External Costs of Animal Sourced Food in the EU

Study on the externalities attributed to current value chains of EU production and consumption of animal sourced food – and opportunities for change.

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ABOUT IMPACT INSTITUTE

Impact Institute is a social enterprise with the mission is to empower organizations and individuals to realize the impact economy by creating a common language for impact and providing the tools to use it. Impact Institute develops open-source standards for impact measurement and valuation and provides organizations with the tools, training, and services to implement them.

DISCLAIMER

Summary

Domesticated animals play a major role in human agricultural and food systems, both historically and today. The continuous growth in global wealth, as well as increased efficiency and industrialisation of animal sourced food production, has created both unprecedented quantities of, and access to, animal sourced food. The European Union's agricultural sector had a value of around €449 billion in 2021, of which approximately €163 billion, or 36%, came from animals and animal products. Figure 1 below illustrates the quantity of animal sourced food produced and consumed in the EU in 2022.

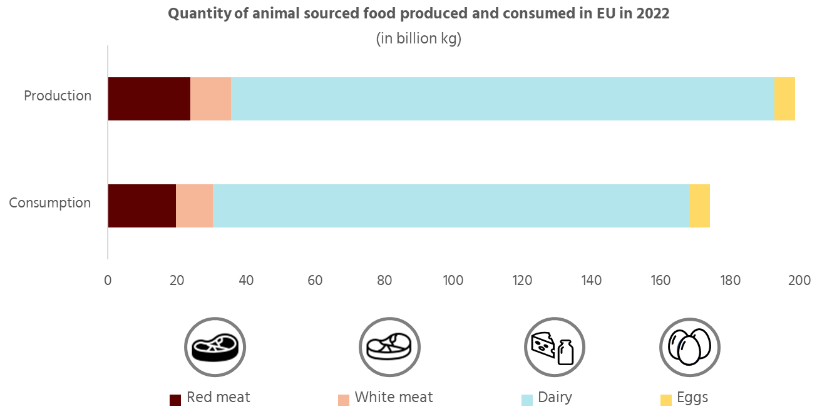


Figure 1 Total production and consumption of animal sourced food in the EU. Red meat includes beef, pork, sheep, and goats. White meat includes chicken. Own elaboration based on Eurostat data.

Simultaneously, this growth has come at a cost. In 2019 alone, at least 8.4 billion animals were slaughtered in the EU while the social, human, and environmental costs associated with the EU's animal sourced food system have grown exponentially in the previous decades. Increasing awareness of the reality and severity of these costs has spurred the European Commission to review and update the European Union's food system-related policies and the animal welfare legislation as part of the Farm to Fork strategy, which aims to make the European food system fair, healthy, and more sustainable.

In view of these developments, Eurogroup for Animals has commissioned an investigation into the true costs of EU animal sourced food production and consumption which was conducted by Impact Institute. This report discusses the assessment of the EU's production and consumption of animal sourced food. It evaluates the extent of external costs to human health, the environment, low animal welfare and human livelihood brought about by producing and consuming animal sourced food. Moreover, the report discusses recommendations to address the *externalities* of the industrial animal food industry. This work can be used to inform policy and decision-making processes regarding the new EU animal welfare legislation.

A key component of the Farm to Fork strategy is a set of revisions to the existing legislative framework on animal welfare. The existing animal welfare legislation is based on what is known as the "five freedoms", which stipulate what conditions are unacceptable for animal physical well-being. The revised animal welfare legislation could instead focus on the Five Domains model, which incorporates notions of mental well-being into the animal welfare framework, as well as the promotion of positive experience instead of only prevention of negative experience. This analysis aims to capture the positive benefit of animal welfare revisions to social, human, and environmental impacts.

Definition of externalities

Externalities are the **costs to society** associated with (unsustainable) external effects. These external effects are the negative effects of an economic activity that **breach the universal rights of current and future generations** and which impact people and communities not party to that economic activity, or not sufficiently free to choose to be a party to the economic activity.

Translating external effects into externalities (which are expressed in monetary terms) requires **remediation costs**: the minimum costs to restore, compensate for, prevent re-occurrence of, and/or as retribution for the harm done (True Price Foundation, 2020).

The methodology that was used in the quantification of the external costs animal sourced food is the True Price method, an application of True Cost Accounting that offers a method for quantifying and monetising negative externalities of production and consumption in agri-food industries. This report applies the True Price method[1] to estimate the external costs of animal sourced production and consumption in the European Union and compares these results with a 'better' production scenario and a 'less' consumption scenario representing a dietary shift towards less animal sourced and more plant-based food.

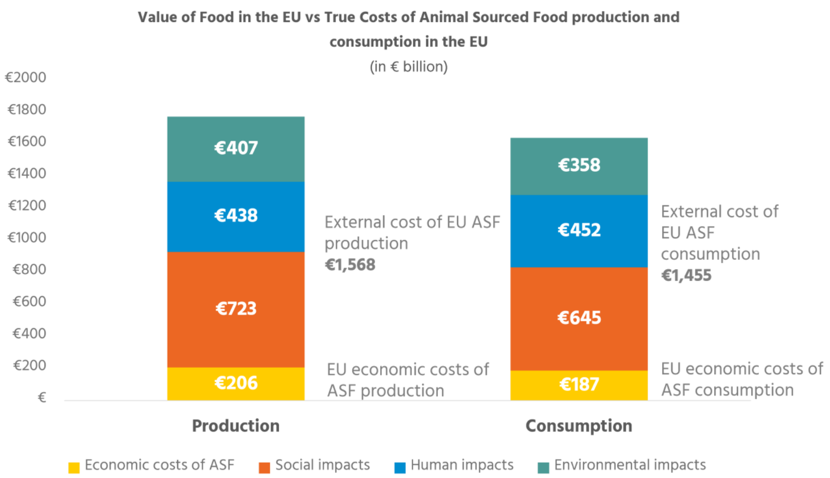


Figure 2 Economic costs of EU animal sourced food production and consumption compared to total costs of animal sourced food production and consumption based on available data and the True Price method.

[1] For more detail, please see *Principles for True Pricing* and *Monetisation Factors for True Pricing* (True Price Foundation, 2021).

The results of the analysis (see Annex 6.4 for a full list of assumptions and limitations) of current EU animal sourced food production and consumption indicate that the costs to society are several times larger than the financial value, as seen in Figure 2 above. The external cost of EU animal sourced *production* (animal sourced food produced in the EU, including exports) in 2022 is €1,568 billion, or approximately 7.6 times higher than the economic costs of producing animal sourced food. The main drivers of quantified external cost of EU animal sourced food production are low animal welfare (45%), diet-related disease (28%), air pollution (12%), and land use (7%).

The external cost attributed to EU animal sourced food *consumption* (animal sourced food produced in the EU, minus exports but including imports) is €1,455 billion, or approximately 7.8 times higher than the economic costs of EU animal sourced food consumption. The main drivers of these quantified external costs are low animal welfare (44%), diet-related disease (31%), air pollution (11%), and land use (7%). Both the external costs of production and consumption are likely underestimations due to several costs that either could not be quantified or were outside the scope of this study such as deforestation for pastures or feed crops and antimicrobial resistance stemming from overapplication of antibiotics in farm animals.

Overall, based on the model, most external costs are attributed to red meat and white meat, with beef and pork representing significant costs for red meat. Red meat represents the greatest share of both human health and environmental impacts, as red meat consumption is a major driver of non-communicable diseases such as cardiovascular disease, kidney disease, and cancers, and environmental impacts due to land use, water, and feed inputs needed in production. White meat (particularly, broilers) represents the greatest share of low animal welfare. This is due to the relatively low life quality of broilers, high stocking density, and the large number of animals slaughtered to produce a kilogram of white meat. In terms of environmental impact, the causes of externalities associated with white meat are air pollution resulting from ammonia emitted during broiler breeding, and air pollution (mostly from ammonia, particulate matter and nitrogen oxide emissions) and land use associated with producing agro-inputs such as animal feed.

These impacts represent real and immediate costs to society. The EU is already experiencing the first impacts of climate change, including severe weather and drought – almost one fifth of which can be attributed directly to greenhouse gases from meat and dairy production (Dunne, 2020). Fortunately, there is plentiful room for improvement – some of which is captured by the improved animal welfare provisions in the alternative scenarios analysed.

In the 'better' scenario, which includes an increase in organic production and improved animal welfare measures such as lower stocking density and reduced transport times, the greatest impact reduction is seen in quantified impacts related to animal welfare. However, it is also the case that the positive benefits to the environment of organic production are not well captured in the Life Cycle Analysis upon which True Cost Accounting is based and are likely under-represented. Simultaneously, improvements in animal welfare are tied to reductions in zoonotic disease and improved soil quality. The 'less' animal sourced food scenario sees a reduction of external costs in all impact areas, reducing total impact by €1,146 billion (79% of baseline impact) – even when accounting for increased impact from plant-based food.

These results underline that there are significant positive effects to society of combining better production of animal sourced food with decreased consumption. Lowering production intensity can improve animal welfare and human health as well as lower the environmental costs associated with the conventional production of animal sourced food. This will require a simultaneous decrease in the consumption of animal sourced food products, as lower intensity production would imply greater land use without concurrent reductions in consumption. Fortunately, provisions that promote animal welfare, such as lower stocking densities, also positively influence impacts such as zoonotic disease and soil quality, which in turn lower the risk of future pandemics and improve long-term resource efficiency. However, it is still important to reduce the quantity of animal sourced food consumed globally, but particularly in the EU. According to the European Commission (2021), "many EU citizens have dietary protein intakes above the recommended intake levels", illustrating the possibility for reducing protein intake while still ensuring a healthy diet.

In conclusion, combining better production with less consumption of animal sourced food supports the EU's ambitions to improve animal welfare, optimise land use and address the threats to biodiversity which currently harm ecosystem services. Greater focus on animal welfare can support this better production and less consumption of animal sourced food to ensure long-term food security and a fair, healthy, and more sustainable EU food system. Therefore, based on the findings of this report, it is recommended that:

- Animal welfare be considered in tandem with environmental and human health provisions, as they are intrinsically connected;
- Resources are invested in understanding the footprint of production systems (in this case organic and conventional, but also agroecological or other) to enable accurate comparisons;
- A relative increase in organic production is combined with a dietary transition to more plant-based food.

Content

Introduction

1 Introduction

1.1 EU's Animal Sourced Food system

Raising cattle for beef or dairy and poultry for eggs and meat, among others, is a long-standing tradition and way of life for many European farmers. The production of animal sourced food in the EU is therefore an integral part of both the historical and current European food systems. The EU has enacted a set of legislation with the intention of supporting the maintenance of the quality and quantity of animal sourced food production.

1.1.1 EU animal welfare legislation

The current legislative framework of the European Union (EU) on animal welfare consists of five directives and two regulations. The first directive, the Council Directive 98/58/EC or the "General Farming Directive", was adopted in 1998. It pertains to a general set of rules for the protection of all animals kept for farming purposes (Council of the European Union, 2007). The General Farming Directive reflects the notion of the five freedoms of animal welfare – a framework that defends the elimination of negative experiences to free animals from: hunger and thirst; discomfort; pain, injury and disease; fear and distress and any constraints allowing the expression of natural behaviour (European Commission, 2023).

Given developments in animal science since the 1990s, the framework of the five freedoms of animal welfare is considered outdated. A revised EU animal welfare legislation that better reflects an understanding of animal welfare could be based on the Five Domains model, which is increasingly replacing the five freedoms in both academia and practice. The Five Domains acknowledge the sentience of farm animals, give more priority to their mental well-being, and place more emphasis on offering opportunities for positive experiences for all animals in human care rather than solely minimising negative experiences (Mellor, et al., 2020; Eurogroup for Animals, 2021).

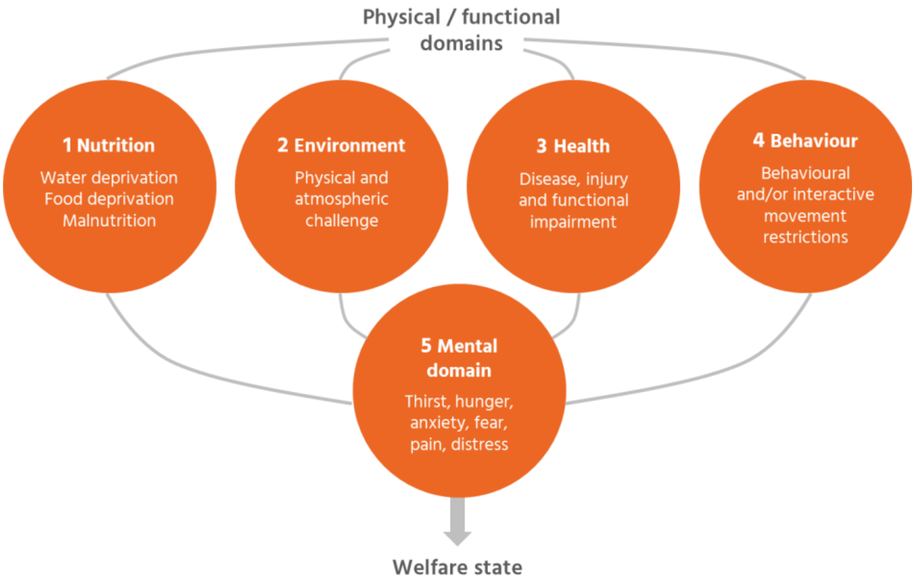


Figure 3 Five domains of animal welfare based on Mellor and Reid (1994).

The first directive of the EU's current animal welfare legislation, the General Farming Directive, is supplemented by four complementary directives. These directives are species-specific and provide minimum standards for the protection of laying hens, broilers, pigs and calves (Council of the European Union , 2008; Council of the European Union, 1999; Council of the European Union, 2007; Council of the European Union, 2007). There are also two regulations regarding animal welfare during transport and during time of slaughter (Council of the European Union, 2005; Council of the European Union, 2009).

1.1.2 Challenges in the current system

The EU Farm to Fork strategy aims to make the European food system fair, healthy and more sustainable (European Commission, 2020). The current European food system, part of which consists of the production and consumption of animal sourced food, is associated with negative externalities to the environment and people as well as to animal welfare.

In 2018, 17% of the EU's greenhouse gas emissions stemmed from the animal farming sector (Heinrich Böll Stiftung, Friends of the Earth Europe, and Bund, 2021). These emissions can be attributed to expansion of farmland, production and processing of animal feed, and emissions of methane gas from the digestive tract of ruminants (Heinrich Böll Stiftung, Friends of the Earth Europe, and Bund, 2021). Furthermore, the use of synthetic pesticides as well as livestock manure for fertilising feed crops contribute significantly to soil, water, and air pollution. 80% of the EU agricultural ammonia emissions to air and nitrogen emissions to water are linked to livestock production (Greenpeace, 2019). Organic fertiliser further contributes to the spread of antimicrobial resistance (AMR) in humans, as high levels of antimicrobial use in livestock can transfer antibiotic resistant bacteria (ARB) and antibiotic resistant genes (ABG) to agricultural soils, which can then further be transferred to humans through interactions with the contaminated environment (Graham, et al., 2019).

Interconnectedness of low animal welfare and other impacts attributed to EU food system

The safety of food chains is directly related to the health and well-being of farmed animals. Stress and poor care of animals in intensive farming systems increases the transmission of **zoonotic diseases**, thereby exposing consumers to significant health risks (UN Environment Programme, 2019). Relatedly, the use of antibiotics for farm animals has significantly contributed to the rise of **antimicrobial resistance** – a critical threat to human health. In addition, a fair food system is dependent on addressing the maltreatment, suffering and pain of animals kept in human care (Eurogroup for Animals, 2021).

Finally, intensive breeding and production practices which are harmful to animal welfare also contribute to crucial environmental risks including climate change, water and air pollution and loss of biodiversity (FAIRR, 2019). Some of the key drivers of these environmental risks are: the use of pesticides and fertilisers for crop feed production, expansion of land occupation for livestock breeding and emissions from manure waste.

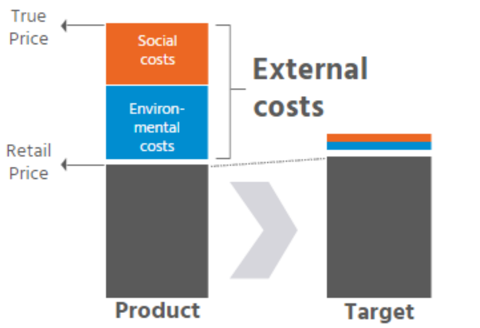
1.1.3 Opportunities for change

Transitioning to fair, healthy, and more sustainable food systems is strongly interlinked with improved animal welfare. As part of the European Commission's objective to make the European food system fair, healthy and sustainable, the Commission seeks to revise existing legislation on animal welfare. The aim of revising the animal welfare legislation is to broaden its scope, strengthen the enforceability of the animal welfare legislation, ensure a higher level of welfare protection, and align with the latest scientific evidence. The revision will thereby support improved animal welfare in the EU food system and act as a steppingstone for achieving the ambitions outlined in the EU's Farm to Fork strategy.

This report discusses the assessment of the EU's production and consumption of animal sourced food. It evaluates the extent of external costs brought about by producing and consuming animal sourced food to human health, the environment, low animal welfare and human livelihood. Moreover, the report discusses recommendations to address the externalities, or societal costs not reflected in the market price, of the industrial animal industry. This work can be used to inform and support policy and decision-making processes regarding the new EU animal welfare legislation.

1.2 Enabling food system transformation through True Cost Accounting

The assessment discussed in this report is based on **True Cost Accounting, which creates transparency within production chains about the sustainability impacts of those chains and their associated costs to society.** Within the field of True Cost Accounting, the True Price method is used for quantifying and monetising negative externalities of production and consumption in agri-food (True Price Foundation, 2020). The method offers comparable, quantitative insights into the direct environmental and social costs which are not part of the purchasing price of a product, but which are paid by society nonetheless – for instance, the increase in certain health risks or the contribution to climate change.



