Food and Environmentally Responsible Consumption: Towards Healthy Food Patterns for a Healthy Planet

Background document for the food triangle recommendations (2021)

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Colophon

This report is a product of the Flemish Institute for Healthy Living (Vlaams Instituut Gezond Leven vzw) in collaboration with the Department of Environment and Spatial Development (Departement Omgeving) of the Flemish Government and with the support of the Agency for Care and Health (Agentschap Zorg & Gezondheid) of the Flemish Government.

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Management summary

Food is high on the agenda, both in Flanders and elsewhere. This is because food takes an important place in our society. The need to stimulate healthy and environmentally responsible eating patterns is increasing all the time. In the past, these two aspects, health and environment, were considered separately. With the revision of the food triangle in 2017, environmental aspects were included in the Flemish recommendations for the first time. But a robust foundation was lacking. This report brings together for the first time the most recent and relevant scientific knowledge to underpin the environmental dimension of the food triangle.

Today's diet puts heavy pressure on the environment and our health. What and how we produce and consume in Flanders, has an impact that does not stop at the borders of our region. Our food system has global consequences and it is necessary to gain a better understanding of these consequences. The food system puts considerable pressure on the planetary boundaries. The consumption phase is one of the most important links in the food system. Changing consumption patterns to healthy and environmentally responsible diets is therefore crucial to making the food system more sustainable.

The link between health and the environment is present, but not always obvious. For example, what is good for your health is not necessarily the best choice for a low environmental impact. However, there is a great synergy between the two aspects. It remains important to be attentive to possible contradictions and trade-offs. But what are healthy and environmentally responsible diets? This report uses two ways of answering that question: at the dietary level and the foodstuff level.

The first and most important level is the dietary level. We make choices about what we eat several times a day. If we add these choices up, we arrive at the level of the food pattern. The four most important principles at the dietary level are

- achieving a balanced protein intake;
- avoiding food waste;
- limiting products with high energy density and low nutritional value (empty calories for short);
- avoiding over-consumption.

By taking these principles sufficiently into account, the consumer achieves the greatest gains, both in terms of health and the environment.

The second level is in the area of foodstuffs. The choices we make at the dietary level are the most important because they deliver the greatest benefits. Nevertheless, additional advice at the foodstuffs level is possible and desirable for additional environmental gains. The focus here is on making better choices within the same product group. Various product groups are examined to give a clear direction for reducing the environmental impact (taking into account a healthy diet).

In this report, the most recent scientific insights about the environmental impact at the level of the food pattern and foodstuffs are brought together. Where possible, Flemish or Belgian data have been used. Where necessary, other insights were used, taking into account their usefulness for our region. The focus of the environmental impact is on the climate impact, the use of land, the use of water, and the impact on biodiversity.

This report provides a robust framework for the next step in formulating recommendations that help consumers achieve a healthy and environmentally responsible diet. It provides nuance and makes trade-offs that are necessary for this topic. Above all, this report provides an excellent basis to build on to better meet the challenges surrounding nutrition. By working together and integrating different objectives, we contribute to moving towards a good food future for all.

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1 Introduction

Healthy and sustainable food are top priorities on the international agenda. For example, nutrition is central to the United Nations 2030 Agenda for Sustainable Development with a set of seventeen Sustainable Development Goals (SDGs) (United Nations General Assembly, 2015) and the UN Food Systems Summit in 2021.

The 'Farm to Fork Strategy' of the European Commission puts forward an action plan with attention to healthy and sustainable food patterns (European Commission, 2020a). The Flemish Government is on the same wavelength and wants to work towards sustainable eating patterns, described as eating healthier, more seasonal, varied and local, avoiding overconsumption, wasting less food, and a more balanced protein consumption (Flemish Government, 2019a, 2019b).

The Flemish government is already taking several initiatives towards better-eating patterns (Platteau, Lambrechts, Roels, & Van Bogaert, 2018; Platteau, Van Gijseghem, Van Bogaert, & Vuylsteke, 2016; VMM, 2018a). For example, the Flemish government is working on an integrated food policy and in February 2021 the Flemish Protein Strategy was launched in which an objective was included concerning sustainable protein consumption (Department of Agriculture and Fisheries, 2021). Authorities such as the Department of Environment & Spatial Development of the Flemish Government and expertise centers such as the Flemish Institute of Healthy Living (a partner organization of the Agency for Care and Health) are encouraged from various groups and from progressive insight to include sustainability in the development of dietary guidelines and derived methodologies for Flanders.

In the revision of the food triangle in 2017, the emphasis was on the effect of food on health, but environmentally responsible food was also included as an additional starting point for the first time. An environmentally responsible diet takes into account its environmental impact and aims to make food choices within the carrying capacity of the earth. However, the substantiation and development of recommendations in this area did not then follow the same thorough procedure as for health. This report aims to strengthen the aspect of environmentally responsible nutrition within the framework of the food triangle - based on scientific knowledge and data - and to embed it more firmly in the instrument and its derivatives. To this end, the same process was followed as it was for health, with the cooperation of various experts from Flemish and Dutch knowledge institutions. The synergy and trade-offs between the two are examined.

It is important to emphasize that the impact on health and the environment are only two aspects, which in themselves are insufficient to talk about sustainable eating patterns. Economic and social aspects (fair price, animal welfare, cultural acceptability, food security ...) are not addressed in this document. We invite research institutions and organizations with expertise on these topics to build on this work and to complement it with those aspects of sustainable diets, to arrive at an integrated vision and strategy.

More and more, caring for ourselves and our planet are seen as very much interlinked. This raises the question of whether the best choices for our health are also the best choices for the planet. And conversely, whether the most environmentally responsible choices are also good for health (Kickbusch, 2010; van Dooren, 2018). This report aims to clarify and contribute to greater coherence and more unambiguous messages to the outside world. In doing so, together with the expert group, we take into account the complexity of the subject as much as possible. Simplified messages inevitably lose their nuance, but they are necessary for communicating something. This substantiation allows for this nuance and provides a solid basis for arriving at these messages.

Based on this report, practical recommendations for consumers are formulated to support healthy and environmentally responsible food choices. After all, consumers benefit from reliable information and clear recommendations when it comes to their consumption patterns. This will be published in a separate report.

As the food triangle focuses on people's food consumption, we start from a consumption perspective. Behavioral change is therefore a very important factor in the pursuit of a healthy and environmentally responsible diet (Garnett, 2016; Slabbinck, Vandenbroele, Van Kerckhove, & Vermeir, 2016; VMM, 2018a). The consumer plays an important role within the food system. However, this does not alter the fact that other actors also play a role, on the contrary. The consumer can strongly contribute to a more sustainable food system, but he cannot do this alone. By using the consumer's perspective, it becomes clear which actions they can take. In addition, the recommendations are at the service of actors who, in turn, reach out to consumers and can take targeted actions to stimulate and facilitate the recommendations.

How did this report come about?

The food triangle of the Flemish Institute for Healthy Living is the nutrition information model for the Flemish population. In 2017, the food triangle was revised and the focus was on the effect of food on health. For the first time, (limited) attention was also paid to the environmental impact of eating patterns.

In 2021, the aspect of environmentally responsible nutrition is extensively underpinned and integrated into the recommendations of the food triangle. To this end, the Flemish Institute for Healthy Living (a partner organization of the Agency for Care and Health) and the Flemish government's Department of Environment & Spatial Development have joined forces. The result of this exercise is the substantiation report that you are now holding in your hands or reading on the screen.

The insights from the scientific literature were coordinated with environmental experts from (academic) knowledge and research institutes and are bundled in this document. We would like to thank all the experts for their advice and input towards the preparation of this report. The authors retain responsibility for the final text.

The following experts were actively involved in the realization of this report: Dr. ir. Stef Aerts (Odisee Hogeschool), Dr. Tessa Avermaete (KU Leuven), Dr. ir. Lieselot Boone (UGent), ir. Melissa Camerlinck (HOGent), Prof. Dr. ir. Stefaan De Smet (UGent), Prof. Joost Dessein (UGent), Prof. Dr. ir. Fleur Marchand (ILVO), Anton Riera (UCL), Dr. ir. Liesbeth Temme (Rijksinstituut voor Volksgezondheid en Milieu, the Netherlands), Prof. Piet van der Meer (VUB), Dr. Ir. Corné van Dooren (Voedingscentrum, the Netherlands), Dr. Ir. Peter Van Gossum (INBO), Dr. Ir. Veerle Van linden (ILVO), Klara Van Mierlo (KU Leuven) and Prof. Dr. Steven Van Passel (UAntwerpen).

The insights from this document were ultimately translated into concrete recommendations for the food triangle. The recommendations were discussed with experts in the field of environment, health, behavior, and communication. And they were tested among citizens in terms of comprehensibility, usability, and design, with extra attention being paid to vulnerable groups.

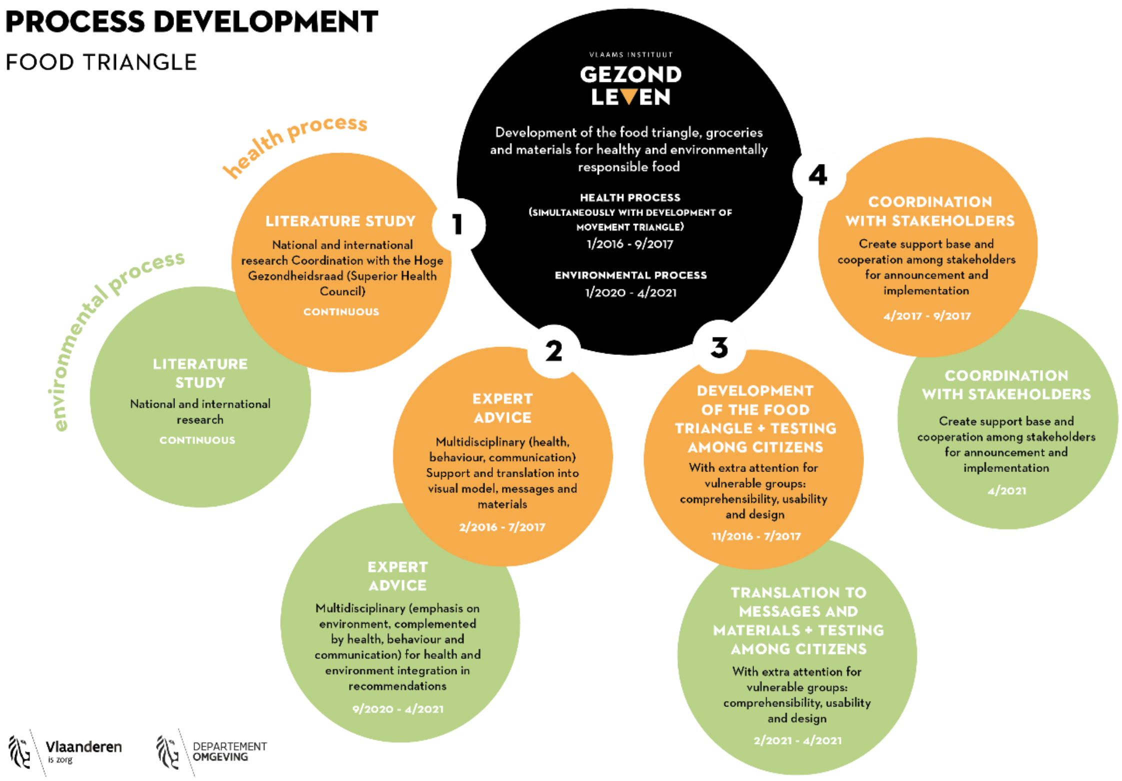

Figure 1: Process Development of the food triangle (Vlaams Instituut Gezond Leven, 2021)

Structure of the report

In the first chapter, the context of the theme is outlined. Nutrition is described at a general level and placed in its (historical) context to frame the theme.

The second chapter outlines the conceptual framework. Here, several aspects are highlighted that serve the rest of the report. Ecological aspects in relation to sustainability are discussed here. In addition, the consumption phase, the starting point of this report, is framed within the broader picture of food systems. Chapter two then presents a definition of an environmentally responsible diet. Finally, the link between environment and health is explored.

This forms the basis for elaborating on the principles of a healthy and environmentally responsible diet in the third chapter. This is done at the level of the entire food pattern.

The fourth chapter looks more closely at foodstuffs. What are the points of attention within the various food categories in terms of their impact on the environment? This is substantiated for each food group.

The fifth chapter briefly discusses the limitations of this report and avenues for further research.

The sixth and final chapter of this report offers conclusions and forms the bridge to the report with recommendations for the consumer. That report takes into account the already existing recommendations of the food triangle for healthy food choices and the current eating habits and consumption levels in Flanders (looking at cultural acceptability and feasibility).

2 The context

Since the end of the Second World War, our diet has been subject to major changes. "Never again war, never again hunger" was the leitmotiv and food security was high on the agenda. The modernization of agriculture led to a significant increase in yields in the field, thanks to growing knowledge of plant breeding, fertilization, nutrient management, technological advances, and improved production methods (Fresco, 2012).

The result was a boost in production that allowed more agricultural products to be grown at a higher quality and made them relatively cheaper. The further development of ships and railways and the expansion of the canal and road network made it possible to transport food quickly and cheaply to consumers (Segers, Loyen, Dejongh, & Buyst, 2002; Steel, 2008). Partly because of this, food security and safety improved. Consequently, the food chain became increasingly global and complex and was split up into specialized links. In addition, progress also brought about negative social, health, and ecological effects (Fresco, 2012).

Price, taste, availability, and accessibility are decisive factors that shape our eating habits. Food and non-alcoholic beverages accounted for only 13% of our consumer expenditure in 2016, whereas immediately after World War II they accounted for around 50% (Platteau et al., 2016). This phenomenon is also known as Engel's law[1]: as disposable income increases, there is a decrease in the share of spending that goes to food.

Increased prosperity and urbanization contributed to an increase in average food consumption per person and a change in the composition of the diet. There has been a shift from a diet largely composed of staple crops (cereals, root crops, and tubers) to a pattern with more animal products, sugar, vegetable oils, and highly processed foods.[2] The dietary pattern in developed countries shifted from 'not sufficient to 'too much food, and especially of the wrong kind' (Garnett & Finch, 2018; Tilman & Clark, 2014). For years, the focus was on filling people rather than feeding them (Neven, 2018).

Dietary patterns are not static and are sometimes subject to rapid change, even within a generation. But old habits are sometimes very fixed and difficult to change. Today's Flemish eating pattern is quite diverse. There is a great deal of variation in the product groups consumed. There is also a high proportion of products with a high energy content and low nutritional value (also called 'empty calories') on the one hand, and high consumption of meat and meat products on the other (De Ridder et al., 2016a; Platteau et al., 2016). Little or no processed food such as vegetables and fruit, whole grains, legumes and nuts are under-consumed (Vlaams Instituut Gezond Leven, 2017b). Globally, the demand for food is growing and eating patterns are also

[1] Named after the German statistician Ernst Engel (1821-1896).
[2] This is called Bennet's law: industrialization inevitably leads to eating more meat, dairy, alcoholic beverages and processed products - and less starchy products such as cereals and legumes. Like any rule, Bennet's law has exceptions: for example, in India meat consumption hardly increases with increasing income. The religious and cultural context plays also play a role.

shifting, with a growing demand for food that is high in calories and requires a lot of (natural) resources (European Environment Agency, 2015; Ranganathan et al., 2016).

3 Conceptual Framework

3.1 Planetary boundaries and donuts

Sustainability is a concept with many meanings and dimensions. The three dimensions that always recur when talking about sustainability are People (social), Planet (ecological), and Profit (economic).

The current food system[3] consists of long and increasingly global chains. What and how we produce and consume in Flanders has an impact that does not stop at the borders of our region. Our food system, therefore, has global consequences and it is necessary to gain a better insight into this. The food system puts considerable pressure on the planetary boundaries. We are currently facing problems on four planetary boundaries: climate change, biodiversity loss, land-use change and the nitrogen, and phosphorus cycles (Steffen et al., 2015).

The **planetary boundaries** describe a safe space within which humanity must continue to take into account the carrying capacity and resilience of our planet. Overstepping these boundaries increases the risk of irreversible damage and causes tipping points that endanger, if not make impossible, the survival of mankind (Rockström et al., 2009).

An important framework for action towards greater sustainability is provided by the United Nations Sustainable Development Goals (SDGs). Johan Rockström and Pavan Sukhdev conclude that all SDGs are directly or indirectly linked to sustainable and healthy food (Grosso et al., 2020; Stockholm Resilience Centre, 2016).[4]

Raworth's (2017) donut model (Figure 2) takes a similar view. The model takes the planetary boundaries as an upper limit[5] and adds a new dimension. It describes a level of material and immaterial resources that indicates the lower limit. When we go below that limit, people go hungry, live unhealthy lives, and live in poverty. It is, therefore, necessary to stay above this minimum and below the maximum in what she describes as a "safe and just space for humanity" (Raworth, 2017). The donut model is a way to bring our society back into balance, a model in which endless (economic) growth is no longer a guiding paradigm. By living, working, and developing within the boundaries of ecological and social carrying capacity, well-being grows, instead of focusing on prosperity.

[3] The use of the term "food system" creates the false impression that there is one global food system. In reality, there are several food systems operating. For the sake of readability, the singular form is used throughout the text.
[4] Grosso et al. (2020) discuss food and nutrition in the SDGs in more detail.
[5] The planetary boundaries themselves are, however, not static and are subject to technological developments and our behavior. Nonetheless, they form an interesting framework of thought against which to test future developments.

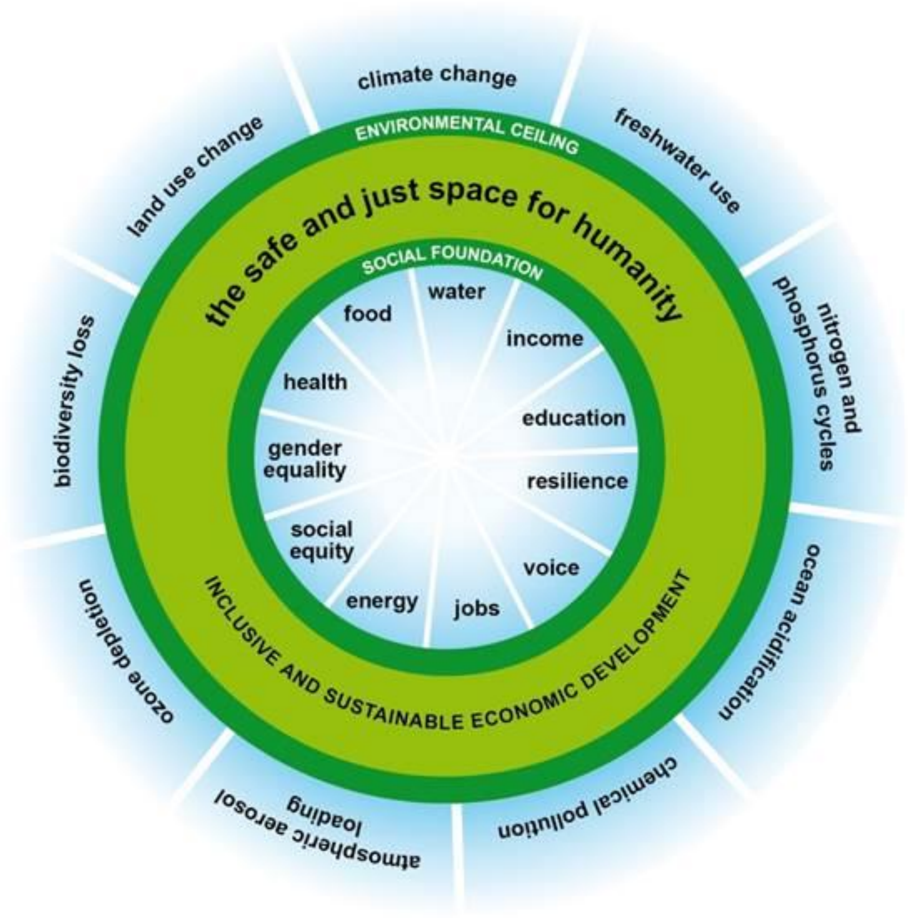

Figure 2: Donut model (Raworth, 2017)

The space between the upper and lower limits is sometimes called the 'consumption corridor'. Within this corridor, the needs of citizens are met while respecting the limits of the system (Alfredsson et al., 2018).

3.2 Why focus on consumption?

3.2.1 Consumption as a link in the food system

The consumption phase is one of the links that together make up the broader food system (see Figure 3 'Consumer behavior'). The relationship between supply and demand is a complex interaction and transcends policy levels. After all, what we produce in Flanders is not fully consumed in Flanders and vice versa. Consequently, domestic demand does not entirely determine domestic supply.

To reduce the environmental impact of our diet, we can take various pathways. Should we focus on improvements in the area of production (reducing environmental impact per product)? Is there a greater need for a different diet (eating different foods, avoiding overconsumption and food losses)? Or should we rather focus on a combination of these factors? It is clear that, given the urgency and the challenge, action is required at several levels. This report focuses on the consumption phase.

Several sources indicate that changing diets can have a greater impact than measures aimed at the production phase (Directorate-General for Research and Innovation, 2018). In 2019, the Netherlands Environmental Assessment Agency (PBL) published a comparative study in which various measures, both in terms of production and consumption, were compared in terms of greenhouse gas emissions and land use, based on predefined scenarios (Keating, Herrero, Carberry, Gardner, & Cole, 2014; Westhoek, 2019). These measures are at the level of more sustainable eating (e.g. fewer animal products), avoiding food losses, producing more efficiently (e.g. higher crop yields) and producing more carefully (e.g. higher animal welfare). The results represent the reduction potential of all these measures, and a combination of measures led to the greatest effect. However, the greatest potential in this exercise was found to be in dietary changes, particularly in eating fewer animal products in the context of current animal production. This had a greater effect than measures aimed at increasing efficiency in food production and reducing food losses in the consumption chain (Keating et al., 2014).

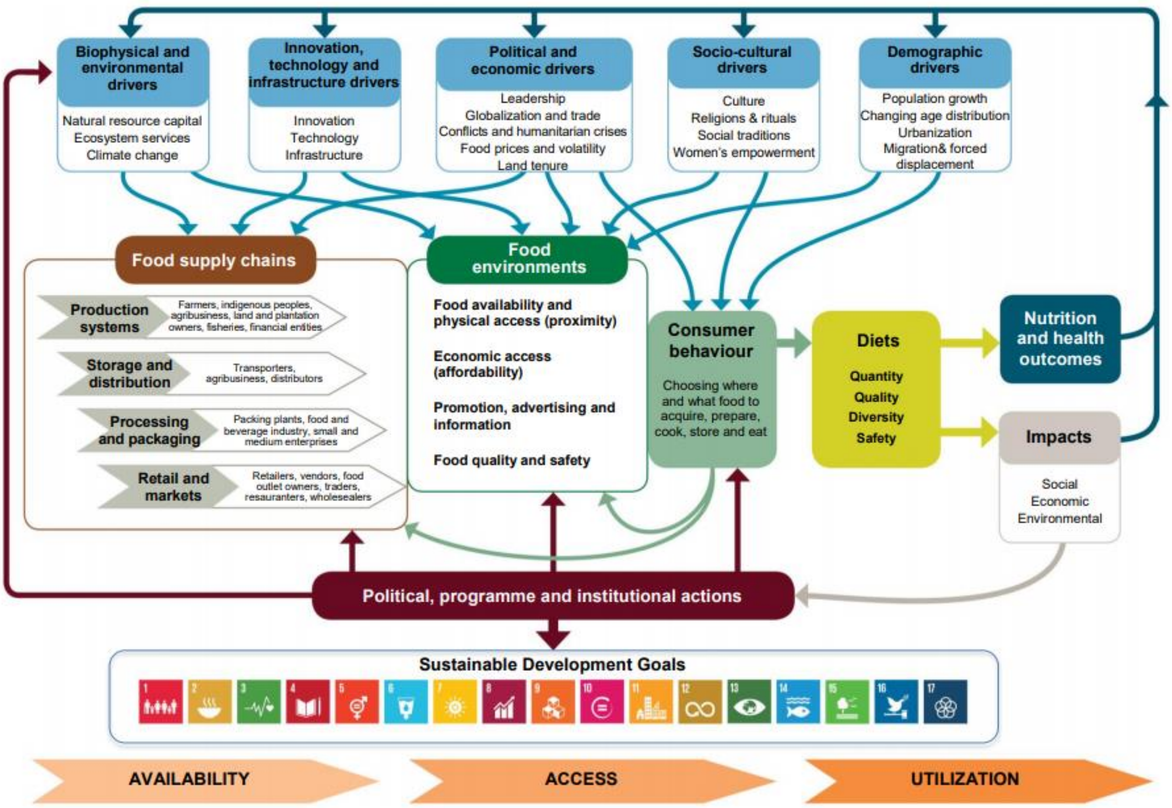

Figure 3: Conceptual framework for food systems (HLPE, 2017)

3.2.2 How are food choices made?

Consumer choices are determined by all kinds of factors. More specifically by an interaction between individual and environmental factors that influence food choices and healthy eating habits (Brug, 2008). Eating habits can arise from reflective motives such as consciously choosing a particular diet emanating from a particular attitude or outcome expectation. Such motives can be positively influenced by imparting several competencies, such as knowledge about what constitutes healthy and environmentally responsible food. In addition, the food consumption process is characterized by quick and routine decisions or automatic motivations (e.g. the habit to go for a cake for a snack). However, these individual factors alone cannot explain why obesity and other health problems have increased so much in recent decades. The food environment[6] also plays an important role (Vanoutrive & Cant, 2020). Thus, both types of individual drivers can to a large extent be influenced by external factors (Slabbinck et al., 2016). For example, personal preference is an important individual factor or driver, which can be influenced by external factors such as convenience, values, traditions, culture, available supply ... (HLPE, 2017).

Eating habits are shaped by an interplay of factors such as norms and expectations, knowledge and skills, and the available supply. There are also time and space-related aspects such as fitting in with work, school, and leisure routines or the place where people live in relation to shops or collection points (Van Lancker, Hubeau, & Marchand, 2018). How food is chosen, bought, prepared, and presented for consumption varies not only between regions, countries, and cultures but equally between communities, households, and individuals (HLPE, 2017; Mertens et al., 2019).

Changes in the consumer behavior can therefore make a major contribution to more environmentally responsible food systems. Acting on this starts with understanding how our (eating) behavior comes about and what factors influence it. Flemish Insitute for Healthy Living developed a model (the Behaviour Wheel) that combines individual and environmental determinants and applied it to food behavior.

The Wheel of Behaviour (Figure 4) formulates three conditions that are necessary to be able to adapt or change a certain behavior:

- You have to be able to do it and know it and thus need certain competencies.
- You must want it and therefore need certain motives.
- It must be possible - and feasible - within the context in which you live.

Behavior is not only influenced by individual factors, but also by our environment. When these three conditions are met, the likelihood of exhibiting certain behavior increases. The competencies, drivers, and present context are then levers towards making healthy and environmentally responsible food choices. But when certain competencies, drivers and/or context factors are missing, or have a negative influence on healthy behavior or behavioral change, they form barriers to making healthy and environmentally responsible choices.

[6] The food environment points to the nutritional value, food safety, price, information, and promotion of food in the environment where people's daily lives take place. It is this environment that determines the possibilities and choices to follow a certain dietary pattern (Vanoutrive & Cant, 2020).

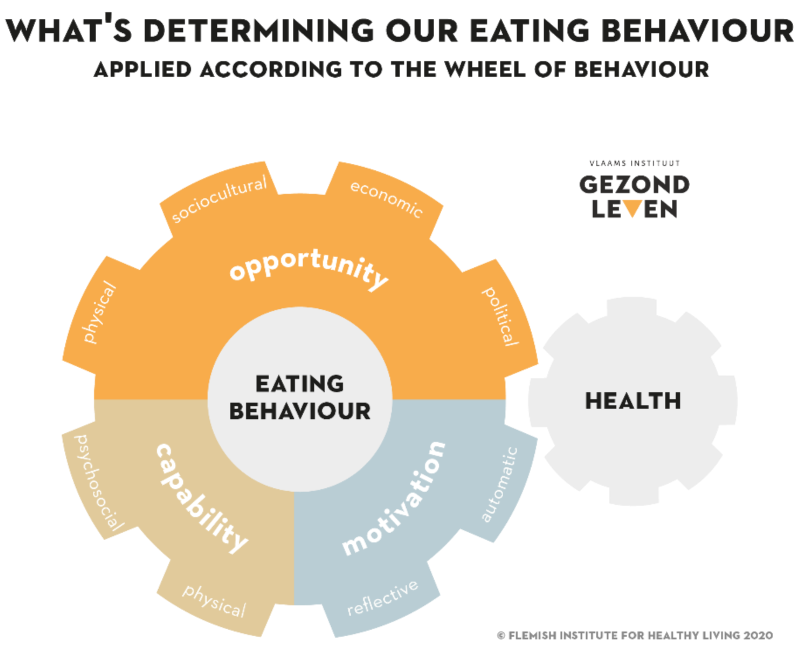

Figure 4: The Wheel of Behaviour (Vlaams Instituut Gezond Leven, 2020a)

To change behavior a mix of different strategies is needed: from adaptations to the food environment (e.g. through regulation or nudging) to interventions aimed at the competencies of consumers (e.g. increasing knowledge and awareness). Examples of the former are taxes and subsidies or food purchasing policies, while examples of the latter are education and food-based dietary guidelines (HLPE, 2017). A focus on consumption does not imply that the responsibility for a better diet lies solely with the consumer. Policy and the actors involved ((primary) producer, retail, catering, etc.) play an important role in making healthy and environmentally responsible food choices easier and more attractive for consumers (A. Drewnowski, Monterrosa, de Pee, Frongillo, & Vandevijvere, 2020).

Food consumption, or eating behavior, is thus a complex topic that is influenced by a multitude of actors and factors. The consumer plays a central role as an actor on the whole. In addition to consumers, other actors in the food system (Figure 3) play an important role in shaping eating behavior. Changing eating behavior therefore requires a collective effort: consumers cannot do this alone. All actors in the whole food system will, therefore, have to take on a role in working towards healthy and environmentally responsible eating patterns (de Krom, Vonk, & Muilwijk, 2020; Van Lancker et al., 2018).

3.3 Defining an environmentally responsible diet

To arrive at a good definition of an environmentally responsible diet, we start from the concept of sustainability. An environmentally responsible diet is situated within the broader framework of sustainable food patterns and sustainable food systems.

Sustainability in the field of food encompasses many aspects. According to some, we should not talk about sustainable food but sustainable food systems. This refers to the entire system of production, processing, distribution, and consumption of our food (de Valk, Hollander, & Zijp, 2016). The post-consumption phase - the waste or recycling phase - is the closing or starting point of the food system. How each link in the chain performs, from farm to fork (and beyond), determines whether or not we can speak of a sustainable food system (Avermaete & Keulemans, 2017).

The Food and Agriculture Organization (FAO) of the United Nations defines sustainable food as "food with a low impact on the environment, which contributes to food security and food safety and ensures good health for current and future generations. It is an eating pattern that preserves biodiversity, respects ecosystems, and is culturally acceptable[7]. It is a diet that is open to all, equitable, and economically viable. It is nutritious, safe and healthy and makes optimal use of natural and human resources" (FAO, 2012). In 2019, a definition of sustainable and healthy diets was put forward by the FAO and the World Health Organization (WHO). "Sustainable and healthy diets are diets that support all aspects of individual health and well-being; have low environmental pressures and impacts; are accessible, affordable, safe and equitable; and are culturally acceptable" (FAO & WHO, 2019).

The present document focuses on the environmental aspects of the food system. This means that elements such as the impact on soil, water and air quality, greenhouse gas emissions, land use, respect for biodiversity and ecosystems, internalization of external environmental costs, optimal use of natural resources, and raw materials are considered here. This is not to say that economic and social aspects such as a fair price for farmers, food sovereignty, food safety, animal welfare, and fair trade are unimportant. They are an integral part of a (broad) sustainable food system but are not addressed in this document.

3.3.1 How to measure the environmental impact?

The most complete way of calculating the environmental impact is by performing a life cycle analysis (LCA). LCA is a method to determine the environmental impact of a product based on its entire life cycle, i.e. from the extraction of the raw materials, production, transport, and use, through to waste disposal (Brouwers et al., 2017). Thus, this methodology is often used as a management tool to gain insight into where in the process the impact is greatest and where it can best be reduced. This methodology goes into more detail than the Ecological Footprint methodology. Consequently, more time and data are needed to make a good analysis. Although LCA is a standardized tool that takes into account many environmental pressure factors, the method also has some major shortcomings. An LCA is a quantitative analysis that

[7] Together with the communication and behavioral experts, this aspect is monitored as closely as possible in the development of the recommendations and action perspectives.

does not take into account certain aspects that are difficult to quantify, such as soil quality and ecosystem services provided. In addition, the aspect of (local) ecological carrying capacity is not integrated into the methodology by default (Goossens, De Tavernier, & Geeraerd, 2018). An additional difficulty is that choices have to be made, for example, according to the functional unit and system boundaries, which often makes the comparison of LCA studies difficult (Westhoek, 2019). By necessity, several assumptions are made in such analyses (Brouwers et al., 2017).

Despite the shortcomings of LCA, this method is the most appropriate for obtaining the most complete overview of the environmental impact of a food product or food pattern. However, it remains advisable to interpret the results with caution and also to use additional analysis tools where possible (Notarnicola et al., 2017). The European Commission's initiative to improve and harmonize the life cycle methodology (product environmental footprint or PEF) aims to provide a solution to better compare the environmental impact of products (Lupiáñez-Villanueva, Tornese, Veltri, & Gaskell, 2018).

Easy-to-use procedures to estimate the environmental impact for each product are not available today. Individual measurement figures are not always available and individual calculations are time-consuming and expensive. In this report, we rely on the available meta-studies and databases to formulate recommendations for the consumer. Where possible, a specific adaptation is made for the Flemish or Belgian context. Although we do not have an LCA of every product, it is clear that some products and product groups have a significantly heavier environmental impact compared to others (United Nations General Assembly, 2015; van Dooren, 2018; VMM, 2018a).

3.3.2 The ecological footprint as a yardstick?

When talking about the environmental impact of food, the ecological footprint is often mentioned. The ecological footprint measures the biologically productive land and water area needed to supply renewable raw materials and process waste according to current technologies. It is an indicator that integrates the use of land (infrastructure, recreational facilities...), the use of biomass (wood, crops, fish...), and the CO2 emissions resulting from the use of fossil fuels into a quantitative quantity, which is comparable to the available biocapacity on earth. The unit of the ecological footprint and the biocapacity is a global hectare (gha) (Geerken, Vercalsteren, Van Hoof, Cleymans, & d'Ursel, 2011; Van der Linden, Vercalsteren, & Dils, 2010).

The ecological footprint maps the environmental impact of the food system at a high level of abstraction and provides insight into where the hot spots lie. This methodology is less suitable for formulating recommendations at the product level. After all, the environmental impact strongly depends on the way a product is produced. Different production characteristics, transport methods, packaging, or storage techniques mean that the environmental impact can differ greatly even within the same product group. LCAs are more suitable for making these more detailed considerations.

3.3.3 Definition of an environmentally sound diet

To arrive at a good definition of an environmentally responsible diet, we must go back to the Oslo Roundtable Conference on Sustainable Production and Consumption of 1994. Sustainable consumption was defined as "the use of goods and services that correspond to basic needs and provide a better quality of life. This is done while minimizing the use of natural resources, toxic materials, waste streams, and polluting emissions throughout life cycles so as not to jeopardize the needs of future generations" (Lorek & Vergragt, 2015).

Given the above elements, we arrive at a definition of an environmentally responsible diet. This definition is made concrete by the basic principles (see 3.)

An environmentally responsible diet stays within the carrying capacity of the ecosystem and at least maintains its biodiversity. This diet has an acceptable environmental impact by taking into account the planetary boundaries. Overconsumption and food losses are avoided as much as possible and efficient use of (natural) raw materials and resources are put forward, whereby polluting emissions and waste flows are minimized.

3.4 General attitude of consumers towards environment and food[8]

Throughout the years, questionnaires have been sent to Flemish citizens. These questionnaires sought to ascertain the attitude of the Flemish citizen vis-à-vis certain themes and issues.

From research (GfK, 2018a) commissioned by the Flemish Government's Department of Environment & Spatial Development, it appears that the majority of the Flemish people are convinced of the importance of taking account of the environment in their consumption decisions, for their future and that of the next generations. The Flemish citizens see a too high-cost price as the main barrier to more sustainable consumption. They also mention obstacles like the lack of sustainable alternatives in shops, too little knowledge, and general disinterest.

The interviewees put forward 'better for the environment' and 'better for my health' as reasons for consuming more sustainably. The main purchasing criteria for food are no surprise. The freshness, price, and quality of the product are mentioned as the most important criteria (VLAM, 2019). These criteria have been the same for several years. Consumer research from 2010 already came to the same findings then (Figure 5), but gives a more nuanced picture about other criteria such as smell, environmental care, and animal welfare. We see, for instance, that when the respondent is helped by being offered more options ('with help' in Figure 5), many more criteria are taken into

[8] In this section, general attitudes are presented. Further on in the report, the specific food groups will be discussed in more detail. An important note is that these results concern intentions to change consumption, which do not necessarily translate into effective behavior.

consideration. This shows that consumers are open to other criteria and that these can be activated (Research and Information Centre of Consumer Organizations, 2010).

