. This investment will support us in the upcoming half year to compose future diets taking into account as many aspects as possible.

Table 4 provides the planning for the delivery of the future diets, including foreseen tasks for each WP. Interactions are currently ongoing with WP1, WP2, WP4, and WP5 to gather data on consumer preferences, alternative protein food prototypes, nutrient composition, protein digestibility, and environmental sustainability. It is expected that future dietary scenarios 1 and 2 can be delivered in November 2023, future dietary scenarios 3 and 4 can be delivered in January 2024, and the evaluation of all future dietary scenarios can be completed in March 2024.

Table 4. Planning for composing future diets, including tasks for each WP and expected month of delivery.

Planning		
WP	**Task**	**Expected delivery**
WP4	Data on nutrient composition and protein digestibility	October 2023
WP7	European food-based dietary guidelines	October 2023
WP7	Future dietary scenarios 1 and 2	November 2023
WP2	Alternative protein food prototypes	November 2023
WP5	Data on environmental sustainability	December 2023

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WP1	Results consumer surveys	December 2023
WP7	Future dietary scenarios 3 and 4	January 2024
WP7	Data on safety and allergenicity	January 2024
WP7	Evaluation future dietary scenarios	March 2024

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Appendix

Table A1. Details of national food consumption surveys for the adult population available from the EFSA Comprehensive Food Consumption Database [1].

National food consumption surveys						
Country	**Survey name**	**Period**	**Method of dietary assessment**	**Number of days**	**Age range**	**Sample size**
Austria	AT-NATIONAL-2016	2014-2018	24-hours dietary recall	2	18-64	2250
Belgium	NATIONAL-FCS-2014	2014-2015	Food record 24-hours dietary recall	2	3-64	3305
Bosnia and Herzegovina	B&H MENU	2017-2020	24-hours dietary recall	2	10-64	1529
Bulgaria	NSFIN	2004	24-hours dietary recall	1	16-95	1204
Croatia	NIPNOP-HAH-2011-2012	2011-2012	24-hours dietary recall 48-hours dietary recall	3	18-64	2002
Cyprus	CY 2014-2017-LOT2	2014-2017	24-hours dietary recall	3	10-76	1016
Czechia	SISP04	2003-2004	24-hours dietary recall	2	4-64	2353
Denmark	DANSDA 2005-08	2005-2008	Food record	7	4-75	2700
Estonia	DIET-2014-EST-A	2013-2015	24-hours dietary recall	2	11-75	3049
Finland	FINDIET 2017	2017	24-hours dietary recall	2	18-75	1773
France	INCA3	2014-2015	Food record 24-hours dietary recall	3	0-79	4847
Germany	NATIONAL NUTRITION SURVEY II	2007	24-hours dietary recall	2	14-80	13,926
Greece	GR-EFSA-LOT2 2014-2015	2014-2016	24-hours dietary recall	2	10-75	798
Hungary	EU MENU DIETARY SURVEY OF HUNGARY	2018-2020	Food record 24-hours dietary recall	2	1-74	2689
Ireland	NANS 2012	2008-2010	Food record	4	18-90	1500

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Italy	INRAN SCAI 2005-06	2005-2006	24-hours dietary recall	3	0-97	3323
Latvia	LATVIA_2014	2012-2015	Food record 24-hours dietary recall	2	0-80	3595
Montenegro	EUMENU ADLT	2017-2021	24-hours dietary recall	2	10-74	1513
Netherlands	FCS2016_CORE	2012-2016	Food record 24-hours dietary recall	2	1-80	4313
Poland	IZZ FAO 2000	2000	24-hours dietary recall	1	1-96	4134
Portugal	IAN-AF 2015-2016	2015-2016	Food record 24-hours dietary recall	2	0-84	6429
Romania	RO-DIET-NATIONAL-STUDY-2019	2019-2020	24-hours dietary recall	2	10-74	1730
Serbia	RS_ADULTS	2019-2020	24-hours dietary recall	2	10-75	2737
Slovakia	SK MON 2008	2008	24-hours dietary recall	1	19-59	2761
Slovenia	SI.MENU-2018	2017-2018	Food record 24-hours dietary recall	2	0-74	1981
Spain	ENALIA2	2013-2015	24-hours dietary recall	2	18-74	968
Sweden	RIKSMATEN 2010	2010-2011	Web-based dietary record	4	18-80	1797
United Kingdom	NDNS ROLLING PROGRAMME YEARS 1-3	2008-2011	Food record	4	>1	3073

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Table A2. Three lists of alternative protein sources within GIANT LEAPS.