Assessing EU production and consumption of animal sourced food using the True Price method supports the transition towards a fair, healthy and more sustainable food systems in the following ways:

1. Presents transparent, accessible information to policymakers and consumers about the environmental and social impact of animal sourced food consumption and production;
2. Demonstrates the need for industry change within the animal farming sector in order to transition towards more fair, sustainable and healthy European food systems;
3. Empowers policymakers to make comparative evaluations of different policy options by providing insight into a 'better and less' scenario in terms of true costs.

This report is set up as follows: Chapter 2 describes the assessment method used, including approach, scope, assumptions and limitations, and key data sources. Chapter 3 presents the results of the true cost assessment. Finally, Chapter 4 discusses conclusions and recommendations to move towards fair, healthy, and more sustainable EU food systems.

Method

2 Method

This chapter discusses and explains the key aspects of the method used in the true cost assessment.

- **2.1: True Price methodology.** This section describes the methodology developed and published by the True Price Foundation and its suitability for the true cost assessment on EU production and consumption of animal sourced food.
- **2.2: True cost approach.** This section discusses the approach used to assess the true costs of EU production and consumption of animal sourced food.
- **2.3: Scope.** This section introduces the scope of the assessment. This includes the value chain activities, geographical scope, impacts and scenarios. Moreover, it introduces the key data sources used in the assessment and the main assumptions and limitations.

2.1 True Price methodology

The true cost assessment of EU production and consumption on animal sourced food is performed using the True Price methodology. Developed and made publicly available by the True Price Foundation, it is used in the field of True Cost Accounting (True Price Foundation, 2020). This section elaborates on the concept of 'true pricing', the underlying principles of the True Price methodology and corresponding quantification methods.

2.1.1 True price methodology within the field of True Cost Accounting

The true price is the sum of the market price (the price at which a product is offered in the market) and the true price gap (the social and environmental costs generated in the value chain during production). It is a unique method for quantifying the 'hidden' costs of products. These hidden costs, called external costs or externalities, reflect the damages experienced by current and future generations resulting from activities in the production stages of value chain. Examples of activities resulting in external costs are the prevalence of child labour and processing operations that generate (toxic) emissions to air, soil or water.

This true pricing method is part of the field of True Cost Accounting: an accounting method in which businesses and other stakeholders assess and report on the environmental, social, and human impact of business activities using a monetary value. The True Price methodology is chosen to assess the external costs of the production stages in the value chain because its normative foundation is rights-based. This means the method acknowledges the existence of universal rights of both current and future generations, and the complementary responsibility of value chain actors and regulatory actors to respect those rights forms the basis for determining the remediation costs associated with damages caused to current and future generations (True Price Foundation, 2020).

These same principles are applied to assessing the external costs of the consumption stage of the value chain. This ensures comparability of the results. Examples of external costs at the consumption stage are impacts to human health. In this true cost assessment, the impacts to human health are assessed using remediation costs in line with the principles published in the True Price methodology.

2.1.2 Calculating external costs

The process of calculating external costs of products requires assessing effects of activities in the value chain on a per-unit basis and monetising the resulting footprint based on relevant remediation costs to account for the damage to people, animals, and planet. For each of the relevant impacts of the current study, the magnitude of the impact in natural units (or 'footprint indicators') can be measured or estimated using primary or secondary sources. To obtain the monetised value of an impact, the impact expressed in its natural units (or footprint indicators) can be multiplied by its corresponding monetisation factor.

2.1.3 Footprint indicators

Footprint indicators are variables that quantify the actual social and environmental impacts that are in scope to calculate the true price (True Price Foundation, 2023). An example of a footprint indicator for the impact of contribution to climate change is the metric measuring CO_2-equivalent. This unit can be used to quantify and compare emissions from various greenhouse gases based on their global warming potential. For human health impacts, an example of a footprint indicator that can be used to quantify and compare the impact of diseases on human health is the metric Disability-Adjusted Life Years (DALYs). Footprint indicators must be calculated in such a manner that they can be monetised and compared meaningfully across different life cycle steps.

2.1.4 Monetisation factors

Monetisation factors are the monetary values used to calculate the societal cost associated with damages to people, animals, and nature. By multiplying footprint indicators with corresponding monetisation factors, the externalities can be expressed as a monetary value. In accordance with the *Principles for True Pricing*, monetisation factors are based on the cost required to remediate negative impacts on society.

Example: contribution to climate change

The environmental impact, 'contribution to climate change' is quantified by the greenhouse gas emissions expressed by the footprint indicator kg CO_2-equivalent.

The remediation costs associated with the impact of 'contribution to climate change' are based on the carbon price required to restore greenhouse gas levels in the atmosphere to a safe level. As a result, the monetisation factor for 'contribution to climate change' is €0.163/kg CO_2-eq.

Remediation refers to the correction or counteraction of activities which cause environmental and social damage. This principle builds on the UN Guiding Principles on Business and Human Rights and links directly to the rights-based approach (see *Principles for True Pricing* (True Price Foundation, 2020)). Remediation costs are required to restore, compensate, prevent re-occurrence and as retribution for violations of universal rights of both current and future generations. See Annex 5.1 for more details on the establishment of these monetisation factors.

2.2 True cost approach

This section discusses the approach and scope for the true cost assessment. Firstly, it introduces the different components of the assessment. Secondly, it presents the steps undertaken in the assessment.

2.2.1 Introduction to true cost assessment

The true cost assessment of the EU's animal sourced food production and consumption contains two parts:

1. **Baseline study:** the baseline study is an assessment of the external costs of the *current status* of the EU's animal sourced food production and consumption.
2. **Comparative study:** the comparative study contrasts the results of the baseline study to a *'better and less'* scenario in which animal sourced food is produced better and consumed less. 'Better' production is defined as increased organic production and implementation of animal welfare measures. 'Less' consumption of animal sourced food is defined as a dietary shift to consuming less animal sourced food. The scope of the 'better and less' scenario is further explained in Section 2.3.5. The aim of the comparative study is to understand how the 'better and less' scenario – in which animal sourced food is produced and consumed in a manner more in line with fair, healthy, and more sustainable food systems – impacts the external cost of animal sourced food production and consumption.

2.2.2 Approach

Performing the true cost assessment follows a five-step approach. The five steps of the assessment are described below. An elaborate explanation of each step is provided in Annex 5.2.

i. **Scoping:** In the scoping phase, the variables included in the study are determined. This includes decisions on the impacts, value chain steps, geography, activities, and scenarios that are included in the study. The scope is based on the relevance to EU animal sourced food production and consumption and data availability. The scope of this study is discussed in Section 2.3.
ii. **Data collection:** After the scope is determined, primary and secondary data is collected. This data is used to quantify and calculate the true cost of EU animal sourced food production and consumption. The key data sources used are described in Section 2.3.6.
iii. **Model building:** Based on the data and the True Price methodology, calculation models are developed to analyse the data and make the assessments.
iv. **Analysis and validation:** The primary and secondary data are combined and analysed using the models developed. Both the models and analyses are validated by experts to ensure high-quality results.
v. **Reporting.** The results of the assessments are compiled into this report and validated by Eurogroup for Animals.

2.3 Scope

This third section outlines the scope of the true cost assessment, elaborating on the activities, geography and impact included in the assessment. This is followed by a description of the 'better and less' scenario assessed in the comparative analysis and an explanation of the attribution of impacts along the value chain. This section also provide insight into the key data sources used for the study and main assumptions and limitations. For each part of the true cost assessment, the year of measurement is 2022 (the most recent complete year).

2.3.1 Activities in the value chain

The true cost assessment includes both animal sourced food production in the EU and consumption in the EU. Figure 5 shows a simplified version of the animal sourced food value chain.

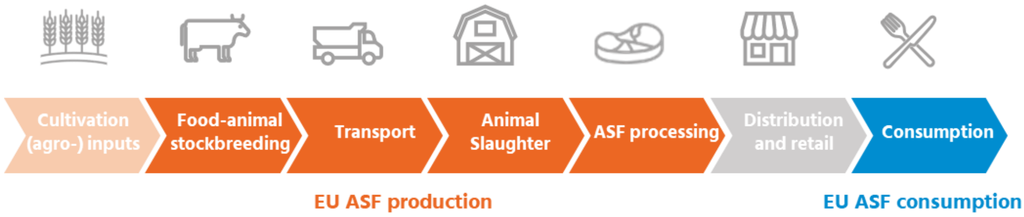


Figure 5 Simplified visualisation of the animal sourced food value chain

EU animal sourced food production consists of the value chain activities; food-animal stockbreeding, transport, animal slaughter and the processing of products. The impact of the cultivation of agro-inputs is also included in the assessment as this is an important factor in the upstream value chain of animal sourced food. This includes the impact resulting from the land use for the production of agro-inputs, representing the decreased availability of land for other purposes. However, the impact of land transformation, representing the change of natural ecosystems to allow agricultural production through, for example, deforestation, is not included in the present study. The assessment of EU animal sourced food consumption focuses on the last step of the value chain: consumption.

Food waste in the EU

Food waste represents any food that has entered the value chain but has then been discarded during production and manufacturing stages or at final consumption. The EU produces nearly 57 million tonnes (127kg per inhabitant) of food waste annually (Eurostat, 2022). This amounted to approximately 10% of the total food produced in the EU in 2020.

The true cost assessment assumes that 10% of animal sourced food is wasted along the value chain. This does not affect impacts in the production scenario, as the food is produced whether it is wasted or not. For consumption impacts to human health (diet-related and zoonotic disease), however, the quantity of food actually consumed is assumed to be 10% less than the quantity of food available for consumption based on production quantities.

The quantity of animal sourced food produced in the EU is determined based on data from the FAO and Eurostat. The quantity consumed is based on total quantity produced within the EU plus imports to the EU, minus the quantity exported to countries outside of the EU. This presents the quantity of animal sourced food available for consumption in the EU. The quantity available for consumption is used to calculate social and environmental impacts. For human health impacts, however, food waste should be accounted for. The amount of food wasted along the value chain in the EU (around 10%) is subtracted from the quantity *available* for consumption to obtain the quantity of animal sourced food that is *actually consumed*.

2.3.2 Geographical scope

Studying the externalities resulting from EU production of animal sourced food means addressing the direct and indirect externalities occurring in the full relevant value chains. Animal sourced food that is produced within EU-borders may require inputs (such as animal feed, machinery, energy supplies) that are imported from outside of the EU. The externalities resulting from the production of such inputs must be accounted for when analysing the impact of EU animal sourced food production. Additionally, the animal sourced food produced in the EU may be consumed in the EU or exported to non-EU countries for consumption elsewhere.

Likewise, studying the externalities resulting from EU *consumption* of animal sourced food means addressing the direct and indirect externalities occurring in the relevant value chains. For EU consumption, this implies accounting for the externalities resulting from animal sourced food produced in EU countries and non-EU countries which is consumed within EU-borders. Figure 6 provides a visualisation of the different value chains that are relevant for the true cost assessment of EU's animal sourced food production and consumption. The figure includes the quantities (in thousands of tonnes) of agro-inputs, and animal sourced food production exported from and imported to the EU.

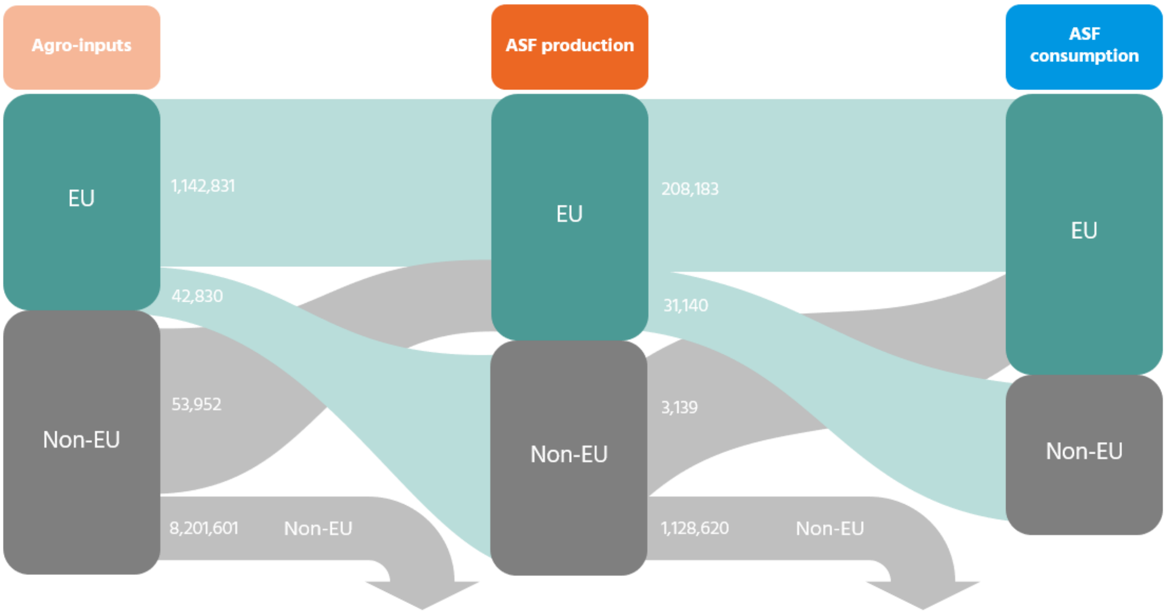


Figure 6 Illustration of the value chains relevant for animal sourced food production and consumption in the EU (x1000 tonnes). Values are representative of the year 2022, either through 2022 specific data or approximations based on 2019-2021 data.

2.3.3 Impacts in scope

The impacts assessed in this study can be divided into three categories: social impacts, human impacts, and environmental impacts.

- **Social impacts:** Negative impacts on people and communities caused by production and consumption of animal sourced food. In the context of a true price assessment, social impacts are defined as unsustainable externalities related to breaches of human rights and labour rights. In this study, this definition is extended to include the mental and physical well-being of non-human animals.
- **Human impacts:** Negative impacts on individual people caused by production and consumption including health and well-being.
- **Environmental impacts:** Negative impacts on the environment caused by production and consumption of animal sourced food. In the context of a true price assessment, environmental impacts are unsustainable externalities related to the breaches of environmental rights.

For each category the impacts in scope are described in Table 1. Table 2 elaborates further on the quantitative and geographical scope of each impact and specifies which sectors are included in the assessment for each impact. Detailed information on the footprint indicators and a description of the remediation cost used to quantify and monetise each impact is provided in Annex 5.3.

Table 1 Description of the impacts in scope for the true cost assessment

Category	*Impact*	*Description*
Social Impacts	Low animal Welfare	The physical and mental state of an animal in relation to the conditions in which it lives and dies.
	Underpayment	The gap between workers' wages, the local minimum wage and the local living wage.
Human Impacts	Zoonotic diseases	The human health impact caused by zoonotic diseases transmitted from animal to humans through direct contact with infected animals or contamination of food.
	Antimicrobial resistance (AMR)	The human health impact caused by AMR, which occurs when pathogens change over time and no longer respond to medicines.
	Diet-related disease	The human health impact of diseases attributable to diets.
	Air pollution	The impact of emissions to air other than climate change, including ozone layer depletion, acidification, photochemical oxidant formation, particulate matter formation, nitrogen deposition from emissions to air, terrestrial and aquatic ecotoxicity and human toxicity from toxic emissions to air.

Environmental Impacts	Water pollution	The impact of emissions to water contributing to eutrophication of marine- and freshwater.
	Contribution to climate change	The rise of the global mean temperature caused by increased emissions of greenhouse gases (GHG) due to anthropogenic activities.
	Land use	The decreased availability of land for purposes other than the current one, through land occupation.
	Soil quality	The physical, chemical, and biological decline in soil quality driven by productive activities, like excessive use of irrigation or unbalanced use of fertiliser. The impacts of soil erosion (from water), soil compaction, and of pesticides emitted to soil on human health are captured.
	Biodiversity loss	The decline or disappearance of biological diversity, understood as the variety of living things that inhabit the planet, the variety of ecosystems and habitats, and the variety of genes and traits available within a species. This impact captures both direct effects (from land use) and indirect effects (from contribution to climate change, air pollution and water pollution).