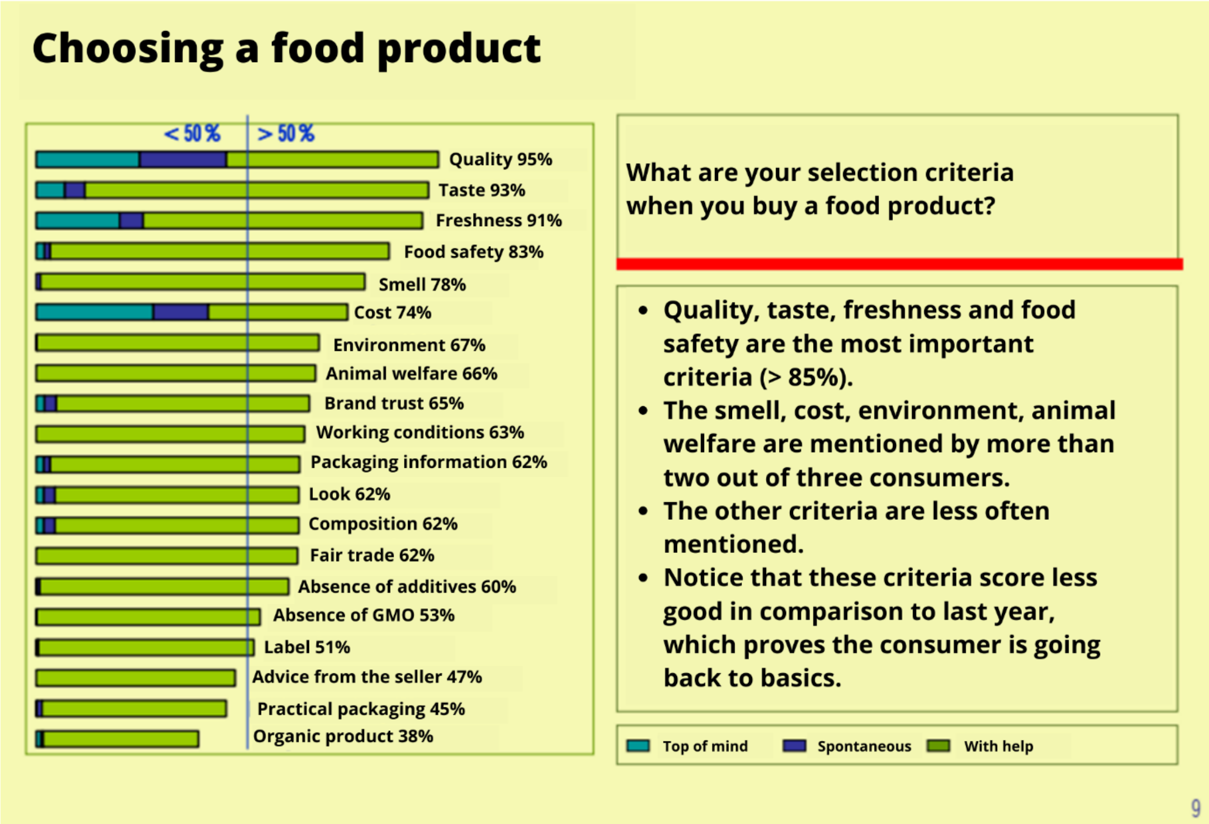

Figure 5: Selection criteria when buying food products (translated from Onderzoeks- en Informatiecentrum van de Verbruikersorganisaties, 2010)

In the 2020 Eurobarometer (European Commission, 2020c), 23% of those surveyed in Belgium indicated that they have switched to a more sustainable diet. Almost one-third of those surveyed see making the food system more sustainable, from production to consumption, as one of the most effective ways of tackling the climate problem. By way of comparison: changing one's consumption behavior is listed first with 36%.

The current efforts that the Flemish people are already making in the area of the environment and food are primarily aimed at throwing away as little food as possible and taking the seasons into account when purchasing food. In addition, the Flemish people indicate that they avoid packaging as much as possible and use products of local origin. It is noteworthy that the Flemish population estimates the reduction of animal products in their diet as an action with a relatively low impact (GfK, 2018a). In a survey by the Flemish Institute for Healthy Living (Vlaams Instituut Gezond Leven, 2018), the vast majority of respondents (71%) would like to change their food patterns in the future. The majority of them want to eat healthier (38%) or a little less (27%).

Consumers find a combined concept of healthy and environmentally friendly food acceptable. Commitment to sustainability implies a commitment to health in fairly equal measure. The reverse cannot necessarily be said: a close involvement with health does not always correspond to close involvement with sustainability (Verbeke, Van Loo, & Hoefkens, 2015).

One may thus conclude that the Flemish people are aware of the importance of environmentally responsible food choices and have the intention to adapt their consumption behavior. To effectively translate these intentions into behavior, however, more is needed (see 2.2). There is still a lack of knowledge about the impact of more environmentally responsible choices. The intention to change eating behavior is present, but there are various barriers (e.g. high cost) to effectively translate into behavior. Several environmental factors - such as supply, availability, freshness, price, etc. - will influence whether certain individual food choices will change in a favorable direction. An important step in stimulating behavioral change towards more environmentally responsible consumption is to provide clear recommendations that are based on a scientifically underpinned framework.

3.5 Health and environment: synergies and trade-offs in previous studies

The environmental and health aspects of food patterns are closely linked and policy emphasis is placed on the integration of both aspects (FAO & WHO, 2019; Swinburn et al., 2019). When talking about food, there should be no need to distinguish between health and environmental aspects. From the point of view of coherence and communicability to citizens, both aspects should be taken into account in an integrated way. Although there is a great synergy between both aspects, sometimes contradictions[9] occur or trade-offs are necessary.

Identifying both the synergies and the contradictions is essential for formulating nutritional guidelines that serve both as much as possible, or provide the consumer with the necessary information to make a trade-off. In recent years, the joint impact of healthy and environmentally responsible diets has been identified in different studies and different ways (e.g. qualitatively, quantitatively). The following is a (non-exhaustive) overview.

3.5.1 Focus on nutrients: the SNRF index

The Sustainable Nutrient-Rich Foods index (SNRF) provides a joint score for health and environmental impact of a food product (van Dooren, Douma, Aiking, & Vellinga, 2017). For the health impact, energy density and nutrient density are taken into account based on Drewnowski's Nutrient-Rich Foods Index (NRF) (Adam Drewnowski, 2009). The existing NRF index was optimized to enhance the identified synergies between nutritional properties and environmental impact. Thus, a distinction is made between animal and vegetable protein. Animal protein sources such as meat clearly have a higher environmental impact compared to vegetable protein sources (see

[9] Some examples of these contradictions: Exotic fruit transported by plane fits into a healthy diet, but carries a high environmental impact compared with similar products (see 4.2.3). The same is true for consuming fish that are threatened by overfishing, although higher consumption of fish does contribute to better health. Sugar-rich beverages, on the other hand, are patently unfavorable to health but have a limited environmental impact per liter of soft drink.

4.1.2). Conversely, the protein quality of animal proteins is higher than that of plant proteins. Nevertheless, vegetable sources can contribute to an adequate protein intake, provided they are sufficiently varied and combined (see 4.1.1.2). Whether plant proteins are healthier than animal proteins is unclear, but the foods that provide plant proteins (legumes, whole grains, nuts, and seeds) are associated with health benefits (see 4.1.1.3 and Table 2 at 4.1.1.4). Another adjustment to the NRF index is the addition of essential fatty acids (both omega 6 and omega 3) as indicators. For the environmental impact, greenhouse gas (GHG) emissions are used as a proxy. GHG emissions are considered a suitable approach because they show a high correlation with other environmental impact categories such as land use and water footprint. The proposed optimized Sustainable Nutrient-Rich Foods index (SNRF) takes into account six nutritional characteristics in relation to energy density: three nutrients to be reduced (saturated fatty acids, salt, and added sugar) and three nutrients to be encouraged (vegetable protein, essential fatty acids, and dietary fiber). Foods that score favorably on these nutritional characteristics contribute to a diet with lower greenhouse gas emissions and higher health scores.

To validate the SNRF index, the GHG emissions of 39 food groups are compared with the outcome of the index for those groups (Figure 6).

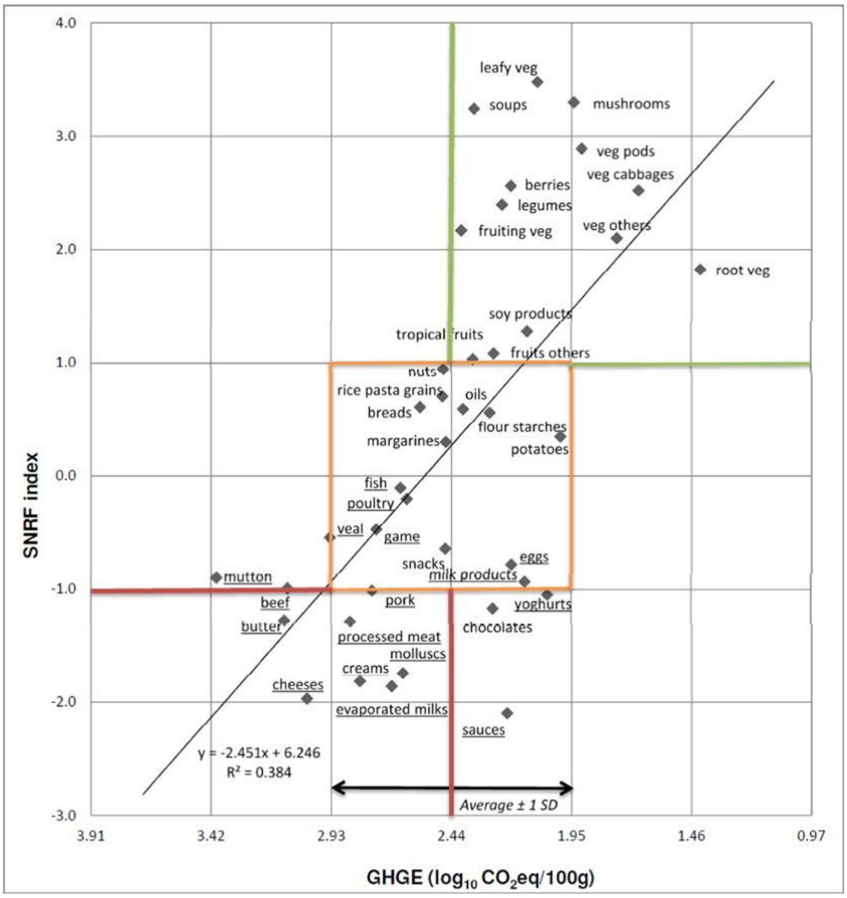

Figure 6: Relationship between Sustainable Nutrient-Rich Foods index and greenhouse gas emissions of 39 food groups (van Dooren et al., 2017)

This comparison shows that the SNRF index of leafy vegetables is much higher than that of vegetables, in other words, the nutrient density of leafy vegetables is higher and the greenhouse gas emissions are lower. Among the protein products, we can see that the SNRF index of beef and pork is similar. Among the vegetable protein sources, legumes have the highest nutrient density combined with the lowest greenhouse gas emissions.

In this figure, the foods are also visually grouped into 3 categories by color (according to the traffic light principle), which allows use for communication to the consumer:

- Foods in the green category, such as vegetables, fruit, and legumes, score best (SNRF > 1). These are generally the least environmentally damaging and contain the most beneficial nutrients per calorie.
- Foods in the orange (middle) category, animal products such as lean meat, game, low-fat milk products, eggs, and fish, have a score between -1 and 0. Vegetable products such as cereals, bread, potatoes, nuts, and vegetable oil score between 0 and +1.
- Foods in the red category, such as red meat, processed meat, cheese, and whole milk products, score the lowest (SNRF < -1). These products have the highest environmental impact and a lower health score.

The SNRF has potential for communication purposes and can serve as a guide to help consumers make their diets healthier and more environmentally friendly. However, there is still room for improvement which could make the results more accurate. For example, the environmental impact has been included to a limited extent and could be expanded to further substantiate that greenhouse gas emissions can be a good proxy. The integration of the health impact can also be refined by better including the protein quality and the supply of micronutrients (vitamins and minerals) in the index.

3.5.2 Focus on food: Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems

The EAT-Lancet Commission (Willett et al., 2019) investigated whether a global healthy diet fits within the planetary boundaries. The recommendations for this diet were formulated quantitatively, with a possible range, for an energy intake of 2500 kcal per day (Figure 7).

The targets formulated for a healthy diet are based on an extensive literature review on foods, dietary patterns, and their effect on health. The justification for the revision of the Flemish dietary triangle in 2017 also followed this holistic approach to nutrition and health.

The authors calculated a Planetary Healthy Diet that can be described as a flexitarian diet. The reference diet consists mainly of vegetables, fruit, whole grains, legumes, nuts, and oils rich in unsaturated fatty acids. It contains a low to moderate amount of fish, seafood, and poultry. It also includes little or no red meat, processed meat, added sugar, refined cereal products (based on white flour), dairy products, and starchy vegetables (potatoes).

The Planetary Health Diet

	Macronutrient intake grams per day (possible range)	Caloric intake kcal per day
Whole grains **Rice, wheat, corn and other**	**232**	**811**
Tubers or starchy vegetables **Potatoes and cassava**	**50** (0–100)	**39**
Vegetables **All vegetables**	**300** (200–600)	**78**
Fruits **All fruits**	**200** (100–300)	**126**
Dairy foods **Whole milk or equivalents**	**250** (0–500)	**153**
Protein sources		
Beef, lamb and pork	**14** (0–28)	**30**
Chicken and other poultry	**29** (0–58)	**62**
Eggs	**13** (0–25)	**19**
Fish	**28** (0–100)	**40**
Legumes	**75** (0–100)	**284**
Nuts	**50** (0–75)	**291**
Added fats		
Unsaturated oils	**40** (20–80)	**354**
Saturated oils	**11.8** (0-11.8)	**96**
Added sugars **All sugars**	**31** (0–31)	**120**

Figure 7: Scientific guidelines for a global healthy diet that fits within planetary boundaries (Willett et al., 2019)

Providing quantitative recommendations (in grams) for a complete diet, taking into account both health and planetary boundaries, is unique. However, there are uncertainties in recommending such specific amounts at a population level, especially when regional differences and the acceptability of the recommendations are not sufficiently taken into account. Like the Hoge Gezondheidsraad (Superior Health Council of Belgium) food recommendations, this advice is aimed at an average person, and not necessarily at each individual (Hoge Gezondheidsraad, 2019). The added value of this exercise is that these recommendations can serve as a touchstone alongside the advice of the Hoge Gezondheidsraad, which has been tested for feasibility with the Belgian population.

The study received a lot of attention and has also been criticized on a number of levels:

- It is not scientifically strong enough because it is mainly based on epidemiological research[10] (this is a discussion within nutritional science and is much broader than EAT-Lancet).

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[10] Epidemiological studies look for possible associations between risk factors (e.g., high intake of saturated fatty acids) and the development or occurrence of disease (e.g., cardiovascular vascular diseases). It gives rise to further research but does not prove a causal relationship.

- The recommendations are nutritionally deficient for certain nutrients: For vitamin B12 it is recognized and indicated by the authors that in some cases supplementation is necessary. For other nutrients, the EAT-Lancet diet is indicated as adequate.

3.5.3 Focus on foods: Multiple health and environmental impacts of foods

This study (Clark, Springmann, Hill, & Tilman, 2019) describes an investigation into the link between health and environmental impact for 15 food groups. These food groups are listed in Table 1. The colors used correspond with the colors in Figure 8 and Figure 9:

Table 1: Overview of the 15 food groups with their corresponding colors for Figures 8 and 9 (Clark et al., 2019)

	Whole grains		Dairy
	Fruits		Eggs
	Vegetables		Chicken
	Nuts		Unprocessed red meat
	Legumes		Processed red meat
	Potatoes		Sugar-sweetened Beverages (SBB)
	Refined grains		Olive oil (as an indicator for plantbased oils rich in unsaturated fatty acids)
	Fish		

To estimate the health impact, five diet-related health risks or outcomes were considered: type 2 diabetes, stroke, coronary heart disease, colorectal cancer, and mortality. These indicators are somewhat of a limitation because they do not give a general picture of the influence of diet on health. For example, there is a clear focus on risks related to overconsumption (negative impact on health), while no attention is paid to the provision of essential nutrients (positive impact on health). In addition, five different environmental impact factors of food production were taken into account: greenhouse gas emissions, land use, water use (taking into account water scarcity), acidification, and eutrophication. To interpret the health and environmental effects, it is necessary to know that this was calculated based on an extra portion on top of the average intake of the food products[11]. In the example of whole grains (Figure 8), the environmental and health impacts of an extra portion of whole grains are shown.

In terms of health outcomes, it was found that foods with a favorable effect on one outcome had a similar effect on the other health indicators. These were nuts, whole grains, fruit, vegetables, legumes, olive oil, and fish.

A similar observation is made for the environmental indicators: a low impact on one indicator, in most cases also implies a low impact on the other four. The lowest impact was found for minimally processed vegetable foods (fruit, vegetables, legumes, nuts, whole grains, potatoes), olive oil, and sugary drinks.

The results of the five health and five environmental indicators were put into web diagrams (radar plots). The lower the score, the better the effect on health and the

[11] Portion sizes for the food groups are: whole grains (30 g dry weight); refined cereal products (30 g dry weight); fruits (100 g); vegetables (100 g); nuts (28 g); legumes (50 g dry weight); potatoes (150 g); fish (100 g); dairy (200 g); eggs (50 g); chicken (100 g); unprocessed red meat (100 g); processed red meat (50 g); sugary drinks (225 g); and olive oil (10 g).

environment. The scores go from 1 to 15 and start in the middle of the web diagram. The left side of a web diagram shows the health impact, the right side visualizes the environmental impact. In general, the smaller the entire web, the lower the total impact.

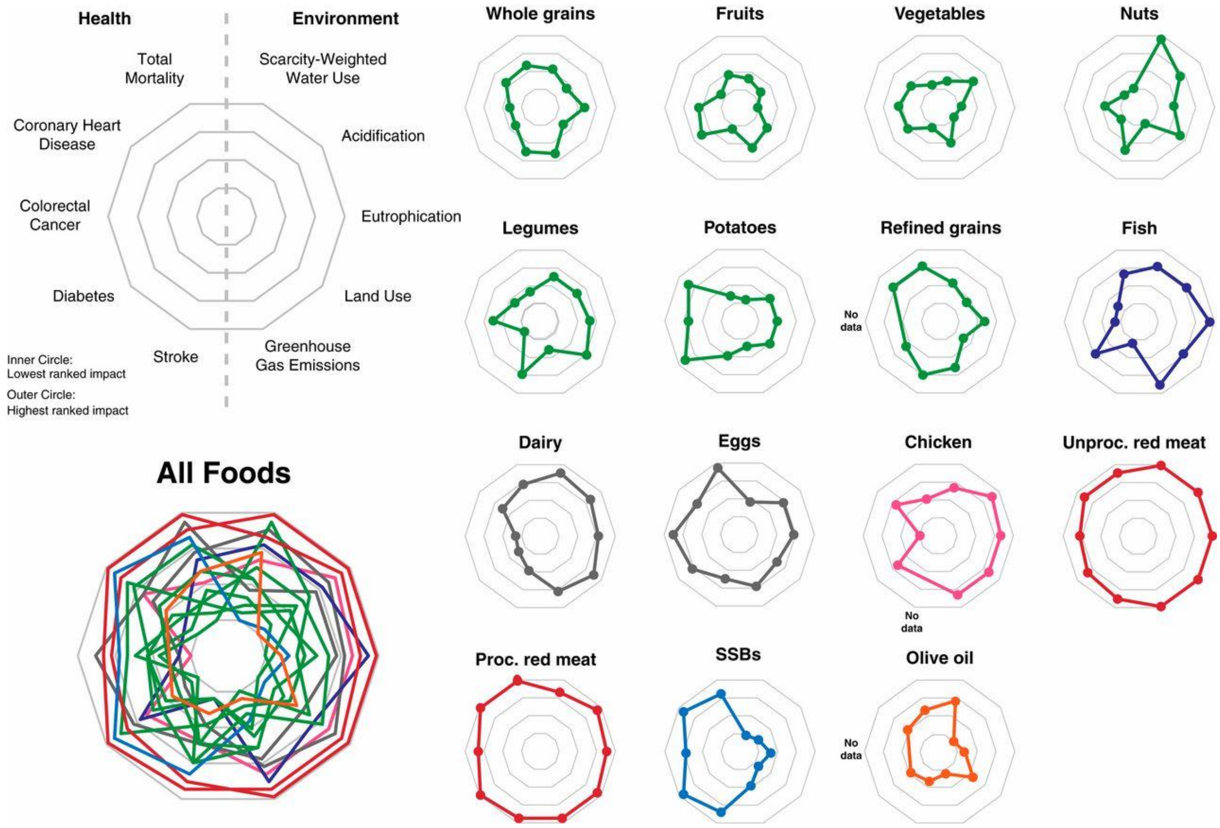

Figure 8: Web diagrams sorted on health and environmental impact based on portion size per day (Clark et al., 2019)

Figure 9 ranks the food products based on the average environmental impact (of the five indicators) with respect to one health outcome, i.e. the mortality risk of one additional daily portion.

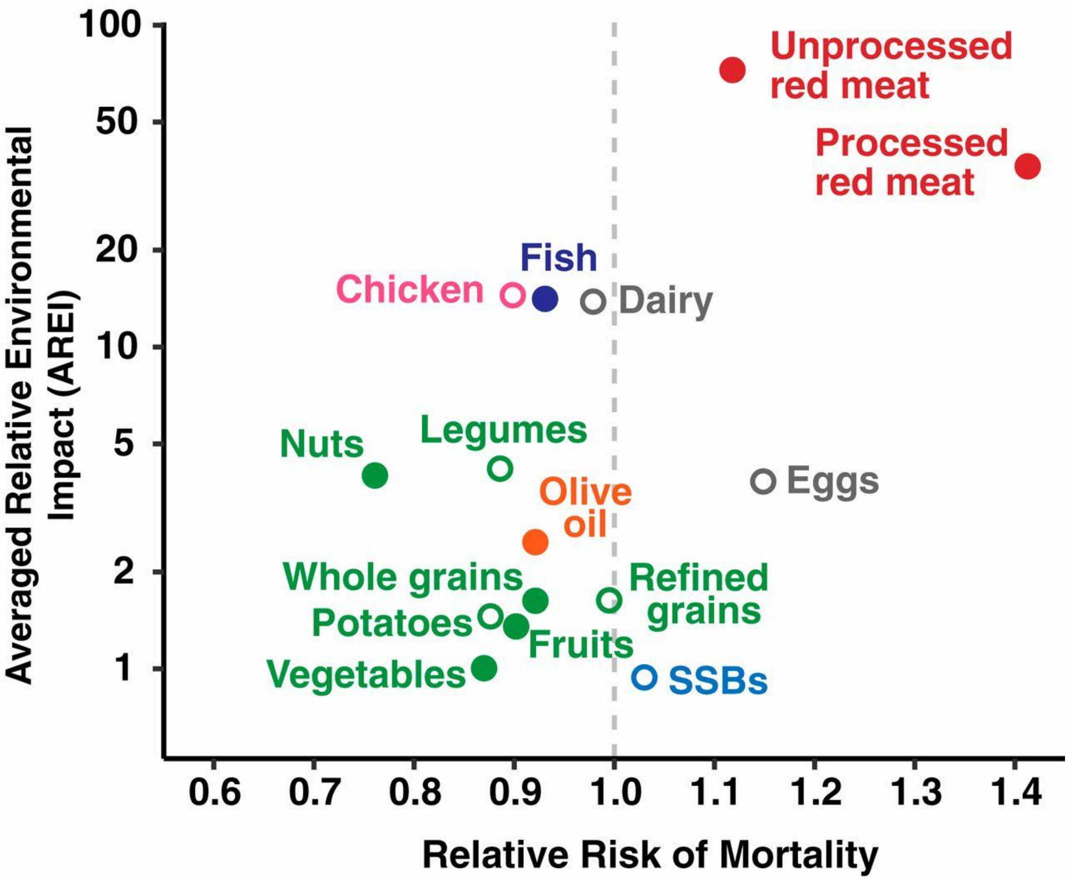

Figure 9: Average environmental impact (expressed in grams of CO2 equivalent per serving) relative to the mortality risk of one additional daily serving (Clark et al., 2019)

Foods that are associated with a significant[12] reduction in mortality each have a lower average environmental impact (except for fish). Foods associated with an increase in mortality have a more variable environmental impact. Red and processed meat have a high environmental impact, whereas sugary drinks have the lowest environmental impact of all the foods in this analysis.

Foods with an average score on the environmental impact or with a rather neutral health impact (refined cereals, dairy products, eggs, and poultry) can contribute to an improved diet in terms of health and the environment when used as a replacement for products with a higher environmental impact or unfavorable health impact. The outcome of this study has a high agreement with the SNRF index (Figure 5). Again, there are analogous limitations that need to be taken into account when interpreting it.

3.5.4 Focus on dietary patterns: Healthy and sustainable diets. Finding co-benefits and trade-offs for the Netherlands

A prospective cohort study (EPIC-NL) among Dutch men and women looked for a link between the environmental impact of eating patterns and the risk of mortality. It was expected that an eating pattern with a lower environmental impact would be associated with a lower risk of mortality, but no link was found in this study. A more

[12] Indicated in the figure as a full circle (unfilled circle = not significant).

environmentally friendly diet is not necessarily a healthier diet and vice versa. It strongly depends on which substitutions are made between foodstuffs. This was checked via a scenario study (Biesbroek et al., 2019).

Replacing a portion of meat consumption (reduction of 35 g per day) with plant-based foods such as vegetables, fruits, nuts, seeds, pasta/rice/couscous, or by fish would have a beneficial effect on survival rates (4-19% lower mortality risk), and would reduce greenhouse gas emissions (4-12%) and land use (10-12%). However, the substitution of fish is controversial in terms of other environmental indicators. Replacing red meat with white meat would also have a combined beneficial effect (Biesbroek et al., 2019).

Another study investigated whether a healthier diet (according to WHO guidelines, according to the DASH diet[13], and according to recommendations of the Dutch Health Council) is associated with a lower environmental impact (calculated based on LCA). This was found to be the case (for the DASH diet only in men). The effect was moderate but was associated with a clear reduction in mortality risk (Biesbroek et al., 2017).

3.5.5 Conclusion: synergies and trade-offs health and environment

Research shows that synergies can be found between healthy and environmentally responsible diets. Thus, health and environmental objectives can be pursued together. This increases the potential for coherence to formulate recommendations.

However, these synergies are not always obvious and, when developing recommendations, care should be taken to avoid negative side effects. Depending on whether one looks at the level of nutrients (3.5.1), foodstuffs (3.5.2 and 3.5.3), or diet (2.5.4), different synergies and trade-offs can be found between healthy and environmentally responsible food choices. This shows that we need to pay attention to the different levels. For example, we need to examine which general guidelines will bring the greatest environmental benefits at the level of a food pattern. In addition, we must look at how we can achieve additional gains through targeted choices within food groups.

4 Advice at the level of food patterns

The food triangle (Figure 10) of the Vlaams Instituut Gezond Leven (2017b) provides extensive advice on healthy food choices at the level of the dietary pattern and within food groups. To provide the consumer with additional advice on points of interest for an environmentally responsible diet, the interaction between healthy and environmentally responsible diets is explored in the first place (Vlaams Instituut Gezond Leven, 2017b). In addition, in chapter four we investigate whether and which

[13] DASH stands for Dietary Approaches to Stop Hypertension. The diet was developed by the National Institutes of Health (NIH) in the United States, based on two studies in the 1990s. Originally, the DASH diet was designed to stop high blood pressure (hypertension) - and thus also cardiovascular disease. In the meantime, it has become widely recognized as a dietary approach that supports health and weight loss. It places staple foods at the center such as fruits and vegetables, whole grains, nuts, and legumes, semi-skimmed and low-fat dairy products, poultry, and fish.

additional gains can be made by making more environmentally responsible choices within food groups.

Scientists investigating environmentally responsible and healthy diets conclude that many foods associated with health risks also tend to have a high environmental impact. Several studies indicate that a diet consisting largely of plant-based foods (such as vegetables, fruit, legumes, whole grains, seeds, etc.) and smaller quantities of animal-based foods (particularly red meat and processed meats) have a lower environmental impact and is more beneficial to health than the average consumption in the Western world. This is provided that the total energy input does not exceed the requirement and if food losses are avoided (Aleksandrowicz, Green, Joy, Smith, & Haines, 2016; Hallström, Carlsson-Kanyama, & Börjesson, 2015; Jones et al., 2016; Nelson, Hamm, Hu, Abrams, & Griffin, 2016; Poore & Nemecek, 2018; Ranganathan et al., 2016; Sustainable Development Task Force, 2015; Westhoek, 2019). Thus, a change of dietary habits to such a dietary pattern will have a positive impact on both areas.

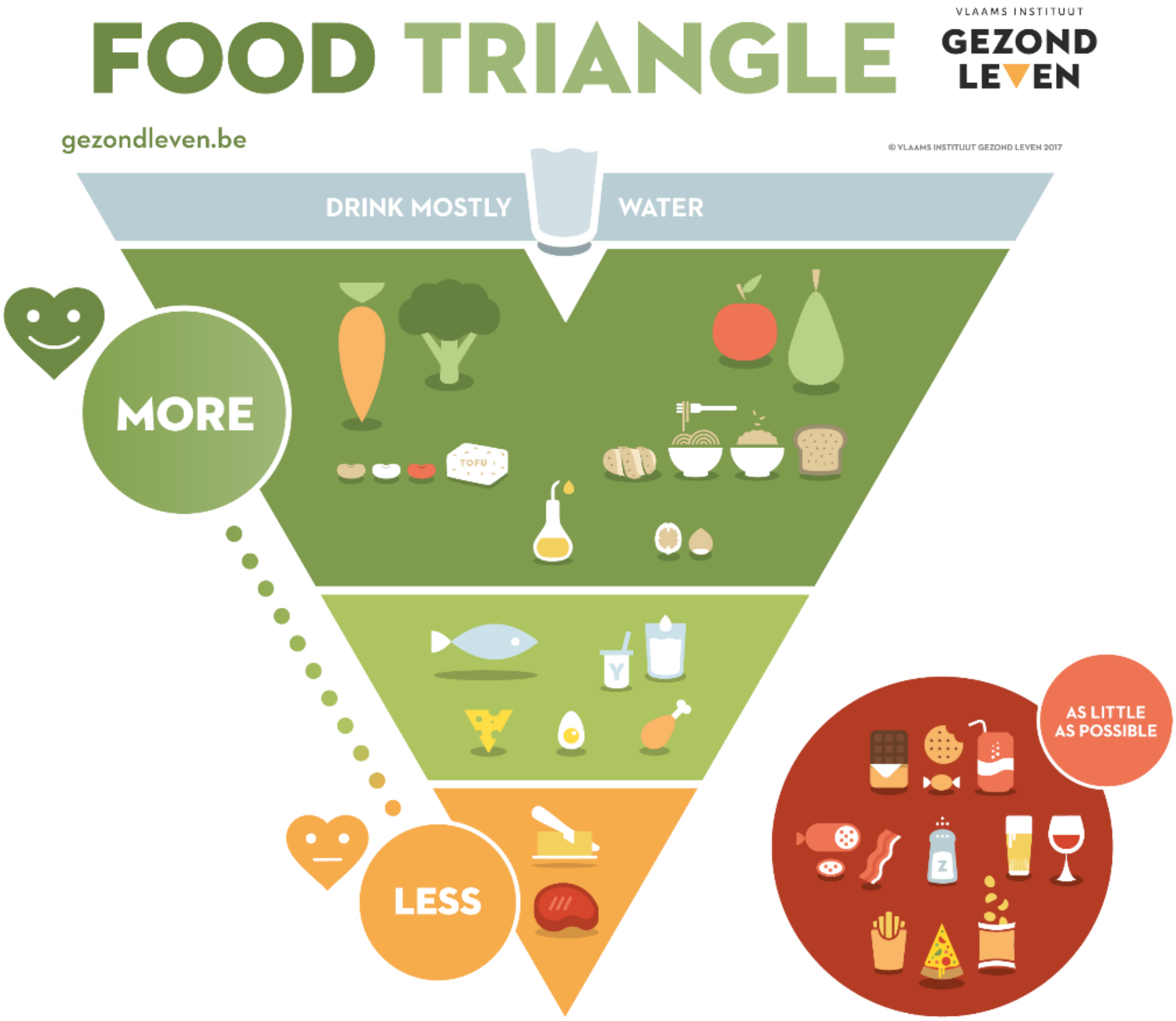

Figure 10: Food Triangle (Vlaams Instituut Gezond Leven, 2017a)

The existing principles for a healthy diet are tested against the environmental impact, and the following considerations or refinements are made:

- Eat proportionally more plant-based food than animal products.

How does the environmental impact of eating patterns rich in plant-based foods compare with the impact of eating patterns rich in animal products?

We look specifically at the protein foods of animal and plant origin. What is the ideal ratio from a health point of view and what further shifts are possible in terms of additional environmental benefits? In this way, we want to achieve a more balanced protein consumption.

- Avoid ultra-processed foods as much as possible.

The term 'ultra-processed food' is problematic in this discussion and will be adapted to a more fitting description. It refers to foods that have a high energy density but a low nutritional value (also called 'empty calories'). A characteristic of these products is that they are often highly processed.

- Do not waste food and moderate your consumption.

Given the differences in dynamics and substantiation, this principle is split into two aspects. In this report, 'avoid food waste' and 'avoid overconsumption' are discussed separately.

Consequently, we develop four principles for a healthy and environmentally responsible diet:

- achieving a balanced protein consumption
- avoiding food loss
- limiting products with a high energy density and low nutritional value (in short, 'empty calories');
- avoiding over-consumption.

In what follows, these principles will be discussed and assessed in terms of health and their environmental impact. The order of these principles is arbitrary and not in order of priority.

4.1 Achieving a balanced protein consumption

4.1.1 Health

4.1.1.1 Protein requirements

Proteins are polymers of amino acids. An amino acid can be essential or non-essential. The former cannot be synthesized by the human body and must be ingested through the diet. Some amino acids are conditionally essential. This means that under normal circumstances they can be synthesized by the body and are therefore non-essential. However, in specific situations, such as during certain phases of life or with certain disorders, they can become essential.

The average protein requirement (i.e. sufficient for half the population) for the maintenance of a fully developed body in adults is around 0.66 g/kg body weight/day. Taking into account a safety margin to cover the needs of 97.5% of the population, the recommended daily allowance (RDA) for protein is 0.83 g/kg body weight/day for an adult. For the 18-59 age group, this amounts to a recommended intake of 52 g protein per day for women and 62 g protein per day for men[14] (Hoge Gezondheidsraad, 2016). Expressed in terms of energy percentages (En%)[15], most sources put the protein requirement at around 15 En%.

These are values that apply to adults, where protein is mainly needed for the maintenance of the (fully-grown) body. A higher intake is recommended in various situations (Hoge Gezondheidsraad, 2016):

- During growth, pregnancy, and lactation
- In men from adolescence to adulthood, due to the build-up of higher muscle percentage
- Vegetarian and vegan food[16]: an increase of the RDA by a factor of 1.2 and 1.3 respectively is recommended.
- For endurance sports (increase up to 1.2 g/kg/day)

A (healthy) human body can easily adapt to intakes far above the recommended average requirement. No adverse effects have been observed in adults with a protein intake of up to about 25 En%. This value is therefore used by the Superior Health Council as a safe upper limit or maximum tolerable intake (MTI) (Hoge Gezondheidsraad, 2016).

4.1.1.2 Protein quality

The protein quality of the diet is important for protein utilization. There are various methods for indicating the quality of a protein. The two best-known methods are the Protein Digestibility-Corrected Amino Acid Score (PDCAAS) and the Digestible Indispensable Amino Acid Score (DIAAS). The PDCAAS was introduced in 1991 by the FAO and WHO, while the DIAAS was published in 2013 by the FAO (World Health Organization, 2007; FAO, 2013). The PDCAAS is calculated by dividing the content of the limiting essential amino acid in this protein (in mg per g protein) by the requirement for this amino acid in a reference protein (also expressed in mg per g protein) and multiplying by the digestibility of the protein. The limiting amino acid is that essential amino acid present in the lowest quantity (FAO & WHO, 1991). The DIAAS is calculated by multiplying the content of the essential amino acid (in mg per g protein) by the ileal digestibility and dividing by the content of that same digestible amino acid (also expressed in mg per g protein) in a reference protein (FAO, 2013).

Although both methods evaluate the levels of essential amino acids and digestibility, there are some fundamental differences. For example, PDCAAS uses the amino acid

[14] Calculated for a reference weight of 62.1 kg for women and 74.6 kg for men (Hoge Gezondheidsraad, 2016).
[15] Energy percentages (En%) are calculated by dividing the input of energy by a given macronutrient by dividing the total energy intake and multiplying by 100.
[16] In a vegetarian diet (certain) animal product groups are not consumed. There are various interpretations of this, but in general, no meat, fish, and seafood are consumed, but milk (products) and eggs are. In a vegan diet, all animal products are eliminated and no dairy, eggs, or honey are consumed. When one eats partially vegetarian, it is referred to as a flexitarian eating pattern.

profile of a reference protein that meets the needs of 3- to 5-year-olds, whereas DIAAS provides different reference proteins depending on age (FAO & WHO, 1991; FAO, 2013). PDCAAS uses fecal protein digestibility, which is calculated by determining the difference between the nitrogen content of the protein consumed and the fecal nitrogen content, correcting for metabolic fecal nitrogen. Metabolic fecal nitrogen is determined by feeding test animals such as rats a protein-free diet (FAO & WHO, 1991). Fecal protein digestibility often overestimates actual digestibility because the microbial flora, mucins, and other cellular material in the large intestine contribute to fecal nitrogen levels (Schaafsma, 2005; FAO, 2013). The DIAAS, on the other hand, makes use of the ileal amino acid digestibility. This involves determining the difference between the content of absorbed amino acids and the content of amino acids present in the terminal ileum (or the last part of the small intestine). The amino acids are absorbed when they reach the terminal ileum, making the determination of ileal amino acid digestibility an accurate method. It is recommended that ileal amino acid digestibility be determined in humans, pigs, and, as the last option, rats (FAO, 2013). The last fundamental difference between the two involves the display of the score. Thus, the PDCAAS score cannot be higher than 100%. If the obtained PDCAAS score is higher than 100%, it will be reduced to 100%, which will negate the additional nutritional benefits of the protein (Schaafsma, 2005). This is not the case with DIAAS, where a score higher than 100% can be obtained (FAO, 2013). DIAAS is a more accurate evaluation method than PDCAAS. However, more data are found regarding PDCAAS because the ileal amino acid digestibility, which is required for DIAAS, is an invasive and intensive method and further research is needed to optimize the method for ileal digestibility (FAO, 2013).