Alternative protein sources		
Long list	**Short list**	**Exploratory list**
Soy (P)	Faba bean (P)	Hemp (P)
Wheat (P)	Lentil (P)	Leaf proteins (P)
(Chick)pea (P)	Oat (P)	Algal fractions (O)
Potato (P)	Quinoa (P)	
Brewer's spent grain (P)	Rapeseed (P)	
Spirulina (O)	Microalgae (O)	
Fish side streams (O)	Single cell bacteria (M)	
Krill (O)	Crickets (I)	
Beef (T)	Cultured beef (C)	
Pork (T)		
Chicken (T)		
Egg (T)		
Milk (T)		
Other dairy (T)		

(P) plant-based proteins, *(O)* ocean-based proteins, *(M)* microbe and fungal proteins, *(I)* insect-based proteins, *(C)* cultured meat, *(T)* traditional animal proteins.

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Table A3. Macro- and micronutrients and amino acids that will be measured in the alternative protein sources, including the responsible WP and current status.

Macro- and micronutrients and amino acid profile				
Type	**Unit**	**Explanation**	**WP**	**Status[1]**
Macronutrients				
Energy	kcal / 100g	Standardize energy intakes	WP4	3 / 22
Carbohydrates	g / 100g	Product formulation	WP4	3 / 22
Sugars	g / 100g	Included in NRF	WP4	2 / 22
Fiber	g / 100g	Included in NRF	WP4	2 / 22
Protein	g / 100g	Included in NRF	WP2	18 / 22
Fat	g / 100g	Product formulation	WP2	18 / 22
Saturated fatty acids	g / 100g	Included in NRF	WP4	3 / 22
Monounsatuared fatty acids	g / 100g	Included in NRF	WP4	2 / 22
Polyunsaturated fatty acids	g / 100g		WP4	2 / 22
Micronutrients				
Vitamin A	µg / 100g	Included in NRF	WP4	3 / 22
Vitamin C	mg / 100g	Included in NRF	WP4	3 / 22
Vitamin D	µg / 100g	Included in NRF	WP4	0 / 22
Vitamin E	mg / 100g	Included in NRF	WP4	3 / 22
Vitamin B12	µg / 100g	Included in NRF	WP4	3 / 22
Vitamin B1	mg / 100g	Included in NRF	WP4	3 / 22

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Vitamin B2	mg / 100g	Included in NRF	WP4	3 / 22
Vitamin B3	mg / 100 g	Largely provided by animal-based foods [27, 28]	WP4	3 / 22
Vitamin B6	mg / 100g	Largely provided by animal-based foods [27, 28]	WP4	3 / 22
Folate	µg / 100g	Included in NRF	WP4	0 / 22
Calcium	mg / 100g	Included in NRF	WP4	3 / 22
Iron	mg / 100g	Included in NRF	WP4	3 / 22
Magnesium	mg / 100g	Included in NRF	WP4	3 / 22
Potassium	mg / 100g	Largely provided by animal-based foods [28, 29]	WP4	3 / 22
Zinc	mg / 100g	Included in NRF	WP4	3 / 22
Sodium	mg / 100g	Included in NRF	WP4	3 / 22
Phosphorus	mg / 100g	Largely provided by animal-based foods [27–29]	WP4	3 / 22
Selenium	µg / 100g	Largely provided by animal-based foods [27]	WP4	1 / 22

Amino acid profile				
Histidine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Isoleucine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Leucine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Lycine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Methionine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Cysteine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Phenylalanine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Tyrosine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22

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Threonine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Tryptophan	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Valine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Arginine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Glycine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Proline	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Serine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Alanine	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Aspartic acid	mg / g protein	Assess protein quality	WP2, WP4	16 / 22
Glutamic acid	mg / g protein	Assess protein quality	WP2, WP4	16 / 22

[1] Number of sources on which data has already been collected relative to the total number of sources.

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