Table 2 Scope of the impacts included in the true cost assessment

Impact	*Scope per impact*
Low animal welfare	Quantified impact in scope: The animal life years suffered as a result of low life quality conditions during the entire production cycle. Factors considered are animals' life quality, slaughter age, slaughter duration (including transport time), number of animals affected per unit of output, and the number of neurons of different animal types. Geographical scope: EU Production: animal sourced food produced/consumed in EU, exports. EU Consumption: animal sourced food produced/consumed in EU, imports. Sectors in scope: Red meat, white meat, dairy and eggs in scope. *Fish is out of scope of the present study.*
Underpayment	Quantified impact in scope: Represents the living income gap of workers in the covered sectors. The living income gap is the difference between the actual wage and a living income as calculated based on cost-of-living estimations for different countries or regions. Geographical scope: EU Production: animal sourced food produced/consumed in EU, exports. EU Consumption: animal sourced food produced/consumed in EU, imports. Sectors in scope: Red meat, white meat, dairy and eggs in scope. White meat and eggs are grouped together because of inability to attribute impact. *Fish is out of scope of the present study.*

Zoonotic diseases	**Quantified impact in scope:** Cases of Salmonellosis and Campylobacteriosis in the EU in 2021. **Geographical scope:** EU Production: animal sourced food produced/consumed in EU. *Consumption of animal sourced food outside of EU is out of scope of the present study.* EU Consumption: animal sourced food produced/consumed in EU. *Production of animal sourced food outside of EU is out of scope of the present study.* **Sectors in scope:** Red meat, white meat, dairy and eggs in scope. *Fish is out of scope of the present study.*
Antimicrobial resistance (AMR)	**Quantified impact in scope:** *The impact of AMR is not quantified due to lack of available data. Instead, a qualitative assessment of the impact is included.*
Diet-related disease	**Quantified impact in scope:** Incidence and human health effect of cardiovascular disease, kidney disease, and cancers attributable to animal sourced food consumption. **Geographical scope:** EU Production: animal sourced food produced/consumed in EU, exports. EU Consumption: animal sourced food produced/consumed in EU, imports. **Sectors in scope:** Red meat, processed meat (predominantly consists of red meat, but also partially poultry). Per kg impact of red meat exclusively covers fresh red meat. Red processed meat only represented in total impact. *White meat, dairy, eggs and fish out of scope of the present study.*
Air pollution	**Quantified impact in scope:** Human and environmental health impact of ozone layer depletion, acidification, photochemical oxidant formation, particulate matter formation, nitrogen deposition from emissions to air, terrestrial and aquatic ecotoxicity, and human toxicity from toxic emissions to air. **Geographical scope:** EU Production: animal sourced food produced/consumed in EU, exports. EU Consumption: animal sourced food produced/consumed in EU, imports. **Sectors in scope:** Red meat, white meat, dairy and eggs in scope. White meat and eggs are grouped together because of inability to attribute impact. *Fish is out of scope of the present study.*
Water pollution	**Quantified impact in scope:** Marine and freshwater eutrophication resulting from nutrient leaching and the dissolving of animal feed in water bodies. *Does not include water quality metrics such as particulate matter content.* **Geographical scope:** EU Production: animal sourced food produced/consumed in EU, exports. EU Consumption: animal sourced food produced/consumed in EU, imports. **Sectors in scope:** Red meat, white meat, dairy and eggs in scope. White meat and eggs are grouped together because of inability to attribute impact. *Fish is out of scope of the present study.*

<table>
<tr><td>Contribution to climate change</td><td>Quantified impact in scope:
Greenhouse gas emissions (including CO_2, CH_4, N_2O, etc., measured in CO_2 equivalents)
Geographical scope:
EU Production: animal sourced food produced/consumed in EU, exports.
EU Consumption: animal sourced food produced/consumed in EU, imports.
Sectors in scope:
Red meat, white meat, dairy and eggs in scope. White meat and eggs are grouped together because of inability to attribute impact. Fish is out of scope of the present study.</td></tr>
<tr><td>Land use</td><td>Quantified impact in scope:
Opportunity cost of ecosystems services lost as a result of using land for a non-original purpose. Represents current opportunity cost (annual), does not account for impact of initial land use change (the transformation of natural ecosystems to land used for other purposes, such as agricultural production).
Geographical scope:
EU Production: animal sourced food produced/consumed in EU, exports.
EU Consumption: animal sourced food produced/consumed in EU, imports.
Sectors in scope:
Red meat, white meat, dairy and eggs in scope. White meat and eggs are grouped together because of inability to attribute impact. Fish is out of scope of the present study.</td></tr>
<tr><td>Soil quality</td><td>Quantified impact in scope:
• Water soil erosion resulting from farming of agri-food inputs for animal consumption. Impact of grazing not included.
• Soil compaction resulting from machinery used in farming of agri-food inputs for animal consumption. Impact of grazing not included.
• Human toxic effect of pesticides emitted to agricultural soils during farming of agri-food inputs for animal consumption.
Geographical scope:
EU Production: animal sourced food produced/consumed in EU, exports.
EU Consumption: animal sourced food produced/consumed in EU, imports. Soil compaction impacts of imports out of scope.
Sectors in scope:
Agri-food inputs (animal feed) for red meat, white meat, eggs, and dairy. These include domestically produced and imported inputs. Impact for red meat includes impact of dairy because of inability to attribute impact. Fish is out of scope of present study.</td></tr>
<tr><td>Biodiversity loss</td><td>Quantified impact in scope:
Direct effects on biodiversity loss from land use and indirect biodiversity loss from contribution to climate change (temperature changes and extreme weather conditions result in water scarcity, ocean warming, extinction of fish, disappearance of (rain-)forests and more), air pollution and water pollution (increased exposure to toxic substances resulting in insects going extinct, soil acidification). Biodiversity loss from other indicators such as use of scarce water is out of scope.
Geographical scope:
EU Production: animal sourced food produced/consumed in EU, exports.
EU Consumption: animal sourced food produced/consumed in EU, imports.
Sectors in scope:
Red meat, white meat, dairy and eggs in scope. White meat and eggs are grouped together because of inability to attribute impact. Fish is out of scope of the present study.</td></tr>
</table>

2.3.4 Attribution

Attribution refers to assigning the appropriate share of external costs to the value chain. This attribution is based on levels of responsibility and influence over the respective external costs. For example, the cultivation of (agro-)inputs required to produce a kilogram of red meat may require machinery. The production and use of this machinery likely brings about emissions (thus, external costs). If the machinery is only used to produce the one kilogram of red meat, the full external costs attributed to the production and use of the machinery should be attributed to the value chain of this kilogram of red meat.

In reality, the machinery is likely used to produce a variety of products over a long period of time. Therefore, only a share of the external costs resulting from the production and use of the machinery should be attributed to the value chain of the kilogram of red meat. The remaining share is attributed to the other relevant value chains such that, in total, 100% of the external costs is accounted for but there is no double counting. In this true cost assessment, attribution is applied whenever such 'indirect' external costs apply (for air pollution, water pollution, contribution to climate change, land use and all biodiversity indicators).

2.3.5 'Better and less' scenario

The true cost assessment consists of a baseline study and a comparison with a 'better and less' scenario. The baseline study focuses on the status quo of animal sourced food production and consumption in the EU. The 'better and less' scenario analyses the externalities in a scenario where there is 'better' production and 'less' consumption. 'Better' production is defined as more organic production and implementation of selected measures to improve animal welfare. 'Less' consumption of animal sourced food is defined as a shift to a diet with relatively less animal sourced food consumption. The characteristics of the 'better and less' scenario are described below.

'Better' scenario

The 'better' scenario consists of an increase in organic production and the implementation of selected animal welfare measures. The scenario for organic production is based on the Farm to Fork strategy's objective for 25% of EU's agricultural land under organic farming by 2030. For the true cost assessment, it is assumed that this objective is applicable across the various animal sourced food production categories (i.e., 25% organic red meat, white meat, dairy and egg production). Organic farming in the EU requires additional animal welfare measures compared to conventional farming requirements (Duval et al., 2020). In the context of this analysis, organic animal production consists of more days on pasture for cows, reduced stocking density for broiler chickens and laying hens, and increased surface area for pigs.

In addition, the Farm to Fork strategy emphasises that improved animal welfare "improves animal health and food quality, reduces the need for medication and can help preserve biodiversity" (European Commission, 2020). Therefore, the 'better' scenario includes a focus on improved animal welfare. Elements that can significantly increase the welfare of farm animals are the implementation of cage-free rearing systems (e.g., for laying hens, pigs, and veal calves), a decrease in stocking density (e.g., for broilers and pigs), outdoor access and environmental enrichment. In this analysis, measures for improving animal welfare included in the calculations are reduction in transportation time for slaughter for both conventional and organic production (slaughter duration reduced from 24 hours to 12 hours) and lower stocking density for conventional pigs (half the maximum stocking density currently allowed by legislation) and conventional chicken (broiler: maximum of 30 kg/m², laying hens: maximum of 7 hens/m²).

'Less' scenario

The 'less' scenario represents a dietary shift in the EU. Table 3 provides an overview of current EU animal sourced food consumption for each food group (based on average consumption per EU citizen) and compares this to a flexitarian diet based on values set out by the FAO (FAO, 2020). The quantities of current animal sourced food consumption in the EU are based on production data, import and export data, resulting in a value representing the animal sourced food available for consumption. It is assumed that 10% of animal sourced food is wasted along the value chain. To calculate the quantities of actual consumed food, this 10% is subtracted from the quantity *available* for consumption to obtain the quantity of animal sourced food that is *actually consumed*.

For the scenario with less animal sourced food consumption, the values for the reduction of the food groups red meat, white meat, dairy and eggs are based on the flexitarian diet described by the FAO (FAO, 2020). To ensure realistic comparison, the loss of nutrients from lower consumption of animal sourced food is offset in the 'less' scenario by other food sources. The loss of protein intake is based on the difference in intake of animal sourced food between the FAO's *Baseline* and *Flexitarian* diets, estimated as a decrease of 17.2g of protein per person per day. The additional intake of plant-based protein products needed to replace the 17.2g of protein from animal sourced food is estimated to be 99.5g of plant-based protein **product** per day for each person. Plant-based protein products can include meat alternatives, tofu, tempeh or other soy-based products, as well as legumes, nuts or other protein rich food. This analysis only includes the protein intake needed to account for the decrease in animal sourced food, other protein intake that is part of a healthy diet is out of scope of this analysis.

Table 3 Quantities of animal sourced food consumed in the EU for the baseline and the less scenario (gram/day/person)

	Current average EU consumption		**Less scenario EU animal sourced food consumption** (based on Flexitarian diet by FAO)		
Food Group	**Grams of product/day**	Grams of protein/day***	**Grams of product/day**	Grams of protein/day	Difference vs current consumption
Red meat (Beef, Lamb, Pork)	**109**	18.6	***12****	2.0	**-89%**
White meat (Poultry)	**58**	10.1	***19****	3.3	**-67%**
Eggs	**32**	4.0	***10****	1.2	**-69%**
Dairy	**761**	24.0	***155****	4.9	**-80%**
Plant-based protein product	*Not included in analysis*		**99.5****	17.2	
Sum of protein consumption/day****		56.7		28.7	

* Based on Flexitarian diet FAO (FAO, 2020); ** Plant protein to offset consumption of animal proteins. Based on difference animal sourced food between Baseline diet FAO and Flexitarian diet FAO (FAO, 2020); *** Based on USDA data (USDA, 2019); **** Recommended daily intake is 0.8g of protein per kg of body weight (European Commission, 2021).

2.3.6 Key data sources

Table 4 Overview of the main data sources

Source	Description
Global Impact Database (v.3.4.3)	The Global Impact Database (GID) is a database of impact-related information collected, analysed and maintained by Impact Institute. It allows us to quickly estimate the impact of an activity by quantitatively describing the global economy, estimating economic, social and environmental impacts for 140 countries with 65 sectors, making a total of 9,100 country-sector combinations (version 3.4.3). The GID estimates this impact based on data on the interconnectedness of industries in various countries and their economic, environmental and social performance from global databases (mainly EXIOBASE). The output of the GID model can be used for top-down impact estimates of value chain impacts.
FAO	The Food and Agriculture Organization (FAO) is a specialised agency of the United Nations that leads international efforts to defeat hunger. The FAO provides free access to food and agriculture statistics for over 245 countries and territories.
Eurostat	Eurostat is the statistical office of the European Union, providing high-quality statistics and data on Europe.
European Commission	The European Commission website provides data and analysis on farming, sustainable agriculture, agricultural trade, animals and animal products, and key policies within the EU.
Global Burden of Disease	The Global Burden of Disease study is the largest ever systematic effort to describe the global distribution and causes of a wide array of major diseases, injuries, and health risk factors.
European Centre for Disease Prevention and Control	The European Centre for Disease Prevention and Control (ECDC) is a public health agency of the European Union (EU), and collects, analyses and shares data on more than 50 infectious diseases.

2.3.7 Main assumptions and limitations

Table 5 presents the main assumptions and limitations that apply to the true cost assessment. Impact specific assumptions and limitations are included in Annex 5.4.

Table 5 Overview of the most important assumptions and limitations of the true cost assessment

Study focus	Assumption & Limitations
Baseline & Comparative study	It is assumed that animal sourced food production in the EU - exports + imports - food waste is the total actually consumed in EU. Furthermore, it is assumed that all animal sourced food that is imported from outside the EU, is consumed in the EU.
Baseline & Comparative study	Animal sourced food production, import and export quantities for the EU are based on the latest available data from 2021. This value is updated by taking the average change per year between 2017-2021 and multiplying this with the value of 2021 to get an estimate for the year 2022.
Baseline & Comparative study	The true cost assessment assumes that 10% of animal sourced food is wasted along the value chain. This does not affect impacts in the production scenario, as the food is produced whether it is wasted or not. For consumption impacts to human health (diet-related and zoonotic disease), however, the quantity of food actually consumed is assumed to be 10% less than the quantity of food available for consumption based on production quantities.
Comparative study (Less scenario)	To offset the decreased protein intake associated with reduced consumption of animal proteins (17.2g of protein), consumers will need to increase their consumption of plant proteins. Ideally, this replacement should consist of a nutritious and balanced assortment of different plant proteins (tofu, legumes, nuts, etc.). However, for the purpose of this analysis, soy was chosen as a proxy to estimate the impact of increased plant protein consumption. With approximately 17g of protein per 100g of product (similar to many meat products) and a high concentration of essential amino acids, soy offers a viable alternative to meat consumption as a source of global proteins.
Baseline & Comparative study	The true cost assessment is in part based on data from Impact Institute's Global Impact Database (GID) (version 3.4.3). It uses data from Exiobase, Eora26, ILOSTAT and WageIndicator and estimates impact 140 countries with 65 sectors in the global economy. For this assessment a selection of sectors has been included that best represent the scope of animal sourced food. One limitation is that the excluded sectors potentially contain animal sourced food that has not been included in the current analysis.

Results

3 Results

The true cost assessment shows that the quantified external costs attributed to animal sourced food production in the EU are €1,568 billion (2022). **In terms of size, the external costs of producing animal sourced food in 2022 are ~7.6x higher than the economic costs (€206 billion).**

The true cost assessment shows that the quantified external costs attributed to animal sourced food consumption in the EU are €1,455 billion (2022), which is ~7.8x higher than the basic price paid to producers for the value of animal sourced food goods consumed in the EU. **Figure 7** demonstrates that the external costs of EU animal sourced food production are greater than those of EU consumption, and that they are significantly higher than the economic costs of those goods. Figure 8 illustrates the quantity of food (in kilograms) produced and consumed per type of animal sourced food. Red meat consists predominantly of beef, lamb and pork, while white meat represents chicken. Dairy is by far the most consumed animal sourced food by weight, followed by red meat, white meat, and finally eggs.

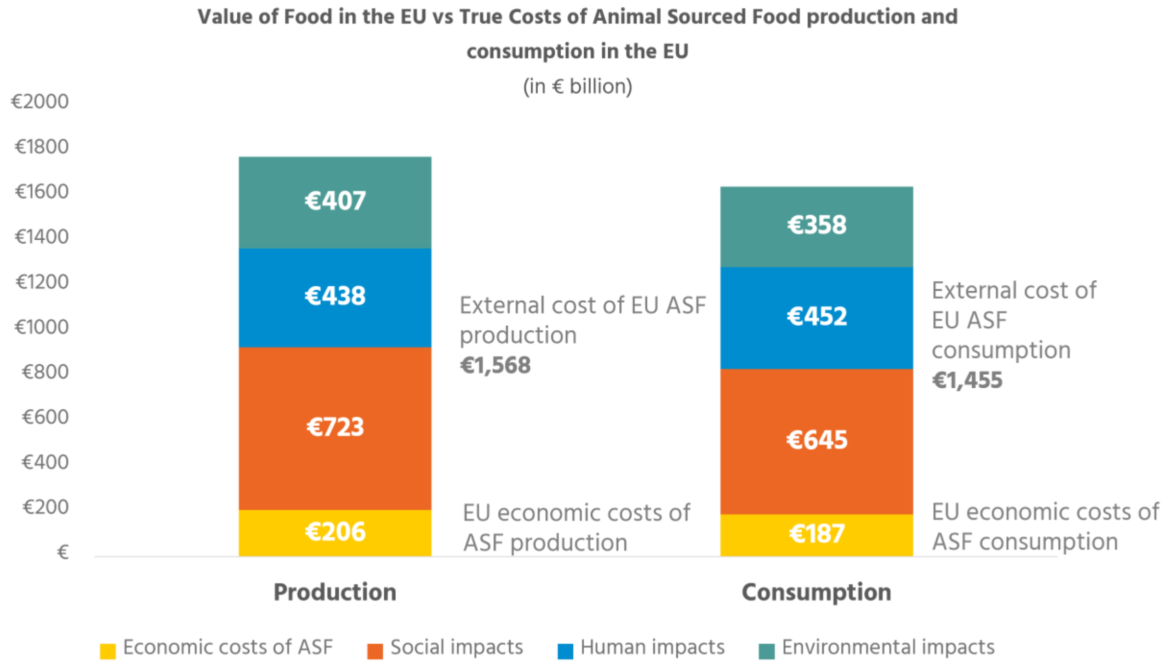


Figure 7 Quantified impact of current EU animal sourced food production and consumption in 2022 compared to economic costs of animal sourced food production and consumption in 2022 (not subtracting tax but including subsidies received by producers) (in € billion). *Additional externalities attributable to the EU animal sourced food system are related to deforestation and AMR, which have not been quantified but which are addressed qualitatively in this report.*

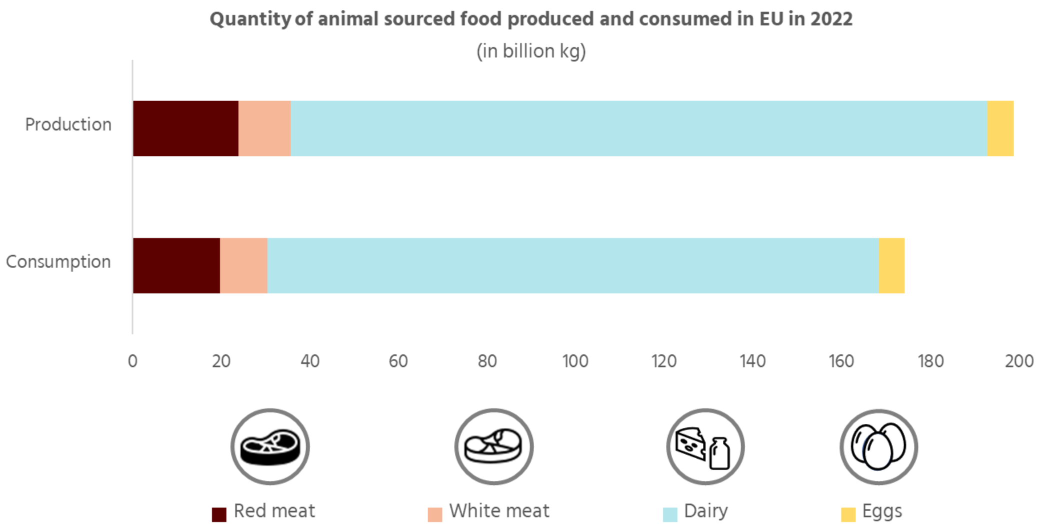


Figure 8 Animal sourced food produced in the EU (both animal sourced food produced and consumed in EU and exports) and animal sourced food consumed in the EU (animal source food produced and consumed in EU excluding exports but including imports) (in billion kg).