In general, the protein quality of animal foods is higher than that of plant sources. An exception is soy, which has a protein quality similar to that of animal protein sources. Most other plant products have a specific limiting amino acid (the least present in relation to requirements). These include methionine for legumes and lysine for maize and wheat. By combining and varying vegetable protein sources within the diet, the intake of all essential amino acids can be met.

The average Belgian consumes both animal and plant-based foods. In this protein mixture, all the essential amino acids are present in sufficient quantities. Lysine is the limiting amino acid for lacto-ovo-vegetarians and especially for vegans. For a lacto-ovo vegetarian diet (milk/wheat as the source of protein), the PDCAAS would be 84%; for a vegan diet (wheat/soya as the source of protein), the PDCAAS is 77%. This is accommodated by the advice to increase protein intake in vegetarian and vegan diets compared to a mixed diet (Hoge Gezondheidsraad, 2016).

4.1.1.3 Effect on health of plant-based versus animal protein?

Research has also been carried out into the health effects of the various sources of protein, both the various animal sources and animal versus vegetable protein. It should be noted that this does not concern the proteins themselves or their quality, but other components (e.g. fiber, fatty acids, vitamins, and minerals) inherent to certain animal or vegetable protein sources in the diet (Hoge Gezondheidsraad, 2016). No conclusions can therefore be drawn for the effect on the health of vegetable versus animal proteins at the nutrient level. However, the effects of the foodstuff as a whole can be considered, as was done in the development of the food triangle in 2017 (see 4.1.1.4).

4.1.1.4 Recommendation of the food triangle

The literature review on foods and their effect on health conducted in the function of the development of the food triangle in 2017 is summarized in the following table (Table 2) (Vlaams Instituut Gezond Leven, 2017b).

Table 2: Ranking of foods according to their effect on health (Vlaams Instituut Gezond Leven, 2017b)

Strong evidence for health enhancing effect or association	**Neutral (=) or mixed evidence (>=<) for health effect or association**	**Strong evidence for unfavourable health effects or association at high consumption**
Fruits and vegetables	Poultry (white meat) (>=<)	Red meat
Whole grains	Eggs (=)	Processed meat products
Legumes	Milk and milk products (>=<)	Alcohol
Nuts and seeds	Cheese (=)	Sugary drinks (and food high in sugar)
Plant-based oils and other fats rich in unsaturated fatty acids	Potatoes (>=<)	Butter, coconut oil, palm oil and other fats rich in saturated fatty acids
Fish	Refined grain products (>=<)	Salt (and foods rich in salt)
Tea	Coffee (>=<) (filtered versus unfiltered)	

Summary based on: (Fardet A, Boirie Y., Nutr Rev. 2014; Gezondheidsraad Nederland, Richtlijnen goede voeding 2015; Dietary Guidelines Advisory Committee USA, Scientific report 2015; Anses, Actualisation des repères du PNNS 2017)

It is noticeable from this overview that predominantly plant-based foods are associated with health benefits when consumed at higher levels (except fish). Animal products such as poultry and dairy represent a neutral or have no effect. High consumption of red and processed meat has been found to be associated with adverse health effects.

For more information on the health aspects of the various food groups, see the information on the food triangle.

4.1.1.5 Recommendations of the Hoge Gezondheidsraad

The Hoge Gezondheidsraad (Superior Health Council of Belgium, HGR) identified the link between nutrition and health specifically for Belgium, based on the Global Burden of Disease study. An overview is given in Table 3.

Table 3: Practical dietary recommendations for adults: an overview in order of importance (Hoge Gezondheidsraad, 2019)

Foods	Practical dietary recommendations	Tips & tricks
Whole grain products	At least 125 grams of whole grain products per day.	Eat enough whole grain products each day to meet your energy needs. Replace refined products with whole grain products.
Fruit	250 grams of fruit per day.	Give preference to fresh fruit.
Vegetables	300 grams of vegetables per day.	Vary the types of vegetables and allow yourself to let the seasons guide you.
Legumes	Eat legumes weekly.	Replace meat with pulses at least once a week.
Seeds and nuts	15 to 25 grams per day.	Prefer products rich in omega 3 (e.g. walnuts). Choose nuts and seeds without salty or sweet shells.
Milk and milk products	Use between 250 and 500 ml of milk or milk products per day.	If consumption is lower than 250 ml/d, attention should be paid to other sources of protein, calcium and vitamins.
Fish and seafood	Eat fish and seafood once or twice a week, including oily fish.	Eat fish once or twice a week, preferably sustainable fish rich in omega 3 fatty acids.
Red meat	Eat a maximum of 300 grams of red meat per week.	Red meat can be replaced by pulses, fish, poultry, eggs and other substitutes. Choose substitutes that fully replace meat.
Processed meats	Eat a maximum of 30 grams of processed meat per week.	Replace processed meats (charcuterie) with tinned fish, legumes or vegetables, fruit, fresh cheese.
Drinks and foods with added sugar	Drink as few drinks with added sugar as possible.	Prefer drinks without added sugar with water as the first choice.
Foods	**Practical dietary recommendations**	**Tips & tricks**
Calcium	Aim for a sufficient intake of calcium from different sources including milk and milk products.	Consume at least 950 mg of calcium daily.
Polyunsaturated fatty acids with a focus on omega 3 fatty acids	Prefer rapeseed, soybean and walnut oil and use nuts and seeds.	Prefer non-tropical oils, grease and liquid cooking fats to hard margarines and butter.
Sodium and salt	Limit your salt intake to a maximum of 5 grams per day.	Choose products low in salt and limit the addition of salt to preparations and at the table. Herbs and unsalted spices are good alternative seasonings.

The HGR then formulated practical recommendations at the food level (so-called food-based dietary guidelines). These are in line with the recommendations of the food triangle and give additional quantitative advice. They recommend limiting red meat consumption to a maximum of 300 g per week and processed meat consumption to a maximum of 30 g per week (Hoge Gezondheidsraad, 2019).

The HGR does not advise on the recommended intake of white meat (poultry) or eggs. For legumes and fish, a frequency is recommended (weekly and once or twice a week respectively) but no quantitative advice is given. For nuts and seeds, however, this is the case: 15 to 25 g per day. For milk and milk products, an intake of 250 to 500 ml per day is recommended (in the function of the RDA for calcium intake). With an intake lower than 250 ml per day, sufficient attention should be paid to the intake of calcium, vitamins B2 and B12, and protein from other sources (such as calcium-rich vegetables and fortified dairy alternatives).

4.1.2 Environment

4.1.2.1 Animal and plant-based production

In comparative studies, the category of animal products generally scores high in terms of environmental impact. Poore and Nemecek (2018), who collected data from 123 countries and 38,700 farms, point out the disproportionate impact of animal products on the environment. They take into account the impact on greenhouse gases, land use, water use in relation to water scarcity, acidification, and eutrophication. In addition to the high environmental impact per kilo of meat, the large quantity of meat consumed also contributes to a higher overall environmental impact (Poore & Nemecek, 2018).

However, there are significant regional differences, also depending on the intensive or extensive nature of the production system (FAO & LEAD, 2006). There is a variation by a factor of 12 to 50 between the different meat products and producers. This variation is also confirmed in other (meta)studies and applies to environmental parameters such as land use, greenhouse gas emissions, and water use (Nijdam, Rood, & Westhoek, 2012; Searchinger et al., 2013). Despite the large range of results within one specific category, a clear ranking can be established (Figure 11) (Bergsma, Nijenhuis, Bijleveld, & Dalm, 2014; González, Frostell, & Carlsson-Kanyama, 2011).

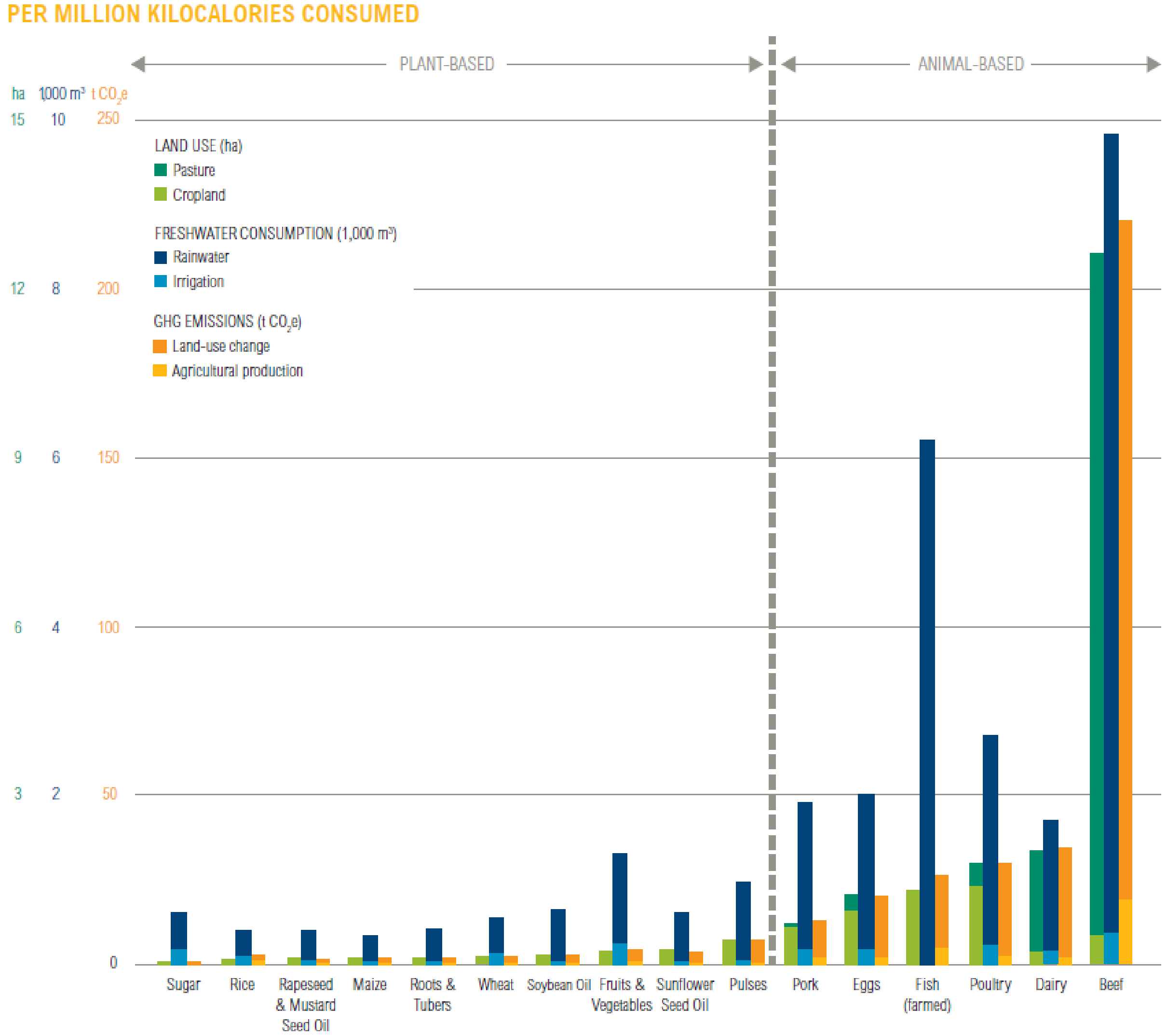

Figure 11: Impact by product category by land use, water use, and greenhouse gas emissions per kilocalorie (Ranganathan et al.,.2016)

Animal products have a higher impact in terms of land use, greenhouse gas emissions, and water use compared to plant-based alternatives. On average, livestock production is more than six times less efficient for producing protein compared to plant-based production. It requires many inputs, such as feed, and makes heavy demands on the use of land and water. Livestock production also results - compared to plant production - in significant emissions of greenhouse gases and nitrogen oxides (European Environment Agency, 2017).

There are various ways of comparing the impact of animal products with plant-based alternatives. A comparison per kilogram says something about the absolute quantity, but nothing about the nutritional value of these products (González et al., 2011). In the graph above (Figure 11), kilocalories are taken as the basis for comparison. In the light of better protein diversification, it is advisable to make an analogous analysis with protein content as the basis of comparison. This is elaborated on in the following sections. It should be noted that a comparison based on kilocalories or protein content is still limited but more accurate than a comparison based on an index that includes several nutrients. An index combines several aspects, however, you lose information.

4.1.2.2 Climate impact

The climate impact can be expressed in terms of the carbon footprint[17]. Two perspectives can be applied: the consumption perspective and the production perspective. Whenever figures are put forward, it is important to make clear which perspective is being considered.

Let us start with the consumption perspective. Food takes up 15% of the total carbon footprint of households[18]. In the Flemish food pattern, the share of meat products in the total carbon footprint of the food pattern is the highest. The categories 'meat' (28%) and 'milk, cheese & eggs' (18%) make up almost half (46%) of the carbon footprint (Vercalsteren et al., 2017).

The emissions that lie behind this carbon footprint are not emitted within our borders. That is why they are referred to as indirect emissions. Generally speaking, over 85% of the greenhouse gas emissions from our diet originate outside Flanders (Vercalsteren et al., 2017). This means that a large part of the greenhouse gas emissions are, as it were, exported because they are emitted outside our borders and therefore do not appear on the Belgian and Flemish balance sheets. Animal production in Belgium thus exports about 45% of greenhouse gas emissions to countries outside the EU (Sandström et al., 2018).

The production perspective differs to the extent that it looks at the carbon footprint of production within Flanders (in this case). Direct emissions are therefore discussed. This carbon footprint, therefore, represents a part of the Flemish consumption, but not the entire consumption. This carbon footprint also includes the part that is exported. Imported materials and supplies such as fodder and artificial fertilizer are not included in this carbon footprint.

The share of the agriculture and food industry counts for 12% of the Flemish greenhouse gas emissions, three-quarters of which come from agriculture. Over two-thirds of these are linked to production for export (Brouwers et al., 2017). Greenhouse gas emissions from Flemish agriculture and horticulture decreased slightly in the period 2000-2016 until 2008. After 2008, we even see a slight increase (VMM, 2018b).

The animal sector is responsible for more than 63% of the total greenhouse gas emissions of the Flemish agricultural and horticultural sectors (Platteau et al., 2018).

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[17] The carbon footprint of Flanders includes all greenhouse gas emissions that arise globally as resulting from Flemish consumption (Vercalsteren et al., 2017). These are:

- greenhouse gas emissions that arise in the production and distribution chains of the goods and services that households purchase;
- greenhouse gas emissions that arise at households themselves through the use of fuels in the home and for driving the car;
- greenhouse gas emissions associated with investments by companies and governments in buildings and infrastructure, machinery, ICT equipment, etc;
- greenhouse gas emissions are linked to public services that the consumer does not pay for directly, such as education and defense.

[18] Housing (40%) and transportation (19%) together with food lead the top three (Vercalsteren et al, 2017).

The share of agriculture and horticulture in the total greenhouse gas emissions for Flanders gives a limited picture of the climate impact of the diet.

Agricultural production contributes to greenhouse gas emissions, in particular carbon dioxide, methane, and nitrogen dioxide. For worldwide methane emissions, an important greenhouse gas, meat production is the main source. Overall, livestock production is responsible for over 80% of greenhouse gas emissions from total agriculture (European Environment Agency, 2017). Plant-based products tend to have a lower climate impact, but this is not always the case. For example, rice production has a proportionally similar climate impact to that of poultry (Figure 12) when protein supply is considered. Moreover, on average, rice has a relatively low protein content.

Environmental impact in relation to the proteins

The environmental impact can be viewed in relation to the proteins supplied. In the graph below (Figure 12)[19], the large scope and mutual differences between the various protein sources become clear (see also Tilman and Clark (2014)).

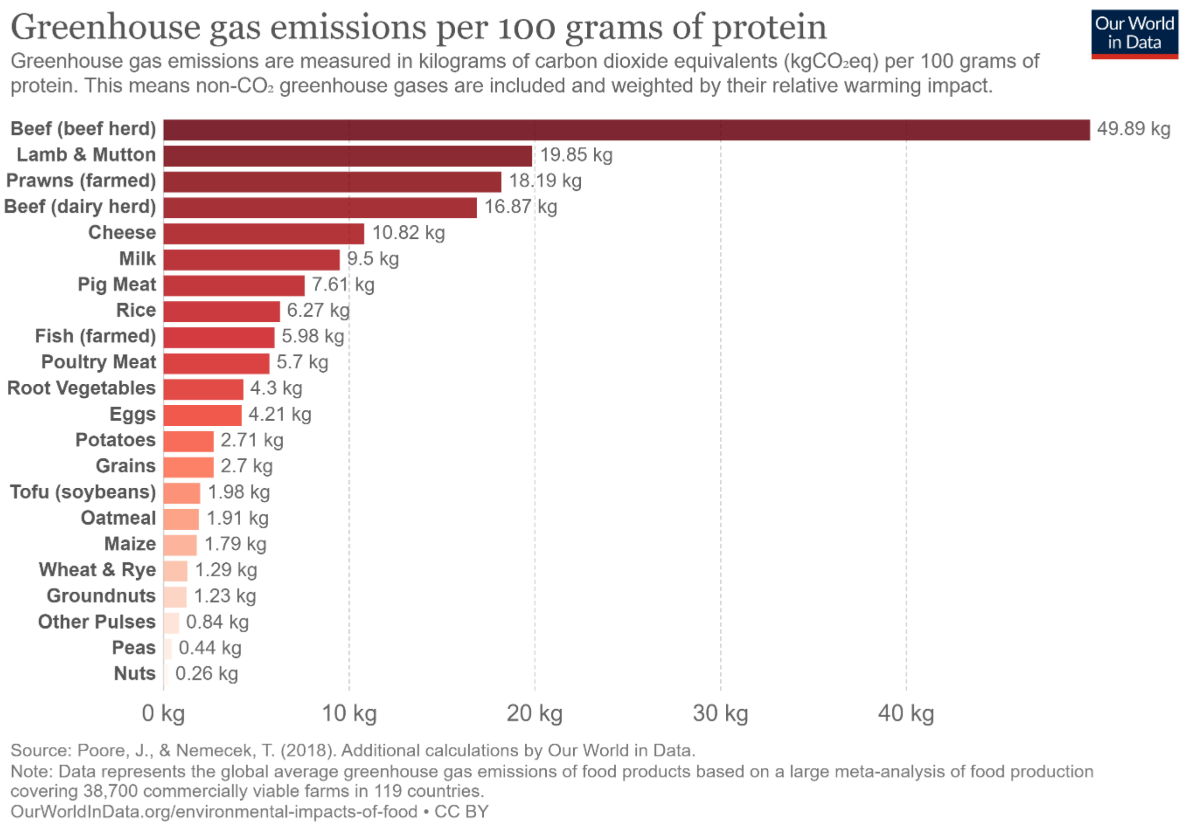


Figure 12: Greenhouse gas emissions for different food categories per 100 g of protein (Ritchie, 2020 after Poore & Nemecek, 2018)

In terms of protein content, there is a clear distinction between plant-based and animal products, with animal products generally scoring highest in terms of greenhouse gas emissions (Clune, Crossin, & Verghese, 2017; Directorate-General for Research and Innovation, 2018; Keulemans et al., 2015; Nijdam et al., 2012; Ranganathan et al., 2016; van Dooren et al., 2017). A diet with lower consumption of

[19] In Appendix 1, Figure 12 is reproduced with kcal as the functional unit (Figure B1).

animal products in favor of plant-based products that is also nutritionally adequate has a significant reduction potential for environmental impact (van de Kamp et al., 2018; Westhoek, 2019).

The degree to which protein is applied in relation to greenhouse gas emissions is expressed in terms of the protein delivery efficiency (number of grams of protein per kilogram of CO_2 equivalent). A high protein delivery efficiency indicates a high level of protein relative to greenhouse gas emissions. The potential of legumes and cereals as excellent sources of protein is particularly striking among plant products (Table 4). Rice has a low delivery efficiency comparable to fish or chicken, partly due to its high methane emissions (González et al., 2011).

Table 4: Protein delivery efficiency for different food products (González et al., 2011)

Category	Product	Protein delivery efficiency	Category	Product	Protein delivery efficiency
Meat	Beef	7.1	**Vegetables**	Potatoes	89
	Lamb	7.6		Red beet	146
	Pork	25		Pumpkin	106
	Poultry	39		Tomato	27
	Fish	67		Tomato (heated greenhouse)	1.7
Dairy, eggs	Eggs	42		Cucumber	84
	Milk	31		Cucumber (heated greenhouse)	3.9
	Cheese	28		Carrot	81
Legumes	Beans	246		Onion	116
	Peas	495		Salad	61
	Soy	505		Broccoli	75
	Broad beans	277	**Fruits**	Appel	9.2
Grains	Wheat	192		Orange	22
	Corn	141		Cherry	31
	Oats	359		Strawberry	18
	Barley	187			
	Rye	283			
	Rice	56			

Large differences within the same category

Not only are there large differences between the various animal products (e.g. difference between beef and poultry), even within the same category of animal products the impact can vary significantly (e.g. the range for beef) (Garnett, Smith, Nicholson, & Finch, 2016; Girod, van Vuuren, & Hertwich, 2014). This is illustrated in Figure 13, which looks at these large differences within one category on a global scale. This is largely explained by the variation in agricultural practices and production methods. On average, intensive production systems emit fewer greenhouse gases (per kg) compared to extensive production systems. The opposite is true when greenhouse gas emissions are considered per hectare.

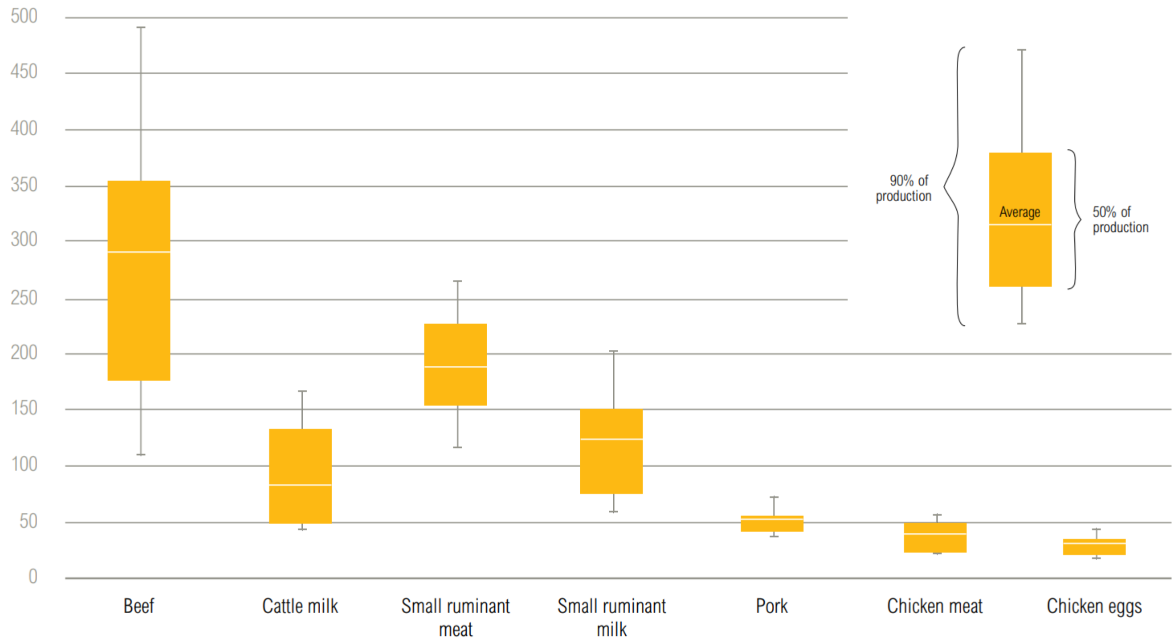


Figure 13: Range of greenhouse gas emissions by category of animal products per kilogram of protein (kgCO2-eq per kg protein) (Searchinger et al., 2013)

The difference in impact between the different animal products can be attributed to a number of issues: relatively inefficient feed conversion rate[20] (Ranganathan et al., 2016); rumen fermentation in ruminants (methane gas); nitrous oxide or nitrous oxide (N2O) emissions from the soil (through manure use and storage) (Buckwell & Nadeu, 2018), and CO2 emissions from land-use change (for growing fodder crops). Pork and chicken, fish, and dairy products (except butter and cheese) score better within the animal protein category (de Valk et al., 2016).

Carbon storage and animal production

Grazing of grasslands is often seen as one of the major benefits of livestock production as it is said to stimulate carbon storage in the soil. This is also known as carbon sequestration (Garnett et al., 2016). However, there are large regional differences and this depends on how intensively the grassland is used (Garnett et al., 2017). The profit potential of better grassland management is estimated at 4-11% of

[20] This is the required feed for one kg of meat. For further discussion, see "4.1.2.3 Land use".

total emissions from livestock farming (Garnett et al., 2017; Godfray et al., 2018). Despite cautiously positive results, the evidence for this is meager and much research remains to be done (Brouwers et al., 2017; Garnett et al., 2016). For other trade-offs, both positive and negative (also in terms of animal welfare), further research must show in which direction the balance tilts (Hayek & Garrett, 2018). The utilization of grasslands in Flanders, as elsewhere in the world, is rather declining (see 4.1.2.3 Land use).

4.1.2.3 Land use

Worldwide, the livestock sector (meat, aquaculture, eggs, and dairy) accounts for about 77% of the agricultural area.[21] It should be noted that 57% of the land currently grazed by livestock is unsuitable for the production of crops for human consumption due to soil and climate conditions. This includes, for example, the Sahel region and parts of the Mongolian steppe (Honnay, 2020). The rest of the land use involves grasslands and the space needed to grow feed on land that is also suitable for arable farming. Thus, around 40% of arable land worldwide is used for the production of animal feed (Van Zanten et al., 2018). Given that, globally, animal production only provides 37% of the protein and 18% of the calories, the share of this land use can be seen as disproportionate (Figure 14) (Nijdam et al., 2012; Poore & Nemecek, 2018; H. Westhoek et al., 2011).

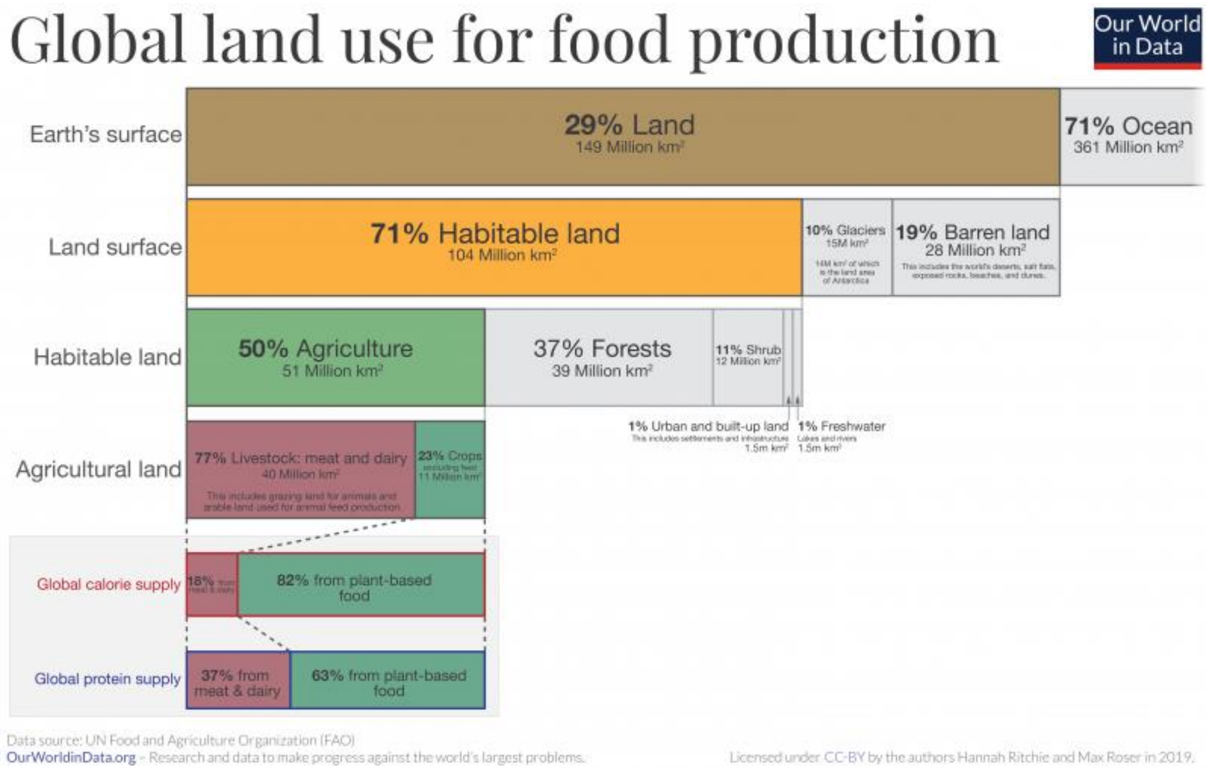


Figure 14: Graphical representation of the global use of land for food production (Ritchie, 2020)

[21] The exact percentages vary, but the same orders of magnitude are found in other studies found such as Van Zanten, et al. (2018) and Meier, et al. (2014).

In a theoretical reflection of the Flemish Department of Agriculture & Fisheries, it was shown that the current diet of the Flemish people cannot be covered with the available agricultural land in Flanders (Danckaert, Deuninck, & Van Gijseghem, 2013).

In Flanders, 57% of the agricultural land is currently used for cattle breeding (Platteau et al., 2018). The difference compared to the global figure is mainly because in Flanders production is efficient and part of the feed is imported. For animal production, the land is mainly used for fodder crops (21%) and as grassland[22] (36%). In Flanders, the area of permanent pasture has been declining for several years. The share of grassland in the total utilized agricultural area decreased from 42% to 36% between 1990 and 2018. Especially permanent grassland has been declining over this period (-22%), in favor of temporary grassland, maize, and industrial crops (Department of Environment, 2019).

Animal production also has a negative impact on food security because of three aspects (Mottet et al., 2017). These relate to land use.

- Production of animal feed on land that is also suitable for human food production
- Relatively low feed conversion
- Feed containing products that are also suitable for human consumption

These aspects can be used to estimate the use of space and the associated environmental impact of animal production.

Non-land-based intensive livestock production fosters feed-food competition

Flemish agriculture is characterized by a high concentration of intensive livestock farming (cattle, pigs, and poultry) where the available land is not sufficient for the required feed production. While most cattle farms still largely provide for their own roughage production, this is hardly the case for pig and poultry farming. The feed for these species consists of large quantities of imported raw materials (grains and especially protein-rich raw materials such as soy) in addition to by-products from the Flemish food industry. This loss of local land use puts pressure on the environment because the nutrient cycles are partially broken. There is a surplus of manure that cannot be used judiciously on Flemish soil and has an impact on water quality, among other things.

Cereals and protein-rich raw materials for animal feed are largely produced (locally or elsewhere in the world) on land that can also be used for arable farming or horticulture for direct human consumption. This is the so-called food-feed competition (Van Zanten et al. 2018). Even though this produces high-quality food of animal origin, the use of a large proportion of arable land for the production of animal feed places additional pressure on global land use, the global food supply, and the environment (Meier et al., 2014). After all, the production of 100 grams of animal protein always requires more land than 100 grams of plant protein. This is illustrated by Figure 15[23] below.

[22] Temporary pastures and permanent grasslands.
[23] In Appendix 1, Figure 15 is reproduced with kcal as the functional unit (Figure B2).

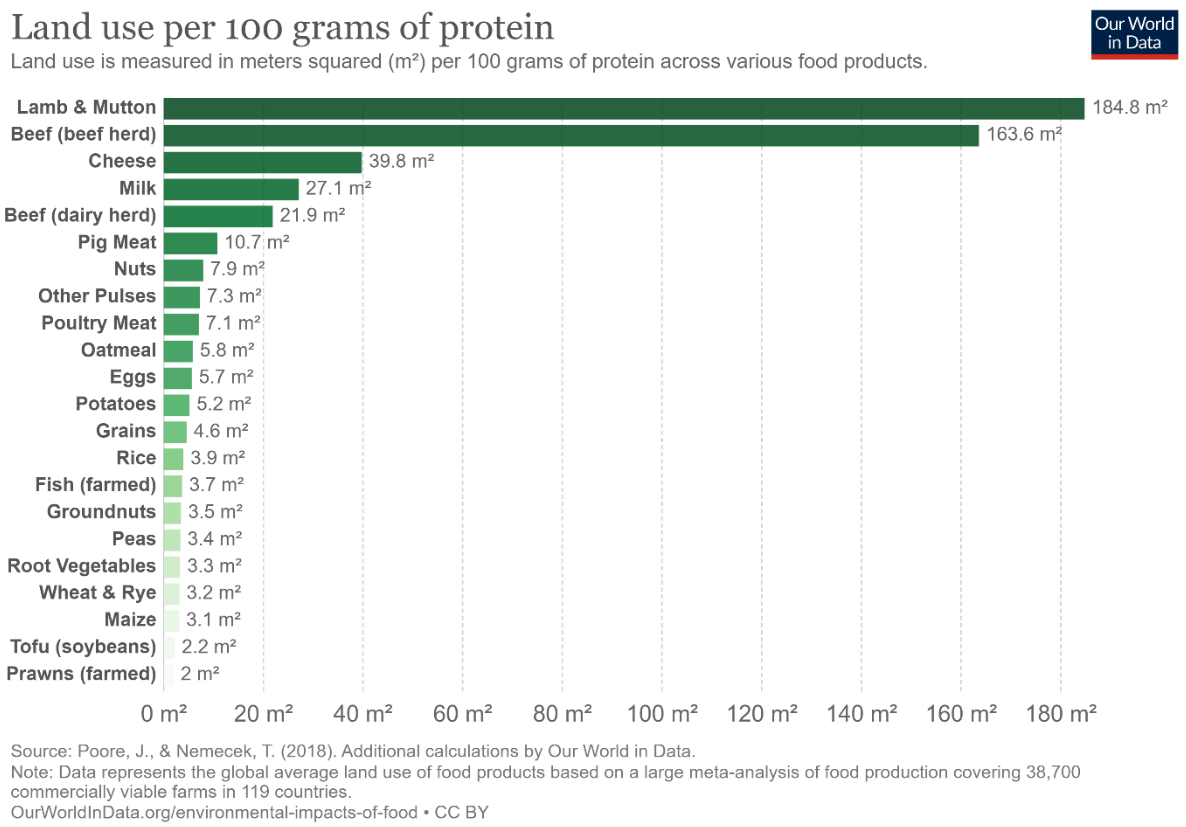


Figure 15: Land use for different food categories per 100 g of protein (Ritchie, 2020 after Poore & Nemecek, 2018)

Historically, animals were only fed with what humans could not digest. Today, however, livestock farming cannot exist on grass and by-products alone (Avermaete & Keulemans, 2017). Additional (concentrated) feed is always necessary. This feed has to be cultivated and this requires space (land). Over 57% of the cereals grown in the EU are intended for cattle feed, while in Belgium it is somewhat higher with 62% (Riera, Antier, & Baret, 2019). At the same time, in some EU Member States, as in Belgium, the proportion of grazing livestock is declining and the feed sector is therefore increasingly dependent on feed imports to meet demand (Buckwell & Nadeu, 2018).

Locally, the use of space for livestock production will vary greatly depending on efficiency and animal species. However, no matter how efficient animal production is, using fertile land for animal production is less efficient than using the land directly for plant-based food for human consumption. However, to better estimate land use and feed competition, we must also take into account feed turnover, species, and type of feed.

The contrast between feed conversion efficiency and the feed food competition

The number of kilograms of feed needed to produce one kilogram of animal product varies considerably between the different categories of animal products and is in line with land use. For example, one kilogram of beef requires significantly more feed than one kilogram of pig or chicken (Figure 16) (European Environment Agency, 2017; Poore & Nemecek, 2018). On average, ruminants require more feed than monogastric species due to their digestive system. However, the intensity of production has a major influence on the feed requirements for all species and is inversely proportional to the food-feed competition. Animals in extensive systems, using lower-value feeds, generally have higher feed requirements. On the other hand, these are often feeds which are not suitable for human consumption or which come from marginal land. Intensive systems, on the other hand, require less feed for the same production, but use raw materials in competition with direct human consumption to a large extent.

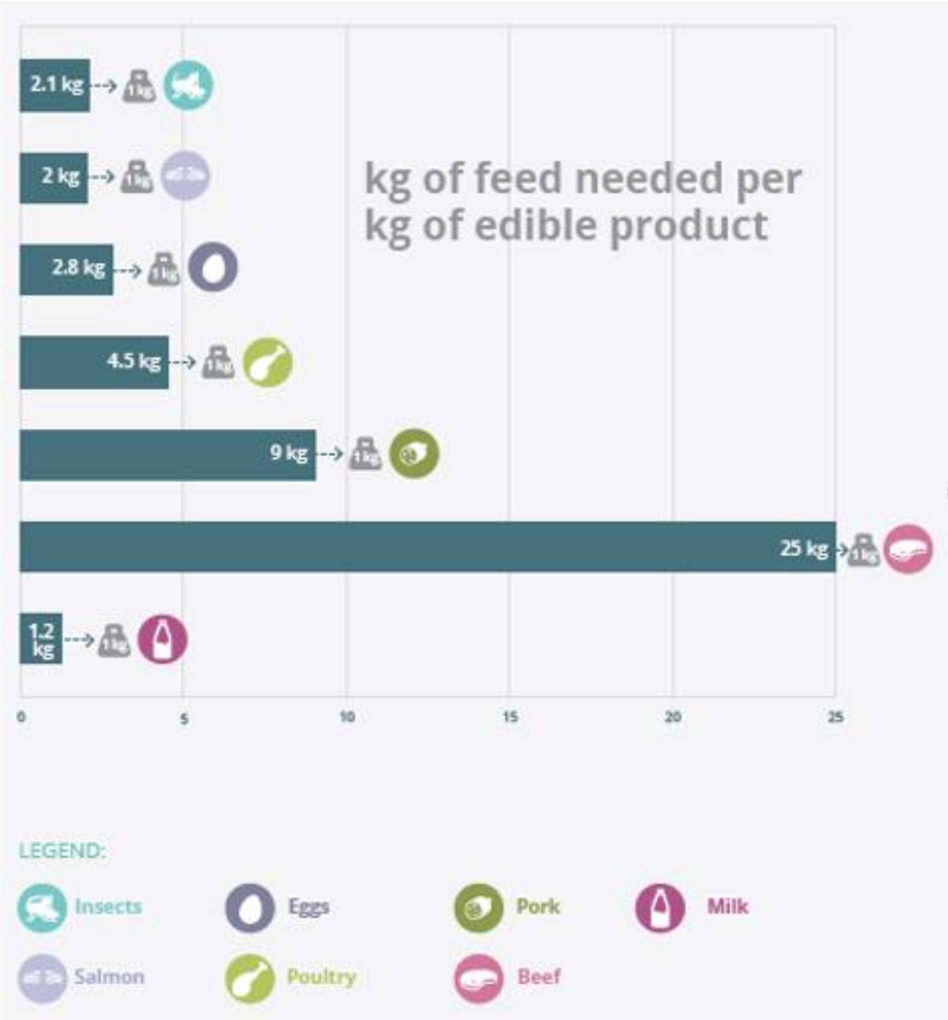


Figure 16: Number of kilograms of feed needed for one kilogram of edible product for animal products (European Environment Agency, 2017)

Compared to beef and pork production, poultry has an efficient feed conversion. Poultry convert on average 12% of the calories and about 40% of the proteins in their feed into meat (Cassidy, West, Gerber, & Foley, 2013). They are raised for consumption in a short time, which leads to a relatively low climate impact (Bergsma et al., 2014). Cattle convert only 3% of the calories and 5% of the proteins in their feed into meat (Cassidy et al., 2013). For milk and egg production the conversion efficiency is higher. However, poultry is fed a high proportion of cereals, which contributes to the feed-food competition. Some production systems allow cattle to graze on marginal land, which in turn reduces feed-food competition (Van Zanten et al., 2018). The type and origin of feed and whether it is suitable for human consumption is an important aspect.

Animals can convert raw materials that are not suitable for human consumption, such as grass and by-products, into edible products. In addition, they produce manure, which can be used to keep the land fertile for arable farming. In a circular food system with a closed 'soil-plant-animal' cycle, animal production is, therefore, indispensable. The proportion of the required feed that is not suitable for humans is therefore a better measure to assess the food-feed competition. This is captured in the human-edible feed conversion efficiency. If we take this aspect into account, there hardly is any difference on average between ruminants (cattle) and non-ruminants (pork and poultry). For one kg of meat, an average of 2.8 kg of feed is used for ruminants that can also be consumed by humans. In the case of non-ruminants, the average is 3.2 kg. Again, this is highly dependent on the production system, e.g. extensively grazed ruminants and poultry fed mainly on by-products can be net producers of protein (Mottet et al., 2017).

The current intensive livestock farming is far removed from such a circular system. There is room for improvement on the production side to reduce environmental impact. However, this must be accompanied by lower production and consumption if we are to meet the climate and environmental challenges.

Drivers of deforestation

Agriculture is one of the major drivers of worldwide deforestation (Searchinger et al., 2013). The cultivation of fodder crops such as maize, soy, and grasslands is believed to be responsible for 67% of deforestation (Poore & Nemecek, 2018; Ranganathan et al., 2016). This entails a loss of biodiversity as well as an increase in greenhouse gas emissions (Van Zanten et al., 2018).

Like other European countries, Flanders imports soy for animal feed, mainly from South America, the US, and Canada (Belgian Feed Association, 2019). The feed sector makes efforts to import soy in a socially responsible way, which is coordinated with the international Round Table of Responsible Soy. Intensive livestock farming, which is characteristic of the Flemish situation, is based on concentrated feed: cereals (including maize), fishmeal, soy meal, and residual products from the food industry such as sugar beet pulp, wheat gluten feed, rapeseed meal, and so on.

Animal production in a circular system

Natural grasslands and biomass residues are used for livestock production to produce food for human consumption (Berners-Lee, Kennelly, Watson, & Hewitt, 2018; Buckwell & Nadeu, 2018; Searchinger et al., 2013). Moreover, these grasslands are often not suitable for growing crops (Buckwell & Nadeu, 2018). Not all land can be used for arable farming. In some regions, livestock farming allows people to obtain food (and thus essential nutrients) from land that cannot be used for arable farming or to use crop residues and food waste. Part of the grassland is thus only suitable for grazing, and residual products from food production can be used as feed for cattle, pork, and poultry. This is also called a 'low-cost livestock' (Van Zanten et al., 2018) or livestock farming with ecological surpluses (Röös, Patel, Spångberg, Carlsson, & Rydhmer, 2016). An eating pattern without animal products leaves this capacity unused (Platteau et al., 2016; Solér, 2018; van Dooren, 2018).

Globally, 19% of meat production and 12% of milk production are produced on (irrigated) grasslands. For Europe, the shares are estimated at 20% and 4% respectively (Boonen, 2015). We have no specific figures for Belgium or Flanders.

Towards a Safe Operating Space (SOS) for livestock production

In a study on livestock farming in the United States, an exercise was carried out to determine how much of today's output could be generated if cattle were raised only on grasslands. Only 27% of the current output would then be achieved (Hayek & Garrett, 2018).

The RISE Foundation, a European think tank that researches a sustainable and internationally competitive agricultural economy, did a similar exercise (Buckwell & Nadeu, 2018). They calculated a safe space for the production and consumption of animal products: a production that stays within the local and global ecological carrying capacity. This is called a Safe Operating Space (SOS).[24] At present, the EU is not in the SOS and about 50% of the current livestock population could remain on the available grasslands. The variation between the different Member States is great. For Belgium, between 13 and 26% of the ruminants could remain.

The researchers emphasize that a commitment to more efficient production (change in feed, better manure management, change in intensity of livestock farming) is necessary but insufficient to meet the various climate and environmental objectives. Changing consumption patterns towards a more varied mix of meat types consumed, replacing meat with alternative (animal and plant) proteins, and reducing meat consumption are essential to bring the food system into SOS.

Several studies have zoomed in on the question of how many animal products we could consume as a global population if we only used feed that is not fit for human consumption. This means feed from grasslands not suitable for arable farming, by-products from the food industry, and food waste. The availability of animal protein ranges from 11 to 32 g per person per day (Garnett et al., 2017). Translated into foodstuffs, this implies 7-135 g pork, 2-55 g beef, 2-14 g chicken, 138-519 g milk, and/or 2-24 g eggs per person per day. These ranges show the possibilities that exist when fully committed to the respective production. Adding up the different figures is therefore not correct. The researchers indicate that the consumption of ruminants (beef and milk) in the high regions of the range gives rise to more greenhouse gas emissions, mainly in the form of methane emissions. There is a trade-off here between different environmental pressure factors: a positive impact from a land-use perspective has a negative impact on climate emissions. In any case, the emissions from production on a low-cost livestock farm are lower than the current situation. This is mainly due to a lower livestock population (Van Zanten et al., 2018).

4.1.2.4 Water use

Agriculture is a major user of water, accounting for approximately 70% of water abstracted globally, of which more than a quarter (29%) can be attributed directly and indirectly to meat production. In a study by the JRC, a reduction in meat consumption

[24] This Safe Operating Space (SOS) inscribes itself within the philosophy of planetary boundaries of Rockström et al. (2009) and in the donut model of Raworth (2017) (see 3.1).

has been shown to significantly reduce the total water footprint (Vanham, Comero, Gawlik, & Bidoglio, 2018).

Water use must always be considered in relation to the level of water scarcity. Flanders is dependent on both surface water and groundwater for its water use. Compared to Europe, Flanders puts a lot of pressure on its water resources (MIRA, 2013). Products with a large water footprint that are grown in places with water scarcity, therefore, put extra pressure on the environment. Dutch figures show that about one-third of the water extracted is in countries where water availability is 30 to 70 times less than the global average. So, water scarcity is relatively high in these countries. The main countries are Spain, the Netherlands itself, South Africa, Chile, India, and the United States (Hollander A. et al., 2021). One way of taking this into account is the AWARE methodology developed by the WULCA research group. This methodology, a contraction of 'Available Water Remaining', calculates the water footprint, taking into account water scarcity (Boulay et al., 2018).

There is not much data available for Flanders or Belgium on water use related to water scarcity. A study with Dutch figures, using the AWARE methodology, shows that plant-based products in most cases have a lower water use compared to products of animal origin. However, there are exceptions such as nuts and certain fruits. Following recommendations have the greatest potential to reduce water use within a healthy diet: (1) reduce intake of animal products (meat and dairy); (2) favor Dutch fruit varieties such as apples and pears and (3) reduce consumption of non-alcoholic beverages such as coffee, sugary soft drinks, and juices in favor of tap water (Hollander A. et al., 2021).

Figure 17[25] below shows blue water consumption (see 'Water footprint as a measure?'), taking into account relative water scarcity, per product group and per 100 g protein. The impact of nuts stands out as the product group with the highest water use, taking water scarcity into account. It is also striking that beef has a low impact in contrast to other environmental pressure factors. Poultry even has a similar footprint to legumes (excluding soy). This is again due to the relatively high feed conversion and the shorter life span from birth to slaughter of poultry. Overall, we see that the products with the highest impact come from the animal category (except nuts and rice).

[25] In Appendix 1, Figure 17 is reproduced with kcal as the functional unit (Figure B3). In Appendix 2 Figure 17 resumed in terms of blue water use, both with kcal and protein content as the functional unit (Figures B4 and B5).

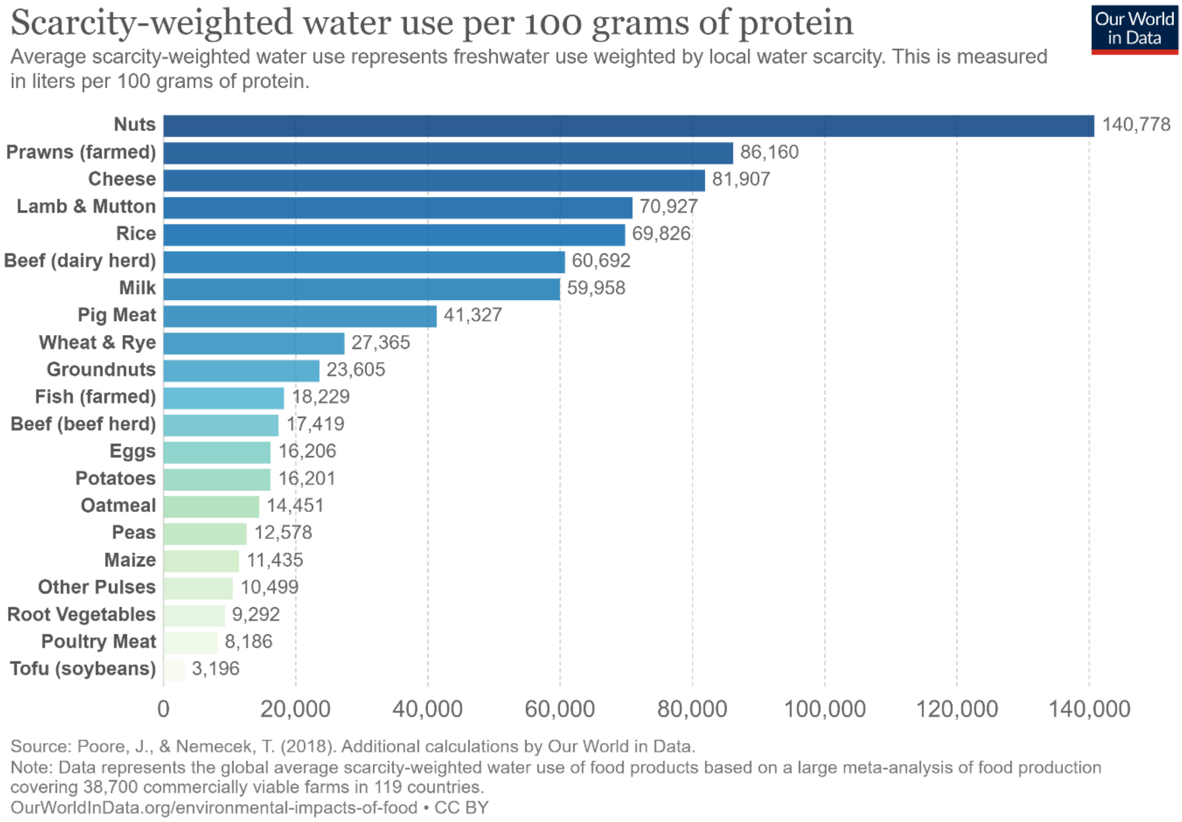


Figure 17: Scarcity-weighted water use for different food categories groups per 100 g protein (Ritchie, 2020 after Poore & Nemecek, 2018)

Emissions to water

The impact of meat production is not limited to water use. Emissions to water affect mainly the local level, in contrast to greenhouse gas emissions which have a global effect. Fertilisation and acidification (in the form of nitrates, ammonia (NH3), nitrogen oxides (NOx) and phosphorus) but also antibiotic residues from animal excreta have an impact on both surface and groundwater (Buckwell & Nadeu, 2018; Godfray et al., 2018). The manure issue has been a problem in Flanders for many years, not least because of the large concentration of livestock farms in our region. Water pollution also occurs in crop production, especially when there is an (excessive) use of plant protection products (pesticides). In terms of eutrophication and acidification, the animal products with the lowest impact invariably score higher than the average impact of plant proteins that can serve as a substitute[26] (Poore & Nemecek, 2018).

Water footprint as a measure?

When discussing water use, this is often done with the term water footprint. The water footprint indicates the total blue, green, and greywater used to produce a unit of food (Mekonnen & Hoekstra, 2012). Bluewater is groundwater, surface water, and tap water that is extracted and used for example in irrigation. Greenwater is rainwater that is effectively used by the plant. Greywater indicates the degree to which the water is polluted after use. It is the amount of water needed afterward to dilute the

[26] See Appendix 3, Figures B6 and B7.

concentration of pollutants in such a way that the pollution can be reduced and so that the water meets the quality or discharge standards.

There is much data on the water footprint, which is why it is often quoted. A major disadvantage of the water footprint is that the methodology does not sufficiently take into account water scarcity. In addition, the three types of water (blue, green, grey) are taken into account, which can distort the picture[27]. For example, cattle has a high water footprint due to the high share of green water. This is largely water that falls on the fields and ends up in the grass. As mentioned earlier, cattle convert this grass into food for humans.

4.1.2.5 Biodiversity

Food production also has an impact on biodiversity, both in Flanders and abroad. Land use causes the greatest pressure on biodiversity loss in the Belgian[28] consumption pattern (70%). In addition, water use (27%) and climate change (7%) determine the biodiversity footprint (Alaerts, 2020). When we look at the consumption sectors that contribute most to this footprint, food takes the largest share (Figure 18).

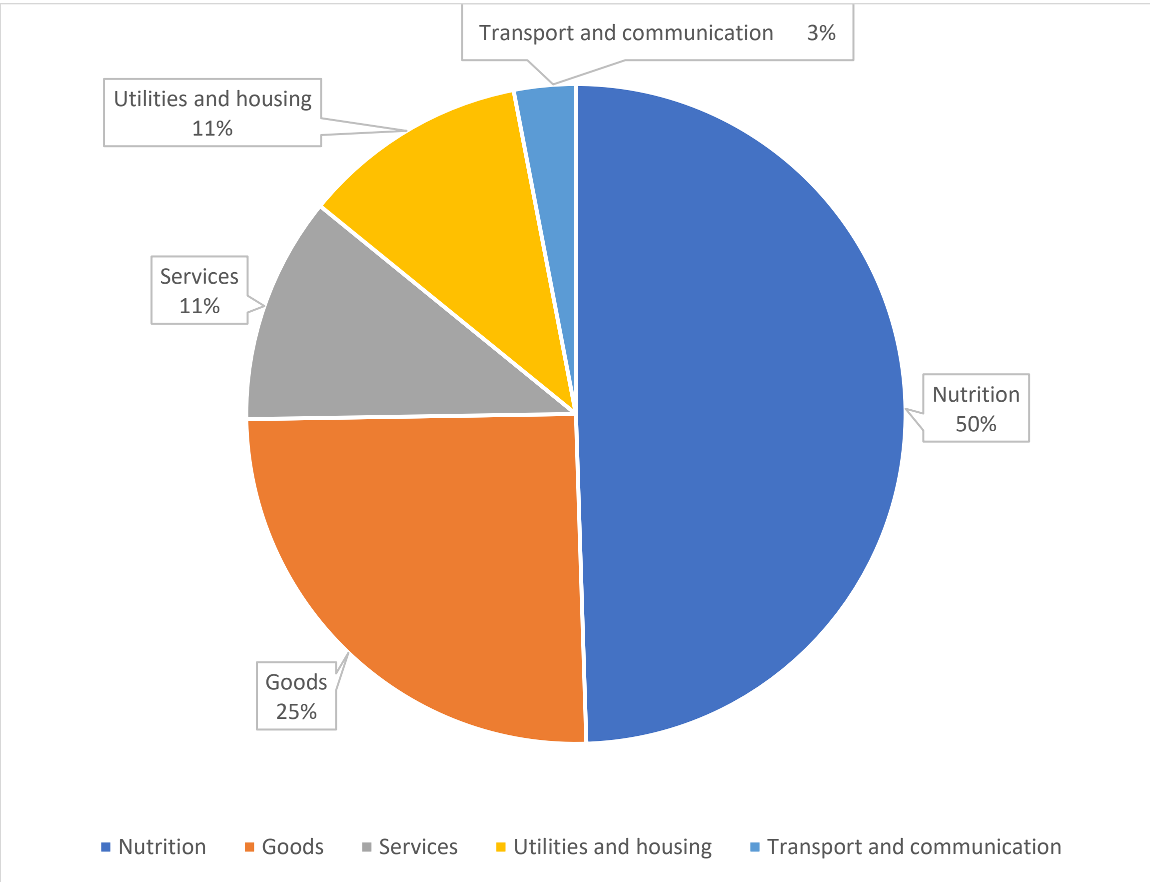


Figure 18: Impact of Belgian consumption on biodiversity by consumption sector (translated from Alaerts, 2020)

[27] See Appendix 4 for an overview of green, blue and, greywater use for various product groups.
[28] We currently do not have a biodiversity footprint for Flanders (Alaerts, 2020).

When looking at European food consumption, beef and pork are the primary drivers of a high footprint. They contribute respectively 27% and 20% to the biodiversity footprint (Crenna, Sinkko, & Sala, 2019).

4.1.3 Current consumption

4.1.3.1 Consumption data

Protein intake

The Hoge Gezondheidsraad states that the recommended daily allowance (RDA) for protein is 15% of the energy intake (see 4.1.1.1). For the whole population (3-64 years), the average protein intake is around this recommended 15 En%/day[29] (De Ridder, 2016). Just over half of the population (52.1%) exceeds the recommended 15 En%/day. The percentage of adults exceeding the recommended daily intake (range 50.3-60.4%) is significantly higher than the percentage in children and adolescents (range 36.7-44.2%). The percentage of men and women exceeding the RDA is similar, at 50.7 and 52.9% respectively.

The recommended daily allowance can also be expressed in grams of protein per day. This requirement varies according to body weight. In comparison with the recommendation in En%, this recommendation (in grams) for proteins is slightly lower. On average, Belgians consume 79 g of protein per day. Based on the reference values for body weight (52 g protein per day for women and 62 g protein per day for men (Hoge Gezondheidsraad, 2016)), 95.6% of women and 98.6% of men appear to exceed this guideline.[30]

According to the Hoge Gezondheidsraad and EFSA, a protein intake that provides a maximum of 25% of the total energy supply (25 En%/day) is a safe upper limit. Almost everyone meets this recommendation.

Main sources of protein

Based on the food consumption survey of 2014-2015 (De Ridder et al., 2016a), Belgian consumers obtain 61.4% of their protein from animal products (including meat substitutes, but that share is very small) (Figure 19 and Table 5).

Meat, meat products and, meat substitutes contribute about 34.6% to the total protein intake. An average of 4 g per day is consumed of 'meat substitutes' (vegetarian products with a protein content of more than 5 g per 100 g, such as tofu, Quorn, tempeh, seitan, etc.). The contribution to the total protein intake is therefore negligible, compared with the average consumption of 114 g/day for meat and meat preparations.

In addition, milk and substitute products make a significant contribution to total protein intake with 19%. Soy-based substitutes (drinks and desserts) are consumed at an average rate of 10 g/day. This is only a small amount compared to the 165 g of milk, milk products, and cheese consumed on average per day, making their

[29] Energy percentages (En%) are calculated by dividing the input of energy by a given macronutrient by dividing by the total energy intake and multiplying by 100.
[30] Calculated for a reference weight of 62.1 kg for women and 74.6 kg for men (Hoge Gezondheidsraad, 2016).

contribution to the 19% figure negligible. Fish, shellfish and eggs, and derived products contribute 6.3% and 1.5% respectively to the total protein intake.

Plant products such as potatoes, cereals, vegetables, legumes, fruits, and, nuts contribute 28.9% of the protein intake. Cereals and cereal products are the main sources of protein of plant origin, contributing on average 21.4%. This is followed by vegetables (3%) and potatoes and other tubers (2.3%). Legumes contribute only 0.3% (Willett et al., 2019). This small share, despite their high protein content, can be attributed to very limited consumption. The remaining 9.7% is mainly in processed products (such as biscuits, cakes, and snacks) whose origin is usually a mix of animal and vegetable protein.[31] In the current diet, therefore, 61.4% of the total protein consumed is of animal origin, 28.9% comes from plant sources and 9.7% is of mixed origin.

[31] Own calculations based on De Ridder et al., 2016a.

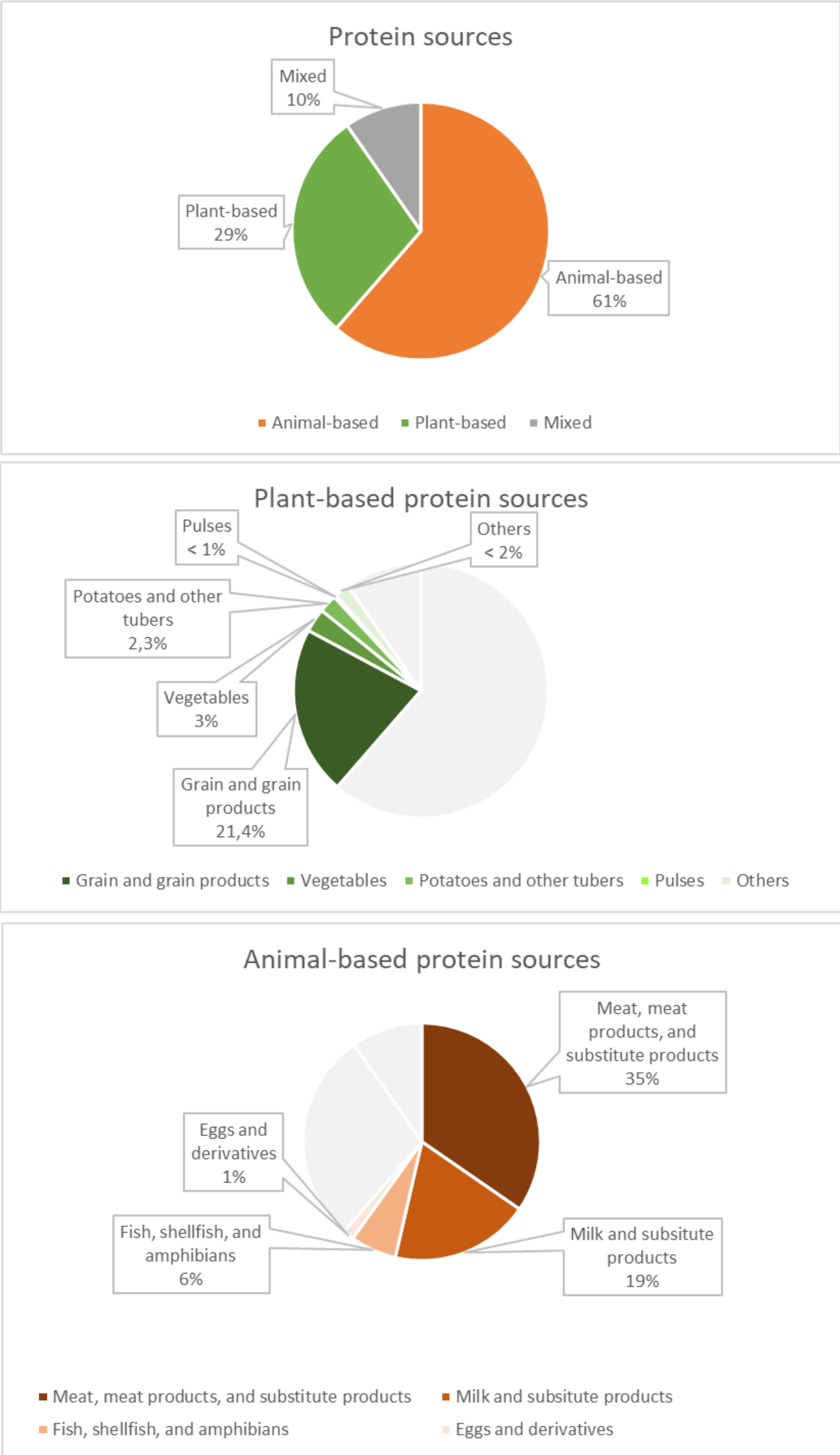


Figure 19: Share of protein intake from animals, plants and mixed sources for the Belgian population. Own figure with data based on the 2014-2015 food consumption survey (De Ridder et al., 2016a)

Table 5: Average daily and weekly consumption of major protein sources (for age groups 18-39 and 40-64). Own calculations based on De Ridder et al. (2016a)

Food group	**Age**	**g per day**	**g per week**	**Recommendations for adults (HGR 2019)**
dairy (excluding cheese)	18-39	130	910	250 – 500 ml milk per day
	40-64	127	889	
cheese	18-39	32	224	
	40-64	33	231	
soy (drinks and desserts)	18-39	10	70	
	40-64	9	63	
meat, fish, vegetarian, egg in total	18-39	146	1022	max 300 g red meat per week; max 30 g processed meat per week
	40-64	159	1113	
meat and meat preparations	18-39	116	812	
	40-64	115	805	
meat preparations	18-39	67	469	
	40-64	63	441	
fish, seafood	18-39	21	147	one to two times a week
	40-64	29	203	
eggs	18-39	10	70	no recommendation
	40-64	11	77	
plant-based substitutes	18-39	4	28	legumes at least once a week
	40-64	5	35	
nuts and seeds	18-39	3	21	15 - 25 g of nuts and seeds per day
	40-64	5	35	

Changes in meat consumption at home

Meat is very much part of Belgian food culture: we are brought up with a piece of meat and carry this through into our later eating habits. The Belgian food consumption survey of 2014-2015 shows that meat consumption remains relatively stable compared to 2004 (Lebacq, 2016). These eating habits do seem to be evolving according to a report by VLAM that focuses solely on home consumption. The consumption of red meat at home has been in decline for several years. In 2019, Belgians bought 16.4 kg of fresh red meat (pork, beef, veal, lamb, mutton, and horse meat) per capita while in 2014 this was still 19.6 kg. In addition, Belgians bought on average 8.4 kg of poultry and game per capita (a decrease compared to 2018), 4.6 kg of fish and seafood per capita, and 0.35 kg of vegetarian meat substitutes. In the long term, the share of poultry, especially chicken, within this product basket will grow, as will the share of meat substitutes. The share of the latter remains limited to 1.1% (VLAM, 2020).

Home consumption of processed meat products is also declining: from 11.6 kg per capita in 2008 to 10.6 kg per capita in 2018. Almost all households occasionally buy meat (97%) or processed meat products (99%) for consumption at home. This percentage appears to have been stable in recent years (VLAM, 2019).

The decreasing consumption at home can be explained by the fact that Belgians eat more out of home because meat is more often alternated with fish, poultry, or vegetarian products. The frequency of meat consumption in 2018 was as follows: 72% stated that they eat meat one to five times a week, 21% eat meat more often and 7% less or never. For 18% of Belgians, a vegetarian dish is on the table at least once a week (VLAM, 2019).

Belgians get more than enough protein, and mainly from animal sources. There is, therefore, room for a reduction in total protein consumption and a shift towards less environmentally damaging protein sources, to reduce the environmental impact of the diet. A reduction in animal protein sources (in particular red and processed meat) through substitution by vegetable protein sources such as legumes (in a low or unprocessed form) and whole grains may also yield health benefits. With a strong reduction of animal products (e.g. in vegetarian or vegan diets), extra attention should be paid to the intake of certain micronutrients (such as vitamin B12 and iron).

4.1.3.2 Attitudes

More than half of the Flemish people think that consuming meat daily entails a major environmental impact. When asked, however, to what extent 'eating less meat or no meat at all' contributes to making the food system more sustainable, 34% of the respondents answer 'To a large extent', 48% 'To a limited extent', 12% 'Not', while 7% have no idea. It is striking that 18-29-year-olds have a higher conviction that this contributes to a large extent (44%). This action scores ninth after actions such as not wasting food, eating seasonally, using less packaging, consuming locally, and avoiding chemical pesticides (GfK, 2018a).

Over 61% of those surveyed agree with the statement that the government should promote an eating pattern with less meat and more fruit and vegetables, 21% disagree and 18% have no opinion. Asked what action they would take now or in the future, 57% said they would consume less meat or no meat at all. When asked about the future, 39% are convinced that we will consume less meat in 30 years. In contrast, 10% of those surveyed believe that we will eat the same amount of meat or more in the future (GfK, 2018a).

4.1.4 Conclusion on protein consumption

In view of the above, we have arrived at the following findings:

- Pursue a diet in which proteins predominantly come from plant-based protein sources for a lower environmental impact.
- There is still room for animal protein sources in the dietary pattern. Smart choices can be made between the various animal product categories with a different environmental impact (see also 5.6).
- Moderate the consumption of red meat and certain processed meat products, for both health and environmental reasons.
- Over the entire population, more than enough proteins are consumed. A (slight) drop in the average protein intake also offers an opportunity to reduce

the environmental impact of the diet and does not immediately pose a health risk.
- In certain situations, however, sufficient attention must be paid to the intake of protein (pregnancy, growing children, the elderly, etc.).

Animal products generally have a higher impact compared to plant-based protein sources in terms of climate, land use, water use and raw materials. In addition, they contribute more to biodiversity loss. This does not mean that food products from animal origin does not play a role in an environmentally responsible and healthy diet. After all, animal products are an essential link in a circular food system and contribute to the supply of several essential nutrients. However, the share that these products represent in our diet needs to be adjusted. To reduce the environmental impact of our diet, we must obtain proportionally more proteins from plant sources.

The above findings support the transition to a more balanced protein consumption. This entails a dietary pattern with an intake of proteins from plant and animal foods in a ratio that is both environmentally responsible and healthy. The consumption ratio of animal to plant proteins is currently roughly 60/40. Improving this ratio is called a protein transition, protein shift, or protein recovery. The word 'recovery' refers to a period in the past when our diet had a better ratio.

What ratio should we aim for? In its recommendations on protein intake, the High Health Council of the Netherlands does not state a target for the ratio of animal to plant protein. The RLI (2018) from the Netherlands suggests a target of 40/60 by 2030. They consider this target possible and desirable because of the climate objective. Within this target, there remains room for eating sustainably produced meat, dairy, eggs, and fish. After 2030, the ratio may shift further.

The Dutch Nutrition Centre (Voedingscentrum, publisher of the 'Schijf van Vijf'[32]) puts forward a 50/50 objective for the short term. When pursuing a vegetarian diet a 40/60 ratio is the result. This objective, which is contained in the 'Schijf van Vijf', already requires a major behavioral change from many people. However, the Voedingscentrum considers this first step advisable to further evolve towards a 40/60 ratio (van Dooren & Seves, 2019).

Taking into account these findings, we propose a protein transition target for Flanders in which 60% of our protein needs are met by plant-based protein sources and 40% by animal products.

4.2 Avoiding food loss

Food loss is defined by the Flemish government as "any reduction in the food available for human consumption that takes place in the food chain, from harvest to consumption". This concerns food loss throughout the chain, from agriculture to the

[32] The 'Schijf van Vijf' ('Wheel of Five') is the visual representation of the Dutch guidelines for healthy and sustainable food. Products in the Wheel are part of a healthy and sustainable diet. Products outside the disk may be consumed occasionally, but not too often. These are similar to the red sphere of the food triangle.

consumer. In the total Flemish agri-food chain, i.e. during this entire pathway from harvest to household consumption, an estimated 907,000 tonnes of food were lost in 2015. The consumption phase was responsible for 23% of all food loss (Vlaams Ketenplatform Voedselverlies, 2019). Consumers can, therefore, play a role in avoiding food losses earlier in the chain by, for example, buying fruit and vegetables that have a strange shape (e.g. actions by Kromkommer (Figure 20).

Figure 20: Campaign image of 'Kromkommer' (Text reads: 'Equal rights for all vegetables and fruits' and 'Bent is the new straight') (Kromkommer, 2019)

4.2.1 Health

Food loss has no direct effect on human health. This is not to say that the two are not related. Reducing food loss poses a risk to our health on three levels (Neff, Kanter, & Vandevijvere, 2015):

- To avoid throwing away leftovers, we may be tempted to eat more than necessary.
- Food loss occurs (among other things) when we are no longer sure of the shelf life of food. When we still eat products that are no longer edible, we may run a risk with regard to food safety in certain product groups (e.g. with an expiry date).
- (Highly) processed foods have a longer shelf life and could therefore contribute to reducing food losses. At the same time, these products often contain a lot of added salt, saturated fat, and sugar (see 4.3.1). The promotion of frozen and canned products does offer possibilities, provided that a minimum of salt and sugar is added for food safety and preservation.

So there is an area of tension between health and the environment when we want to reduce food loss. At the same time, strategies such as planning purchases and drawing up a weekly menu also offer opportunities to improve our food habits (more regularity, less impulse buying, etc.) and to avoid food loss. In the fight against food loss, integration between health and environmental objectives is essential (Neff et al., 2015).

4.2.2 Environment

The environmental impact of food waste consists of the impact of the use of natural resources, and emissions during production and processing. This environmental impact for households is greater than that for the rest of the agri-food chain because the food that is thrown away in the last step of the chain also carries all the environmental costs of all the previous steps (production, harvest, transport, processing, packaging, etc.) (Criel & Fleurbaey, 2019; Goossens et al., 2019a, 2019b).

4.2.2.1 Differences between foodstuffs

Not every discarded food product has the same environmental impact (Vázquez-Rowe et al., 2019). Although products of animal origin are wasted less than, for example, fruit and vegetables, they still have a significant share in CO_2 emissions from food loss due to their higher environmental impact per kilogram. An average Flemish household has a carbon footprint of 5.2 tonnes CO_2 equivalents for its annual food and beverage consumption and a carbon footprint of 140 kg CO_2 equivalents for its annual food loss (Criel & Fleurbaey, 2019).

4.2.2.2 Packaging

Packaging has a bad reputation because of its negative environmental impact, but the use of packaging material is not necessarily 'bad' or obsolete in every case. Among other things, they contribute to better food preservation, which leads to less food loss. This 'avoided' environmental impact (less food loss) sometimes outweighs the additional environmental impact of packaging. The avoided environmental impact depends on the type of product, the type of packaging, and its recyclability.

To understand the relative contribution of packaging to the overall environmental impact, Licciardello (2017) developed a packaging relative environmental impact (PREI) score. Generally speaking, drinks such as wine, beer, and sugared soft drinks have a relatively high PREI. Canned products have a higher impact compared to glass and cardboard packaging, according to the researcher.

Well-designed packaging that extends the shelf life of food - such as smaller pre-packaged portions or resealable packaging - can help consumers to buy the amount of food that is more in line with their needs and thus waste less (OVAM, 2015). In addition, packaging has an important function in providing information such as shelf life, storage advice, sustainability labels, and so on. By optimizing their packaging, food companies ensure that their products are stored in the best possible conditions, thus having a longer shelf life and reaching their final destination safely. Packaging can, therefore, help to reduce food loss at the consumer's end (Vanhee & Roels, 2018).

4.2.2.3 Environmental impact of preservation

To preserve products for a longer time or to be able to eat non-seasonal food products from home, they can be preserved using preservation techniques or processing. Increased ease of use is an additional benefit of food preservation.

In a case study (Broekema & Blonk, 2010) of spinach and French beans, the environmental impact (greenhouse gas emissions, fossil energy consumption, and land use) was compared between (fresh) production from open fields, canned in glass, canned in cans, and frozen. For comparison purposes, the impact of greenhouse produce and foodstuffs imported from abroad by air were included in the analysis.

Both cases show that products from open fields score best in terms of environmental impact. This is followed by preserved products from glass, cans, or deep freeze. The difference between them was minimal. The products from greenhouse cultivation have the highest environmental impact (see also 5.2.2) (Broekema & Blonk, 2010).

4.2.3 Current consumption

4.2.3.1 Consumption data

A Flemish household wastes on average 1.7 kg of solid food and drinks per week or 88 kg per year. Per person, this amounts to an average of 37 kg per year. In total, Flemish people throw away 240,925 tons of food and drinks at home (GfK, 2018b).