This chapter presents the breakdown of the quantified external costs of EU animal sourced food production and consumption in 2022. Firstly, the chapter discusses the external costs attributed to the current EU animal sourced food system. Secondly, it addresses the potential for true cost reduction in the scenario of 'better' production and a dietary shift to less consumption of animal sourced food.

For each impact, the total costs are displayed and main underlying drivers discussed. It should be noted that external costs quantified for EU production and EU consumption overlap. The costs of production represent all animal sourced food goods produced and consumed in the EU as well as exports (consumed in non-EU countries but produced in the EU), while consumption represents all animal sourced food goods produced and consumed in the EU as well as imports (produced in non-EU countries but consumed in the EU). The overlap in external costs therefore occurs for food which is both produced as well as consumed within the EU. **Regarding the consumption of animal sourced food in the EU it is assumed that 10% of food is wasted along the value chain.** Impacts in the production scenario are unaffected by this assumption, as the food is produced (and impacts occur) regardless of whether it is wasted or not. For consumption impacts to human health, the quantity of food *actually consumed* is assumed to be 10% less than the quantity of food initially produced.

3.1 Baseline results

Current production in the EU

The externalities resulting directly and indirectly from the production of animal sourced food in the EU (see Figure 9 below) amount to €1,568 billion. **The main drivers of this total impact are low animal welfare, diet-related diseases, air pollution, and land use**. These costs reflect the size of the industry within the EU and the diversity of impact themes to which it is linked.

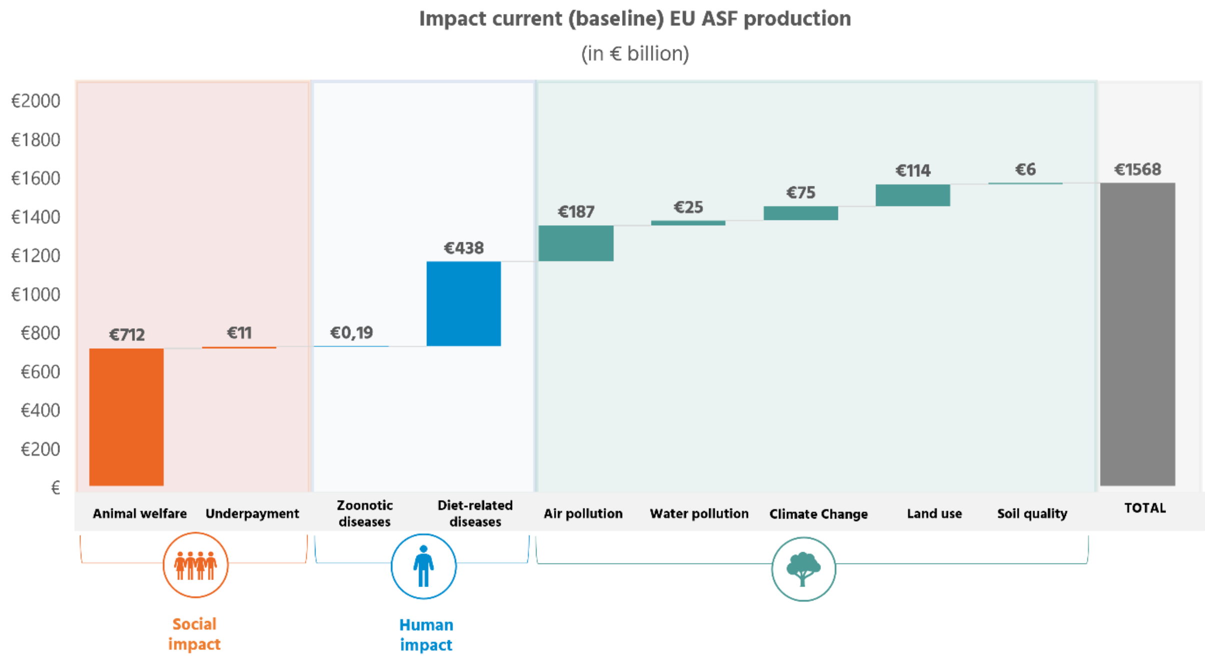


Figure 9 Impact of current EU animal sourced food production (€ billion, 2022).

The contribution of low animal welfare to the total true costs stems predominantly from both the number of animals raised for slaughter annually, as well as the predominant rearing conditions. To place the number of animals affected annually in context, in 2019 at least 8.4 billion animals were slaughtered in the EU (Eurogroup for Animals, 2021). The impact of animal sourced food, of course, strongly correlates with the quantity produced. However, there are significant impacts related to their consumption as well.

Diet-related disease (predominantly cardiovascular and kidney diseases, as well as cancers) is attributable to the consumption of red and processed meats. The impact of diet-related disease is largely the result of over-consumption of animal sourced food products. Europeans consume more than twice the world average of animal sourced food products, with these products providing more than 50% of EU total protein intake (European Commission, 2020).

Similarly, the large relative impact of air pollution is in line with its status as the largest environmental mortality risk factor globally (GBD 2017 Risk Factor Collaborators, 2018). Further, animal source food is behind most health impacts of agriculture related to air quality (Domingo, et al., 2021). Land use further plays a major role in the impact of the production of animal sourced food through both land use for pasture (predominantly for beef cattle, but also other animals to a lesser extent) and for animal feed production (predominantly for pork, then dairy cattle, and then poultry).

Current consumption in the EU

The externalities resulting directly and indirectly from the consumption of animal sourced food in the EU (see Figure 10 below) amount to €1,455 billion. **As for EU animal sourced food production, low animal welfare, diet-related disease, air pollution, and land use contribute to a large share of the (quantified) consumption impact.**

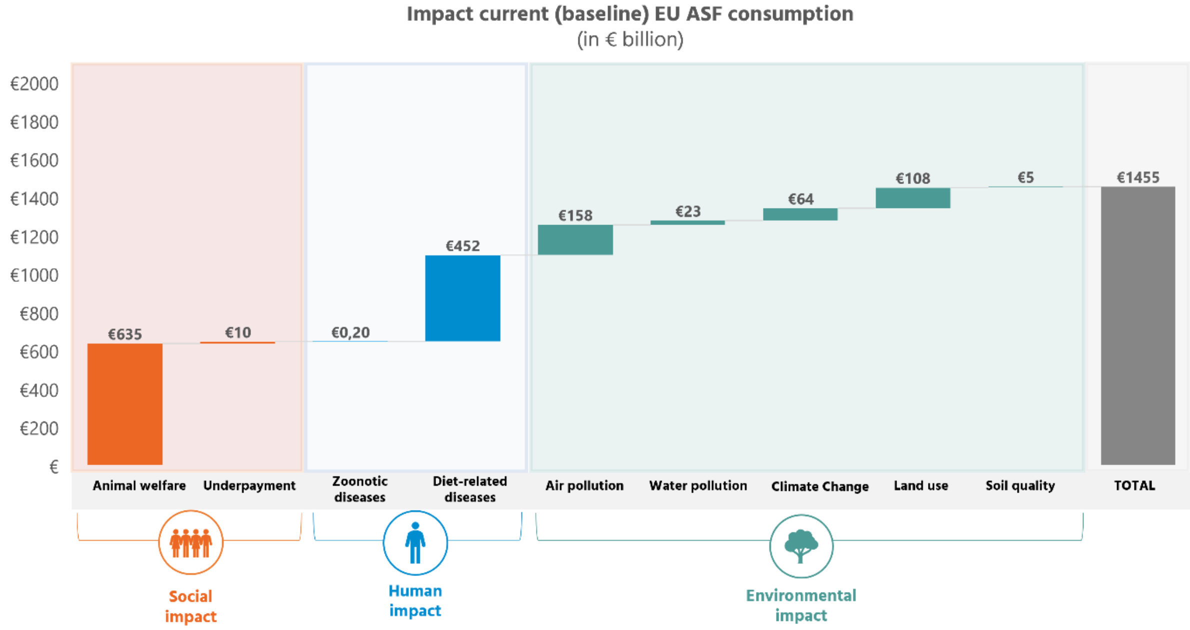


Figure 10 Impact of current EU animal sourced food consumption (€ billion, 2022).

There is a difference between the true costs attributed to current *production* and *consumption* of animal sourced food in the EU. This is the result of two main drivers:

1. Total quantity of animal sourced food;
2. Impact intensity (impact per kg of product).

The quantity of animal sourced food produced in the EU is higher than the quantity consumed in the EU. If the *impact intensity* was similar for both systems, the quantity produced versus consumed would explain the difference in true costs attributed to production and consumption of animal sourced food.

However, **it is observed that the impact intensity for animal sourced food produced outside of the EU (for EU consumption) is relatively high compared to animal sourced food produced within the EU.** This mitigates the variance between impact attributed to production and consumption of animal sourced food in the EU. Notably, the results show the *average* impact per kilogram of product produced in the EU is lower than the *average* impact per kilogram of product in the rest of the world. This is not to say that production practices in the EU are always better than practices elsewhere. Rather, it implies that on average the impact of production in the EU is lower. This is likely due to a combination of factors, including stricter regulations and enforcement of restrictions, such as on pesticide and land use as well as minimum legal animal welfare requirements.

Next, the chapter dives into social impact, human health impact and environmental impact in more detail. Each section is built up the same way. Firstly, the section presents the impact relevant to the value chains of producing animal sourced food in the EU. Secondly, the section presents the impact relevant to the value chains of consuming animal sourced food in the EU.

3.2 Social impact

Low animal welfare

Animal welfare is about the mental and physical well-being of non-human animals (Carenzi & Verga, 2009). In practice, assessments of animals' well-being are based on the satisfaction of their needs, as animal welfare cannot be measured directly. In order to quantify the impact of low animal welfare, we calculate the *animal life years suffered* as a result of rearing practices for animal sourced food, and multiply those with the morally adjusted monetary value of a disability-adjusted life year (DALY; see 5.5.1) (Scherer, Tomasik, Rueda, & Pfister, 2018). The factors considered to calculate the life years suffered per animal type are:

1. the animals' life quality;
2. their lifetime until slaughtering;
3. the slaughter duration (including transport time);
4. the number of animals affected per kg of output;
5. the moral value of different animal types compared to humans based on number of neurons[2] (Scherer, Tomasik, Rueda, & Pfister, 2018).

The total impact of low animal welfare attributed to animal sourced food *production* in the EU in 2022 is estimated to be €712 billion. This value can be understood as the external costs of total animal life years suffered in connection with all animal sourced food products consumed in the EU. The largest contribution came from the impact of white meat which accounted for €296 billion (41%), followed by red meat with €275 billion (39%), dairy with €78 billion (11%) and eggs with €63 billion (9%).

This is largely driven by the number of animals affected annually. For instance, in 2020 in Europe, 11.5 billion chickens were slaughtered in comparison to 328 million pigs, 67 million sheep, and 39 million cows (Orzechowski, 2022). Beyond demand, the large difference in the number of affected animals can be related to yield – the average chicken yields 1.69kg of meat while the average cow yields 231.5kg (FAO, 2023c). This means that 1kg of white meat results in the loss of 0.6 chicken lives, while 1kg of beef only accounts for slaughtering 0.004 cows. In terms of actual lifetime suffered, average broiler chickens live 6 weeks before they are slaughtered, compared to 6 months for pigs and 18 months for beef cattle (Farm Transparency Project, 2020). Calculated per kilogram of product, this translates to low animal welfare costs of €8.95/kg for red meat, €22.01/kg for white meat, €0.50/kg for dairy, and €10.60/kg for eggs. Differences in impact can also be attributed to variations in life quality measurements per animal. The life quality of cattle is

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[2] The authors of this report stress that the methodology for measuring the impact on animal welfare was developed for this report and remains a first elaboration open to review. The decision to assign a moral value based on number of neurons relative to humans was necessary to monetise the results. However, the way moral value is currently assigned can evolve as discussions regarding animal intelligence and sentience continue to evolve. The current methodology was chosen to allow for monetisation in line with other impacts measured in the report. More details on the methodology used to assign moral value can viewed in Annex 5.5.1.

measured based on the average number of days on pasture, which in the EU is relatively high at 137 days. In contrast, the life quality for broiler chickens and laying hens (white meat and eggs) is measured according to stocking density. The average stocking density of EU broiler chickens is 17/m^2 and for laying hens 12/m^2. Given that the FAO indicates that the comfortable stocking conditions for chickens is 4-5 birds/m^2 and 3 birds/m^2 for hens, it is evident why the low animal welfare impact of white meat and eggs is high relative to other sectors (Sonaiya & Swan, 2004).

Additional aspects of animal welfare

Low animal welfare is a difficult impact to quantify, as discussions in both policy and scientific circles continue on what constitutes positive animal welfare and ideal conditions. The low animal welfare quantified impact in this analysis is limited to a specific set of indicators (days spent on pasture for cattle, stocking density for broiler chickens, laying hens, and pigs, and transport times for all).

There are three main frameworks which have been used to understand low animal welfare. These are based on 1) meeting the needs of an animal to function biologically, 2) the animals' subjective experience, and 3) the ability of an animal to live according to its nature and engage in natural behaviour (Hartcher & Jones, 2017). Historically in the EU, the predominant focus has been on the first one in the form of the Five Freedoms: 1) freedom from fear and distress, 2) freedom from pain, injury or disease, 3) freedom to express normal behaviour, 4) freedom from hunger and thirst, and 5) freedom from discomfort. As the language of the Five Freedoms indicates, the focus of this framework is the prevention of negative affects by providing for survival critical measures. However, advances in the field of animal welfare understanding have demonstrated that merely being free from conditions which negatively affect survival is insufficient in providing true welfare.

As a result of this development in understanding, scientists are increasingly embracing the framework of the Five Domains which goes beyond this negative physical effect prevention structure and provides a means of analysing the experienced welfare of animals through the addition of a mental welfare component. The first four domains (nutrition, environment, health, and behaviour) are physical/functional domains, the positive experience of which contribute to (but do not define) a positive mental affective state (Mellor, et al., 2020). The domains are linked, with deprivation of a physical/functional domain contributing to a negative impact on the mental affective state while simultaneously underlining the important contribution of positive experiences in the promotion of animal welfare. Frameworks such as the Five Domains can be a useful tool in the development of animal welfare legislation which goes beyond the prevention of negative health outcomes in animals and instead promotes experiences of mental welfare in animals, farmed or otherwise.

Underpayment

The impact underpayment refers to the gap between workers' wages, the local minimum wage and the local living wage. Underpayment affects livelihoods in a variety of ways: it puts people in vulnerable positions and has been related to increased food insecurity for rural communities as well as higher risks of child labour (High Level Panel of Experts, 2022). In addition, underpayment in the value chain has been linked to increased levels of rural migration as younger generations (if they have the opportunity) are likely to seek alternative sources of livelihood (FAO, 2016). In terms of global food production, underpayment and underearning in the value chain may therefore pose a risk to future food security.

The total impact of underpayment from EU animal sourced food *production* in 2022 was €10.5 billion with €5 billion (48%) attributed to the production of agricultural inputs for red meat, white meat and eggs, dairy, and fish. This may be related to EU dependence on soybean meal imports from South America for the production of animal feed (European Environment Agency, 2020). The livestock industry is an important source of income for several rural communities. However, challenges in terms of underpayment and economic insecurity in the value chain remain (FAO, 2023b).

For EU animal sourced food *consumption*, the impact of underpayment in the value chain amounted to €10.4 billion in 2022. **The underpayment impact of animal sourced food products consumed in the EU is driven by imported products. Workers in non-EU countries who produce these products for consumption in the EU often face significant underpayment.** This might either result from relatively few workers facing a large gap between the local living wage and their actual wage, or many workers being paid relatively little below the local living wage. The main driver of this underpayment in 2022 is the red meat industry with €4.9 billion (47%), followed by dairy with €3.6 billion (35%).

3.3 Human health impact

The quantified human health impacts addressed in this section are zoonotic disease and diet-related disease. This section also includes a qualitative assessment of the impact of EU animal sourced food production on the development of antimicrobial resistance in animals and humans.

Zoonotic disease

Zoonotic diseases are caused by zoonotic pathogens that can spread from animals to humans. Zoonotic pathogens may be bacterial, viral or parasitic, or may involve unconventional agents and can spread to humans through direct contact or through food, water or the environment (World Health Organization, 2020) In the present study, the impact of zoonotic diseases is quantified for zoonotic diseases acquired by direct contact and foodborne zoonotic diseases:

- **Zoonotic diseases acquired by direct contact** occur when humans become infected with zoonotic diseases through direct transmission during animal rearing or meat processing resulting from contact with infected animals or contaminated biological material. The impact of zoonotic diseases acquired by direct contact can be allocated to the production of animal sourced food in the EU.
- **Foodborne diseases** result from the consumption of contaminated food. The impact of foodborne diseases can be allocated to the consumption of animal sourced food in the EU.