Of the food that Flemish households throw away, 66% is solid food: mainly bread and pastries, fruit, vegetables, and potato products. Among the 34% more or less liquid products (soup, liquid dairy products such as milk and yogurt, alcoholic and non-alcoholic beverages) (GfK, 2018b), the large amounts of coffee and tea are particularly striking (Figure 21).

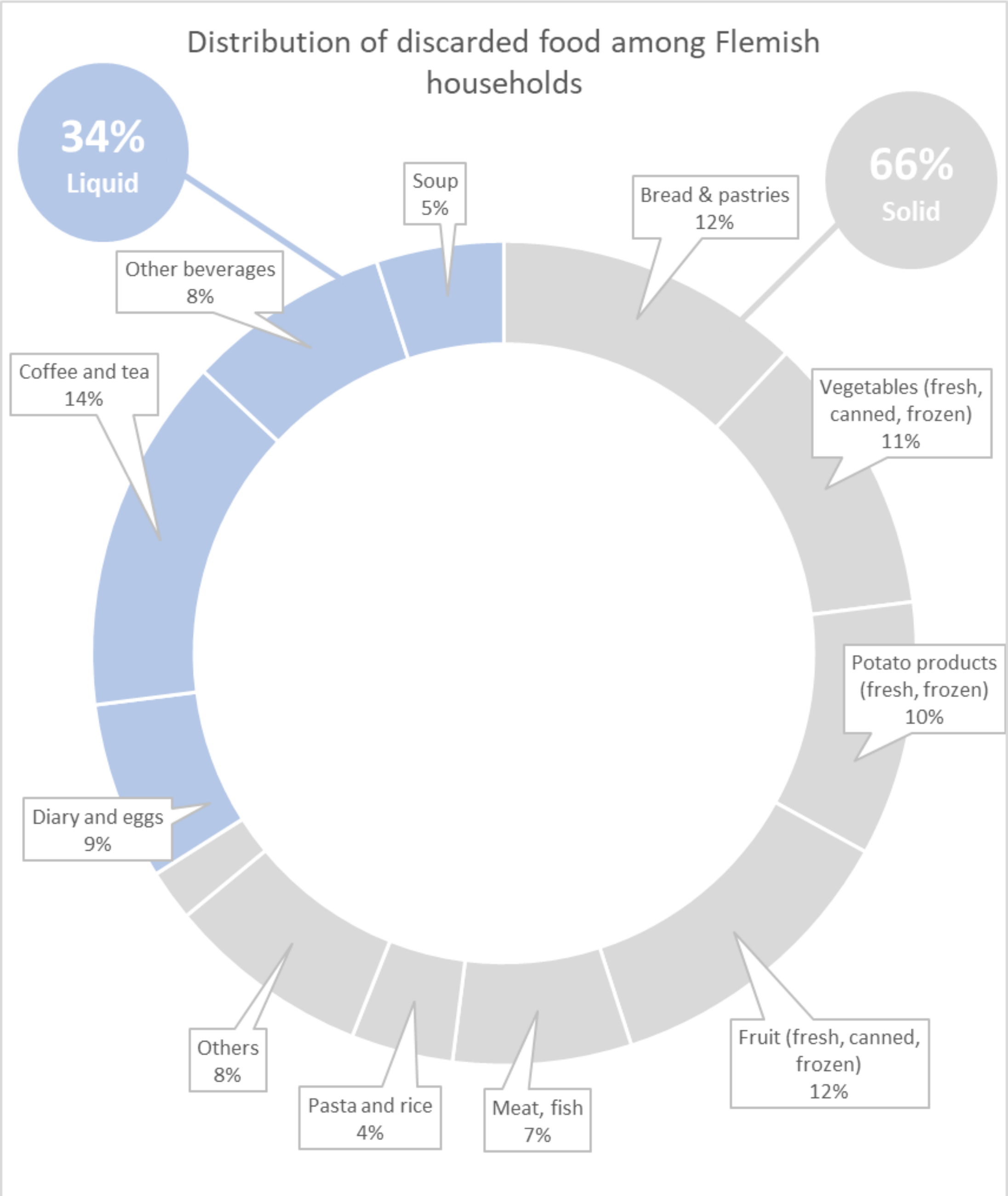


Figure 21: Distribution of discarded food among Flemish households (translated from Criel & Fleurbaey, 2019)

A comprehensive study in which Flemish households kept a diary for a week (GfK, 2018b) shows that the majority of food and beverages are thrown away because they were not used on time (57% of total food loss) or because too much was prepared, put on the plate or poured (30% of total food loss).

Products such as coffee and tea, rice, pasta, and potato products are mainly thrown away because they were over-prepared, over-cooked, or over-poured. Bread and pastries, dairy products, vegetables, and fruit, on the other hand, are mainly thrown out because they were not used in time. There are various reasons for this: buying too much, too much in the packet, forgetting it was in the house, changing the schedule, storing it incorrectly, etc.

Household practices often play a decisive role in the rate of food loss: planning purchases and meals; making impulse buys; keeping an overview of the food stock; preparing the right portions, and using leftovers. Not storing food optimally and not preparing the right portions are other common causes. In addition, consumers have become accustomed to everything looking good and fresh, which means that many edible but damaged or 'not nicely shaped' products are thrown away or not purchased (Criel & Fleurbaey, 2019).

An important element in household practices is the factor 'time'. Time has become a scarce resource in today's society and is in direct competition with food waste avoidance. Spending less time preparing a shopping list and shopping in a hurry results in buying too large quantities or products - some with too short a shelf life - that we may not be able to consume completely (Wilson, 2019).

4.2.3.2 Attitudes

The vast majority of the Flemish population is convinced that throwing away food is irresponsible and brings about a feeling of guilt (Figure 22). Despite of this conviction, the prevention of food loss is a very complex challenge. The amount of food loss that occurs in households is determined by a combination of interacting elements. For a more in-depth description, we refer to Criel and Fleurbaey (2019)[33].

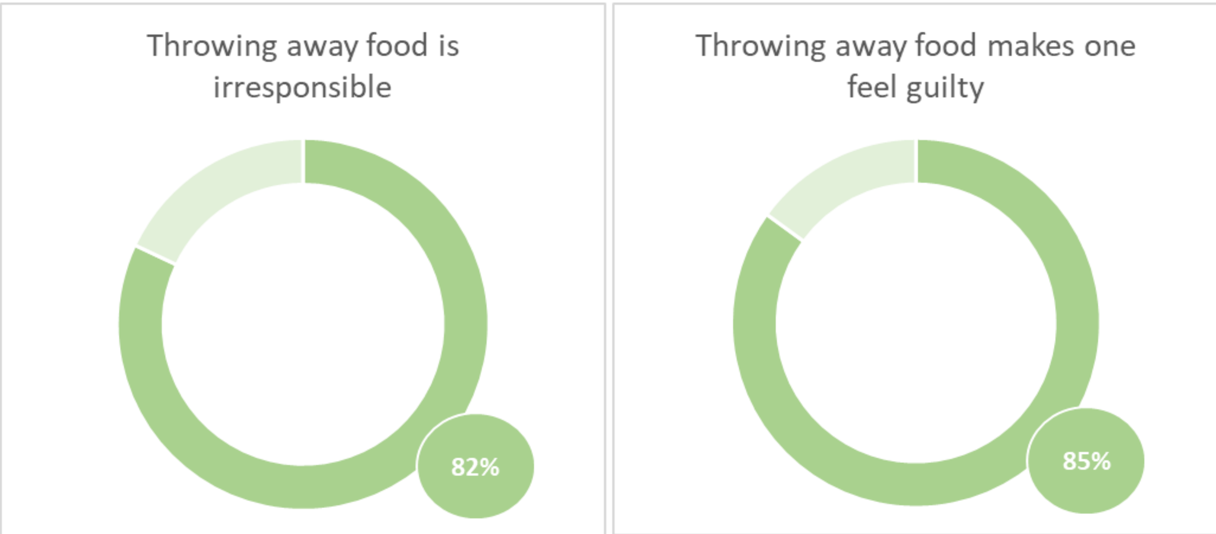


Figure 22: Results of a survey of Flemish households regarding attitude towards food loss (translated from Criel & Fleurbaey, 2019)

4.2.4 Conclusion on food loss

The fight against food loss can put health and environmental impact against each other. Misjudging a portion and therefore eating too much has a detrimental effect on health (overconsumption). Consuming surpluses or leftovers that may not be entirely safe to eat anymore can also have a negative impact on health. In contrast, solutions such as meal planning not only offer benefits in terms of food loss but can also lead to a healthier diet.

[33] Dutch only.

Any form of food loss harms the environment. Raw materials and products suitable for consumption are lost. The draft 'Action Plan Food Loss and Biomass (Residual) Streams Circular 2021-2025' (Actieplan Voedselverlies en Biomassa(rest)stromen circulair 2021-2025') puts forward the objective to prevent 30% of food loss by 2025, to recycle the losses as food, or to valorize them in a higher value compared to 2015. This objective applies to the entire chain, whereby a proportionate effort is expected from each link, including the consumer. Packaging can help reduce food losses (e.g. by extending shelf life) and optimize portion sizes. In addition, they can also contain information with tips on storage, preparation, and so on. Although packaging contributes to the environmental impact, in net terms it does not necessarily contribute to a higher environmental impact.

4.3 Limiting empty calories (foods with high energy density and low nutritional value)

4.3.1 Health

The red sphere of the food triangle (Figure 10) includes, on the one hand, foods for which research has sufficiently demonstrated an unfavorable health effect at a certain level of consumption: alcoholic drinks, sugary drinks (e.g. soft drinks), and processed meat products. On the other hand, this zone includes foods for which there is no such scientific evidence, but which are characterized by high energy density and low nutritional value (also known as "empty calories"). These are often products with high levels of added (saturated) fat, sugar, and/or salt, but with little or no nutritional content such as protein, fiber, vitamins, and minerals. A common feature of these foods is their high level of processing (Vlaams Instituut Gezond Leven, 2017b).

The processing of food generally brings many benefits. For example, processing such as cutting, freezing, cooking, pasteurizing, and fermenting ensure better storage conditions (and therefore safer food and less food loss), better digestion, higher availability of nutrients, and increased convenience. Functional and balanced use of additives, sugar, and salt also contributes to a better shelf life and food safety of processed products.

The scientific literature often speaks of 'ultra-processed' foods. This concept was launched by the NOVA classification, which classifies foods according to their degree of processing. The term "ultra-processed foods" refers to all foods that have undergone complex industrial processes: fractionation, chemical modification, extrusion, etc. This also includes the addition of sugar, fat, and/or salt as well as additives. Ultra-processed foods can be recognized by their long list of known and lesser-known (by the public) ingredients and additives. Frequently used ingredients include sugar, refined flour, palm oil (and other fats rich in saturated fatty acids), and salt. Examples include frozen pizza, sweets, soft drinks, processed meats, and 'fantasy breakfast cereals' (breakfast cereals containing less than 50% whole grains and with added sugar, chocolate, and/or additives) (C. A. Monteiro, Cannon, Lawrence, da Costa Louzada, & Pereira Machado, 2019; C. A. Monteiro, Levy, Claro, de Castro, & Cannon, 2010).

These products generally have an unfavorable nutritional value[34], but high consumption also entails other health risks. For example, there appears to be an increased risk of numerous disorders, such as metabolic syndrome, type 2 diabetes, cardiovascular and cerebrovascular disorders, cancer, and even depression. They can also lead to risk factors such as increased abdominal girth and disturbed blood lipids. Moreover, these products easily give rise to overconsumption and indirectly constitute a major contribution to the development of obesity (Gupta, Hawk, Aggarwal, & Drewnowski, 2019; Hall et al., 2019; C.A. Monteiro et al., 2019; Pagliai et al., 2020; Vlaams Instituut Gezond Leven, 2020b). Therefore, it is recommended to limit the consumption of such products as much as possible. In a background paper on ultra-processed food, the link with health is elaborated in more detail (Vlaams Instituut Gezond Leven, 2020b).

4.3.2 Environment

4.3.2.1 Empty calories, ultra-processed foods

Products with high energy density and low nutritional value have, when consumed in high quantities, negative effects on health. They also often, but not always, have a high environmental impact. Sugared soft drinks, for example, have a very low environmental impact, but are detrimental to our health (A. Drewnowski et al., 2015; Payne, Scarborough, & Cobiac, 2016; van Dooren et al., 2017).

Individual studies from different countries show, on average, a significant impact of this food group on several environmental indicators, which is probably also applicable to other Western countries. In the Netherlands, the contribution of products outside the 'Schijf van Vijf'[35] to the total environmental impact of the diet was calculated. On average, this product group had a 12% share (Voedingscentrum, 2016). Given the health disadvantages of these products, the environmental impact can be regarded as avoidable excess.

Research in Australia (Hadjikakou, 2017) estimates that the consumption of 'discretionary foods' (similar to the definition of 'empty calories' and ultra-processed foods, but not identical) is responsible for one-third of the total food consumption-related environmental impact: 35% of water use, 39% of energy use, 33% of greenhouse gas emissions in CO_2 equivalents, and 35% of land use. Processed meat is included, and makes a significant contribution.

Empty calories have a high energy density but hardly any nutritional value. Ultra-processed foods are classified according to the degree of processing and are the result of complex industrial processes that add sugar, fat, and/or salt as well as additives. In general, these foods have an unfavorable nutritional value and can be considered empty calories. There are also exceptions, such as high-tech meat substitutes that may have a favorable nutritional value, but are also ultra-processed.

[34] There are exceptions. For example, high-tech meat substitutes can have a favorable nutritional value but can still be considered ultra-processed.
[35] The Disk of Five is the visual representation of the Dutch guidelines for healthy and sustainable food. Products in the disc are part of a healthy and sustainable diet. Products outside the disc may be consumed occasionally, but not too often. These are similar to the red sphere of the food triangle.

Discretionary foods are foods that are superfluous to a diet because they do not contain the necessary nutrients. There is a strong overlap with the previous concepts, but here butter and cream are also considered superfluous.

There is little data available on the environmental impact of processed foods that takes into account the effect of the entire production chain (LCAs), including the packaging phase, consumer behavior (preparation, storage, etc.), and waste processing. Specifically for ultra-processed food, more research is needed to estimate the environmental impact, as this often involves complex processes using multiple ingredients (such as sugar, salt, and fat) that would not occur in unprocessed form (Gonzalez Fisher & Garnett, 2016).

A recent review addresses this issue by calculating the environmental impact of ultra-processed foods based on individual environmental indicators. The researchers concluded that a reduction in the consumption of these products could contribute to the transition towards a more sustainable diet and food system, without compromising the nutritional quality of the whole diet. They included the following indicators in their study: greenhouse gas emissions, energy and water use, loss of biodiversity, land and water degradation, and the use of plastic packaging. We discuss some of these indicators in more detail (Fardet & Rock, 2020).

4.3.2.2 Greenhouse gas emissions

A French study from 2014 made a ranking of food groups according to associated greenhouse gas emissions, calculated by means of an LCA (Table 6). In this ranking, unlike many other tables and figures, composite dishes and products high in fat, sugar, and salt were also included. These foods have lower greenhouse gas emissions than animal products (meat, fish, eggs), but higher emissions compared to fats, spices, starchy foods (cereals, potatoes, and legumes), fruits, and vegetables. Soft drinks, which also have an unfavorable nutritional value and are considered ultra-processed, have the lowest emissions in this comparison (Masset, Soler, Vieux, & Darmon, 2014).

Table 6: Ranking of food products by greenhouse gas emissions without considering low-energy food products (such as water and diet drinks) (GHGE= greenhouse gas emissions) (Masset et al., 2014)

Meat, fish, and eggs	High GHGE ↑
Mixed dishes and sandwiches (animal based > plant based) Products with high levels of fat, sugar, and salt = *UPF-like foods*	
Fats (butter > oils, margarine) and condiments Starchy foods (grains, potatoes and legumes) Fruits and vegetables	
Soft drinks	Low GHGE

The SNRF score (3.5.1) demonstrates that foods with lower energy density, less saturated fatty acids, salt, and added sugars, but more vegetable protein, essential fatty acids, and dietary fiber, have lower greenhouse gas emissions. Not only reducing the proportion of animal foods but also reducing the consumption of foods of unfavorable nutritional value (such as empty calories, ultra-processed foods) can contribute to the pursuit of a diet with lower environmental impact (van Dooren et al., 2017).

In a large-scale study with nearly 500 products, GHGE was calculated based on weight and energy input (kcal). In general, most products with a high energy density can be associated with a higher environmental impact when the product weight (100 g) is taken as a criterion. When the energy input is taken as a parameter, the picture is different. Ultra-processed products such as sweets, crisps, biscuits, and chocolate in that case have a low greenhouse gas intensity, whereas processed, and frozen fruit and vegetables have a high greenhouse gas intensity (Figure 23) (A. Drewnowski et al., 2015). This is mainly due to the carbohydrate content. Carbohydrates generally have the lowest environmental impact per kilocalorie.

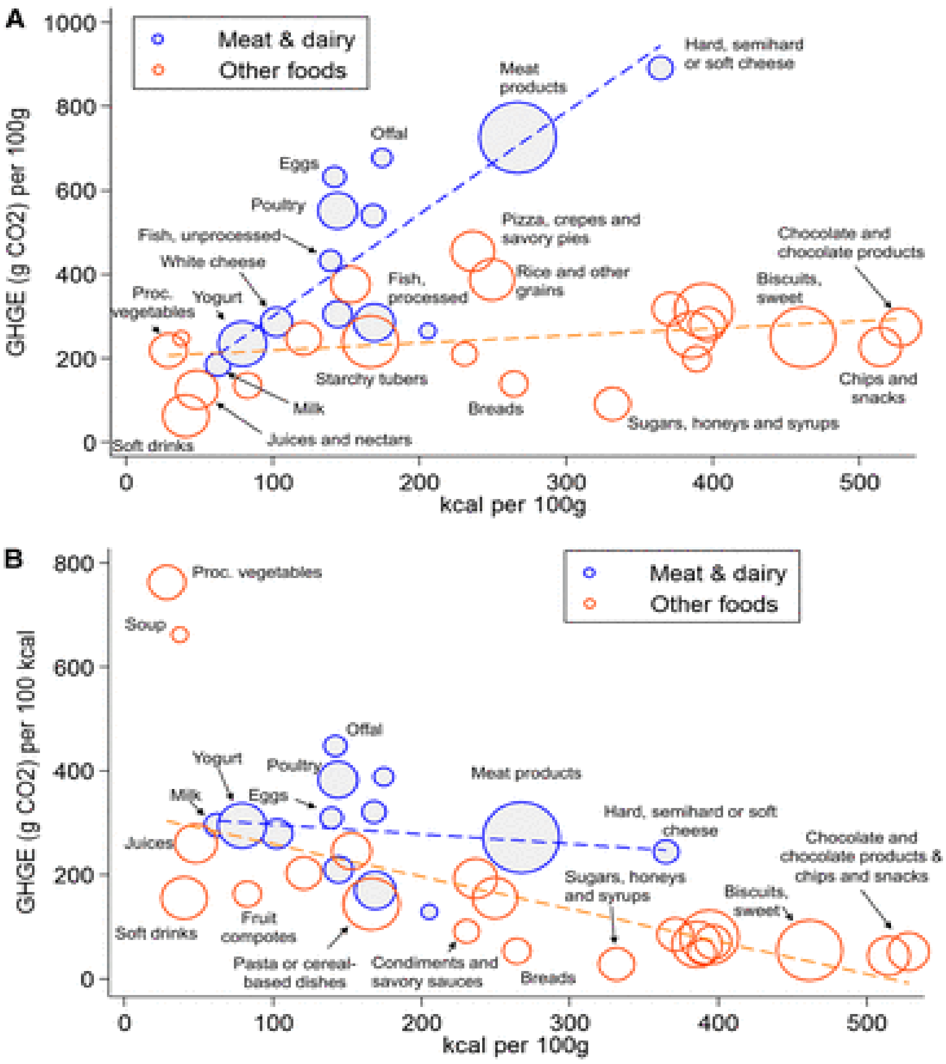


Figure 23: Association between geometric mean energy density for 34 food groups and GHGE values per 100 g (A) and 100 kcal (B). The size of the circles represents the number of foods per food group. GHGE = greenhouse gas emission; Proc. = processed. (A. Drewnowski et al., 2015)

4.3.2.3 Energy-intensive processes

Foods with high energy density and low nutritional value are often (ultra) processed. Compared to other steps in the food system, food processing is considered the second most energy-intensive step (after primary production). The more processing they undergo, the more energy is required. This also depends on the types of processing that take place. Examples of energy-intensive operations are flour milling, thermal processes (heating, cooling, freezing, drying), and the production of dairy products (especially cheese and milk powder). Certain products require a lot of energy during the production process: instant coffee, milk powder, chips, and bread (Fardet & Rock, 2020; Ladha-Sabur, Bakalis, Fryer, & Lopez-Quiroga, 2019).

Data on energy use during food processing is very fragmented. Studies focus on a limited number of processes and products, making it difficult to get an overview of energy use in the food sector. Nevertheless, each additional step in the food processing process has an environmental impact. On the other hand, food processing can reduce food loss (longer shelf life), which in turn has a positive impact on the environmental impact (see 3.2.2).

4.3.2.4 Water use

The largest amount of water is used during the primary production phase. However, on average, 30% of the total amount of water is consumed in the processing phase of the production process. This does not mean that all that water ends up in the foodstuff. It also includes the water needed for food hygiene and machine cleaning (Ladha-Sabur et al., 2019; Meneses, Stratton, & Flores, 2017). In addition, if water-intensive crops or ingredients are used that require a lot of input (such as palm oil, see below), the water consumption of the product increases even more.

4.3.2.5 Commonly used ingredients

Ultra-processed food is usually produced in large volumes and at a low cost. This category of food products is characterized by several ingredients that have a high environmental impact. Here we discuss some of them.

Palm oil

The production of palm oil has increased rapidly in recent decades and palm oil is currently one of the most widely used vegetable oil in the food industry, including in the production of ultra-processed products. Palm oil is used in cakes, ice cream, ready meals, spreads, and margarine. The palm oil industry is partly responsible for the deforestation of large areas of tropical forest. This leads to the loss of forests, biodiversity, and consequently high greenhouse gas emissions[36], soil acidification, and water and soil pollution (Barthel et al., 2017; Kadandale, Marten, & Smith, 2019; Khatun, Reza, Moniruzzaman, & Yaakob, 2017). There is a large environmental impact associated with the primary production of palm oil, but the operations required to extract palm oil and its distribution also contribute to a high environmental impact (Barthel et al., 2017). Nevertheless, some palm oil plantations strive for more sustainable production, without cutting down tropical forests. There are some certificates (e.g. RSPO and ISPO) for sustainable palm oil, but due to the large

[36] See Appendix 5, Figure B8.

economic interests involved in the sale of palm oil, the credibility of these certificates is under pressure (Richardson, 2015).

Sugar

On average, 80% of total sugar production comes from sugar cane (mainly produced in tropical regions), while 20% comes from sugar beet (of which 50% is produced in Europe). The production of sugar worldwide is expected to increase further, whilst in Europe a slight decrease is expected. Sugar is one of the most widely used ingredients in food processing and is strongly present in ultra-processed products (European Commission, 2020b; Food and Agriculture Organization, 2019). An increase in production is expected of the most common alternative calorific sweetener, HFCS (high fructose corn syrup, extracted from maize and mainly used in the US for sweetening soft drinks). Currently, 90% of caloric sweeteners come from sugar and 10% from HFCS. In Europe, a decline in sugar production is expected due to competition with HFCS and non-caloric sweeteners (Food and Agriculture Organization, 2019). Sugar production contributes to biodiversity loss, deforestation, water scarcity, greenhouse gas emissions[37], and water, soil and air pollution. Especially the high need for irrigation water result in higher water use, especially for sugarcane[38] (Hashem et al., 2015). Depending on the type of sugar produced - sugar cane or beet, (un)refined - there is a big difference in greenhouse gas emissions. Refined sugar has a higher environmental impact than unrefined sugar. During the primary production phase, the processing of raw materials and transport, greenhouse gas emissions would be highest (Naresh Kumar & Chakabarti, 2019). As with palm oil, there are ongoing initiatives to improve the sustainability of sugar production.

Food additives

Several types of food additives are used in ultra-processed foods. These may come from natural sources or may be artificially made. It is unclear to what extent the use of food additives contributes to the environmental impact. Research into the environmental impact of the production and use of food additives is rather limited. A German study compared the environmental impact of natural dyes from plants and animals with that of artificial dyes. The use of energy and water was highest for the plant-based pigments, followed by artificial pigments and animal-based pigments. More energy and water-intensive processes are required to obtain vegetable pigments compared to other pigments. On the other hand, the production of vegetable pigments often produces by-products that can be used in animal feed or for the extraction of other components, such as phenols (bioactive substances) (Gebhardt, Sperl, Carle, & Müller-Maatsch, 2020). Additives (such as phenols) can also be obtained from micro-organisms. Due to the potential for intensification of such controlled bioreactor production processes, this would be a more sustainable production method compared to the long production process needed to obtain additives from plants or animals, or even chemical biosynthesis (Mark, Lyu, Lee, Parra-Saldívar, & Chen, 2019). There are differences between the different types of additives, but more research is needed to draw definite conclusions. In addition to the environmental impact caused by the

[37] See Appendix 5, Figure B10.
[38] See Appendix 5, Figure B10.

production of food additives, the effect on food safety and shelf life should also be taken into account, as this can help to reduce food losses.

4.3.2.6 Processed meat and protein alternatives

Within the group of ultra-processed foodstuffs, processed meat products[39] and protein alternatives deserve extra attention. This is certainly the case in the context of a more balanced protein consumption, as this type of product is promoted as a replacement product with a lower environmental footprint.

During the production of processed meat and meat products, the meat is processed (extra) and various ingredients are added. The processing steps create an additional environmental impact, which, according to an Australian study, is negligible compared to the impact of primary production (Biswas & Naude, 2016). This can be explained by the fact that the impact of fresh meat, even without processing, is already very high (4.1.2).

In recent years, more and more plant-based meat substitutes have been introduced to the market. These products range from tofu and tempeh to breaded vegetable burgers, mycoproteins[40], and even vegetable burgers that look very much like meat (e.g. Beyond Meat®). The environmental impact of high-tech plant-based alternatives is generally lower than that of beef, but the difference with the environmental impact of chicken is less clear. The impact of tofu and legumes is lower than that of animal products. This is demonstrated in Figure 24 below for greenhouse gas emissions.

Many of these vegetable alternatives can be regarded as ultra-processed ('plant-based' in Figure 24). Think, for example, of the high-tech vegetable alternatives to meat that make use of protein extrusion technologies, among other things. More traditional alternatives are tofu, tempeh, seitan, and vegetable burgers based on legumes and vegetables. These products are described as processed rather than ultra-processed.

[39] Processed meats include products such as sausage, hamburger, and chicken nuggets. Processed meats include products such as smoked or dried meat, salami, and ham sausage. In Flanders, we speak of charcuterie. The term 'processed meat products' can be confusing, because only cured, dried, and smoked meat belongs to the category of processed food according to NOVA. All other processed meats (such as salami) are considered ultra-processed, as are processed meats (e.g., sausages hamburgers).
[40] These are fermented proteins or proteins derived from fungi. These fermented proteins are used as the basis for certain plant-based meat substitutes.

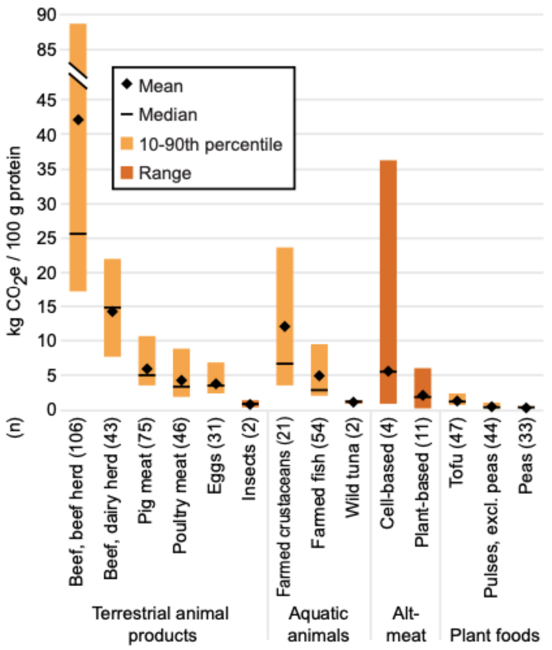


Figure 24: Greenhouse gas emissions per 100 g of protein for different protein products (Santo et al., 2020)

In terms of water and land use, plant-based meat replacements often score better than meat (Ercin, Aldaya, & Hoekstra, 2012; Santo et al., 2020). There are many sources of plant protein that can be used to produce meat substitutes: soybeans, chickpeas and other peas (such as the yellow pea), beans, lupine, hemp, quinoa, seaweed, etc. (van Diepen et al., 2018). The cultivation of these products usually causes a lower environmental impact compared to animal products.

To make a proper comparison, the nutritional qualities of these products must be considered. Research indicates that the consumption of meat substitutes can contribute to a lower environmental impact on the diet while providing a nutritionally equivalent alternative (Mertens et al., 2020; Van Mierlo, Rohmer, & Gerdessen, 2017).

4.3.3 Processing rate

It is generally argued that legumes will play an important role in sustainable food systems and food patterns due to multiple environmental benefits (Stagnari, Maggio, Galieni, & Pisante, 2017). Crops such as soybeans, field beans, lupins, chickpeas, and wheat are often processed into concentrates or isolates with higher protein content as ingredients for meat substitutes. These processes require a relatively large amount of energy and protein is lost during the process. Furthermore, the environmental impact (in terms of climate impact, energy use, and land use) of protein isolates is generally higher than that of protein concentrates and the environmental impact of protein concentrates is higher than that of meal. High-tech crops such as algae and insects also have high energy consumption and therefore a high impact on climate change (Figure 25). It is not only the primary production of the plant-based protein source that is important, the processing must also be taken into account. The more processing steps, the higher the environmental impact of the end product. However, this does result in a nutritionally better end product that can serve as a fully-fledged plant-based protein alternative to meat. In addition to the impact of the protein source, the other ingredients also contribute to the environmental impact of the final product (van Diepen et al., 2018).

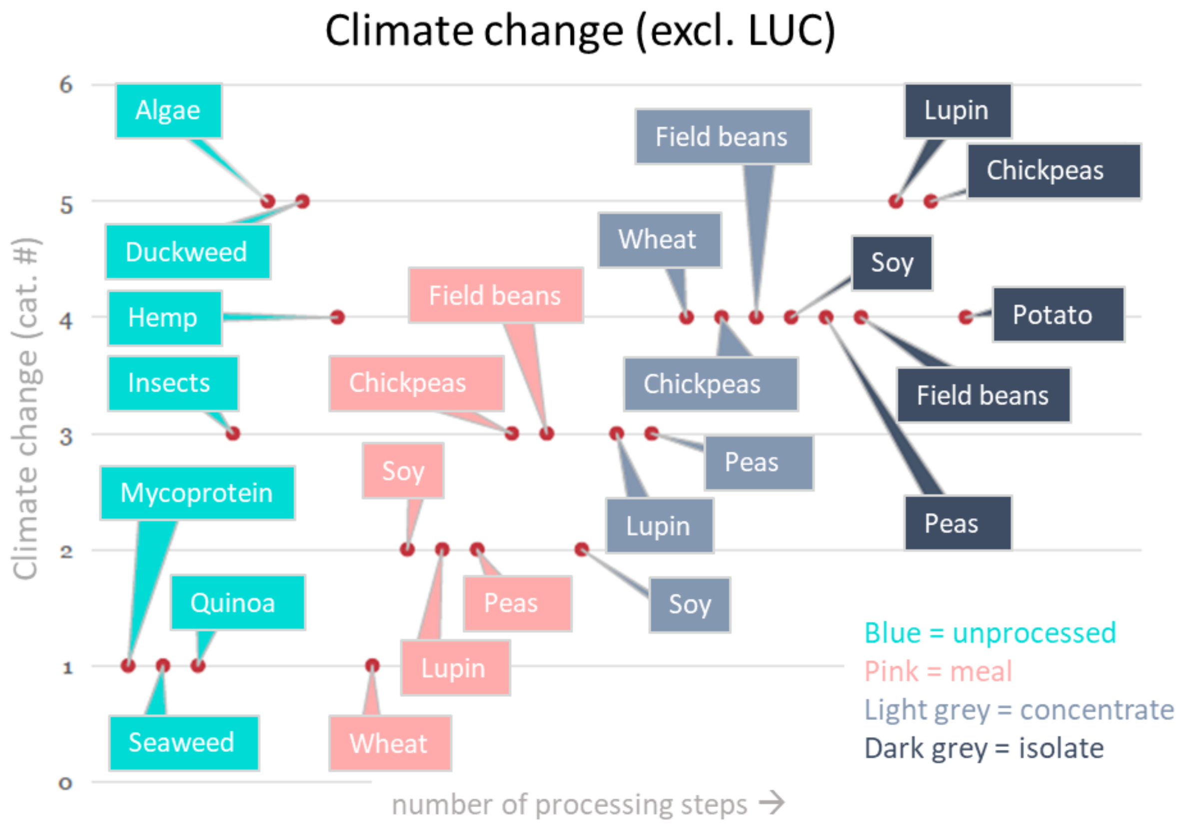


Figure 25: Contribution to climate change for different protein ingredients for meat substitutes for a number of processing steps (LUC = land use change) (translated from van Diepen et al., 2018)

Based on the protein content, animal proteins generally have a higher climate impact than plant proteins (see 4.1.2.2). In general, it can be said that meat substitutes based on plant protein sources, but also those based on insects and algae, have a lower environmental impact (Broekema & van Paassen, 2017; Mertens et al., 2019; van Diepen et al., 2018).

Cultured meat has also been gaining attention recently. It uses animal cells that are raised and the product is not yet available on the market. The production of cultured meat is still in a research phase and it is difficult to estimate exactly how much energy and which raw materials will be needed. It is, therefore, hard to estimate the environmental impact (van der Weele, Feindt, van der Goot, van Mierlo, & van Boekel, 2019; van Diepen et al., 2018). With current knowledge, the production of cultured meat requires a large energy consumption (*cell-based* in Figure 24). However, it is too early to make a general statement about this (Sinke & Odegard, 2021; Smetana, Mathys, Knoch, & Heinz, 2015).

4.3.4 Current Consumption

4.3.4.1 Consumption

The Belgian food consumption survey of 2014 - 2015 provides information on the consumption of processed foods (according to the NOVA classification). In the Belgian population (3 to 64 years), 36.4% of the total food intake (expressed in grams) comes from ultra-processed food and 42.2% from unprocessed or minimally processed food. As much as 29.9% of total energy intake comes from ultra-processed foods and 21.3% from unprocessed or minimally processed foods. The largest contributor to ultra-processed food consumption was processed meat(s) (Vandevijvere, De Ridder, Fiolet, Bel, & Tafforeau, 2019).

Young children (3 to 9 years, 33.3%) have a significantly higher energy intake from ultra-processed foods than adolescents and adults (29.2% and 29.6%, respectively). There were no significant differences in consumption of ultra-processed foods according to gender, socio-economic status, or weight. Although the energy intake of ultra-processed foods was similar across population groups, the energy intake of unprocessed and minimally processed foods was higher in women and higher educated people. People who ate more than two meals per day together with their families had a higher energy intake of unprocessed and minimally processed food (Vandevijvere et al., 2019).

For the total population (3 to 64 years), the following food groups contributed most to the energy intake from ultra-processed foods: processed meat(s) (14.3%), cakes, pies and pastries (8.9%), dry cakes and biscuits (7.7%) and soft drinks (6.7%). There were no notable differences in consumption of specific foods between different age groups, by gender. Data for the elderly are not available (Vandevijvere et al., 2019).

Table 7: Average contribution of the different food groups to the total energy intake of the total population (translated from De Ridder et al., 2016b).

Food group	Average contribution to total energy intake in 2014 (%)
Potatoes and other tubers	4,2
Vegetables	2,4
Pulses	0,2
Fruit	5,2
Milk and substitute products	12,6
Grain and grain products	22,5
Meat, meat products and substitute products	13,5
Fish, shellfish, and amphibians	1,9
Eggs and derivatives	0,7
Oil and grease	6,6
Sugar and confectionery	7,5
Cakes and sweet biscuits	8,3
Non-alcoholic beverages	5,2
Alcoholic beverages	3,6
Spices, sauces and yeast	3,6
Stock	0
Various[1]	0,2
Savory snacks[2]	1,5

Percentages are weighted for age, gender, season, and day of the week

1 some vegetarian products, meal replacements, diet products

2 potato chips, salty cookies and appetizers

Adding up the foods that can be considered empty calories gives a cumulative percentage of about 26% of the total average energy intake[41]. Cereal products (22.5%), meat, meat products, and meat substitutes (13.5%), and milk products (12.6%) complete the top four (Table 8).

The researchers of the Food Consumption Survey also expressed the usual consumption from the rest group[42] (including alcohol) in kcal per day. This amounts to an average of 656 kcal per day for Belgians (3-64 years). Men consume significantly more calories from this rest group compared to women, respectively 792 kcal/day and 536 kcal/day. Adolescents (10-17 years) and young adults (18-39 years) consume the most calories from the rest group, namely more than 700 kcal/day (De Ridder et al., 2016b).

Foods with high energy density and low nutritional value (such as ultra-processed products) are therefore consumed at relatively high levels.

[41] Based on Table 8: savory snacks, alcoholic drinks, non-alcoholic drinks, cakes and sweet biscuits, sugar and confectionery.
[42] The results of De Ridder et al. (2016b) are based on the residual group from the previous food triangle. It largely corresponds to the red sphere of the current food triangle but is not identical. The study does provide a picture of the calorie intake of foods that can be considered superfluous.

4.3.4.2 Attitudes

At this moment, we lack good sources to gain insight into attitudes towards the (over)consumption of foods with a high energy density and low nutritional value.

Nevertheless, several characteristics may explain the (high) consumption of such products: relatively low cost, ease of use, familiar flavors that play on our ingrained desire for fat and sugar, and strong marketing. Many people experience a lack of time and do not want to put a healthy meal on the table at the end of the day. Or they lack the skills/knowledge to cook healthy meals themselves. However, it is unclear what the state of cooking skills is among the Flemish population. (Vlaams Instituut Gezond Leven, 2020b).

Despite the high consumption of these foods, many Flemish people (40%) think that all processed foods are unhealthy and 20% do not know. There are several misconceptions about food processing (Vlaams Instituut Gezond Leven, 2019). The negative attitude to food processing, as well as to additives, is also evident from other research - both Belgian and worldwide. Part of the population wants to go back to basics: simple ingredients and less artificial and processed food. Worldwide, only 44% of the population would trust industrially prepared food (Nielsen Company, 2016; Van Buggenhout, Roels, Vervloet, & Vuylsteke, 2016).

4.3.5 Conclusion on empty calories

Products that have no useful or possibly even negative contribution to health - what we call empty calories in this report - by definition have a superfluous environmental impact. The share of this type of product in the Flemish diet is fairly high and has a considerable environmental impact. Avoiding empty calories therefore not only has a positive effect on our health, but it also saves a superfluous environmental impact.

Food processing is necessary in some cases and can bring benefits: better storage (and thus safer food and less food loss), better digestion, higher availability of nutrients, and increased convenience. It is therefore too easy to unilaterally write off this type of product. That is why it is important to look at the nutrient content and why the term empty calories is a better guide.

These products use some ingredients that have a significant environmental impact. Think of palm oil and refined sugar. The cultivation of these products still often leads to deforestation, which contributes to the loss of biodiversity and the emission of greenhouse gases. Insights into other ingredients and their production processes are needed to get a better picture of the problem.

There are meat substitutes on the market that have to go through many processing steps before they end up on our plates. That is why we call them ultra-processed. Despite these processing steps, it appears that such meat replacements can contribute to a lower environmental impact of the diet. Even when a nutritional quality equivalent to that of meat alternatives is taken into account. It is not surprising that the average vegetable meat substitute has a higher environmental impact compared to basic ingredients such as legumes. The more processing, the higher the environmental impact. It is still advisable to keep an eye on the nutritional properties of these products at all times, and preference is given to products that are less heavily processed.

4.4 Overconsumption

4.4.1 Health and the environment

When we as humans are confronted with an abundance of food (as in the West, and paradoxically increasingly in developing countries), we tend to eat more than we need and buy more than we can finish - leading to health problems and food loss. Excessive energy intake is a common threat to health and the environment (Hollander, Temme, & Zijp, 2017; Macdiarmid, 2013; Westhoek, Ingram, Van Berkum, Özay, & Hajer, 2016). We eat too much and too much of the wrong food. Overconsumption (energy intake from food being higher than the energy consumption) leads to obesity and the associated health risks, as already described in the substantiation of the food triangle in terms of health (Vlaams Instituut Gezond Leven, 2017b). There is also a possible link between overconsumption and the previous section on ultra-processed food. Recently, an intervention study was able to demonstrate for the first time that people unconsciously eat up to 500 kcal more from a diet consisting mainly of ultra-processed foods (see 3.3) compared to a diet consisting mainly of unprocessed or poorly processed foods (Hall et al., 2019). This overconsumption represents not only the risk of obesity and associated health risks but also an unnecessary environmental impact (Biesbroek, 2019; Mertens et al., 2019).

The impact of excessive energy intake (overconsumption) on the environment can be seen as a form of food loss, as more food is consumed than necessary (Alexander et al., 2017). This is also described as inefficient use of food (Macdiarmid, 2013; Roels & Van Gijseghem, 2011). Reducing (over)consumption thus also has a positive effect on the environmental impact of the diet (Mertens et al., 2019; Westhoek et al., 2016). Although there is a correlation between energy intake in the population and greenhouse gas emissions, focusing on reducing energy intake will not necessarily be accompanied by a reduction in, for example, greenhouse gas emissions, but it is very plausible. This confirms once again that attention must be paid to the different starting points and levels. For example, a diet with a high level of consumption of meat and/or dairy products but a low total energy intake will still have a greater ecological impact. The focus should be on reducing consumption of foods with high energy density, low nutritional value, and high environmental impact (empty calories, see 4.3).

4.4.2 Current Consumption

4.4.2.1 Consumption

Energy intake

The 2014 - 2015 Food Consumption Survey shows that the average energy intake of an adult Belgian is around 2288 kcal/day for the 18-39 age group, and around 2177 kcal/day in older adults (40-64 years), after excluding under-reporting (De Ridder et al., 2016a).

Because there is a correlation between energy intake and energy requirement (depending on individual factors such as weight, height, and activity level), it is not possible to make a quantitative assessment of the adequacy of energy intake at the population level.

However, the results have been qualitatively compared with the recommendations of the Superior Health Council of Belgium (as a function of a hypothetical age-specific activity level). Based on this comparison, the energy intake of children and adult males can be considered adequate (after excluding under-reporters). The energy intake of adolescents and adult women (mainly those aged 18-39) is even on the low side in this comparison (De Ridder et al., 2016a).

Bodyweight

Bodyweight is another way of estimating the energy balance of a population. A positive energy balance (energy intake > energy expenditure) can lead to weight gain, while a negative energy balance (energy intake < energy expenditure) leads to weight loss. To maintain a healthy body weight, one aims at an energy intake that is more or less equal to the total energy consumption. The BMI is used to classify adults at the population level according to different weight classes (underweight, healthy weight, overweight, obese). For children and adolescents (< 18 years), limit values according to age and gender are used to determine the prevalence of overweight and obesity.

The Health Survey 2018 shows that the average adult Flemish person has a BMI of 25.3. Almost half (48%) of the Flemish people are overweight (BMI higher than 25), with significantly more men (55%) than women (42%). 15% of the Flemish population is obese (BMI higher than 30). The prevalence of overweight and obesity has followed an upward trend since the first Health Survey in 1997. The prevalence of both overweight and obesity increases with age, up to about 65 - 75 years. In addition, low-educated people run a higher risk of being overweight and obese. The prevalence of overweight (19%) and obesity (6%) is also high in children, but the figures remain relatively constant over the years. Especially young children (2 - 4 years) are overweight (24%) and obese (12%). In addition, children from households with a lower level of education have a higher risk of being overweight and obese (Drieskens, Charafeddine, & Gisle, 2019).

The increasing trend in the prevalence of overweight, as well as the measured abdominal girth in 2004 and 2014 among 15- to 64-year-olds in Belgium (88 cm and 91 cm, respectively) (Lebacq, 2015) suggest that energy intake in Belgium is higher than what was reported in the Food Consumption Survey and that overconsumption does exist.

4.4.2.2 Attitudes

There are no studies that provide information on attitudes towards overconsumption.

4.4.3 Conclusion on overconsumption

We speak of overconsumption when we eat more than the body needs. Food is ubiquitous in Flanders, relatively cheap and easy to consume. The food environment strongly influences our food choices and consumption. The figures on overweight and obesity point to the fact that overconsumption is a problem for large parts of the population. This is not only a challenge for Flanders, but this situation typifies the entire (Western) world.

This situation has an adverse effect on health, but it can also be seen as a cause of unnecessary environmental impact and, in that sense, a form of food waste. Reducing this overconsumption has a beneficial effect on our health but may also reduce the environmental impact of the diet. It is important to focus on reducing the overconsumption of empty calories and foods of animal origin.

5 Advice at food level

The main recommendations for reducing the environmental impact of our diet are aimed at the diet as a whole. Nevertheless, to achieve additional environmental gains, additional advice at the foodstuffs level is possible and desirable. The focus here is on better choices within the same product group (Gezondheidsraad, 2011).

In this chapter, we discuss the most relevant impact categories, starting from a healthy diet. This means that some food categories are discussed in limited detail. For example, no comparison is made between beers and wines, two products that appear in the red sphere next to the food triangle (Figure 9).

5.1 Beverages

5.1.1 Water

One of the recommendations of the food triangle reads: "Drink mainly water". There is a choice between bottled water and tap water. The packaging and transport mean that bottled water has a larger environmental impact compared to tap water. The environmental impact of tap water, and more specifically the emission of greenhouse gases, is approximately 300 times lower than that of bottled water. The water footprint of tap water is about five times smaller than that of bottled water. A glass of tap water consumes only 0.4 L of water, compared to 2 L for a glass of bottled water. This is because a lot of water is needed for the production of bottled water (Botto, 2009). Switching from bottled water to tap water can reduce the environmental impact of water consumption in a family by up to one-fifth (Thomassen et al., 2021).

The quality of our tap water is regularly checked and is good. The obligations that water companies must fulfill for the quality of tap water are included in the Flemish drinking water legislation. The Vlaamse Milieumaatschappij (Flemish Environment Agency) and the Agentschap Zorg & Gezondheid (Agency for Care and Health of the Flemish Government) monitor this. Tap water supplied by one of the water companies is, therefore, a better alternative to bottled water. This means that tap water is preferred to bottled water.

5.1.2 Coffee and tea

Coffee and tea are part of a healthy and environmentally responsible diet. Good choices can be made to limit the negative environmental impact.

The cultivation of coffee beans is associated with deforestation. Not only to create new coffee plantations but also because the harvested wood is used as fuel in production. Deforestation has a negative impact on biodiversity, soil, and greenhouse gas emissions. The use of pesticides, (artificial) fertilizers, and emissions to water also contribute to a higher environmental impact (Kuepper & Kusumaningtyas, 2020). To separate the bean from the pulp, one of two methods is usually used: the wet method and the dry method. For the water footprint, the difference between these two methods appears to be very small. Nevertheless, they often involve pumped water, which has an additional impact in water-scarce regions. The wastewater from the wet method is also often heavily polluted (Chapagain & Hoekstra, 2007). Labels, such as that of the Rainforest Alliance, can help consumers choose coffee that takes these ecological issues into account (Alaerts, 2020; Krishnan, 2017; Kuepper & Kusumaningtyas, 2020).

Coffee has a relatively low carbon footprint and low land use (Poore & Nemecek, 2018). When deforestation occurs (Schneiders et al., 2020) or when, for example, milk is added to the coffee (e.g. coffee latte), the relative environmental impact increases. In the production of coffee beans and thus the preparation for consumption, the largest part of the carbon footprint is caused by roasting the coffee (MVO Vlaanderen, 2014). Boiling the water (energy use) has in comparison a much smaller impact on the carbon footprint. The waste phase is also an important aspect. In the production of beans, for example, the flesh of the bean can be put to good use (e.g. as animal feed). It also happens that this waste stream disappears into rivers, with harmful consequences for the environment. The material from which the coffee is drunk (disposable or reusable cup) also affects the environmental impact. The aspect of food losses also plays a role here. Of course, and as mentioned above, this is very important for this type of product: so do not make more coffee than you plan to drink or make smaller quantities of coffee several times if that makes it easier to estimate how much coffee you still need.

The production of tea faces similar environmental problems as coffee (Mukhopadhyay & Mondal, 2017). Nevertheless, tea generally has a lower impact compared to coffee. For the production of a cup of tea, the water footprint (34 liters) is significantly lower than for a cup of coffee (140 liters) (Chapagain & Hoekstra, 2007). A major source of greenhouse gas emissions is the packaging phase and, to a lesser extent, the boiling of water (Munasinghe, Deraniyagala, Dassanayake, & Karunarathna, 2017).

5.1.3 Other beverages

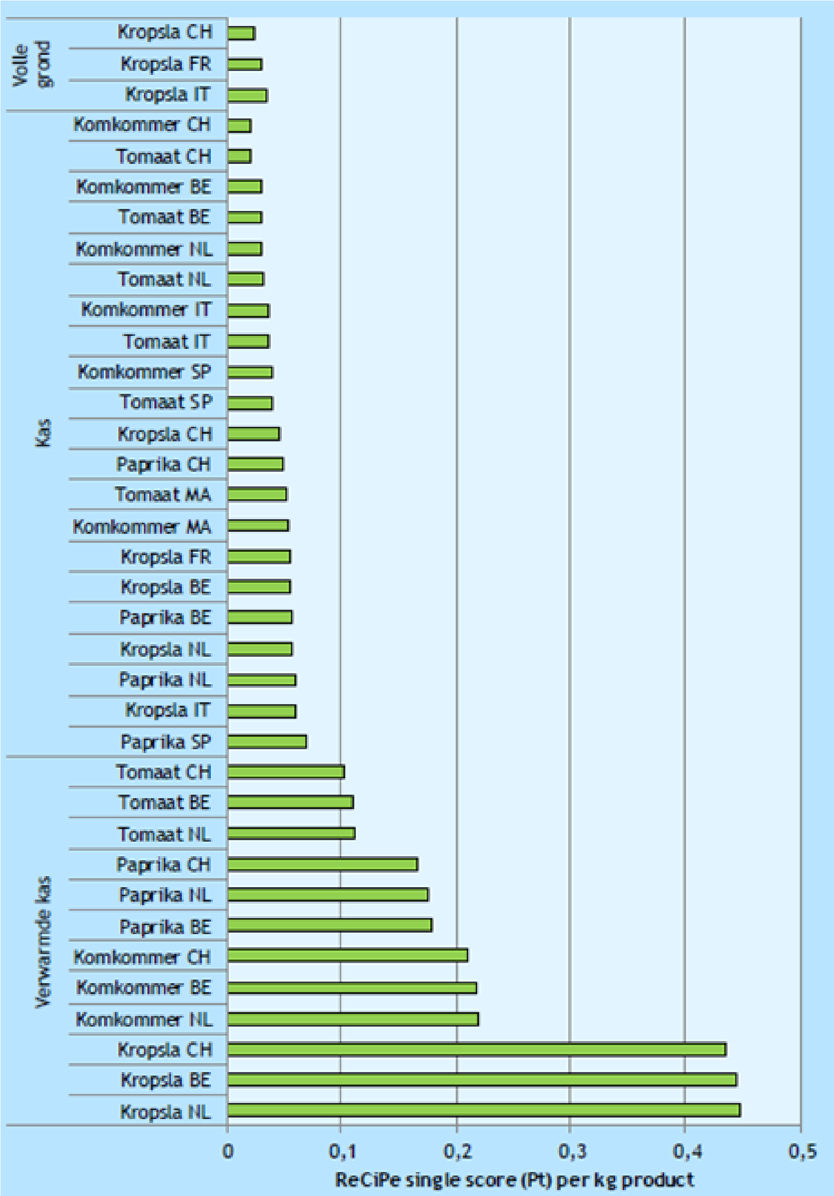
The cultivation of raw materials for beverages contributes to the share of greenhouse gas emissions and land use for food. The rule of thumb is the more concentrated the drink, and therefore the more pure raw material is used, the greater the contribution to the impact. The contribution of transport to the environmental impact depends on distance, weight, type of packaging, and means of transport. The less packaging material used per liter of drink, the better. Large-capacity packaging, therefore, scores better than individual small packs, provided it does not encourage overconsumption and waste (Pluimers, Blonk, Broekema, Ponsioen, & van Zeist, 2011). As previously demonstrated, sweetened soft drinks have a relatively low climate impact (4.3.2.2). As these belong to the category of empty calories (4.3), their consumption should be limited anyway.

5.2 Fruit and vegetables

Water, soil, fertilizers and other additives, plant protection products, and energy (for heating as well as transport and cooling) are needed to grow fruit and vegetables. The extent to which these are used entails a certain environmental impact. For example, the cultivation of fruit and vegetables is responsible for emissions to soil and water and also emits greenhouse gases. There is a wide variety of vegetables and fruit. It should come as no surprise that the environmental impact between these species can vary considerably. Not only is there a difference between, say, tomatoes and cucumbers, but also within one particular product group (e.g. tomatoes) there can be considerable differences depending on production and transport methods (Bergsma et al., 2014; Goossens et al., 2019a, 2019b).

5.2.1 Recommendations on fruit and vegetables

The example of lettuce (kropsla) in Figure 26 below shows that differences within one product group can sometimes be greater than the difference between different vegetable types (Bergsma et al., 2014). It is therefore not easy to determine which types of fruit and vegetables should be avoided to reduce their environmental impact. How can we explain the considerable differences between one type of lettuce and another? Several factors, such as the cultivation method, the region (origin), the transport method, and seasonality, among others, determine the total environmental impact of a crop to a greater or lesser extent.



Horizontal text: kropsla = lettuce; komkommer = cucumber; tomaat = tomato
Vertical text: volle grond = field-scale; kas = greenhouse; verwarmde kas = heated greenhouse

Figure 26: Environmental impact of various crops from greenhouses and open ground (Bergsma et al., 2014)

5.2.2 Field-scale and greenhouse cultivation

The cultivation phase of fruit and vegetables is the biggest impact factor for the total environmental burden of these product groups (European Environment Agency, 2015). The cultivation method can differ depending on whether the product is grown in the open (field-scale) or heated greenhouses with or without renewable energy. Figure 27 shows that products grown in a (heated) greenhouse have a significantly higher environmental impact than when grown outdoors.

In most cases, the cultivation method is a better predictor of the total environmental impact than the country of origin (see further) (Bergsma et al., 2014; Broekema & Blonk, 2010). The same conclusion applies to fruit that has a lower environmental impact when grown outdoors. Moreover, greenhouses that are heated without using renewable energy (and/or cogeneration) contribute significantly to a higher climate impact (Bergsma et al., 2014; Berners-Lee, Hoolohan, Cammack, & Hewitt, 2012; de Valk et al., 2016; Girod et al., 2014). An advantage of greenhouse cultivation is that there is more control over, for example, weather conditions, which can minimize possible production losses.

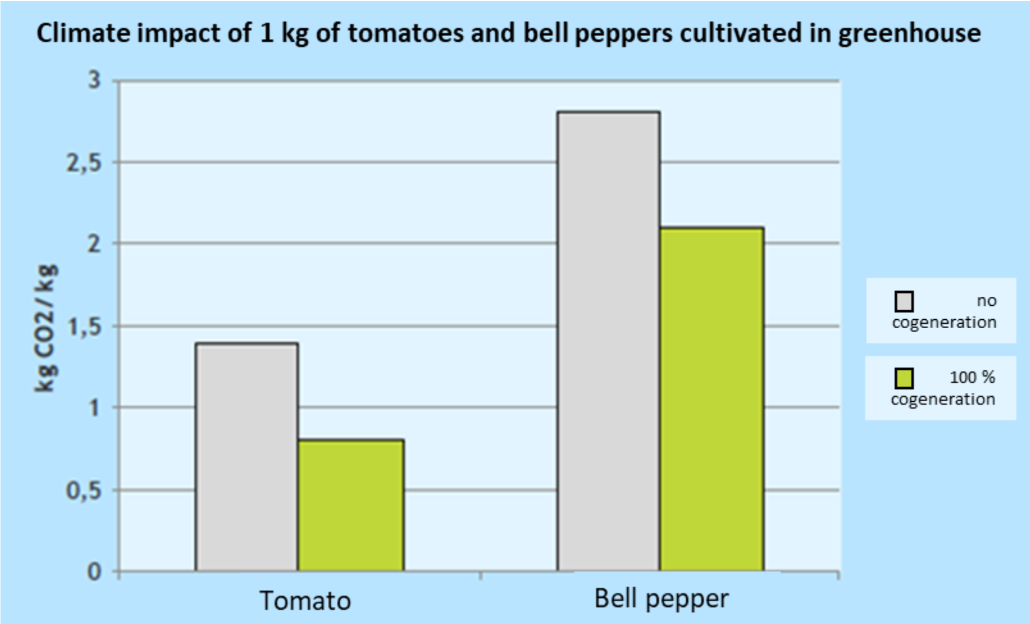


Figure 26: Comparison of climate impact for crops from greenhouse with and without cogeneration (translated from Bergsma et al., 2014)

The cultivation method of products is not always visible in Belgium. For (fresh) food products in Switzerland, the cultivation method used is indicated, although it is not yet clear which form of greenhouse cultivation is used: that with or without renewable energy (Figure 28).

Figure 27: Indication of cultivation method groundless cultivation (Hors - Sol) and greenhouse cultivation (Gewächshaus / Sous serre) (own image)

5.2.3 Transport modes versus food miles

Transport from the country of origin to the Flemish market contributes to the total environmental impact. Contrary to what is often assumed, the impact of the so-called food kilometers is often limited compared to the total impact (Edwards-Jones, 2010; European Environment Agency, 2015; Macdiarmid, 2013). The share of food kilometers is typically estimated to be around 3-6% of the total environmental impact (Kramer & Blonk, 2015; Platteau et al., 2016; Sandström et al., 2018). With long distances, the differences between products may be greater (Goossens et al., 2019a, 2019b).

More decisive is the method of transport. Transport by airplane causes a considerably higher environmental impact compared to transport by truck or (sea) ship (Berners-Lee et al., 2012; Clune et al., 2017; de Valk et al., 2016; Girod et al., 2014; Nijdam et al., 2012). An example is given in Figure 29 for white asparagus.

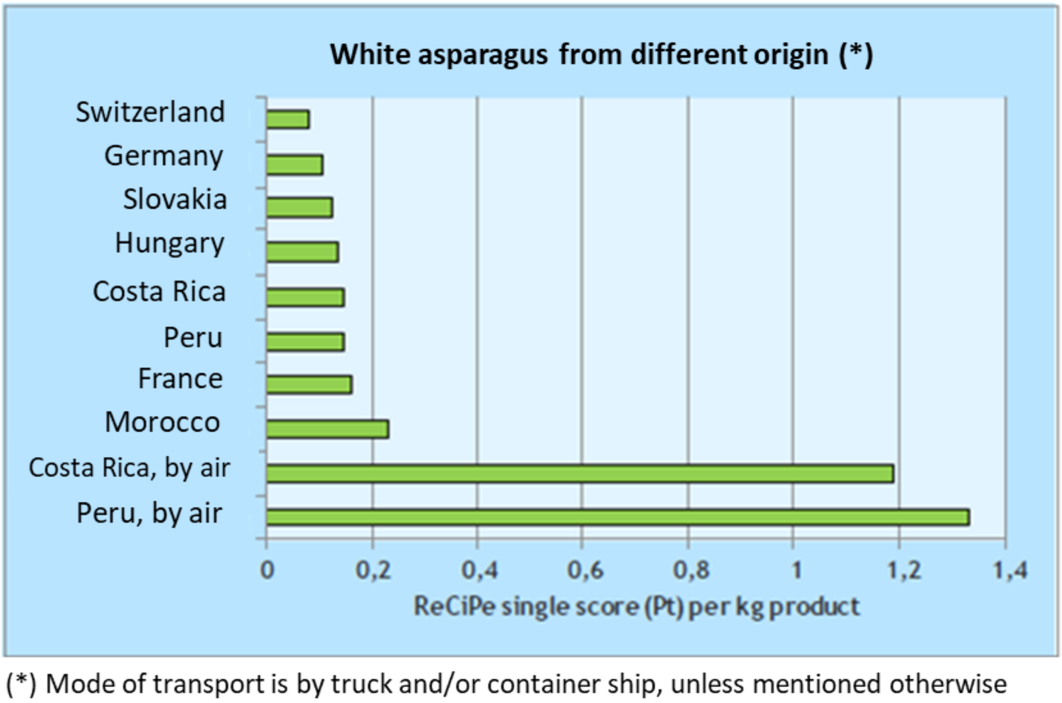


Figure 28: Impact weighted environmental score for asparagus of various origins (translated from Bergsma et al., 2014)

Perishable vegetables and soft fruits from overseas usually arrive in Belgium by plane (Bergsma et al., 2014). These often have to be transported by refrigerated transport, which additionally contributes to a higher environmental impact. A review shows that the majority of global food miles are done by boat (58.9%). Road transport accounts for 30.9% of food miles[43] while rail transport (9.9%) and air transport (0.16%) account for a significantly lower share (Poore & Nemecek, 2018).

The mode of transport of the products is almost invisible in the shop. It is therefore difficult for consumers to take it into account. What makes the problem even more

[43] Food miles is a unit expressed in tonne-kilometers: the transport of one tonne over one kilometer. This unit thus takes into account the difference in quantity that a means of transport can carry.

complex is that when the mode of transport is visible, as in the example of 'by air' (Figure 30), the consumer does not necessarily perceive this as a negative element. For example, the 'by air' aspect may indicate the freshness or exclusivity of the product, rather than a higher environmental impact.

Figure 29: Indication of transportation method 'by air' (own image)

The impact of transport (and food miles) does not depend solely on the method of transport. The efficiency of the means of transport and whether or not it is refrigerated for transport and storage is part of the total environmental impact (Garnett et al., 2016).

The cultivation method and the transport method thus have a greater or lesser impact on the total environmental impact. This makes the focus on local production and consumption of fruit and vegetables, from an environmental point of view, problematic. A tomato in season from Spain has a lower environmental impact than the same type of tomato grown by a glasshouse farmer around the corner (Macdiarmid, 2013). There is no denying that local cultivation is an important connecting factor and that it brings the citizen (consumer) and the producer closer together. The link between local food and seasonal cultivation can offer a solution to this contradiction.

5.2.4 Seasonal consumption: global or local

Seasonal products can be a good guide to reducing the environmental impact of the diet (Garnett et al., 2016; Mathijs, 2017). Seasonality can be defined in two ways: production only, or the combination of production and consumption. A global view is then the production view: food grown outdoors during a natural growing process for the country or region of origin. A local vision combines production and consumption: locally seasonal. These are fruits and vegetables produced and consumed in the same (climatic) region without the use of energy-intensive storage and heating (or lighting) (Macdiarmid, 2013).

By adding the seasonal aspect, local production of fruit and vegetables can mean a more responsible choice. In terms of environmental impact, the local aspect is then secondary to seasonal. However, it is important to note that seasonal fruit and vegetables can be stored (refrigerated), which increases the complexity of the matter (Edwards-Jones, 2010).

Seasonal as a spearhead?

To take the seasons into account as a consumer, the fruit and vegetable calendars are an aid. On the shop floor, it is often not visible which products are in season. Recent experiments in the supermarket show that a simple indication is possible (Boudry et al., 2018). In other countries, we find examples of an indication on the product (Figure 31).

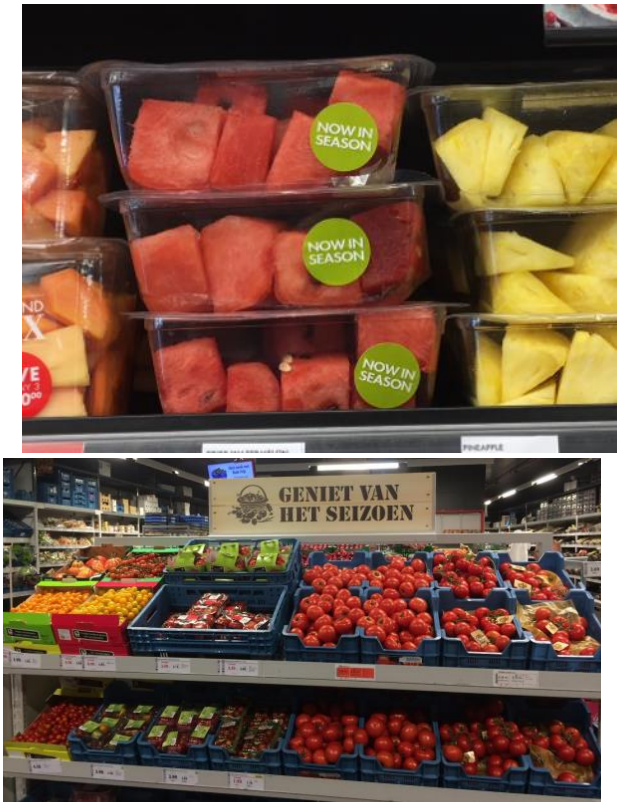


Figure 30: Indication 'In Season' (own image) and 'Geniet van het seizoen' translated 'Enjoy the season' (Boudry et al., 2018) in supermarkets

Few studies are available that examine the relative environmental impact of seasonal consumption. Some researchers suggest that although seasonal consumption has a lower environmental impact, this reduction is small compared to, for example, reducing meat consumption and food losses (Jungbluth, Itten, & Schori, 2012). However, this does not mean that it cannot be done.

5.2.5 Storage techniques

It is difficult to estimate the impact of food storage in the food processing process. This depends from product to product. Preserving food can be better, but the preference remains for consuming as many seasonal vegetables and fruit as possible. If you choose a particular type of fruit or vegetable for variation that is not in season, it is better to opt for the frozen or canned version than, for example, fresh produce transported by air (Broekema & Blonk, 2010). For out-of-season fruit and vegetables, therefore, products in cans, glass, or frozen can be an environmentally friendly alternative. The environmental impact of these three variants is similar. Cans and glass require more energy for processing, but not for storage. The reverse is true for frozen products, although energy is also required for freezing (Broekema & Blonk, 2010). Seasonal and local remain the preferred options, but out-of-season produce costs less energy to process into preserves or cans, compared to fresh greenhouse produce and flown-in fruit and/or vegetables. For example, locally grown canned beans are better than fresh beans flown in from Kenya (OVAM, 2015).

Some locally grown fruit and vegetables are kept in a refrigerator, which causes a higher environmental impact[44]. Packaging around fruit or vegetables can reduce the amount of handling and damage to bulk products during transport or by the consumer, making them unsaleable. In addition, packaging can also guarantee a better shelf life and thus prevent food loss. On the other hand, the energy required to produce the packaging material and the packaging waste mountain. On the other hand, in practice we see that a packaged set of, say, six apples are thrown away completely because one apple starts to turn moldy (Goossens et al., 2019a, 2019b).

5.3 Grain products and potatoes

Grain products and potatoes have a high yield per hectare. An important environmental aspect of grain products and potatoes is water use. This is especially important when groundwater resources are limited and irrigation is needed for crops. Especially the cultivation of rice, but also wheat and rye require many inputs of water (see Appendix 6, Figures B16 and B17). In terms of greenhouse gas emissions, the impact of rice cultivation stands out (Appendix 6, Figures B12 and B13), which is mainly due to high methane emissions.

The degree of processing of cereal products also has an impact on the water footprint. Preference is given to whole grain cereals, whose water footprint is lower than that of their refined counterparts. Cereal products are rich in energy and essential micronutrients. Given both the health benefits and lower environmental impact, minimally processed cereal products (such as whole grain) are preferable to the highly processed varieties (Fardet & Boirie, 2014).

5.4 Nuts and seeds

In general, the cultivation of nuts has a low greenhouse gas intensity (Figure 12), since nut trees absorb a lot of CO2. Also, nut cultivation has a low land footprint, which is comparable to that of poultry (Figure 15). The most important environmental impact category associated with nut and seed cultivation revolves around water use. The average water footprint of nuts is lower or comparable to that of beef, but higher than that of other animal protein sources (Mekonnen & Hoekstra, 2012). Moreover, 74% of the irrigated nut production is grown in regions under water stress (Figure 17). Nuts are considered a healthy and good source of protein and other nutrients. It is not advisable to replace meat one-to-one (in the number of grams) with nuts and seeds, but rather by a variety of nuts, seeds, and legumes.

However, there is a large difference in water footprint between different types of nuts (Downs & Fanzo, 2015). In particular, the cultivation of cashew and almond nuts requires a lot of water. Peanuts or groundnuts (actually legumes rather than nuts) on the other hand have a low water footprint (Vanham, Mekonnen, & Hoekstra, 2020).

[44] Of course it makes a difference what kind of energy is used. This is beyond the scope of this report.

Little data is available on the environmental impact of seeds (e.g. sunflower seed, pumpkin seed, sesame seed, and flaxseed). This category of foodstuffs is often included in a list, which makes it difficult to determine the impact of seeds per se. The little data available shows that seeds in some cases have a lower water footprint compared to nuts (Figure 32) (Mekonnen & Hoekstra, 2011).

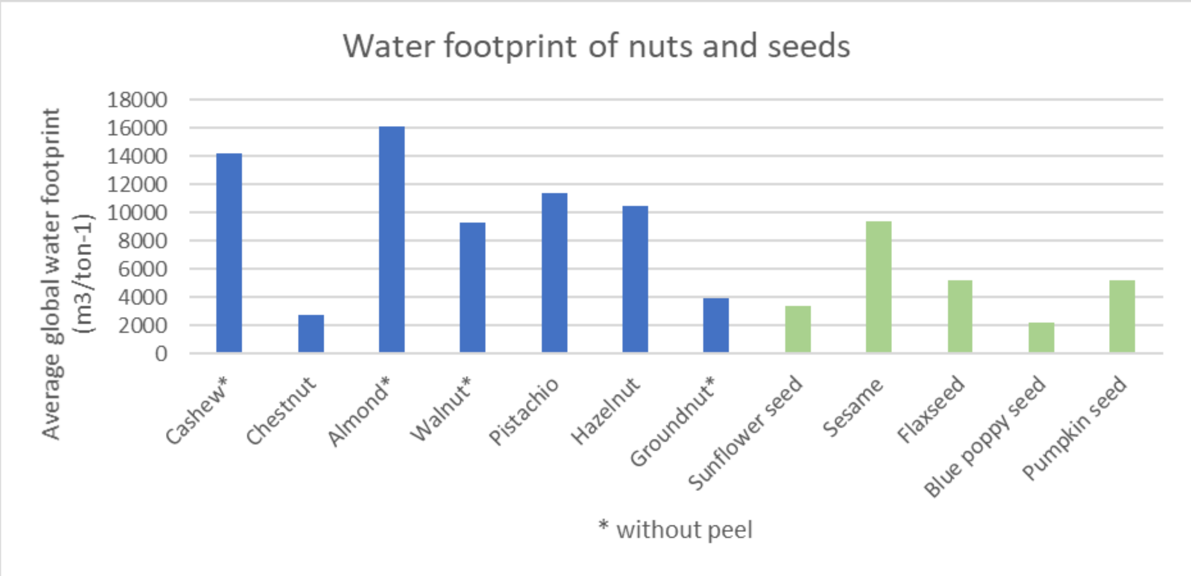


Figure 31: Water footprint of nuts and seeds (based on Mekonnen & Hoekstra, 2011)

5.5 Vegetable oils and butter

A comparison of the ecological footprint can give an idea of the environmental sustainability of different types of fat. Vegetable oils generally have a better fatty acid composition (palm and coconut oil excepted) and a lower environmental impact than butter (van Dooren et al., 2017). A distinction can be made between different types of oils. For example, olive oil has a fairly high water footprint (see also Appendix 5, B10) compared to more local types of oil such as linseed oil, rapeseed oil, or corn oil (Mekonnen & Hoekstra, 2011). Also in terms of land use and greenhouse gas emissions, olive oil has a higher impact than, for example, rapeseed and sunflower oil (see Appendix 5, Figures B8 and B9).

Margarine has long been an alternative to butter. A study compared the environmental impact of these two products. An LCA analysis showed that margarine has a lower environmental impact across almost all environmental impact categories, especially for the carbon footprint, land use, and the risk of acidification and eutrophication. Only in the category 'potential for photochemical ozone pollution' does margarine score significantly higher than butter. This is mainly due to a step in the production process (mixing with hexane) to extract fat from the vegetable source (Nilsson et al., 2010).

5.6 Animal protein products

In the discussion at the dietary level, it became clear that less consumption of animal products can make a significant contribution to health and reduce environmental impact. But also within the group of animal products, better choices can be made. After all, there is a difference in the environmental impact between the various product groups.

5.6.1 Meat[45]

There is a trade-off between environmental impact categories and specific animal products. From a climate point of view or taking water use into account, poultry is preferable to pork. Pork is preferable to beef or lamb. Replacing beef with pork and poultry has a positive effect on reducing environmental impact (Röös, Garnett, Watz, & Sjörs, 2018). Optimal use of grasslands requires the use of grazing animals (both for meat and dairy), provided that the number of livestock is adapted to the local environmental space. A certain level of grazing animal husbandry is also preferable from a circular perspective.

As a result, it is not possible to make an unequivocal choice between one species and another. What does become clear is that every type of meat has its place in a healthy and environmentally responsible diet. The consumption level must then be reduced to such an extent that it remains within the local and global ecological carrying capacity.

In addition to better choices between animal product categories, portion sizes can also be considered. Smaller portion sizes contribute to a lower environmental impact of the diet.

5.6.2 Fish

For health reasons, it is recommended to eat (fatty) fish once or twice a week, because of their contribution to the intake of omega-3 fatty acids. However, the consumption of fish brings up a trade-off between environment and health. Excessive consumption of fish encourages over-fishing and the additional problem of bycatch of some species. This leads to a loss of biodiversity. Despite the wide variety of edible fish species, consumption is dominated by a few species (including cod and salmon). This puts great pressure on just a few fish species (de Valk et al., 2016).

Fishing methods are also important for reducing the level of bycatch. Fish caught in a sustainable manner make a positive contribution to reducing the loss of biodiversity. In addition, overfishing is avoided. Sustainably caught fish is labeled with the Marine Stewardship Council (MSC) label[46] (Vanhee & Roels, 2018).

Farmed fish does not necessarily score better than caught fish. In order to farm fish, feed is needed: fishmeal, fish oil, or fish feed. There is a difference in impact with

[45] For a detailed discussion, see 4.1.2

[46] The MSC and ASC labels are monitored by various independent organizations. However, in 2021 these certification systems for sustainable fish catching and farming have become controversial.

farmed fish between hunting fish species and herbivorous fish species, with herbivorous fish species having a lower environmental impact (Bergsma et al., 2014). This in turn has an impact on biodiversity in seas and oceans or on land use for growing plant food. This is therefore comparable to feeding animals with products that are also suitable for human consumption. Furthermore, the high use of antibiotics, especially in Asia, and pesticides in fish farming can lead to water pollution and antibiotic resistance (Gezondheidsraad, 2011; Lulijwa, Rupia, & Alfaro, 2020). Just as for caught fish, there is a sustainability label for farmed fish: the Aquaculture Stewardship Council (ASC) label. When we look at the protein content, farmed fish scores on the same level as poultry in terms of greenhouse gas emissions (Figure 12). The land use of farmed fish is very low (Figure 15).