The quantified impact of zoonotic diseases for the true cost assessment is based on the prevalence of the diseases Campylobacteriosis and Salmonellosis in the human population. Together these two diseases account for 92% of reported zoonotic diseases in the EU (European Food Safety Authority & European Centre for Disease Prevention and Control, 2022). See Annex 5.5.3 for more information about the transmission pathways and quantification of zoonotic diseases.

The human health impact of zoonotic diseases that is attributed to animal sourced food EU *production* is quantified as the portion of zoonotic diseases (Campylobacteriosis and Salmonellosis) caused by direct contact with farm animals during the production of animal sourced food products in the EU and the impact of EU consumption of animal sourced food products produced in the EU. The impact of animal sourced food produced in the EU and consumed outside the EU is out of scope due to a lack of data on the human health impact of zoonotic diseases outside the EU.

The total impact of zoonotic diseases on human health allocated to animal sourced food *production* in the EU is €192.9 million with €16.5 million (8.6%) attributed to direct transmission during production and €176.4 million (91.4%) attributed to the impact of the consumption of animal sourced food that are produced and consumed in the EU. The human health impact of zoonotic diseases attributed to animal sourced food *consumption* in the EU is estimated based on the proportion of zoonotic diseases that results from the consumption and preparation of animal sourced food in the EU and the impact of viral zoonotic diseases transmitted during EU production of animal sourced food that is consumed in the EU. The total impact on human health caused by zoonotic diseases allocated to animal sourced food consumption in the EU is €196.6 million with €182.7 million (93%) linked to the consumption of animal sourced food in the EU and €13.9 million (7%) resulting from zoonotic diseases transmitted during EU production of animal sourced food that is consumed in the EU. In terms of the impact of zoonotic disease from animal sourced food consumption, 45% is from white meat, 42% red meat, 12% eggs and 1% dairy.

The quantified impact of zoonotic diseases is based on prevalent diseases that can be directly linked to livestock as host. Other infectious diseases such as Ebola, SARS, highly pathogenic avian influenza (HPAI, aka bird flu), and the recent COVID-19 pandemic, are also zoonotic diseases as these diseases all first originated in animals. In fact, 75% of all emerging infectious diseases are zoonotic (UN Environment Programme and International Livestock Research Institute, 2020). Most zoonotic pathogens originate in wildlife and natural ecosystems. However, livestock can serve as an intermediary host and intensive farming systems amplify the risk of these pathogens spilling over into human populations. This makes the intensification of domestic livestock farming a key driver behind the emergence and spread of zoonotic diseases and consequently, a potential incubator for future pandemics. Agricultural drivers, such as factory farming, have been associated with nearly 50% of zoonotic infections since the 1940s (Rohr, et al., 2019).

In particular, the poor animal welfare conditions of industrial farming systems within the EU are highly conducive to the contraction and spread of zoonosis to humans (Brozek & Falkenberg, 2021). The indoor confinement of animals at high densities with little ventilation increases the physical proximity of animals and their waste thereby accelerating inter-farm transmission and increasing the risk of human infection (Brozek & Falkenberg, 2021; Meadows, Mundt, Keeling, & Tildesley, 2018). The density of farm animals has been repeatedly identified as an important determinant for the spread of the swine influenza virus (Ding, 2021; Mastin, et al., 2011; Li, 2021; Salvesen & Whitelaw, 2021). In addition, the transportation of animals to and from factory farms over long distances increases the exposure of farm animals to wildlife pathogens and diseases (Bartlett, et al., 2022).The stress and discomfort inflicted on animals within these conditions exacerbates these risks by impairing animal immune systems making them particularly vulnerable to infection (Anomaly, 2015; Fablet, 2013). Finally, breeding practices within intensive farming systems often lead to high levels of genetic similarity amongst animals. This not only accelerates the spread of new pathogens, but also makes it more likely for existing ones to mutate and evolve, thereby increasing the risk of a mutation transmissible to humans (Espinosa, 2020).

Deforestation, and the destruction of wildlife habitats for land use is a second pathway through which the intensification of livestock farming contributes to the risk of zoonotic pathogen spill-overs (UN Environment Programme and International Livestock Research Institute, 2020). **The conversion of grassland into pastures for livestock breeding or into cropland for animal feed production is a major source of deforestation and biodiversity loss.** In 2022, almost half of the crops imported to the EU for animal feed were made up of soy (European Commission, 2022), primarily from South America (European Environment Agency, 2017). Soybean cultivation is currently the second largest driver of deforestation and biodiversity loss after cattle raising (Heinrich Böll Stiftung, Friends of the Earth Europe, and Bund, 2021). This will be discussed in more detail in the environmental impact subsection of the results (Chapter 3.4). As humans invade natural habitats, there is more frequent and closer contact with wildlife, increasing human exposure to zoonotic diseases (UN Environment Programme and International Livestock Research Institute, 2020). In addition, as their habitats transform, animal hosts typically undergo rapid changes in behaviour that can influence the pathogens that they carry and the probability of diseases spreading to humans (White & Razgour, 2020).

Zoonotic diseases can have catastrophic consequences, both in terms of animal and human health and in terms of economic losses. For example, in 2021-2022 avian influenza caused 2,467 outbreaks in poultry in Europe, resulting in the slaughter of 47.7 million domestic birds in 37 countries (European Food Safety Authority, 2022). Outbreaks of zoonotic diseases, such as the avian flu also heavily impact the economy. In one instance, an outbreak of avian flu (H7N7 virus) in the Netherlands that led to the culling of approximately 30 million birds was estimated as resulting in total economic costs of more than €150 million (European Commission, 2006). Further, as avian influenza is zoonotic, it is possible to transmit from animal to humans. While the disease has not caused a human pandemic (and remains unlikely to do so), the *possibility* of such a pandemic can still lead to significant societal costs. In fact, at the time of writing (March 2023) there is an ongoing avian influenza threat with at least one report of the disease making the jump to a human host, with simultaneous economic consequences as vaccine production and stockpiling becomes necessary (Docter-Loeb, 2023).

The emergence and spread of zoonotic viruses, including the Ebola and corona viruses have demonstrated how zoonotic diseases form a threat to global public health. COVID-19 has resulted in over 1.1 million deaths in the 27 EU countries as of October 2022 (OECD/European Union, 2022). Not only has COVID-19 caused a large number of deaths, but it has also impacted mental health and well-being, disrupted health care systems and resulted in an economic crisis for which the EU has set out a recovery package in 2020 amounting to at least €1.8 trillion (European Commission, 2020). The impact of these diseases shows the importance of preventing the spread of disease among animals and reducing the risk of transmission of zoonotic pathogens between animals and humans.

Human health effect of antimicrobial resistance

Antimicrobial resistance (AMR) is the ability of microorganisms to resist antimicrobial treatments. AMR is a global problem, as bacteria in all parts of the world are becoming increasingly resistant to antimicrobials, making infections increasingly difficult to treat. AMR has a direct impact on human and animal health and causes an economic burden to society due to higher costs of treatments and the loss of productivity caused by illness. An assessment of the impact of AMR on public health in the EU by The European Centre for Disease Prevention and Control estimates that AMR is responsible for 33,000 deaths each year in the EU (European Commission, 2022). Projections suggest that AMR will keep growing in the EU from about 17% of infections with AMR in 2015 to about 19% in 2030 (OECD, 2019). AMR results in longer hospital stays and increased health care expenditure. It is estimated that AMR costs the EU an additional €1.5 billion per year in healthcare costs and productivity losses (OECD/European Union, 2022).

AMR occurs naturally over time, usually through genetic changes. However, increased antibiotics use in human medicine, veterinary medicine and agriculture has been linked to the rise of antibiotics resistance globally. This makes AMR also a food industry issue, as food animals are given antimicrobial agents to treat and, less frequently, prevent the spread of existing disease in large numbers of animals. As a result, AMR increases in the animal population, which in turn increases the risks that these resistant bacteria are passed from animals to humans through direct contact or indirectly through the food chain. Although there is increasing evidence that AMR can spread between animals, humans and the environment, the precise extent of the transmissions of AMR from food animals to humans is still uncertain and studies aiming to quantify the transmission pathways have shown inconclusive results (Emes, 2022).

New research commissioned by World Animal Protection and undertaken by researchers at the University of Bologna (Ardakani, Canali, Aragrande, Balzani, & Beber, 2023) attempts to estimate the contribution of factory farms to the economic burden of AMR on human health based on statistical modelling. The study used available data on resistant infections in humans caused by *Escherichia coli*, *Staphylococcus aureus*, *Campylobacter*, and non-typhoidal *Salmonella* under the hypothesis that all infections are related to the use of antibiotics in farmed animals. The results of this study indicate that globally, in 2019, 403,052 deaths are estimated as attributable to AMR for the selected bacteria *Escherichia coli*, *Non-typhoidal Salmonella* and *Staphylococcus aureus*, corresponding to 13,650,064 DALYs. Due to a lack of data on the global burden from resistant Campylobacter infections, the impact of resistant Campylobacter in Europe and Central Asia could not be calculated. Of the 13,650,064 DALYs, 7.8% of DALYs are associated with the regions Europe and Central Asia based on the share of global antibiotic consumption, resulting in 1,064,705 DALYs. Applying the True Price method to this number results in an estimated impact of AMR on human health in Europe and Central Asia (for the three selected resistant pathogens) of €113 billion.

The study by World Animal Protection builds on various assumptions and hypotheses (due to a lack of available data). Moreover, the geographical scope of the study does not match the scope of this true cost assessment. Therefore, the resulting monetised value of €113 billion cannot be directly compared to the other external costs of EU production and consumption of animal sourced food. However, the study by World Animal Protection does provide a first valuable insight in the magnitude of the economic burden on society of AMR.

Diet-related disease

The global burden of diet-related disease is extensive, with poor diets being responsible for 22% of all deaths among adults in 2017. The primary diet-related health impacts are cardiovascular disease (CDV), neoplasms (cancers), and diabetes or kidney disease (GBD 2019 Diseases and Injuries Collaborators, 2020). That same year, poor diets resulted in over 255 million disability-adjusted life years (DALYs), a measure of disease burden which expresses the number of life years lost by a population because of ill-health summed with years lived with disability. While the risk factors leading to these impacts are diverse, including factors such as diets low in fruits, legumes, and vegetables, two major risk factors in the EU are diets high in red meat and processed meat. According to a meta-analysis of thousands of scientific articles attributing the cause of disease**, in 2019 6.1% of ischemic heart disease and 9.7% of incidences of stroke in the EU were attributable to diets high in red meat, while 5% of ischemic heart disease and 12.8% of cases of diabetes in the EU were attributable to diets high in processed meats** (IHME, 2015).

The total impact of diet-related disease resulting from animal sourced food production in the EU is estimated to be €438 billion. Most of this impact (€369 billion, or 84%) is a result of animal sourced food produced and consumed in the EU, with the remainder (€69 billion, or 16%) representing the global burden of disease resulting from EU-produced animal sourced food products. The largest risk factor driving this impact is red meat produced in the EU and consumed both domestically and abroad, which represents €277 billion (63%) of the diet-related disease impact, with the remaining €161 billion (37%) attributable to processed meat production. The medical condition representing the largest portion of this impact is cardiovascular disease with €251 billion (57%), followed by diabetes and kidney disease with €131 billion (30%), and finally malignant neoplasms with €56 billion (13%).

The total impact of diet-related disease resulting from animal sourced food consumption in the EU is estimated to be €452 billion. Most of this impact (€369 billion, or 82%) is a result of animal sourced food produced and consumed in the EU, with the remainder (€82 billion, or 18%) representing the burden of disease resulting from imported animal sourced food products. The largest risk factor driving this impact is red meat consumption, which represents €277 billion (61%) of diet-related disease impact, with the remaining €174 billion (39%) resulting from processed meat consumption. The medical condition representing the largest portion of this impact is cardiovascular disease with €248 billion (55%), followed by diabetes and kidney disease with €139 billion (31%), and finally malignant neoplasms with €65 billion (14%).

3.4 Environmental impact

The quantified environmental impact attributed to production and consumption of animal sourced food in the EU is €407 billion and €358 billion, respectively. **The production and consumption of red meat are the largest drivers of environmental impact (€6.73/kg), presenting 2.5x the environmental impact of eggs (€2.67/kg) and poultry (€2.65/kg).** The impact of red meat is particularly associated with air pollution (€80 billion), land use (€67 billion) and contribution to climate change (€43 billion). The impact for poultry and eggs is predominantly related to air pollution (€34 billion). Additionally, contribution to climate change and land use both add €8 billion attributable to the impact of white meat and eggs. The relationship between these different environmental impacts and their main drivers will be detailed more extensively below.

Air pollution

Air pollution[3] represents human and environmental health effects from emissions to air other than greenhouse gas emissions. The impact of air pollution attributed to EU animal sourced food *production* in 2022 is €187 billion. The main driver of this impact is ammonia emissions (NH_3) from livestock breeding which contributed €139 billion (74%). Ammonia emissions are directly emitted from the storage and management of animal waste (Zhao, Manuzon, & Hadlocon, 2014).

The total impact of air pollution from EU animal sourced food consumption for 2022 was €158 billion with €66 billion (42%) attributed to red meat and €63 billion (40%) to dairy. While air pollution comprises several indicators, ammonia emissions are again the largest driver of this impact, representing 76% of air pollution impact for red meat and 82% for dairy products. This significant impact footprint is a result of the effect ammonia has on human health when reacting with other polluting sources such as vehicles to form fine particulate matter (Blaustein-Rejto, 2020).

Water pollution

Water pollution is the impact of emissions to water contributing to marine- and freshwater eutrophication. The impact of water pollution from animal sourced food *production* in the EU for 2022 was €25 billion. Freshwater eutrophication from the breeding of bovine cattle, sheep, goats, and horses for red meat and dairy products are the most important contributors to this impact resulting in €13 billion (53%) and €11 billion (42%) respectively for the year in question. This is related to the discharge of animal waste to surface waters through runoff. The high concentrations of nitrogen and phosphorus in livestock waste cause nutrient imbalances in aquatic ecosystems thereby increasing the risk of eutrophication (Sakadevan & Nguyen, 2017). Atmospheric ammonia emitted from animal waste also contributes to freshwater eutrophication (European Environment Agency, 2019). There is further impact from direct nutrient leaching from agricultural soils utilised to grow animal feed inputs, with approximately €2.6 billion (10%) of impact in the EU (including imported feed inputs).

Water pollution from EU animal sourced food *consumption* for 2022 was €23 billion. The most significant contribution to this impact came from the consumption of red meat, which contributed €12 billion (53%), and dairy with €10 billion (42%). This was again driven primarily by the stockbreeding stage of the value chain.

Contribution to climate change

Contribution to climate change refers to the effects of global mean temperature rise caused by increased emissions of greenhouse gases due to anthropogenic activities. The impact of climate change from EU animal sourced food *production* for 2022 was €75 billion, of which €43 billion (58%) is linked to the breeding of bovine cattle, sheep and goats and horses. Rising levels of greenhouse gas emissions can be

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[3] Comprised of: Ammonia (NH3), NMVOC, Nitrogen oxides (NOx), Particulate matters (PM2.5), Sulfur dioxide (SO2), Freshwater ecotoxicity, Marine ecotoxicity, Terrestrial ecotoxicity, Human toxicity (carcinogenic), Human toxicity (non-carcinogenic).

attributed to several aspects of livestock farming. The conversion of forests into pastureland for livestock breeding is a significant contributor to carbon dioxide (CO_2) emissions (European Commission, 2020). Next to CO_2, methane and nitrous oxide are particularly potent greenhouse gases emitted by the enteric fermentation of ruminants and animal waste (European Commission, 2020).

The impact of climate change from EU animal sourced food *consumption* for 2022 was €64 billion. The animal sourced food sectors making the largest contribution to this impact were red meat, which accounted for €36 billion (56%), and dairy with €21 billion (33%). This is unsurprising, **as the global climate change impact of beef cattle per serving is significantly higher than any other meat or plant protein (more than twice as high as sheep, cheese, and dairy cattle in distant second, third, and fourth places), largely as a result of deforestation for pastureland** (Poore & Nemecek, 2018). However, even cattle raised for beef on deforestation-free land represent a significant climate change impact due to their relatively low feed efficiency (kg of feed needed per kg of final product) and significant greenhouse gas emissions resulting from nitrogen production to stimulate grass growth in pastures (Dunne, 2020).

Deforestation & animal feed

Global deforestation remains an urgent problem, not simply due to the intrinsic value of global forests, but also due to the effect it has on climate change through the destruction of carbon sinks (global forests sequestered about twice as much CO_2 as they emitted between 2001 and 2019 (Harris & Gibbs, 2021)) and biodiversity loss (Giam, 2017), as well as a number of other environmental impacts. Deforestation is simultaneously intrinsically linked to animal sourced food production and consumption – in 2021, 75% of deforestation in the Amazon was a direct result of cattle ranching in undesignated Brazilian public forests (Salomão, et al., 2021).

While the EU only imported 271 million kilograms of beef (1% of EU red meat consumption) in 2022, it imported significantly more soyabean meal for animal feed (26 billion kg, or 48% of agri-food inputs imported for feed) (DG AGRI - European Commission, Directorate-General for Agriculture and Rural Development, 2018). Globally, land dedicated to soy production continues to expand. Studies found that instead of directly replacing forests, crop land dedicated to soy is replacing pastures (Barona, Ramankutty, Hyman, & Coomes, 2010). However, global cattle production also continues to grow, turning previously untouched forested areas into pastureland. This illustrates the interconnectedness between cattle production and animal feed production and their shared contribution to deforestation.

Land use

Land use[4] represents the loss of ecosystem services from decreased availability of land for purposes other than the natural one, through land occupation. The impact of land use from EU animal sourced food *production* in 2022 was €114 billion. The main driver is in the rearing phase, where the occupation of pastureland for the breeding of bovine cattle, sheep and goats and horses to produce red meat resulted in

[4] Comprised of: Occupation of cropland, forestry and pastureland.