The emphasis should therefore be on (local) seasonal species that are not overfished and that are caught in a sustainable manner or farmed in an environmentally friendly manner. Over half of the Flemish people (56%) indicate that they already take this into account and do not purchase any endangered or overfished fish species (GfK, 2018a). Sales of MSC and ASC certified fish are indeed steadily increasing. The combined market share of MSC and ASC products is estimated to be around half of the total Belgian home consumption (Vanhee & Roels, 2018).

5.6.3 Eggs

The impact of eggs in terms of greenhouse gas emissions (Figure 12), land use (Figure 15), and water footprint (Table 5) is slightly more advantageous compared to poultry meat, but considerably more advantageous compared to beef and pork (looking at the protein content) (Bergsma et al., 2014). Eggs, therefore, seem to be an interesting meat substitute because of their high protein quality and are also cheap.

5.6.4 Milk and milk products

Milk and cheese have a relatively high impact when greenhouse gases (Figure 12), land use (Figure 15), and water use (Figure 17) per 100 g of protein are considered. These products have a higher environmental impact than pork and poultry. In this respect, cheese always has a higher impact than milk, which is not illogical given that many liters of milk (9 to 10 liters) go into one kilogram of cheese and extra production steps are required (Bergsma et al., 2014).

Again, the same land-use trade-off plays a role here concerning the other environmental impact categories. Through livestock, grasslands not suitable for arable farming and biomass flows not suitable for human consumption can be used for dairy production. In addition, the relative impact decreases when breeds are used for simultaneous production of both dairy and meat (so-called dual-purpose breeds).

Milk and milk products such as cheese are sometimes seen as a meat substitute in a vegetarian dish or diet. However, milk or cheese as meat substitute has a limited potential to reduce the environmental impact of the diet (Röös et al., 2018).

5.6.5 Insects

Insects are often seen as a new and sustainable source of protein for human consumption. However, consumer acceptance is still low (Onwezen, Bouwman, Reinders, & Dagevos, 2021). Breeding insects can have important advantages in terms of land and water use, greenhouse gas emissions (see Figure 23) and requires little feed due to high feed conversion (see Figure 16). In addition, insects can be grown on biomass waste streams such as rice straw and coffee pulp (van Diepen et al., 2018; van Huis & Oonincx, 2017). Insects can also serve as feed for fish or animals, for example (van Huis & Oonincx, 2017). However, the environmental effects of large-scale cultivation are still under investigation. It is therefore too early to make general statements on this (Berggren, Jansson, & Low, 2019).

5.7 Vegetable and alternative protein products

In the context of protein consumption with a lower environmental impact, plant-based and alternative protein-rich products are considered. As already indicated in 3.1.1.2, sufficient variation and combination with plant protein sources are important to achieve an adequate intake of amino acids. This is especially important when eating predominantly plant-based diets. Below, we look more closely at some foods that are put forward as meat substitutes.

5.7.1 Legumes

Vegetable protein sources such as pulses generally have a lower environmental impact than animal protein sources and are therefore a good and environmentally friendly alternative (see also 3.1.2). The advantage of pulses is that they can be stored for a long time and transport does not require refrigeration or speed. Legumes are an important raw material for vegetable meat substitutes. On the one hand, they have the potential to improve soil quality and reduce the use of nitrogen in artificial fertilizers (which have a major climate impact) because they fix nitrogen in the soil (Jensen, Carlsson, & Hauggaard-Nielsen, 2020; Santo et al., 2020).

The use of pesticides is also a concern in the primary production of plant protein sources. In the United States, soybean production is said to be the largest contributor to increased pesticide use, whether grown for animal or human consumption (Santo et al., 2020). Reduced use of pesticides and fertilizers contributes positively to biodiversity and improved soil quality (Santo et al., 2020).

Within the category of legumes, soy occupies a controversial place, both in terms of health and the environment. Soy is an ingredient that is very similar to animal protein sources in terms of protein content and quality and is therefore considered an excellent meat substitute. However, soy is often associated with many environmental issues. We will therefore take a closer look at this specific product.

Soy

In the category of legumes, soy has a negative reputation, due to its link with deforestation in mainly rainforest areas (Bergsma et al., 2014; de Valk et al., 2016;

Van Mierlo, Rohmer, & Gerdessen, 2017). Soy is both consumed directly by humans (whether processed or not) and used as animal feed. A large proportion of soy (in the form of soybean oil, beans, and meal) is processed as feed for chickens, pigs, and cattle. Given the relative inefficiency of converting plant proteins into animal proteins (see also 3.1.2.3), it is more efficient to consume the edible fraction directly (processed into tofu, soy drinks, etc.) (Van Mierlo, Rohmer, & Gerdessen, 2017). Only the non-edible residual flows are best used for feed. In recent years, socially responsible soy cultivation (Round Table on Responsible Soy Association) has been promoted to address concerns about soy production. In addition to social and broader environmental aspects, soy of certified origin also takes deforestation into account (Bergsma et al., 2014). At present, soy for human consumption mostly comes from Europe or North America (Westhoek, 2019). In Flanders, moreover, steps have been taken in recent years towards local soy cultivation (for human consumption).

5.7.2 Plant-based dairy substitutes

Dairy substitutes such as those based on soy, almonds, cashew, rice, and oats are relatively new on the market. For many of these products, there is little data available on their long-term health effects. The nutritional qualities of these plant-based dairy substitutes are often inferior to those of milk. Only soy-based dairy substitutes come close nutritionally in terms of protein content and quality. Therefore, these products are often nutritionally enriched with vitamins (B2, B12, and D) and minerals such as calcium (Röös et al., 2018).

When plant-based dairy substitutes are brought to a nutritionally equivalent level compared to milk, most plant-based products have a clear environmental advantage (Ercin et al., 2012; Röös et al., 2018). Vegetable dairy substitutes based on almonds and cashew will have a higher impact in terms of water use (Figure 17). In terms of greenhouse gas emissions, land use, and water use, a soy-based dairy substitute represents a much lower impact compared to milk (Poore & Nemecek, 2018; Smetana et al., 2015).

5.7.3 Microbial or Single Cell Protein

For some time now, microbial proteins or Single Cell Protein have been considered an important niche within alternative protein sources. A microbial protein is the protein-rich biomass of micro-organisms such as fungi, bacteria, and microalgae. This group of proteins is very large in number and also very diverse. A large number of species can be used as a food source. In addition to high-quality protein, these protein sources also contain favorable quantities of carbohydrates, fats, vitamins, and minerals. Microalgae and fungal protein (also called mycoprotein) are already being used in meat substitutes. A well-known product containing fungal protein is Quorn® (van Diepen et al., 2018).

There is little data available on the environmental impact of these products. In Figure 24, protein fungus and algae are included in the overview as a protein alternative with a climate impact comparable to that of the other alternative protein sources. The same applies to land use (van Diepen et al., 2018).

6 Limitations of this report

This report has been able to bring together many insights about health and the environmental impact of food. Of necessity, the scope has been limited in some respects.

1. As mentioned earlier, the focus on the environment lies within the broader sustainability spectrum. The environment is one of the pillars of sustainability, alongside social and economic aspects. These aspects are of equal importance and deserve to be explored in greater depth. Animal welfare, a fair price for each link in the food system, cultural acceptability, food security, fair trade ... are just some of the aspects we have not been able to cover in this report. This report builds on the work of developing the food triangle (published in 2017) and thus, with this underpinning text, receives an environmental follow-up. The authors call on the relevant actors to continue the exercise and move towards further integration of the different aspects of food.

2. In this report, many figures have been brought together, but some perspectives have been underexposed. Statements have mainly been made about the general relationships between different product categories. The difference in environmental impact between the same products from different production systems has not been addressed, or only to a very limited extent. Concepts such as genetically modified organisms, intensive or extensive cultivation, organic cultivation, agro-ecological cultivation, and the associated discussions on land sparing or land sharing were beyond the scope of this report.

3. Labels are only discussed to a very limited extent in this report. Labels come in many forms and provide information on various subjects, even within the category of environmental labels, for example. Within the scope of this report, the aspect of labels could not be dealt with sufficiently in-depth. This can be elaborated as a next step.

4. In this report, only conclusions on the population level are made, with a view to recommendations for the general population. In the next phase, the translation will be made to practical recommendations for the nutrition triangle. Here too, the recommendations apply at the population level. For individual recommendations, e.g. for medical reasons, for losing weight, with pregnancy and breastfeeding, young children (up to 4 years of age), intense sport, eating disorders, etc., advice tailored to the individual needs of the individual is recommended by a professional. For this purpose, you can consult a dietician, your GP, Kind en Gezin or the Eetexpert helpdesk.

7 General conclusion

Food is an important part of our society. Food is life, pleasure, and a cultural fact. In Flanders, we have sufficient food, of good quality and at a relatively affordable price for most people. This report focuses on the consumption of food at the level of dietary patterns. It is not only important where our food comes from and how it is produced, but also what and how much we eat is of great importance. Today's diet poses some challenges to our society, both in terms of health and the environment. Working on better diets is important to ensure that we have enough healthy food available in the future.

In 2017, the food triangle was thoroughly revised based on evolving scientific insights in the field of nutrition and health. The environmental impact of our food was considered for the first time but lacked a robust foundation. This report remedies this shortcoming and offers a nuanced scientific basis for the environmental impact of the diet. Where possible, Flemish figures have been used; where necessary, studies with data relevant to Flanders have been used. Scientific knowledge about the environmental impact of food is still developing, but that does not prevent us from seeing some clear insights and messages.

When we look at diet, in most cases environment and health go hand in hand. We have been able to substantiate this by starting from the starting points that were formulated in 2017. The principles were confirmed and are:

- achieving a balanced protein consumption;
- Avoiding food waste;
- limiting products with a high energy density and low nutritional value (empty calories for short);
- avoiding over-consumption.

Eating according to the food triangle is therefore not only good for you, but it also reduces the environmental impact of the diet. Environmental experts also agree: the principles used in this report are the most important action points for consumers to reduce the environmental impact of their diet. This report provides the nuanced evidence necessary to advance these principles in pursuit of a healthy and environmentally responsible diet. The consumer should not be held solely responsible for taking up this challenge. The evolution towards healthy and environmentally responsible consumption is a shared responsibility of all actors in the food system.

This foundation shows where environment and health go together, but also points to some contradictions. Integration between environment and health is fortunately possible to a large extent, but is not self-evident and will not be in the future. It is therefore still advisable to be alert to possible contradictions. Additional research and new insights are therefore not only interesting but also necessary.

This substantiation report for environmentally responsible nutrition, together with the substantiation report for nutrition and health (2017), forms the basis for the formulation of recommendations for consumers. This work enables the full integration of health and the environment. The report with recommendations offers a concise summary of both underpinning reports and translates them into practical recommendations for the food triangle. In that sense, the reports contribute to the coherence in the recommendations from the Flemish government to assist the consumer and other actors in the food system in their search for solutions. Together we continue to work on a healthy future, for people, and the planet.

Appendix 1

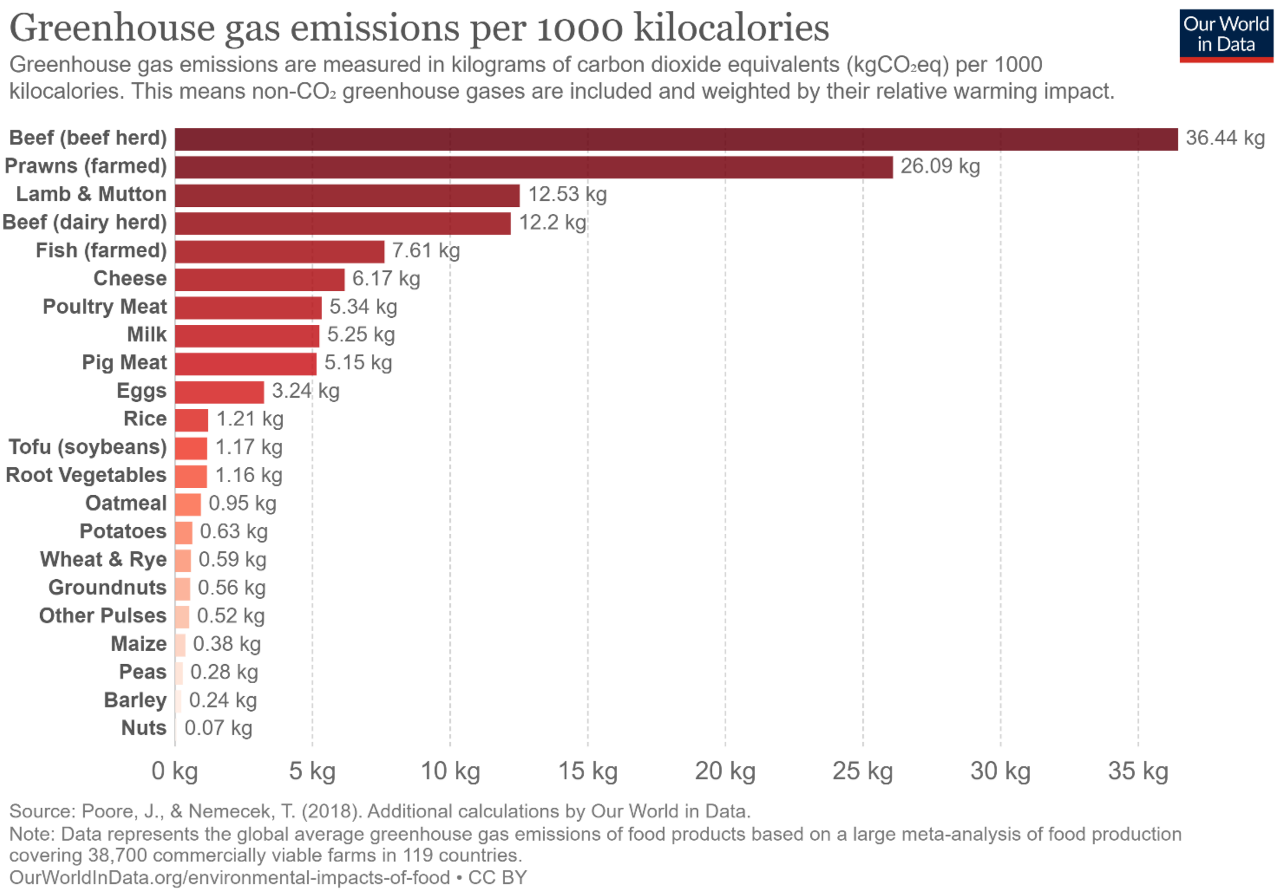


Figure B1: Greenhouse gas emissions from different categories of protein-rich foods per 1,000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

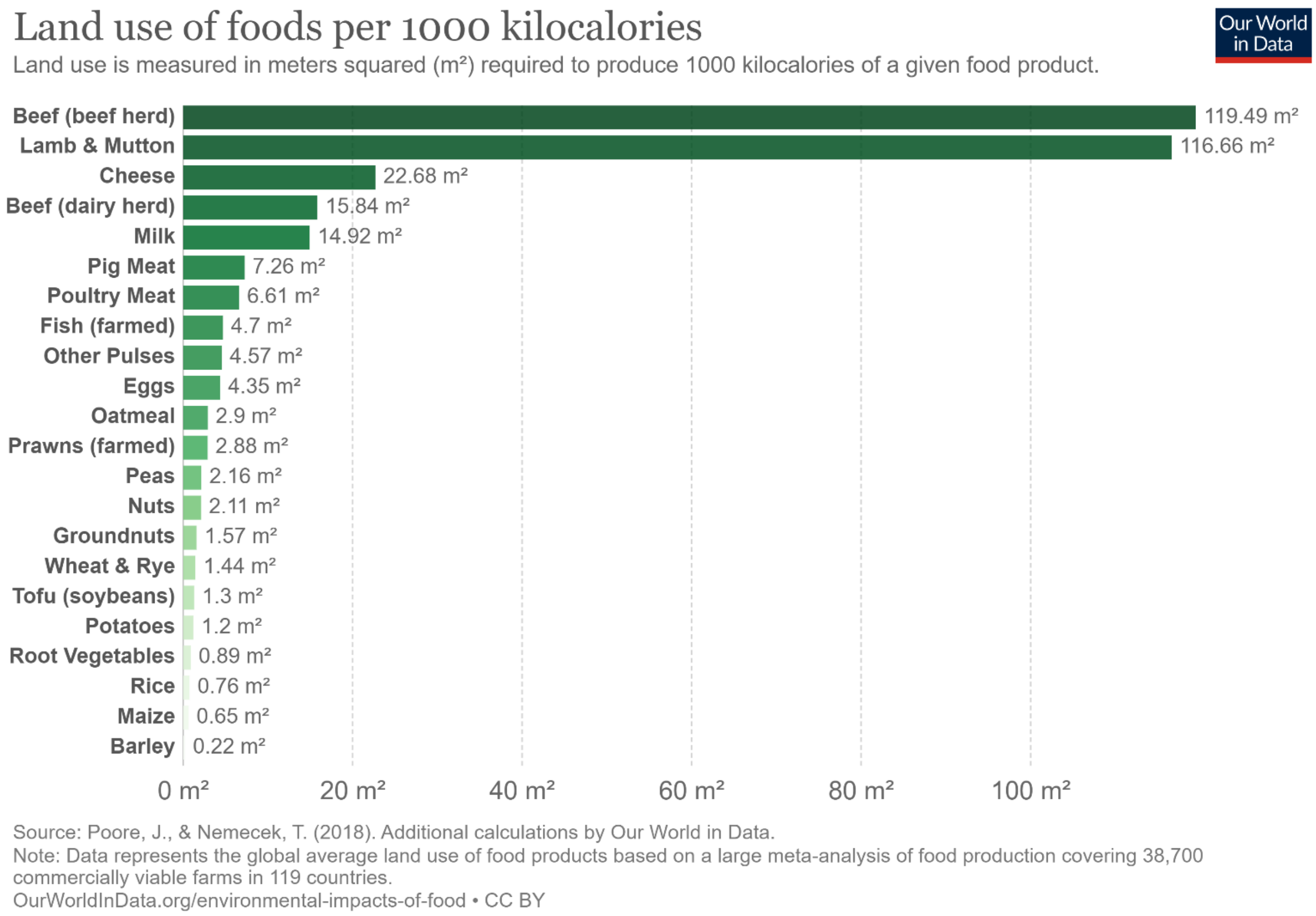


Figure B2: Land use of different categories of protein-rich foods per 1,000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

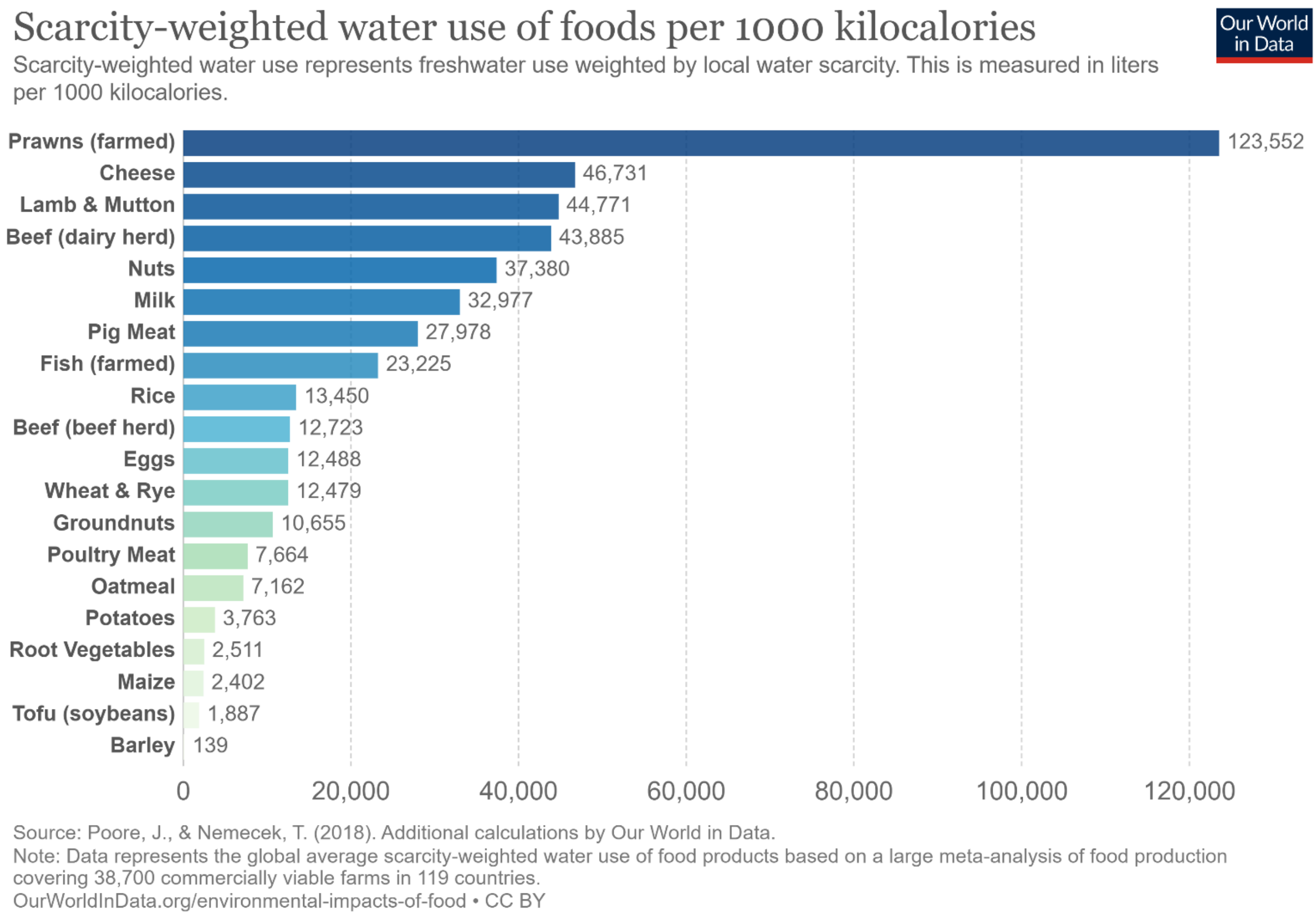


Figure B3: Scarcity weighted water use of different categories of protein foods per 1000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

Appendix 2

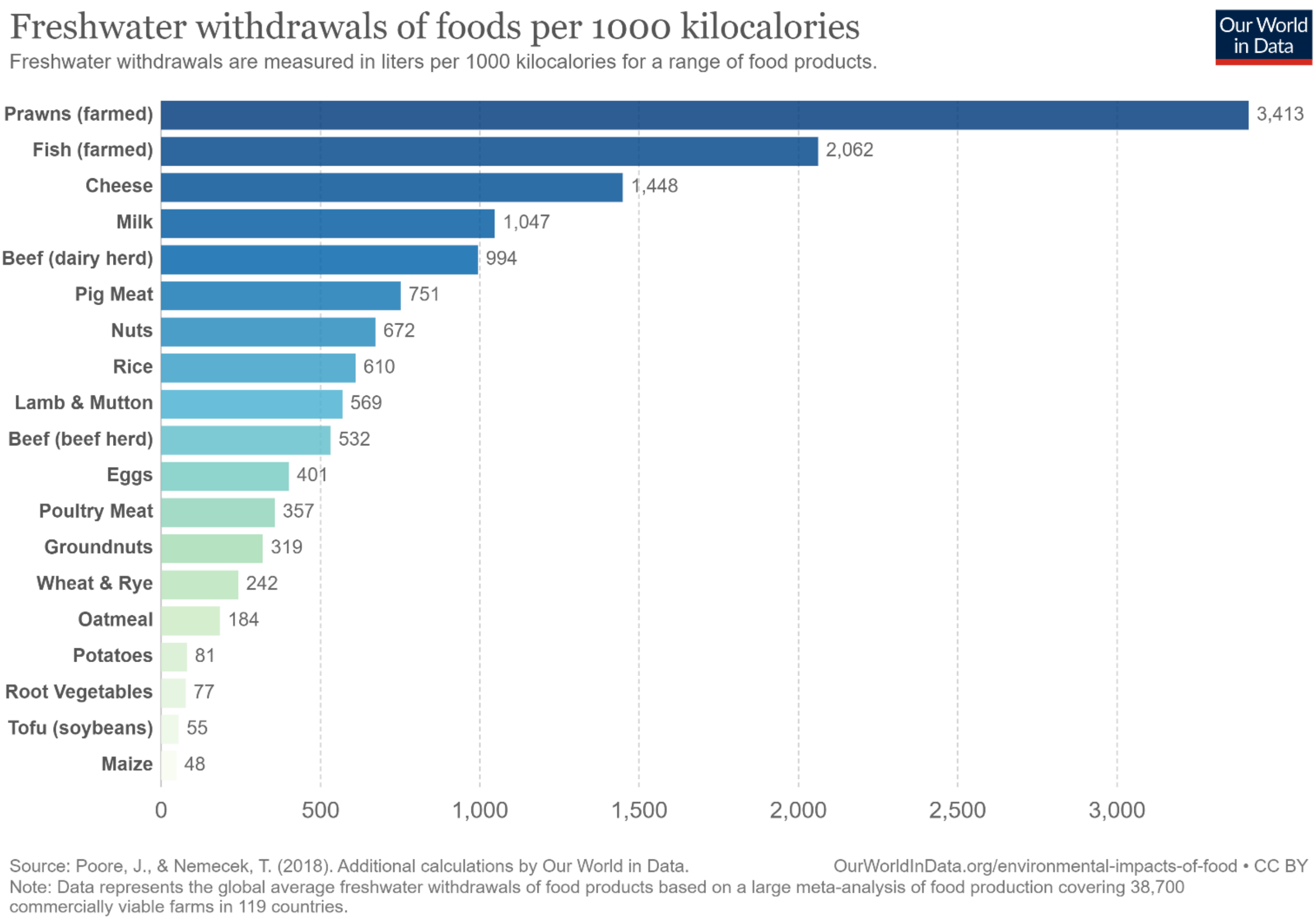


Figure B4: Freshwater use of different categories of protein-rich foods per 1,000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

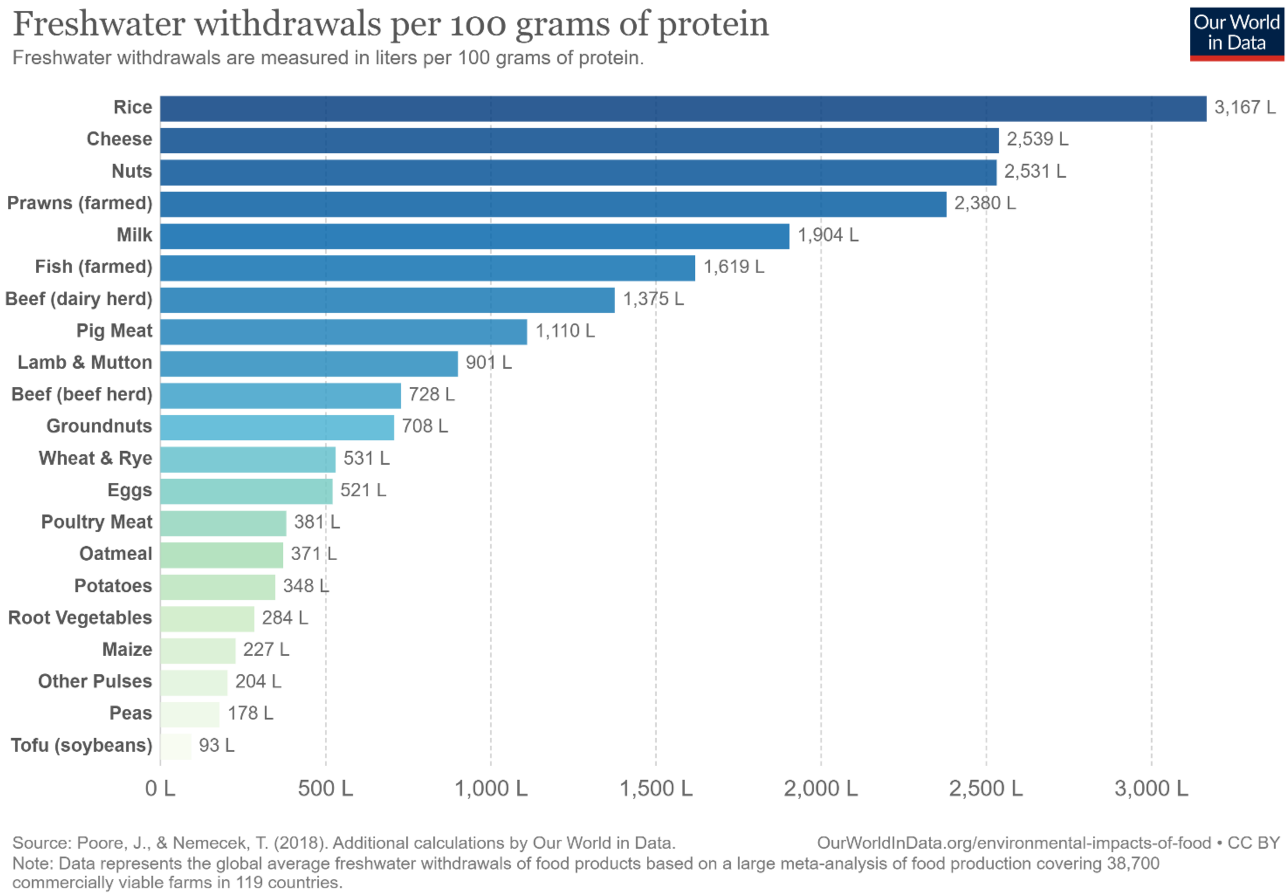


Figure B5: Freshwater use of different categories of protein-rich foods per 100 grams of protein (Ritchie, 2020 after Poore & Nemecek, 2018)

Appendix 3

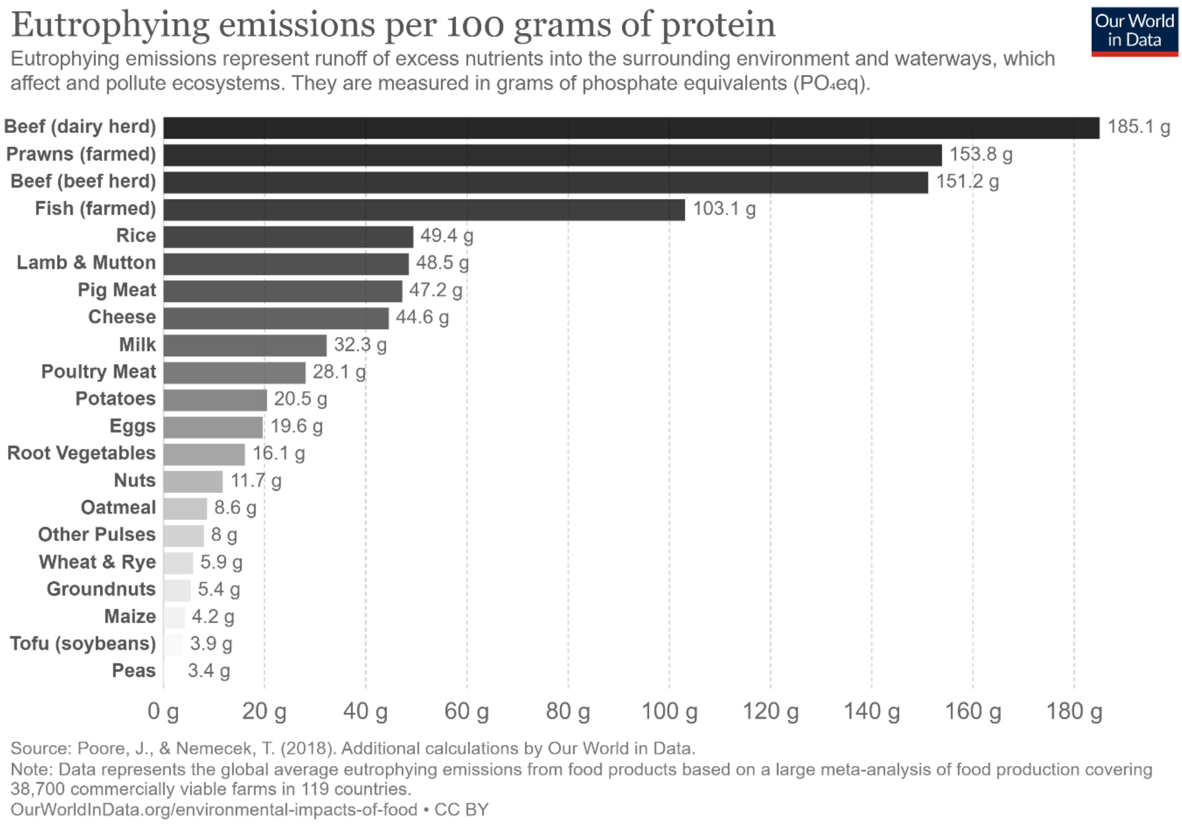


Figure B6: Eutrophying emissions per 100 grams of protein (Ritchie, 2020 after Poore & Nemecek, 2018)

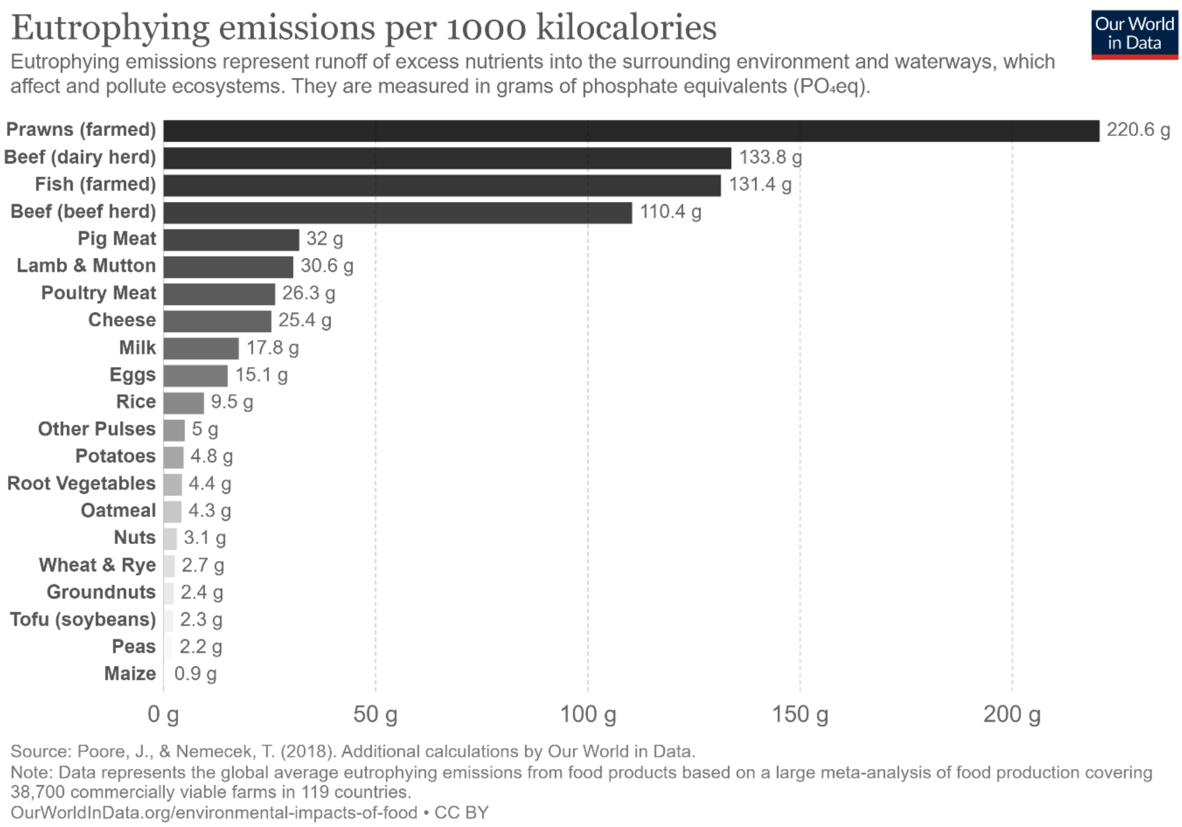


Figure B7: Eutrophying emissions per 1000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

Appendix 4

Tabel B1: Water footprint for different protein foods per in m³/ton and per unit of nutritional value (calories and protein) (Mekonnen & Hoekstra, 2012)

Food type	Water footprint (m^3/ton)				Water footprint per unit nutritional value	
	Green	Blue	Gray	Total	Calorie (liter/kcal)	Protein (liter/g protein)
Sugar crops	130	52	15	197	0,69	0
Vegetables	194	43	85	322	1,34	26
Starchy root crops	327	16	43	386	0,47	31
Fruit	726	147	89	962	2,09	180
Grains	1232	228	184	1644	0,51	21
Oil crops	2023	220	121	2364	0,81	16
Pulses	3180	141	734	4055	1,19	19
Nuts	7016	1367	680	9063	3,63	139
Milk	863	86	72	1021	1,82	31
Eggs	2592	244	429	3265	2,29	29
Chicken	3545	313	467	4325	3,00	34
Butter	4695	465	393	5553	0,72	0
Pig	4907	459	622	5988	2,15	57
Sheep/goat	8253	457	53	8763	4,25	63
Beef	14414	550	451	15415	10,19	112