€54 billion (47%) of this impact and dairy products which contributed €26 billion (36%). **The conversion of grassland and forests into pastureland for livestock rearing and into cropland for feed production is a significant source of land use** (Heinrich Böll Stiftung, Friends of the Earth Europe, and Bund, 2021).

The environmental impact of soy

Soy is a protein and nutrient dense plant protein. With approximately 17g of protein per 100g of product (similar to many meat products) and a high concentration of essential amino acids, it offers a viable alternative to meat consumption as a source of global proteins. In recent years, however, it has earned a negative reputation for its link to global deforestation as described above, as well as for its contribution to climate change through intensive farming. While both impacts do indeed occur, there are further relevant factors to consider when thinking about the impact of soy production.

First, most (~76%) soy produced globally is produced directly for animal feed. The majority is intended to feed poultry (37%), pigs (20%) and fish (6%) (Ritchie & Roser, 2021). This means that when consuming animal products, a consumer is also indirectly consuming soy. In fact, according to research by WWF (Kuepper & Stravens, 2022), when consuming a 100g chicken breast in the EU, a consumer indirectly consumes 109g of soy. In other words, consuming animal proteins often represents a greater impact from soy than eating soy directly, even if not taking into account the impact of other agri-food inputs.

Second, 20% of soy produced globally is intended for direct human consumption – but even then, 66% of this is intended for soybean oil. This means that, of the 353 million tonnes of soy produced in 2020, only 24 million tonnes (7%) were consumed by humans in the form typically seen in grocery stores and restaurants – tofu, tempeh, etc.

It is undeniable that, without livestock consumption of soy, there would not just be a sufficient supply of a product rich in protein and amino acid for human consumption, but also a significant excess. Moreover, given that a large share of current soy production is intended for animal feed (particularly, for poultry and pigs), and current direct and indirect contributions of soy production to deforestation, reducing consumption of animal sourced food (thereby reducing quantities of animal feed production) offers the opportunity to significantly reduce the risk of deforestation.

The greatest land use impact in the agri-food *production* stage (i.e., growing crops for feed) is attributable to red meat, with dairy cattle and pork representing €8.7 billion (31%) and €6.4 billion (22%) respectively of the total €29 billion of impact from this stage in the value chain. Beef cattle also represent significant land use costs, but these are predominantly seen in the rearing phase as a significant percentage of beef cattle are grass and pasture raised (costs attributed to rearing phase). In contrast, dairy cattle and pigs are predominantly raised in confined spaces with animal feed produced from cereals and oilseeds (impact attributed to agri-food stage). Therefore, the impact of pork and dairy cattle is predominantly seen in the agri-food production stage because while the actual rearing of these animals (in the current industrial model) requires relatively little land due to factory farming, the growing of feed crops for their production remains land intensive.

The impact of land use from EU *consumption* for 2022 was €108 billion. The most significant contribution came from red meat with €62 billion (58%) and dairy with €39 billion (36%). Most of the impact results from use of pastureland (86%). It is important to note that these costs only represent the *current* (in this case meaning annual) opportunity cost of using land for pasture instead of leaving it in its pristine state and does not include impacts associated with active land conversion (like deforestation).

Soil quality

Animal sourced food production affects soil quality and human health resulting from emissions to soil through various pathways, among which erosion, compaction, pesticide pollution, and over-grazing. **The impact of animal sourced food on soil quality related to contact with agricultural soils is largely tied to animal feed production.** The indicators of soil quality quantified are caused by crop farming for animal feed production and include:

> **Other indicators of soil quality**
>
> Complementary to the soil quality indicators quantified in this report, there are indicators not yet quantified due to lack of method or required data. Particularly, the ecotoxic impact of pesticides used for animal feed production and the soil erosion and compaction impacts of over-grazing are expected to contribute to soil quality (see Annex 6.5.1 for more information).

1. **Soil erosion**;
2. **Soil compaction**;
3. **Human health impact of pesticides emitted to soil**.

The total impact of EU animal sourced food *production* on soil quality was €6.2 billion in the EU in 2022. This impact is predominantly driven by water erosion (the erosive effect of rainfall, snowmelt, runoff, and poor irrigation management), which results in €4.2 billion (67%). Soil compaction results in €1.8 billion (29%) and human toxic impact of pesticides emitted to agricultural soil €256 million (4%). As expected, most of the impact results from red meat production with €5.7 billion (92%). While the largest part of this impact (€3 billion, or 51% of red meat impact) came from cattle, this impact represents both beef cattle and dairy cattle as it was not possible to distinguish between the two. It is therefore highly likely that the largest soil quality impact is in fact the result of pork production with €2.5 billion (43% of red meat impact) because many beef cattle are grass fed, which generates lower soil quality costs, while pigs in the EU are largely fed with soy and wheat feeds.

The total impact of EU animal sourced food *consumption* on soil quality was €5.4 billion in 2022. This impact is again predominantly driven by water erosion, which resulted in approximately €3.6 billion (66%), followed by soil compaction with €1.6 billion (30%) and finally by the human toxic impact of pesticides emitted to agricultural soil with €223 million (4%). The soil compaction impact of EU animal sourced food *imports* could not be calculated, so the calculated value presented here is likely an underestimation.

Biodiversity

The results of this analysis indicate that the biodiversity impact of EU animal sourced food production for 2022 was €221 billion (see Figure 11) and predominantly related to land use (€97 billion). The conversion of forests and grassland into pastureland for livestock breeding and cropland for feed production leads to the modification or destruction of natural habitats and their endemic species (IPBES, 2019).

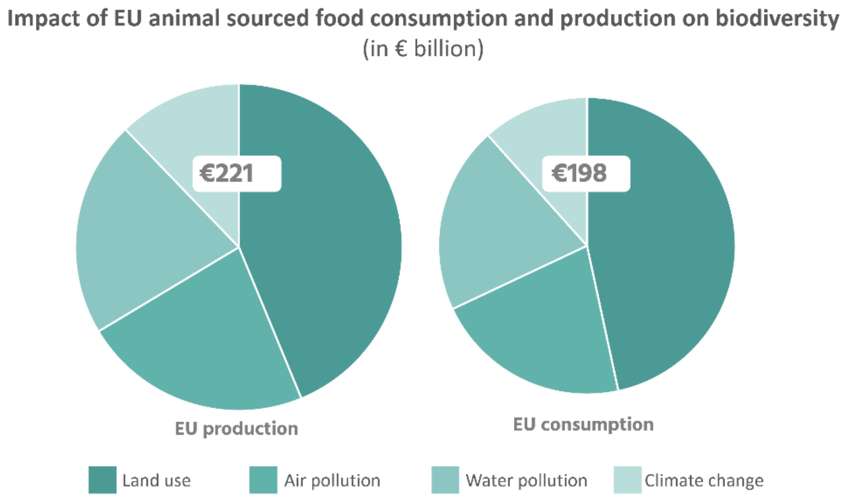

Figure 11 The biodiversity impact resulting from land use, air pollution, water pollution and climate change of EU animal sourced food.

The emissions and waste produced by livestock farming degrade both air and water quality thereby posing a threat to all terrestrial and aquatic life (FAO, 2006). In 2022, the impact of biodiversity loss from air pollution was €50 billion and water pollution €47 billion. Finally, €28 billion of impact can be attributed to biodiversity loss due to contribution to climate change. Fluctuating temperatures due to greenhouse gas emissions affect the survival of species and the functioning of their natural ecosystems (FAO, 2006).

In terms of consumption, the biodiversity impact for 2022 was €198 billion. As for EU production, this is mainly attributed to land use (€92 billion), followed by biodiversity loss from air pollution (€42 billion), water pollution (€40 billion) and contribution to climate change (€23 billion).

Biodiversity loss from current production and consumption

Biodiversity refers to the prevalence of biological diversity, understood as the variety of living things that inhabit the planet, the variety of ecosystems and habitats, and the variety of genes and traits available within a species. The environmental impacts discussed in this report contribute (in)directly to biodiversity and loss of ecosystem services.

An initial analysis of global food systems might conclude that the majority of food consumed globally is concentrated in a few items, predominantly cereals, animal sourced foods, some oilseeds, fruits, and vegetables. It could therefore be easy to conclude that as long as these are preserved, biodiversity loss is no threat to food security. However, the continuing ability of global food systems to produce these staple products is intrinsically linked to an assortment of less visible species, including pollinators, micro-organisms, and other invertebrates such as bats, birds, worms, fungi, and bacteria. They all play an essential role in maintaining soil fertility, plant pollination, and purifying the water and air that crops and livestock need to thrive (FAO, 2019).

Biodiversity further undergirds ecosystem resilience, or the ability to resist change and to quickly recover (Oliver, et al., 2015). Both of these aspects become particularly important in the context of climate change and the rising likelihood of severe weather events. It is therefore particularly concerning that global wildlife populations have fallen by more than two-thirds over the past 50 years (Sauer, 2020), that species are going extinct at an unprecedented rate, and that these developments are further strongly tied to deforestation for crop land, pesticide and fertiliser use for crop stimulation, and growing global appetites for resource-intensive foods such as animal products (Benton, Bieg, Harwatt, Pudasaini, & Wellesley, 2021).

3.5 Results for 'better and less' scenario

The European Union recognises that a shift in its agricultural system is needed to become compatible with the goals set as part of the European Green Deal for, amongst other things, healthy and affordable food as well as clean and healthy air, water, and soil biodiversity (European Commission, n.d.). **There is a rising recognition that climate change and environmental degradation are existential threats to the EU and the world – not only, but also in terms of food security** (European Commission, 2023). At the same time, grassroots driven initiatives such as "End the Cage Age" underline a growing societal attention to and desire for improved animal welfare within European animal sourced food industries (European Commission, 2021).

3.5.1 Better production of animal sourced food in the EU

In recognition of the need for change, the EU is updating many of its animal sourced food production regulations within the boundaries of the Farm to Fork strategy. These updates call for increases in organic farming such that 25% of total farmland is handled using organic farming methods by 2030. Simultaneously, the Farm to Fork strategy announces the revision of current European animal welfare legislation, offering an opportunity for promoting animal welfare through measures such as cage-free farming, lower stocking densities, shorter transport times and use of enrichment materials (Eurogroup for Animals, 2023). For the purposes of this analysis, the 'better' scenario supposes the target of increased organic production and improved animal welfare has been achieved and integrated in animal sourced food production in the EU. In other words, assessing the 'better' scenario assumes 25% of animal sourced food is produced organically, legal stocking density limits are reduced, and transport times are lowered.

In this part of the true cost assessment not all impacts are quantifiable (see textbox). Notably, air pollution is not included due to lack of reliable data on change in footprint indicators (amongst others, on toxicity levels) when shifting from 'conventional' to organic production. Research highlights the urgent need for independent Life Cycle Assessments of a wide variety of footprint indicators relevant to organic food production.[5] In terms of animal welfare measures, only the effect of lower stocking densities and transport times could be quantified, due to the limited scope of the method applied. However, further measures such as cage-free farming and the use of enrichment materials

Impacts not quantified

A selection of impacts cannot be quantified for the better production-scenario due to lack of data or quantification method, namely:

1. Underpayment;
2. Diet-related disease;
3. Zoonotic disease;
4. Antimicrobial disease;
5. Air pollution;
6. *Part of* soil quality.

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[5] *"Current LCA methodology and studies tend to favour high-input intensive agricultural systems and misrepresent less intensive agroecological systems such as organic agriculture. LCA assesses agroecological systems inadequately for three reasons: (1) a lack of operational indicators for three key environmental issues; (2) a narrow perspective on functions of agricultural systems; and (3) inconsistent modelling of indirect effects"* (Knudsen, Cederberg, & van der Werf, 2020).

are also proven as positively influencing animal welfare (Hartcher & Jones, 2017; Godyn, Nowicki, & Herbut, 2019) and are therefore considered complemenetary to the animal welfare measures in scope.

Results

The quantified results on the true cost reduction in the 'better' scenario illustrate the effects of increased organic production and measures such as reduced stocking density and transportation time for slaughter on low animal welfare (see Figure 12).

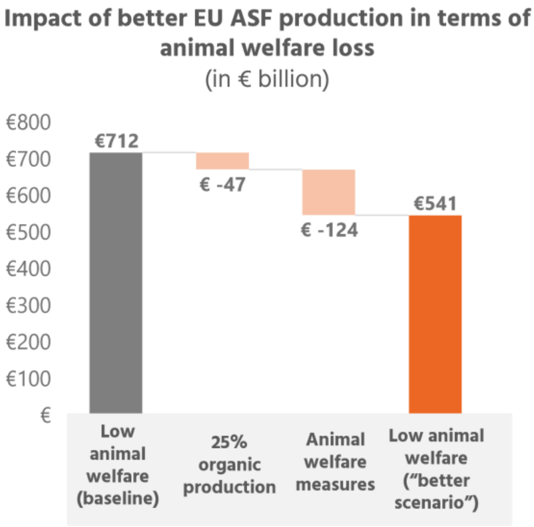

Figure 12 Improved animal welfare due to better production of animal sourced food in the EU (€ billion, 2022). *Increased organic production and improved animal welfare measures decrease welfare loss experienced by animals. Compared to the baseline scenario, the cost of low animal welfare due to stock rearing in the EU is reduced from €712 billion to €541 billion in the 'better' scenario (a reduction of 24%). The majority (€124 million) results from lower stocking densities for pigs, broiler chickens, and laying hens, and shorter transportation times. Increased uptake of organic production results in a €47 million true cost reduction, due to better life conditions for organically compared to conventionally farmed livestock.*

Moreover, **improved animal welfare measures in the production of animal sourced food positively affects human health and the environment**, specifically zoonotic diseases, antimicrobial resistance and contribution to climate change (Herzog, Winckler, & Zollitsch, 2018; Düpjan, 2022). In this assessment, not all true costs are quantitatively assessed due to limited data availability. This section discusses some of the impacts in scope in a qualitative manner. Firstly, it addresses effects on human health (both in terms of zoonotic disease as well as antimicrobial disease). Secondly, it discusses effects on the environment.

Effects on human health: zoonotic disease

Improved animal welfare measures can help prevent the spread of disease among animals and reduce the risk of transmission of zoonotic pathogens between animals and humans. **Given the interlinkages between animal, environmental and human health, a recent consensus has emerged that a more integrated approach is required for addressing the risk of zoonosis** (UN Environment Programme and International Livestock Research Institute, 2020), particularly one that adopts animal welfare management as a key focus (Düpjan, 2022). Indeed, the FAO-OIE-WHO Tripartite alliance has concluded that a One Health Approach, which addresses low animal welfare alongside the environment and human health, is the optimal way of forestalling future zoonotic disease outbreaks and pandemics (FAO-OIE-WHO Collaboration, 2010).

There appear to be three factors related to low animal welfare that are considered important for reducing the spread of zoonotic diseases: limiting stocking density (Brice, et al., 2021; Meadows, Mundt, Keeling, & Tildesley, 2018; Salvesen & Whitelaw, 2021), improving animal health and stress (Düpjan, 2022; Salvesen & Whitelaw, 2021), and reducing the live transport of animals to and from factory farms (Marchese & Hovorka, 2022). Some studies suggest that organic farming practices that allow animals to spend more time outside with better housing and higher quality feed are effective measures for improving overall animal health and resistance to infection (Mie, et al., 2017). These conditions reduce the overall stress of animals, provide more ventilation, and limit the contact between animals, thereby reducing the rate of spread of pathogens among the animals (Greger, 2007).

Nevertheless, some studies suggest that increased outdoor access may increase the susceptibility of animals to infectious and parasitic diseases, as there is greater exposure to environmental contamination, thereby putting overall animal health and well-being at risk (Vaarst, et al., 2008; Vaarst, Padel, Hovi, Younie, & Sundrum, 2005). The increased risk of exposure depends greatly on management practices and appropriate health and safety measures implemented at farms (Vaarst, Padel, Hovi, Younie, & Sundrum, 2005). As such, to maximise the advantages of outdoor access for animals, adapted health plans and proper maintenance and management of outdoor ranges is necessary to maintain optimal animal health and welfare (Lund, 2006; Vaarst, et al., 2008; Sundrum, 2001).

Additional research on the precise measures that improve animal welfare and lower the threat of zoonotic diseases will help to create a better understanding of the effects of different animal welfare management practices on the health of animals and the rate of disease transmission (Kijlstra, 2009).

Effects on human health: antimicrobial resistance

Systematic review and meta-analysis show that restricting antibiotic use in food-producing animals can result in a reduction of between 10-15% in the absolute risk of antimicrobial resistance (AMR) (Tang, et al., 2017). Similarly, the prevalence of AMR in humans was 24% lower for the intervention group compared to the control group, with the strongest effect seen for humans that had direct contact with food-producing animals. These studies indicate that a decrease in the antibiotic use in food-producing animals is likely to contribute to a decrease in the risk of AMR in the human population.

The increased recognition of the contribution of antimicrobial use in livestock production to AMR in the human population has led to various measures taken to reduce use of antibiotics in food-producing animals. Between 2011 and 2020, an overall decline in sales of 43% was observed for the 25 EU/EEA countries that consistently reported since 2011, with a noticeable decrease in sales identified for some of the highest selling countries. However, there is much variability between countries, and for a few countries sales increased by more than 5% (between 8.6% and 79.3%) between 2011 and 2020. On 28 January 2022, the EU banned all farms of routine farm antibiotic use, including prophylactic group treatments (European Union, 2022). This legislation supports the goals of the European One Health Action Plan and the Farm to Fork strategy against AMR, which aims to reduce sales of antibiotics for farmed animals in the EU by 50% by 2030. Though the legislation (amongst others aimed at improving animal welfare standards) has been implemented, marking an important step in the reduction of farm antibiotic use, there are concerns that compliance will be difficult to achieve and antibiotics will continue to be widely used in farming systems.

Besides a ban on prophylactic group treatments, other measures can also contribute to a decrease in antibiotic use in livestock production. For example, organic standards severely restrict the use of antibiotics in any livestock raised for animal sourced food. Various studies have demonstrated that the transition to organic farming systems results in a decrease of AMR among the livestock (Sapkota, et al., 2014). The strict limitation on the use of antibiotics in organic farming systems relies on the establishment of practices that ensures animal health and prevents diseases. This includes practices like supplying nutritious diets, choosing robust breeds that are naturally more resistant to pests and diseases, maintaining strict levels of hygiene and reducing stress. Studies show that overall, better animal welfare measures are associated with lower antibiotic use in farm animals (Rodrigues da Costa & Diana, 2022). **Implementing animal welfare measures and increasing animal health are therefore of key importance in decreasing the use of farm antibiotics and enabling full implementation of the new EU legislation on routine farm antibiotic use.**

Effects on the environment

In terms of *improved animal welfare measures*, there is insufficient data available to fully understand the (positive or negative) effects on the environment through livestock farming (Herzog, Winckler, & Zollitsch, 2018). However, individual cases illustrate there may be a relationship between the two. For example, in the case of dairy cows, access to pasture is considered to have a positive effect both in terms of animal welfare and environmental impact (namely, contribution to climate change, eutrophication and acidification potential) (Herzog, Winckler, & Zollitsch, 2018). However, due to the modest availability of data, this report cannot quantitatively assess the interdependency of animal welfare measures and impact on the environment.

In terms of *increased organic production,* more data is available on the implications of shifting from conventional to (more) organic farming. This true cost assessment is based on various *Life Cycle Assessments* that study these effects on specific indicators of environmental impact (such as CO_2 emissions).

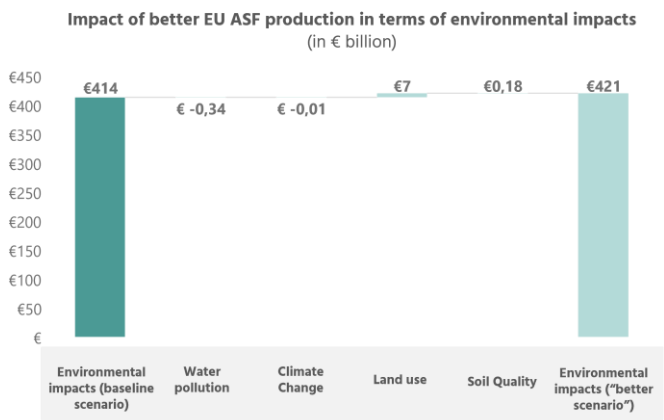

Figure 13 Change in selected indicators of environmental impact due to better production of animal sourced food in the EU (€ billion, 2022). *Results based on change in footprint as outlined in Life Cycle Assessments.*

Amongst others, organic production models the way animals live naturally far more closely – and consequently requires more land per animal, to allow for natural animal behaviours such as grazing, rooting, and foraging. While organic production has not reached the level of efficiency of current industrial production, it is likely there is still opportunity to improve in terms of efficiency, thereby reducing the environmental footprint per kilogram of food product. However, the Life Cycle Assessments based on current average levels of efficiency indicate an increase in *land use* impact (from €115 billion to €121 billion impact) when shifting to more organic production.[6] The connection between lowering consumption volumes and enabling better production conditions is highighted in Section 3.5.2.

The negative impact on soil quality also increases (from €6.2 billion to €6.4 billion) since organic production causes more soil compaction from machinery than conventional production (True Price and Wageningen Economic Research, 2021). Since pesticide use is limited, organic farming generally requires more mechanical weeding and maintenance (European Commission, Organic farming in the EU, 2023). For water pollution, the high levels of efficiency in current conventional production do not offset its pollution (amongst others, from applying toxic substances to soil and water). Hence, the impact of water pollution in the 'better' scenario decreases by €340 million.

As highlighted earlier, there is discussion among researchers on the reliability of current Life Cycle Assessments (LCAs) (like the one used in this true cost assessment) on comparing conventional and organic production. For example, **comparative LCA studies of organic and conventional farming show a wide variation in their observed resource efficiencies that are highly dependent on the context** (Seufert & Ramankutty, 2017). Moreover, such LCAs often do not adequately reflect the specific characteristics of the farming systems subject to the analysis (Meier, et al., 2014). Research also highlights the effects of pesticide use (applicable to conventional but not to organic production) are not always or well included in LCAs, thereby presenting a false image of reality (Knudsen, Cederberg, & van der Werf, 2020). In general, the environmental impacts of organic farming per unit of output constitutes a significant knowledge gap (Seufert & Ramankutty, 2017). While LCA studies are currently unable to fully capture the benefits of organic farming, qualitative research does however indicate where improvements are achieved when compared to conventional farming. Although there are still many uncertainties involved, researchers find that organic livestock production may positively affect local biodiversity and soil health, and result in lower impacts from pesticide use (Meier, et al., 2014; Seufert & Ramankutty, 2017). Eventually, more holistic research on organic agriculture is needed to allow for the assessment of its trade-offs and synergies.

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[6] The growing propensity of intensive animal farming, both in the EU and abroad, carries significant environmental impacts. It is linked to high levels of ammonia emissions to air, nitrogen emissions to water, antimicrobial use which creates reduced efficacy for humans and many other impacts – but it does use land efficiently. As a result of this efficiency, the resulting environmental impact per kg product may perform relatively well, even if the original environmental impact per m^2 land is relatively high (Greenpeace, 2019).

Impact on biodiversity

The environmental impacts discussed in this report contribute (in)directly to biodiversity and loss of ecosystem services. Examples of ecosystem services vital to human life on Earth are crop provision, crop pollination, carbon sequestration, flood control and water purification. Negative externalities to the environment affect such ecosystem services.

As part of this true cost assessment, the impacts of *land use, contribution to climate change* and *water pollution* were translated into their effects to biodiversity and consequential loss of ecosystem services. Land use from animal sourced food has the highest negative impact, representing a €103 billion impact on biodiversity loss (versus €97 billion for current production). Similarly, the biodiversity loss from climate change is €27 billion in the 'better' scenario (which represents a €5 million decrease compared to current production). Finally, the biodiversity loss from water pollution decreases in the 'better' scenario compared to current production by €1 billion in impact.

While initially perhaps counterintuitive, these increases in total impact are in line with expectations. Organic production with better animal welfare requires more land per kg of output, which of necessity leads to greater land use (and associated costs, despite decreases in impact per hectare). This is in line with the argument that 'better' production needs to be tied to 'less' consumption. There is no path to decreased social, human, and environmental impacts to society from animal sourced foods that does not combine these two aspects.

There are two further points that underline this argument. First, the impacts to biodiversity as presented in this analysis are, like the baseline scenario, based on Life Cycle Assessments, which are limited in scope and approach to capturing biodiversity (Winter, Lehmann, Finogenova, & Finkbeiner, 2017) and have a tendency to favour high-input intensive production processes (van der Werf, Knudsen, & Cederberg, 2020). Second, while this analysis aims to comprehensively compare animal sourced food production systems in both the current and 'better' scenarios, several tools, approaches, and impacts have been left out of scope due to insufficient data availability. For instance, research on the impact of chemical use in conventional farming indicates a strong negative impact on soil biodiversity (Gunstone, Cornelisse, Klein, Dubey, & Donley, 2021). Organic farming precludes the use of pesticides and therefore helps preserve soil biodiversity, but this could not be quantified in this analysis due to difficulties finding pesticide use data. Further, the 'better' scenario is limited in scope, again due to data availability and comparability at an EU level.

While the EU's population remains relatively stable, the global population is growing rapidly. This will place an increasing strain upon both food systems and the environment and biodiversity upon which they rely. Transitioning to production that minimises pressure on biodiversity and related ecosystem services will support long-term food security by creating a positively self-reinforcing and sustainable food system. The 'better' scenario as presented here is merely the first step towards this goal – organic farming is a good starting point, but bringing in alternative modes of production will also be crucial. Research indicates that agroecological practices such as no-till farming and limiting blue water use can have significant positive benefits for biodiversity, while modes of regenerative farming can build functional biodiversity and soil health such that both constancy and yield efficiency are supported. These tools and approaches will be needed to shift from conventional and unsustainable methods of production to a system that protects human, animal, and environmental health.

3.5.2 Less consumption of animal sourced food in the EU

To transition to fair, healthy, and sustainable food systems as outlined in the Farm to Fork strategy, it does not suffice to merely address the way in which animal sourced food is produced in the EU. It is widely agreed upon that a shift towards less animal sourced food consumption, and hence towards more plant-based diets, is needed for such a transition (Springmann, et al., 2018).

The results of the comparative analysis of the 'less' scenario reflects the true cost reduction from moving from the currently prevalent diet to a flexitarian diet with less consumption of red and white meats, dairy products and eggs (see textbox). The results of the 'less' scenario offer insights into opportunities for reducing the social, environmental and human health costs that arise from current consumption patterns in the EU.

In line with the baseline analysis, it is assumed that in the 'less' scenario, 10% of food is wasted along the value chain. This does not influence the impact relating to the production of animal sourced food as the food wasted is still produced. However, for the impacts directly related to consumption (zoonotic diseases and diet-related disease) the impact is calculated based on the quantities of animal sourced food actually consumed. This quantity is calculated by substracting 10% of the animal sourced food available for consumptioin to obtain the value of animal sourced food actually consumed.

To offset the decreased protein intake associated with this change in consumption, externalities of consuming a plant-based protein source are added to the scenario results. This allows for comparison between the externalities of the EU animal sourced food consumption in the current and 'less' scenarios, while ensuring the fulfilment of human nutritional needs. Current plant protein consumption in the FAO reference diet is 35 grams (includes soy, nuts, seeds, and legumes). In the 'less' scenario, additional plant-based protein sources must be consumed (specifically, 17.2g of protein or around 100g of plant-based protein product) to compensate for loss of proteins. Whilst a flexitarian diet is expected to include a varied assortment of protein sources, this analysis chose soy as a proxy for plant-based protein to calculate the required increase in land and plant protein consumption.

Consuming less animal sourced food

The FAO's 2020 report on the State of Food Security and Nutrition in the World presents a model flexitarian diet as an alternative for a healthier and more sustainable global dietary pattern. In this diet, fewer animal sourced food products are consumed, while all human nutritional needs are accounted for.

Contrary to proposed shifts to fully plant-based diets, the FAO flexitarian diet takes the continued consumption of animal sourced food products into account. The 'less' scenario in this analysis represents one where the EU both produces and consumes less animal sourced food products in accordance with this diet, with subsequent increases in consumption of plant-based foods.

Results

Figure 14 displays the change in the quantified externalities allocated to EU animal sourced food consumption from the baseline to the 'less' scenario. **Compared to current consumption, the true costs reduce by €1,146 billion (73%) due to the dietary shift.** The changes shown in Figure 14 include the additional impacts that would result from switching to a flexitarian diet, e.g., in terms of land use and contribution to climate change. Compared to baseline EU consumption of animal sourced food, switching to a flexitarian diet enables the reduction of all impacts included in scope of the assessment. The difference is most notably seen in the impacts of low animal welfare and diet-related diseases (reduction in negative impact of €481 billion and €390 billion).

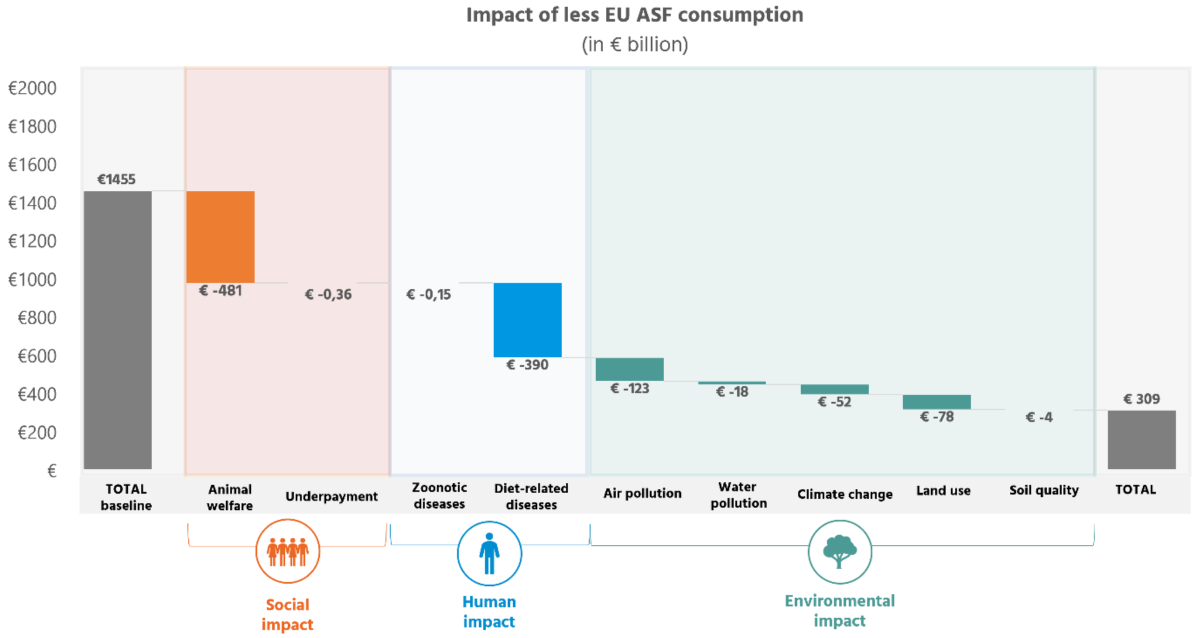

Figure 14 Impact of less EU animal sourced food consumption.

Based on current animal sourced food consumption in the EU (based on Eurostat data and accounting for food waste), the total impact per person per day is €7.88 (allocated to value chains of consumption quantities of red meat, white meat, dairy and eggs) (see Figure 14) (European Commission, 2023). Adhering to a flexitarian diet in contrast results in a total impact per person per day of €2.24. The main drivers of the reduction in externalities attributed to the dietary shift are:

- **Low animal welfare (reduced by 74%).** Reduced consumption of animal sourced food positively affects animal welfare. As previously mentioned, animal welfare in the 'less' scenario represents the largest reduction in negative impact, from €635 billion to €154 billion. While the reduction in other impacts of animal sourced food consumption in a 'less' scenario take increased plant protein production into account, this is not the case for low animal welfare, as plant production does not negatively affect animal welfare. The low animal welfare impact attributed to EU animal sourced food consumption in the 'less' scenario is 74% lower than in the baseline.
- **Diet-related disease (reduced by 86%).** The diet-related disease impact attributed to EU animal sourced food consumption is relevant to red meat and processed meat consumption. There is no scientific consensus on the impacts to health of other animal sourced food. The reduction in diet-

related disease impact of red and processed meat consumption in a 'less' scenario is linearly scaled to the reduction in total consumption, as these impacts are intake dose dependent. The diet-related disease impact attributed to EU animal sourced food consumption in the 'less' scenario is 86% lower than in the baseline scenario.

- **Environmental impact (reduced by 77%).** The largest contributors to the reduction in environmental impact with less consumption of animal sourced food in the EU are air pollution, contribution to climate change and land use. *Air pollution* is reduced from €164 billion in the current consumption system to €46 billion under the dietary-shift scenario. The biggest differences are due to white meat and eggs and dairy respectively. *Contribution to climate change* is reduced from €67 billion in the current consumption system to €15 billion under the dietary-shift scenario. The biggest differences are due to red meat and dairy. *Land use* is reduced from €111 billion in the current consumption system to €19 billion in the dietary-shift scenario. The reason for this 83% reduction in land use is the shift to more direct consumption of food by humans. For example, soy may be either directly consumed by humans, or be fed to chickens which may be later consumed by humans, i.e, the soy is only indirectly consumed by humans. Optimising direct consumption of food by humans supports reducing the true cost of consumption.

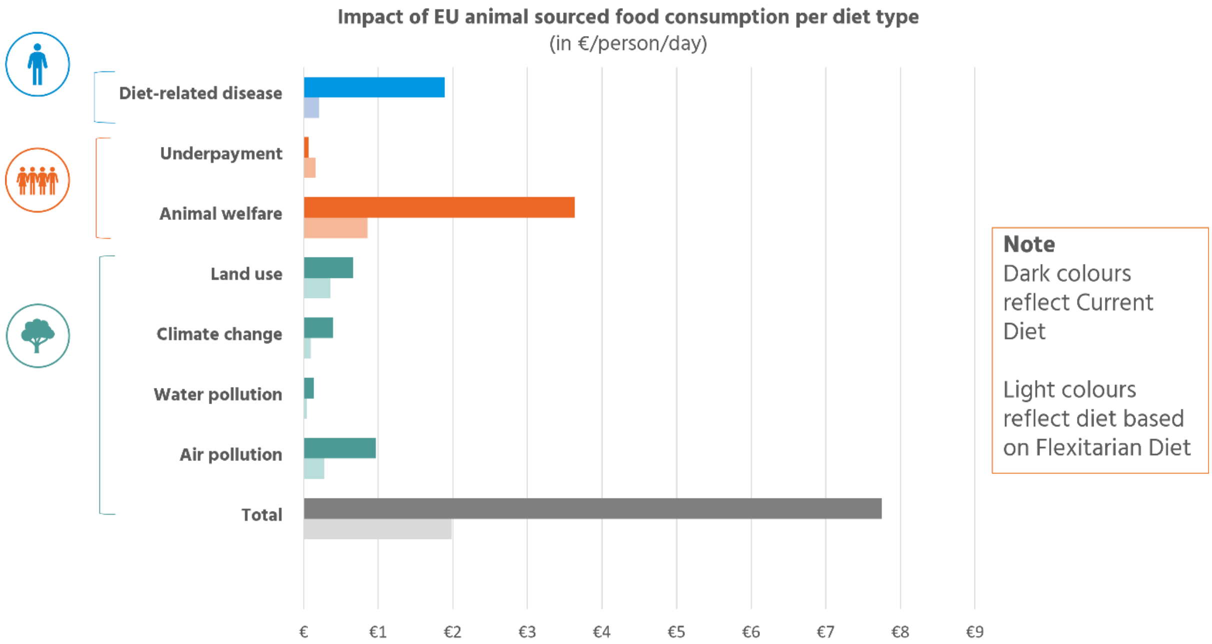

Figure 15 Impact of EU animal sourced food consumption per diet type (€/person/day)

Note: This figure attributes the soil quality impact of dairy to red meat production, as impact of beef vs dairy cattle could not be attributed. Notably, the impact of underpayment is slightly higher in the 'less' scenario. In terms of grams of protein, white meat consumption (which currently includes indirect consumption of soy through animal feed) is more efficient than soy consumption. The underpayment attributed to soy production therefore increases in the flexitarian-diet scenario. Importantly, soy is merely an example of a plant-based source of protein, selected for this true cost assessment. Other plant-based alternatives may be preferable in terms of impact on people and the planet to replace consumption of animal sourced food.