Appendix 5

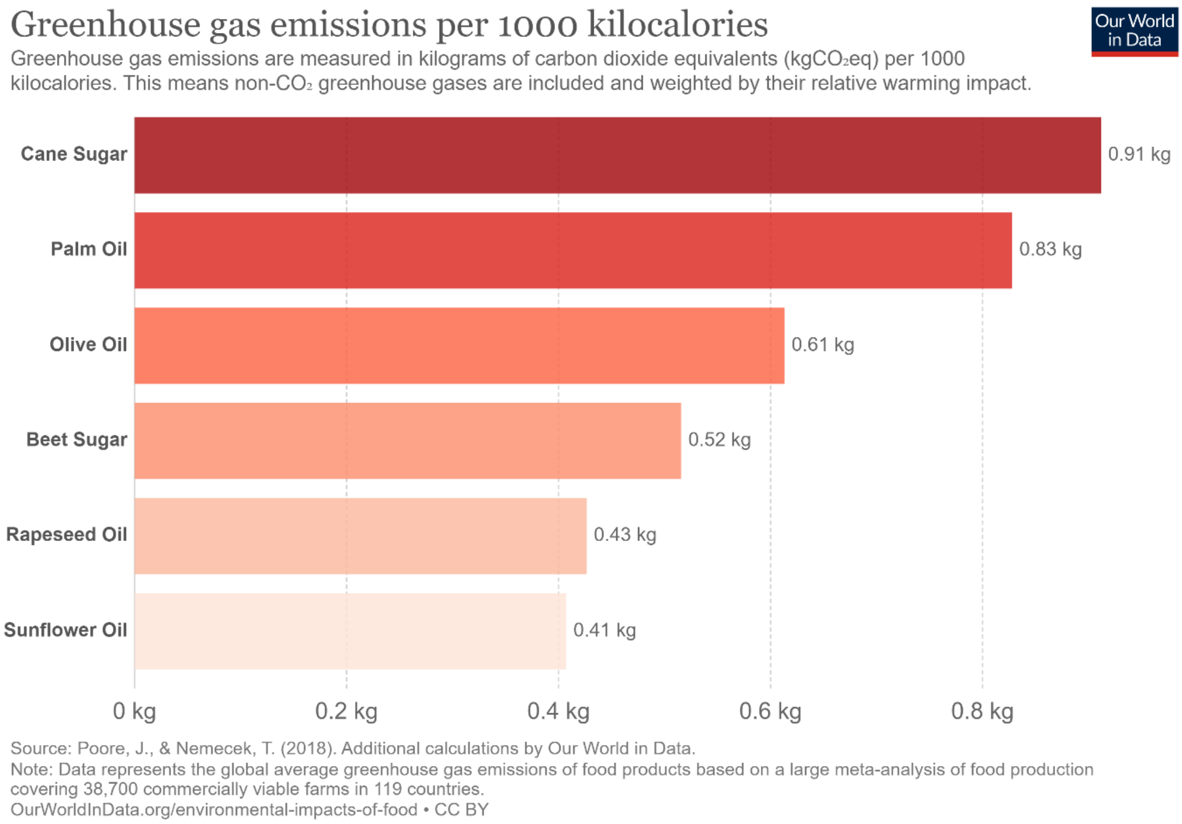


Figure B8: Greenhouse gas emissions from different sources of oil and sugar per 1,000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

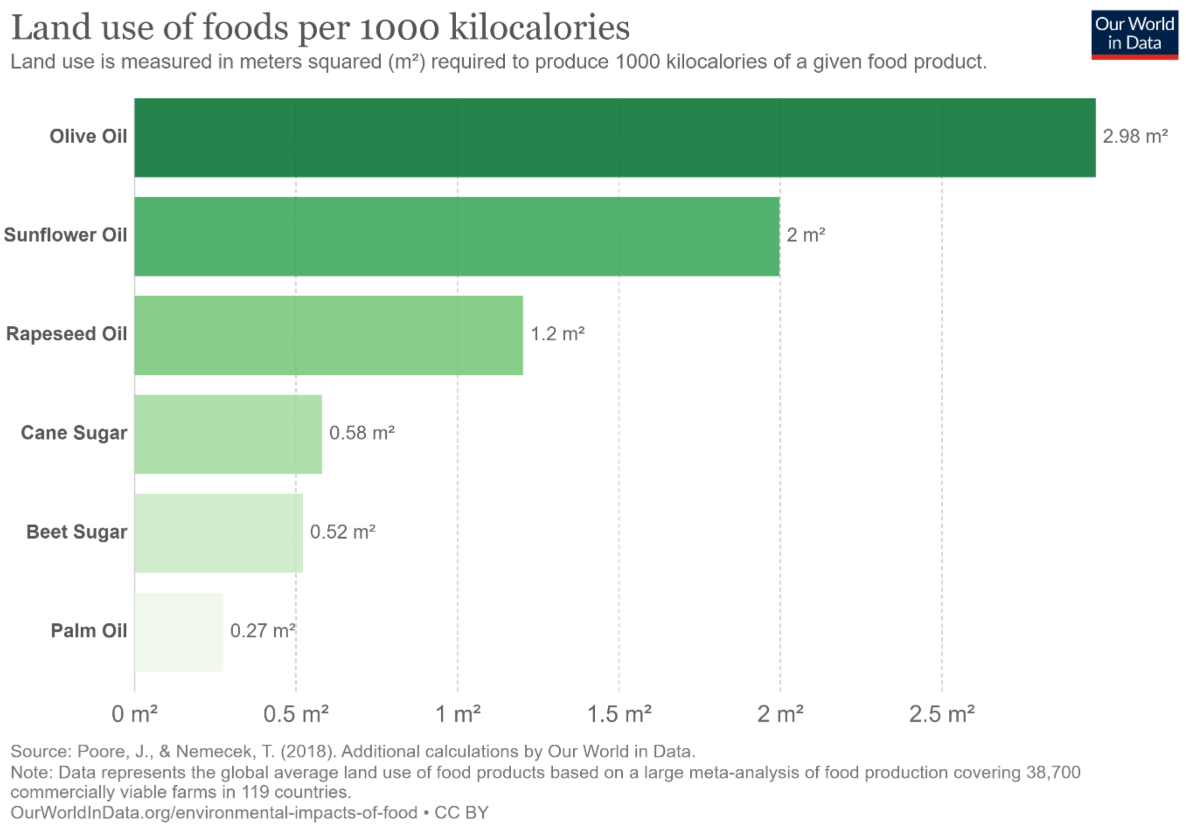


Figure B9: Land use of different sources of oil and sugar per 1,000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

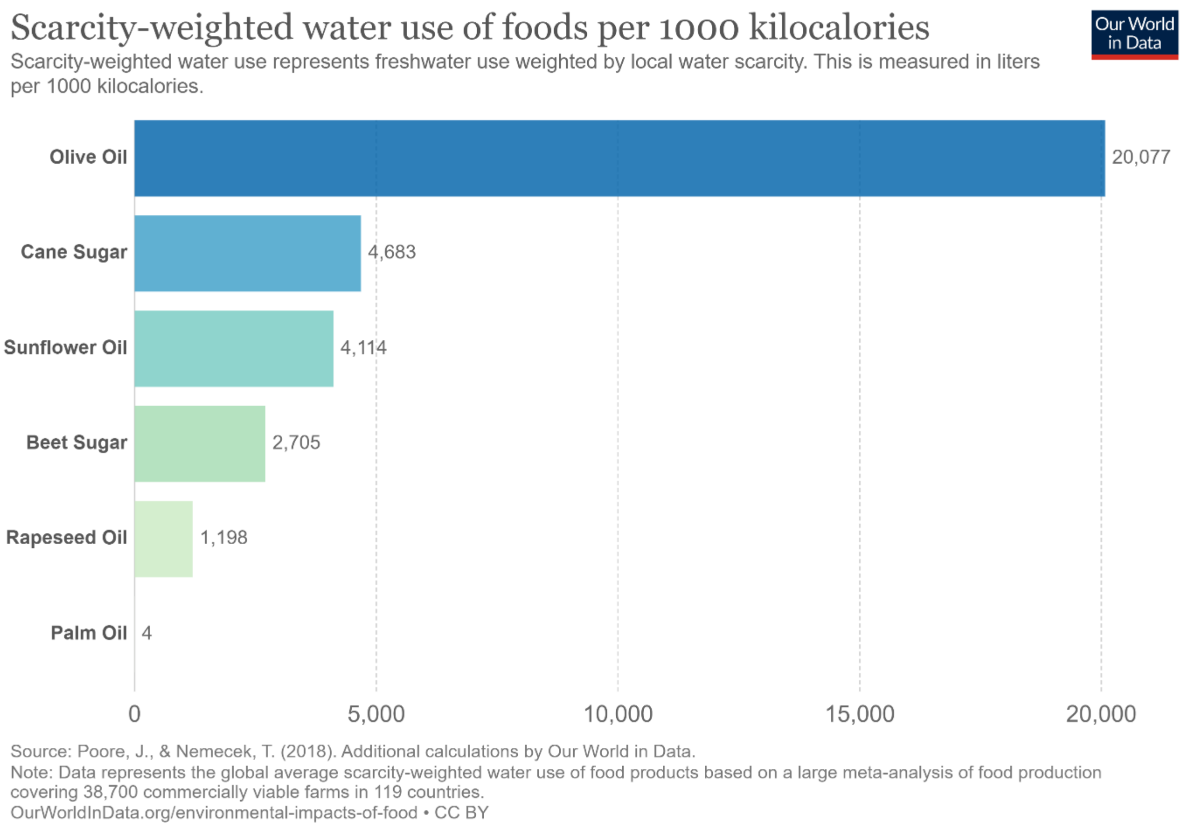


Figure B10: Scarcity-weighted water use of different sources of oil and sugar per 1000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

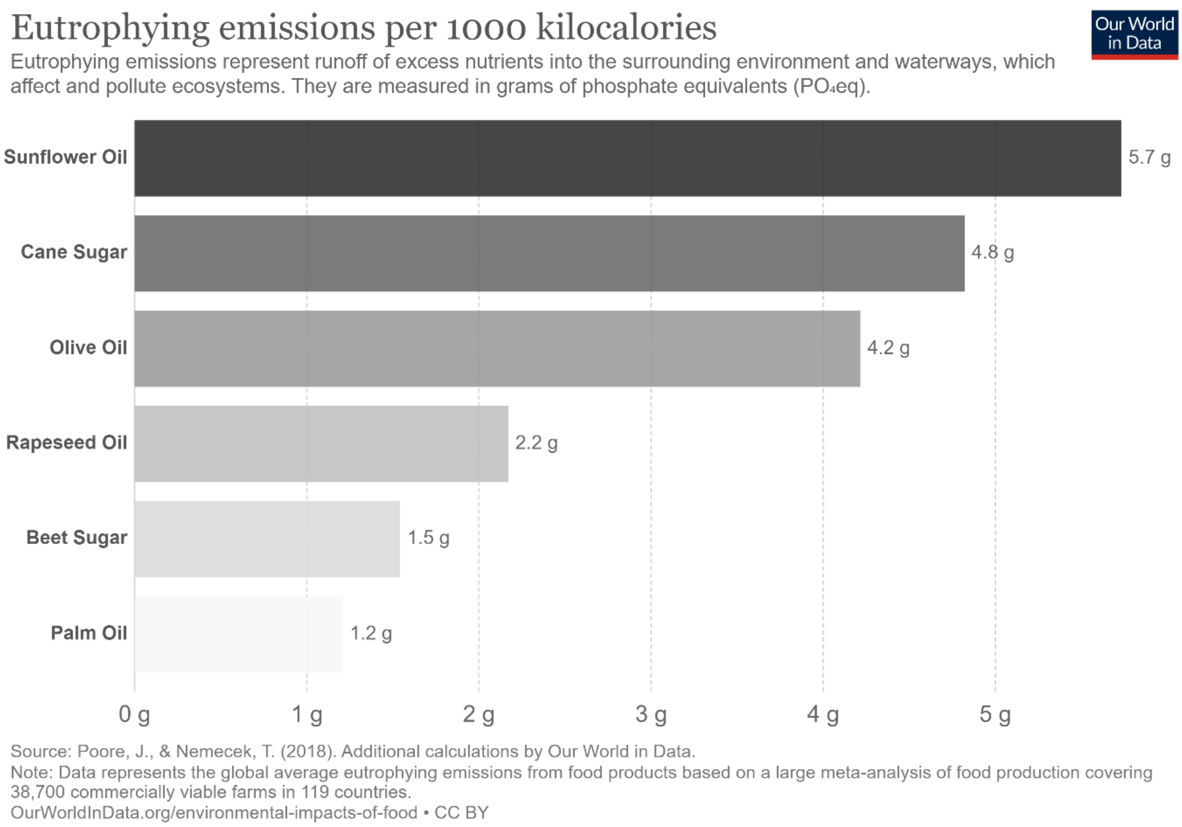


Figure B11: Eutrophying emissions of different sources of oil and sugar per 1000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

Appendix 6

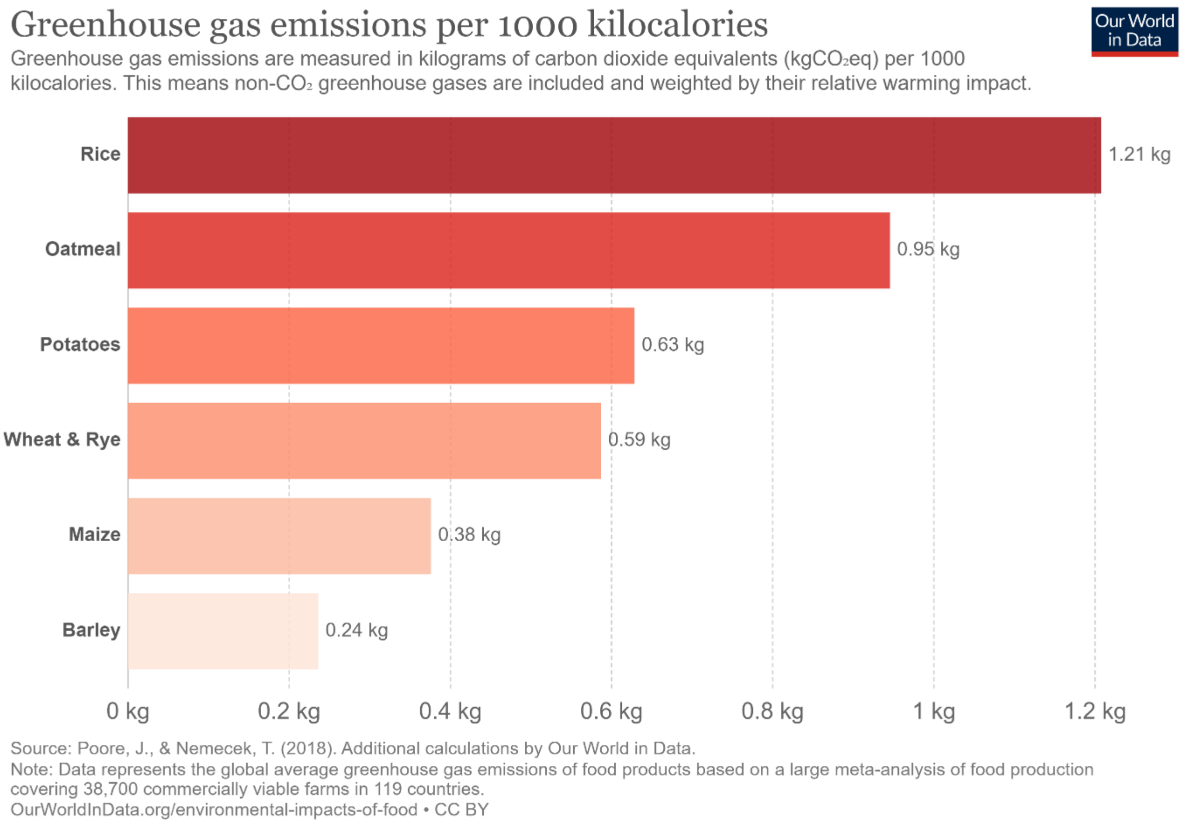


Figure B12: Greenhouse gas emissions from different grain products and potatoes per 1,000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

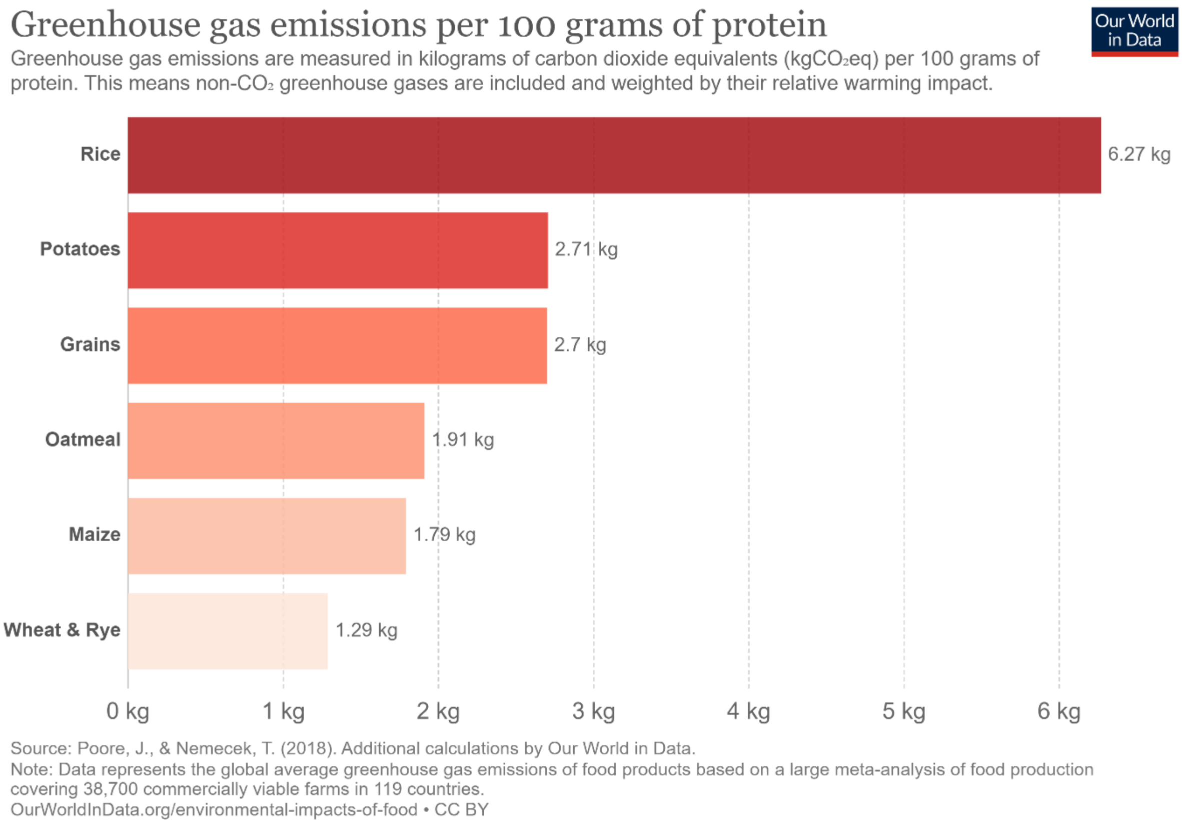


Figure B13: Greenhouse gas emissions from different cereal products and potatoes per 100 gr of protein (Ritchie, 2020 after Poore & Nemecek, 2018)

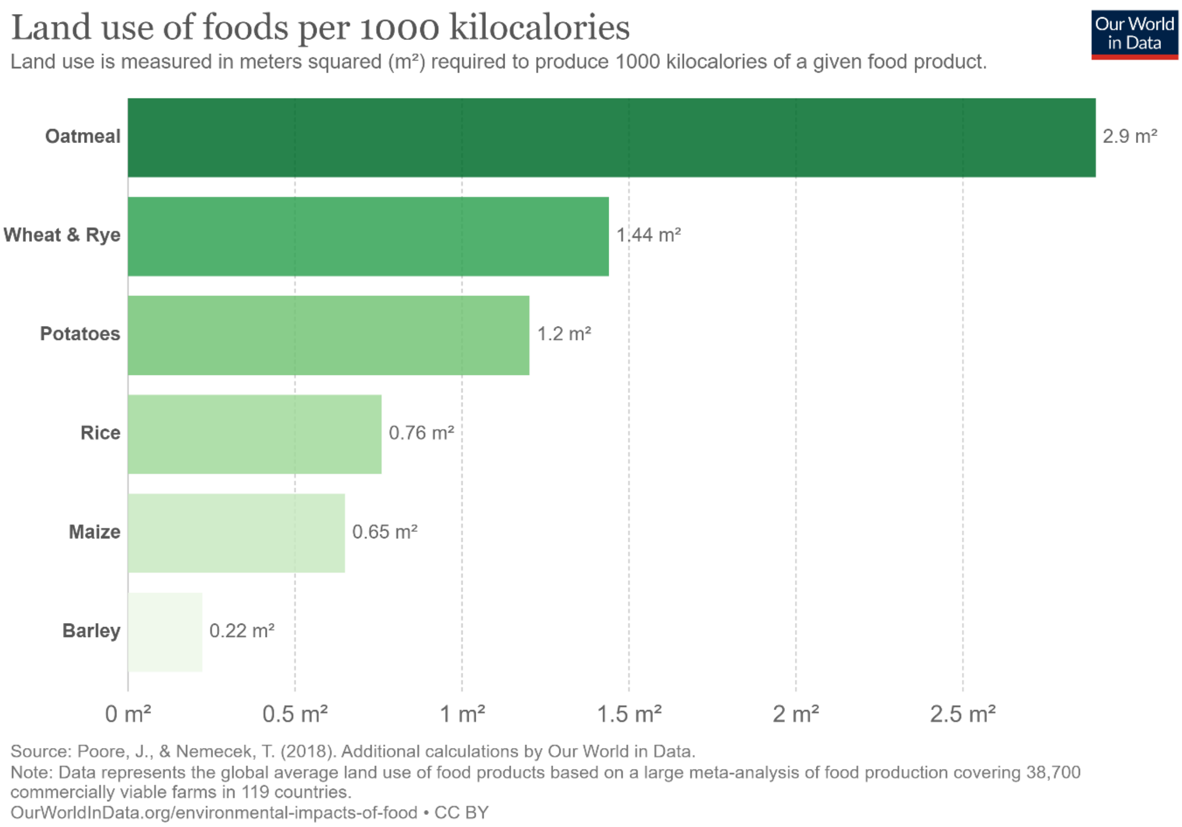


Figure B14: Land use of different cereal products and potatoes per 1,000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

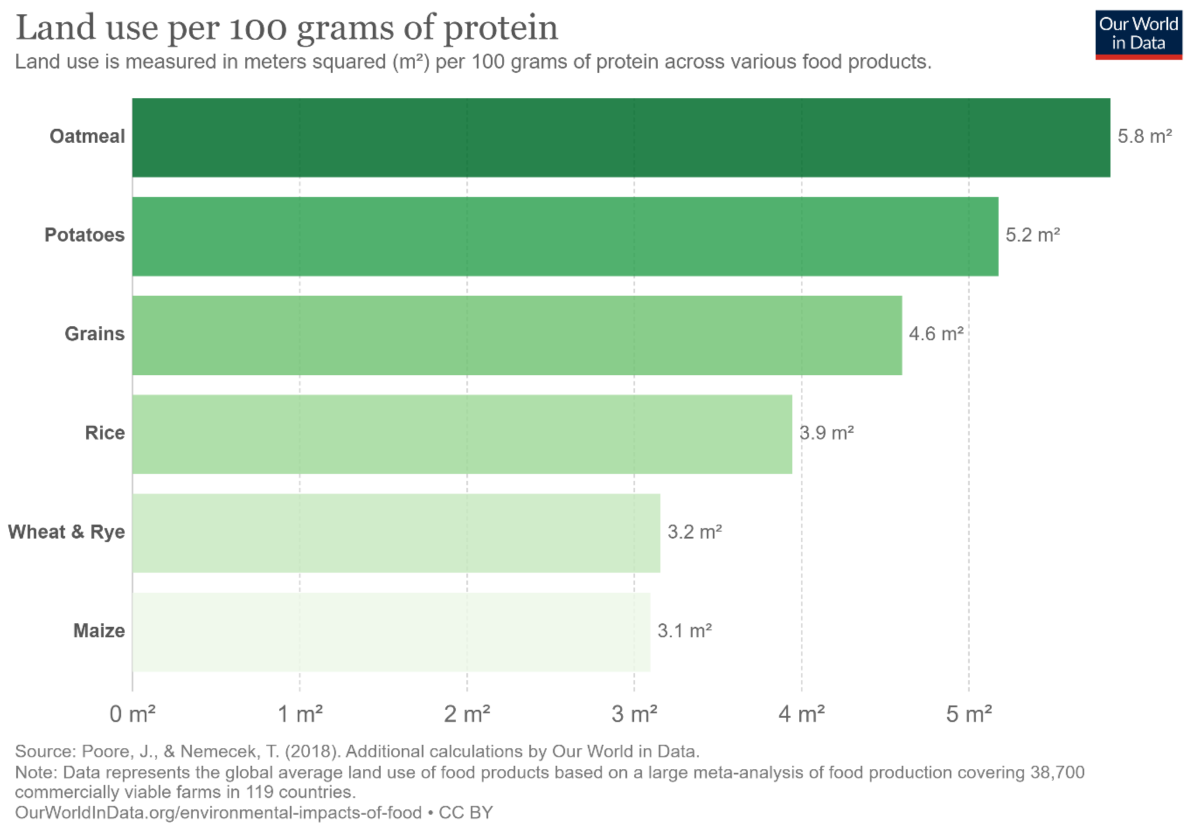


Figure B15: Land use of different cereal products and potatoes per 100 gr of protein (Ritchie, 2020 after Poore & Nemecek, 2018)

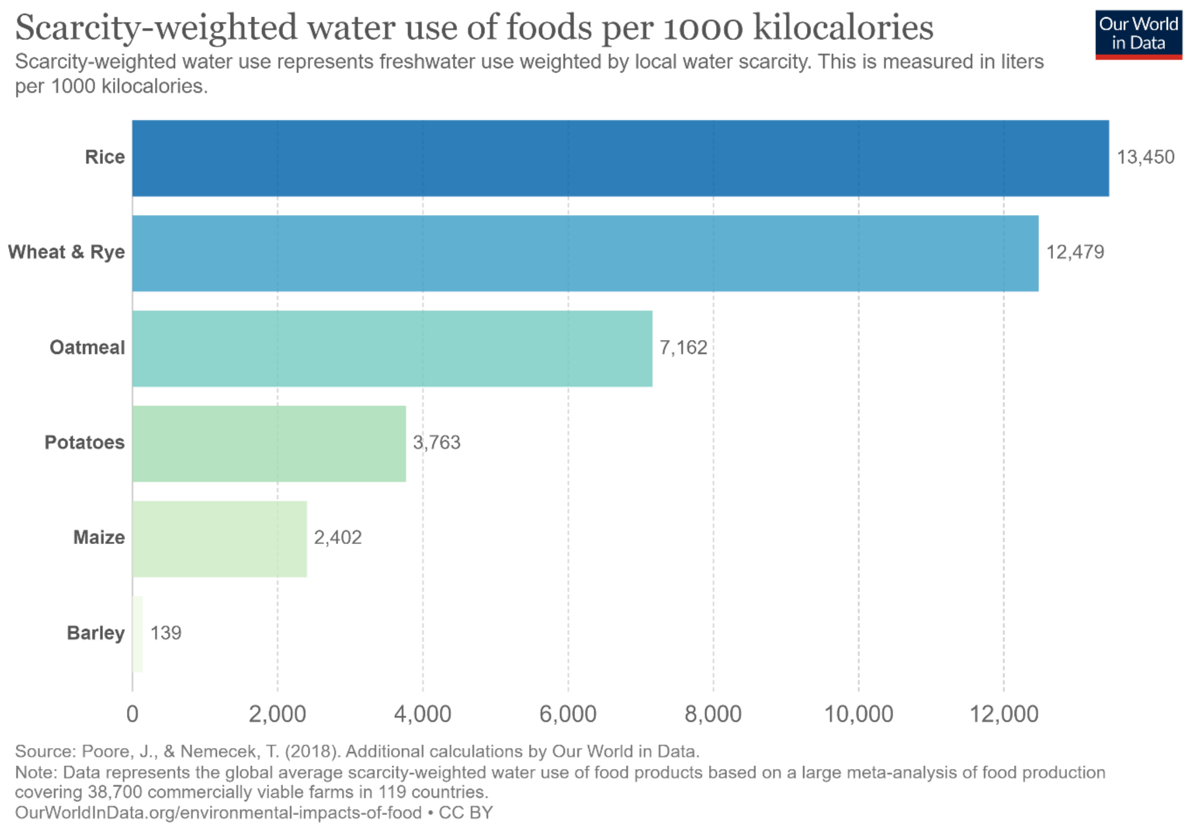


Figure B16: Scarcity-weighted water use of different cereals and potatoes per 1000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

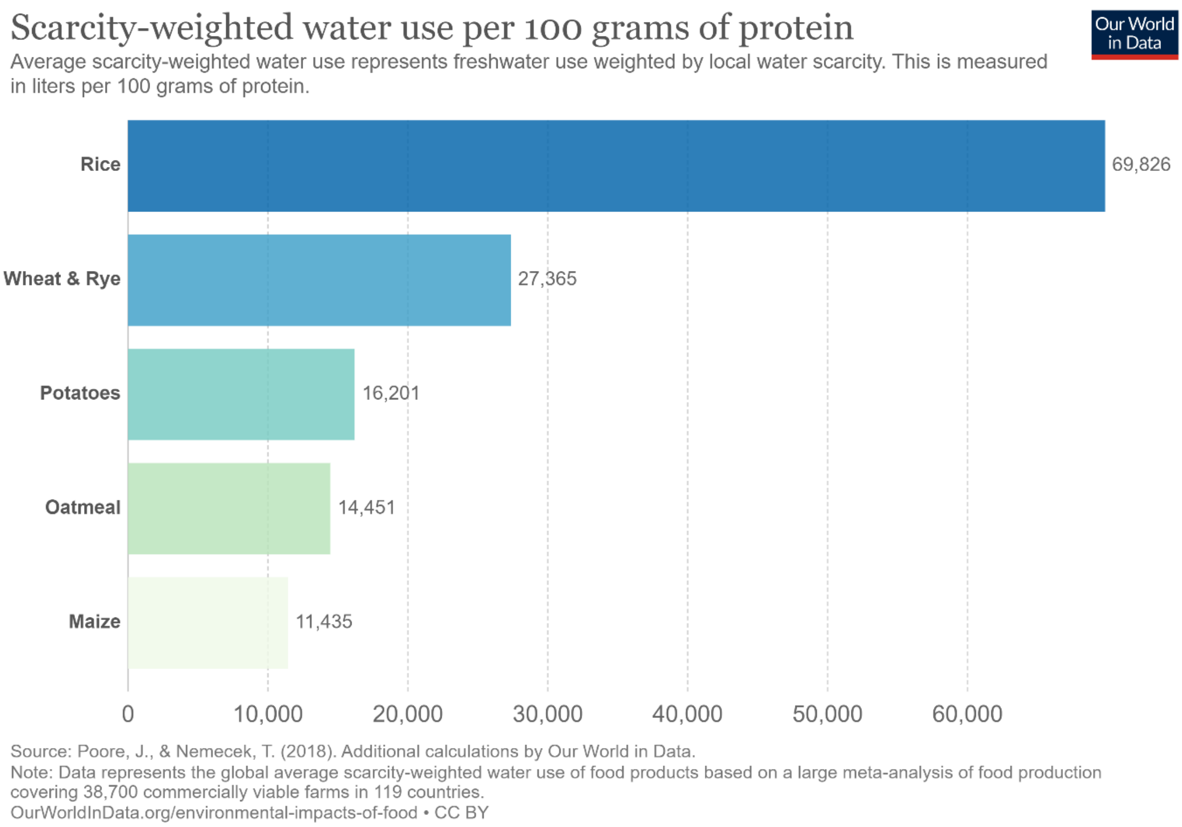


Figure B17: Scarcity-weighted water use of different cereal products and potatoes per 100 gr of (Ritchie, 2020 after Poore & Nemecek, 2018)

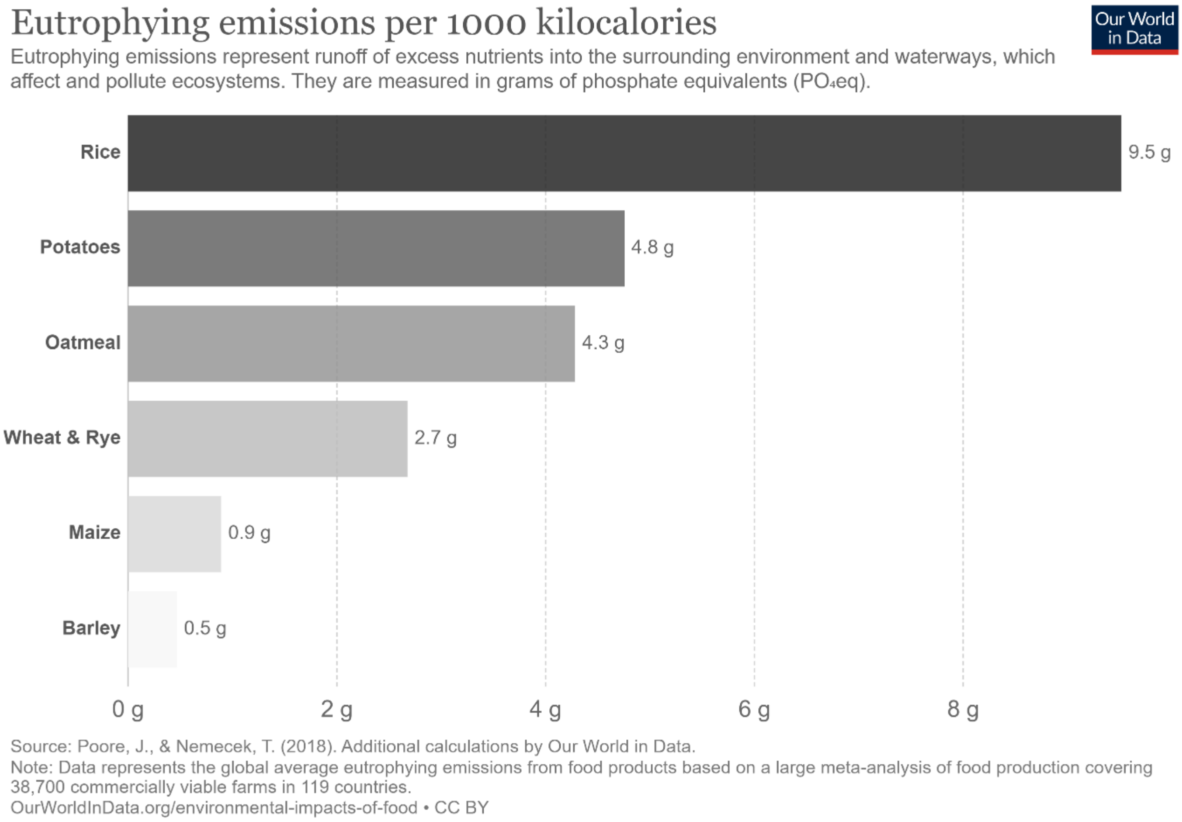


Figure B18: Eutrophying emissions from different cereal products and potatoes per 1000 kilocalories (Ritchie, 2020 after Poore & Nemecek, 2018)

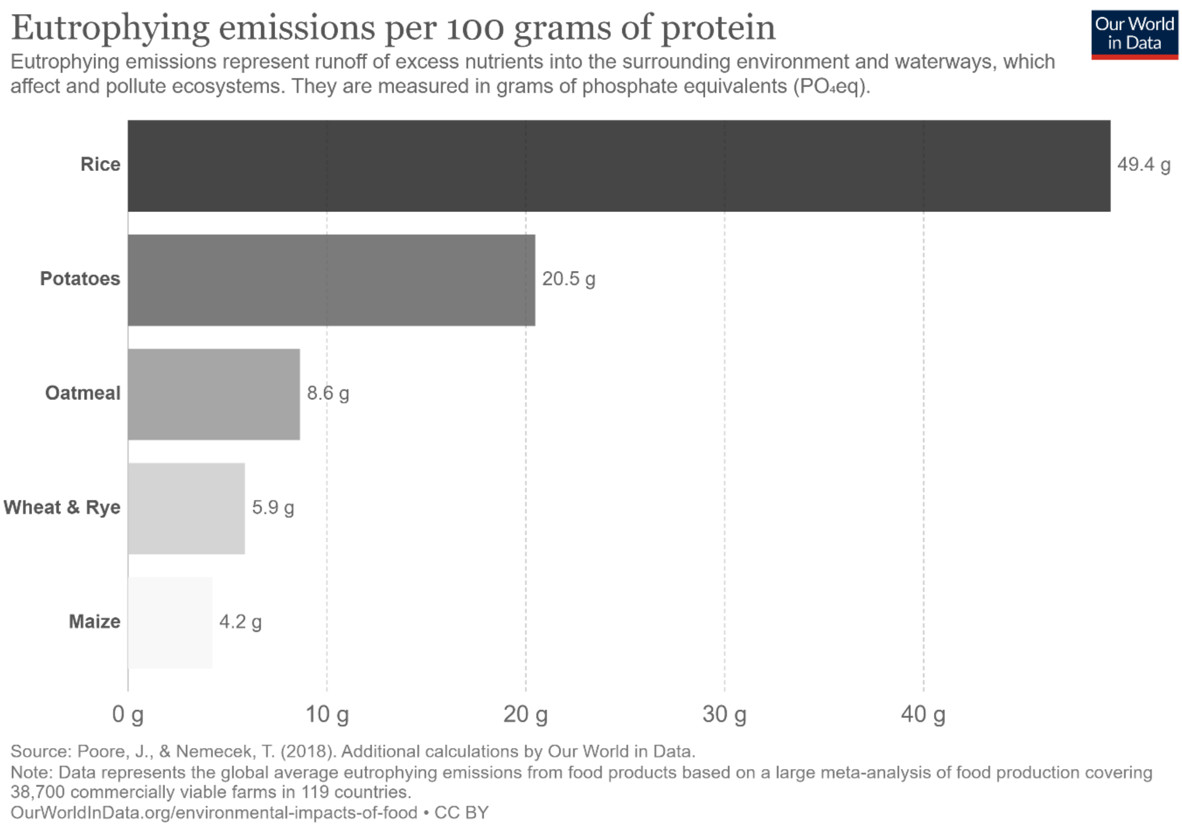


Figure B19: Eutrophying emissions from different cereal products and potatoes per 100 gr of protein (Ritchie, 2020 after Poore & Nemecek, 2018)

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