In conclusion, the section on better production of animal sourced food in the EU discussed the positive effect on animal welfare and the potential for true cost reduction through human health. Simultaneously, if consumption levels of animal sourced food remain the same, the findings emphasise that an increase of organic agriculture and roaming space for livestock will put additional pressure on land use inside and outside the EU if current levels of over-consumption of animal-based products are maintained.

To enable 'better' production, the EU needs to consume less animal sourced food. The results discussed in this chapter illustrate such a dietary shift offers an opportunity for a significant true cost reduction. By combining 'better' production with a dietary shift, the EU can significantly reduce the external costs associated with its food system.

'Better and less' impact on land use

The results of 'better' production illustrate that land use may increase by 6% when increasing organic production levels to 25%. In contrast, the dietary shift discussed in this chapter offers the opportunity to reduce land use impact by 83%.

In the 'better and less' scenario, the relatively small increase in land use impact from more organic production will therefore be offset by the true cost reduction associated to the shift to a flexitarian diet.

Conclusions & recommendations

4 Conclusions & recommendations

The EU Farm to Fork strategy aims to make the European food system fair, healthy and sustainable. Animal sourced food, such as meat, cheese and eggs, is part of European production and consumption systems. Addressing externalities attributed to the production and consumption of animal sourced food (such as impact on the environment, low animal welfare, and impact on human health) will therefore support the Farm to Fork ambition to achieve a fair, healthy and more sustainable European food system. Understanding the drivers of these costs is essential.

This true cost assessment estimates the external costs of EU animal sourced food production at €1,567 billion and consumption at €1,455 billion for 2022.[7] In addition to the quantified external costs, this aspect of the EU food system also faces other externalities (which cannot as yet be quantified) such as the impact of antimicrobial disease. The economic costs of the EU's animal sourced food industry were €207 billion in 2022 (European Commission, 2022) implying that the quantified external costs of producing animal sourced food in the EU is several times larger than the economic costs.

Key causes of the quantified external costs of the current EU animal sourced food system as detailed in this report are low animal welfare, diet-related disease and impacts to the environment (particularly air pollution and land use). These costs are even greater than the contribution of animal sourced food to climate change, while historically receiving significantly less attention. Assessing the current system from the perspective of biodiversity loss arrives at quantified external costs of €220 billion attributed to the production of animal sourced food in the EU and of €198 billion to its consumption.

The biodiversity loss (and consequential loss of ecosystem services that are essential to human life on Earth) resulting from EU's current production and consumption patterns threatens long-term food security. If the external costs resulting from current modes of global food production and conventional food consumption patterns are not addressed and business continues as usual, the likely consequence is a planet that cannot support current and future generations (Leclère, et al., 2020). **This report therefore recommends that the size of these impacts and underlying drivers of external costs be addressed to promote the EU's goal of a fair, healthy and sustainable food system.**

This report has analysed the possible benefits of two approaches to addressing the externalities attributed to the EU's current food system: better production and less consumption of animal sourced food.

Firstly, this report assesses the externalities attributed to current and 'better' production of animal sourced food in the EU. For 'better' production, 25% of animal sourced food is produced organically and legal stocking density and transport times for animals are reduced. The results of the true cost assessment illustrate that shifting to 'better' production has a positive effect on animal welfare, and, in addition, that measures to improve animal welfare (such as lower stocking density) positively influence other impacts such as zoonotic diseases, antimicrobial resistance and contribution to climate change. The connection between animal welfare measures and impacts on human health and the environment (including biodiversity) attributed to the food system stress the need to address these issues holistically. **It is**

[7] These results are based on a selective scope and available data. Full true cost of animal sourced food is likely higher.

therefore recommended that animal welfare be considered in tandem with environmental and human health provisions in legislation, as they are intrinsically connected.

In terms of environmental impact, current data availability and scope of measurement suggest that transitioning the EU's animal sourced food production system to one based on more organic production does not result in lower environmental costs. At the current production and consumption levels of animal sourced food, the environmental costs from land use increase when levels of organic production increase. However, the outcomes regarding environmental costs are highly dependent on the quality of the Life Cycle Assessments used to assess the difference in environmental footprint resulting from conventional and organic production. **It is recommended to further investigate the environmental footprint of conventional and organic production systems to create a more holistic view of their environmental impacts and to enable accurate comparisons.** This is particularly relevant to impacts such as land use and soil quality, as the negative impact of conventional agriculture and the positive impact of organic agriculture to soil micro-biodiversity resulting from pesticide use are undervalued in this analysis.

Further, the slight increase in environmental impact in the better scenario is largely ascribed to lower levels of efficiency associated with current organic production. However, it is highly likely that assessing external costs per hectare farmland used instead of per final kilogram of animal sourced food product will show environmental impact and biodiversity loss are significantly lower for organic production than for conventional production. Within the combination of those two points lies an opportunity. **Combining a relative increase in organic production with less land use for food production offers an opportunity to decrease pressure on biodiversity and preserve essential ecosystem services for current and future generations.** This can most readily be achieved by complementing better production of animal sourced food in the EU with a dietary shift to less land and resource intensive food, such as plant-based alternatives.

The true cost assessment of the 'less' consumption of animal sourced food scenario finds that the shift to a flexitarian diet reduces the external costs attributed to EU consumption of animal sourced food by €1,146 billion (76%). Compared to current consumption, the dietary shift (including compensation for reductions in animal-protein consumption with plant-based proteins) enables reduction of all impacts in scope. The dietary shift enables us to optimise direct human consumption of food such as soy, maize and wheat that may otherwise be used for animal feed and thereby indirectly consumed by humans. This true cost assessment also highlights the significant opportunity in cost reduction through the minimisation of food waste, which is currently approximately 10% along the value chain between producer and end consumer. Both the dietary shift and focus on food waste reduction support the transition to a more sustainable food system.

Combining 'better' production systems with 'less' consumption of animal sourced food supports the EU's ambitions to improve animal welfare, optimise land use, and address the detrimental effects to biodiversity that currently threaten ecosystem services, while simultaneously reducing numerous human health impacts. These food transitions will help create the conditions for long-term food security and a fair, healthy and more sustainable EU food system.

Annex

5 Annex

Content of the annex

5.1 Monetisation factors and remediation costs

This section provides more detail on how monetisation factors are established and the different remediation costs on which monetisation factors are built. Monetisation factors are established by first assessing the type and severity of damage that is associated with the impact. After the damage is identified, the relevance of each type of remediation cost is assessed. The four types of remediation costs are: restoration costs, compensation costs, prevention of re-occurrence costs and retribution costs.

- **Restoration costs:** Restoration costs are the cost of bringing people's health, wealth, circumstances, capabilities, or the environmental stocks and environmental qualities to the state they would have been in the absence of the social and environmental damage associated with an impact. Restoration cost is applied for impacts where restoration is feasible, or feasible and more economically efficient than compensation when the damage to people or communities is not severe.
- **Compensation costs:** Compensation costs are the cost of compensating affected people for economic and/or non-economic damage caused by the social and environmental impacts of producing or consuming a product. In the valuation literature, this is also called damage cost (e.g., compensating for denied income, or the value of lost human health). Non-economic damage can be assessed using the best available stated and revealed preference valuation techniques. Compensation costs are part of the remediation costs for impacts where restoration is not considered feasible.
- **Prevention of re-occurrence costs:** Prevention of re-occurrence cost represents the cost that would be incurred in the future to avoid, avert or prevent the identified social and environmental

impacts of a product from occurring again (e.g., the cost of introducing human rights audits in a supply chain). Prevention cost of re-occurrence is part of the remediation costs in addition to restoration or compensation when the damage is considered more severe and irreversible. Whereas the other types of costs refer to damage that has occurred, this cost relates to the prevention of future damage. It finds its basis in, among others, the UN Guiding Principles mentioned earlier that acknowledge a responsibility to prevent re-occurrence of human rights breaches.

- **Retribution costs:** Retribution costs are the costs associated with fines, sanctions or penalties imposed by governments for certain violations of legal or widely accepted obligations. They represent the damage to society caused by breaking the law. For impacts that correspond to the breach of a legal or a widely accepted obligation, retribution costs are part of remediation costs, over and above restoration, compensation and/or prevention of re-occurrence costs.

More than one type of costs might be relevant (e.g., both compensation and prevention of re-occurrence costs). In some cases, the choice of costs may vary, depending on the country or region where the impacts take place, leading to different monetisation factors in different geographies. Based on economic modelling and data available in the literature, the relevant costs are quantified in a way that can be attributed linearly to one unit of impact as measured by the footprint indicators. Finally, the quantified costs are summed to form monetisation factors. For impacts that have only one footprint indicator, this is a single monetisation factor. For impacts that have a set of distinct footprint indicators, there are monetisation factors for each. See Monetisation Factors for True Pricing for more details.

5.2 Step-by-step approach to true cost assessment

The study was carried out in five steps: scoping, model building, data collection, analysis and validation, and reporting. The step-by-step approach is based on the True Price Assessment method (True Price Foundation, 2023).

Step 1: Scoping

The assessment starts by scoping the boundaries of the project. This includes decisions on the impacts, value chain steps, geography, activities, and scenarios that are included in the study. These boundaries were determined together with EFA during a scoping session. The externalities in scope for this project are air pollution, water pollution, soil pollution, contribution to climate change, land use, underpayment, low animal welfare, and biodiversity loss for animal sourced food production and diet-related diseases, zoonotic diseases and AMR for animal sourced food consumption. The year of measurement was determined to be 2022, the most recent complete year. The proposed geographical scope for production consists of animal sourced food produced and consumed in the EU or exported globally. Included in the analysis for production of animal sourced food is the upstream value chain step of cultivation of agro-inputs, this includes the animal feed and other inputs needed for animal sourced food production. For consumption, the scope was animal sourced food consumed in the EU, either produced in the EU or imported from rest of the world. Finally, the animal sourced food categories in scope are red meat, white meat, dairy, eggs and fish. For each impact the scope has been specified further based on available data.

Step 2: Data collection

Each impact in scope is measured and quantified per functional unit. The quantified social or environmental impact in the equivalent unit is called a footprint indicator. Footprint indicators measure the actual social and environmental impacts in scope. For example, the footprint of the impact 'contribution to climate change' is 'greenhouse gas emissions', expressed in the reference unit 'kilograms CO_2 equivalent'.

Footprint indicators are quantified based on primary and secondary data sources. Data sources used for the true cost assessment are the Global Impact Database and Global Impact Database Biodiversity (explained further in Section 5.6), as well sector reports, international statistics (FAO/Eurostat), and Life Cycle Assessment studies obtained through Ecoinvent 3.6.

In some cases, there is neither primary nor secondary data available that are sufficiently representative for the subject of study. Any such data gaps shall be filled using the best available generic or extrapolated data or the decision is made to narrow the scope of the analysis. Any assumptions made or changes to the scope are documented in Chapter 2 of the main report.

Step 3: Model Building

For each impact, a calculation framework is developed in which the footprint indicators are calculated for EU animal sourced food production and consumption. A monetisation factor is applied to the footprint indicator to value the relevant impact. The result of this step is a set of external costs expressed in the same unit for all impacts that are considered in the study. This includes social costs (monetised social impacts) and environmental costs (monetised environmental impacts).

Allocation factors based on the quantities of animal sourced food produced in the EU, as well as exports and imports are used to allocate the impact to the value chains of EU animal sourced food production and consumption.

Step 4: Analysis and validation

After quantification and monetisation of the impacts, the different social and environmental costs are summed, resulting in the total external costs of EU animal sourced food production and consumption. For each of the impacts, Impact Institute performed an in-depth analysis to identify insights on the underlying causes and drivers. For the comparative assessment, the analysis focused on assessing implications of 'better and less' animal sourced food production and consumption in terms of true costs. The calculation models and analyses were validated by quality experts from Impact Institute to ensure accurate and robust results.

Step 5: Reporting

In the reporting step, all findings, methodologies, assumptions, and limitation are documented. The report includes the external cost of selected value chain steps for EU animal sourced food production and consumption.

5.3 Footprint indicators and remediation costs

5.3.1 Relevant footprint indicators for each quantified impact

Category	*Impacts*	*Indicators*
Environmental Impacts	Air pollution	• NH3 • NMVOC • NOx • PM2.5 • SO2 • Freshwater ecotoxicity • Marine ecotoxicity • Terrestrial ecotoxicity • Human toxicity (carcinogenic) • Human toxicity (non-carcinogenic)
	Water pollution	• Freshwater eutrophication • Marine eutrophication
	Contribution to climate change	• Greenhouse gas emissions (kg CO_2-equivalent)
	Land use	• Land occupation – crops • Land occupation – forests • Land occupation – pastureland
	Soil quality	• Soil erosion • Soil compaction • Human health impact of pesticides emitted to soils
	Biodiversity loss	• Biodiversity loss from land use • Biodiversity loss from contribution to climate change • Biodiversity loss from air pollution • Biodiversity loss from water pollution
Social Impacts	Low animal Welfare	• Animal life years suffered in years
	Underpayment	• Underpayment in euros
Human Impacts	Zoonotic diseases	• DALY/case of illness of Campylobacteriosis and Salmonellosis
	Diet-related disease	• Cardiovascular disease attributable to meat consumption (in DALYs) • Diabetes and kidney disease attributable to meat consumption (in DALYs) • Neoplasms attributable to meat consumption (in DALYs)

5.3.2 Description of remediation cost per quantified impact

Category	*Impacts*	*Description cost*
Environmental Impacts	Air pollution	The compensation cost of toxic emissions, particulate matter formation, photochemical oxidant formation, acidification, and ozone layer depletion, expressing the health-related, social, and economic loss due to pollution.
	Water pollution	The restoration and prevention cost of eutrophication of marine- and freshwater, expressing the average marginal cost of measures to restore nutrient levels (marginal abatement cost).
	Contribution to climate change	The restoration cost of increased emissions of greenhouse gases (GHG), expressing the cost of measures to avoid additional GHG emissions (marginal abatement cost).
	Land use	The compensation cost of land use, expressing the opportunity cost of using the land and displacing ecosystem services.
	Soil quality	**Soil erosion**: The compensation cost of soil erosion. Costs include on-site damage such as loss of nutrients, reduced harvests and reduced value of the land, and off-site damage such as the silting up of waterways, flooding and repairing public and private property. **Soil compaction**: The damage cost based on lost future crop yields. This is calculated based on the average gross revenue of crop production lost due to irreversible subsoil compaction. **Human toxicity:** Compensation cost which expresses the value of a Disability-Adjusted Life Year (DALY) based on a meta-analysis of the Value of Statistical Life (VSL) from 92 willingness-to-pay studies, carried out by the OECD.
	Biodiversity loss	Compensation costs for loss of ecosystem services due to loss of biodiversity resulting from greenhouse gas and other emissions leading to environmental impacts expressed in PDF.m2.yr (PDF = potentially disappeared fractions of species) and biodiversity footprint due to use of land for economic activity, compared to primary vegetation.
Social Impacts	Low animal welfare	Compensation cost which expresses the value of a Disability-Adjusted Life Year (DALY) based on a meta-analysis of the Value of Statistical Life (VSL) from 92 willingness-to-pay studies, carried out by the OECD.
	Underpayment	The restoration cost for wage gap, prevention costs to avoid future violations and compensation cost depending on the size of the wage gap.
Human Impacts	Zoonotic diseases	Compensation cost which expresses the value of a Disability-Adjusted Life Year (DALY) based on a meta-analysis of the Value of Statistical Life (VSL) from 92 willingness-to-pay studies, carried out by the OECD.
	Diet-related disease	Compensation cost which expresses the value of a Disability-Adjusted Life Year (DALY) based on a meta-analysis of the Value of Statistical Life (VSL) from 92 willingness-to-pay studies, carried out by the OECD.

5.4 Assumptions & limitations per impact

This section presents assumptions and limitations per impact that are applicable to the baseline study and comparative study.

Table 6 Overview of the most important assumptions and limitations of the true cost assessment

Study focus	Assumptions and Limitations
Low animal welfare	The method for calculating low animal welfare is based on the *Framework for integrating animal welfare into life cycle sustainability assessment* (Scherer, Tomasik, Rueda, & Pfister, 2018). This framework builds on various assumptions. 1) life quality is never worse than zero and 2) killing is a bad thing. A limitation of these assumptions is that for some animals, killing might actually end their suffering. The framework further includes the assumptions that 3) keeping animals in captivity is a bad thing and 4) lives lost are of greater value for younger than for elderly animals.
	Animal welfare method is monetised through use of DALY for human life years. However, for animals, this is not directly applicable, since animals are killed before they can be restored or compensated. To apply the use of DALYs for animals, the DALYs are adjusted through use of animal moral valuation, where it is assumed that animals have rights and needs that (as the bare minimum) correspond with their sentience. Annex 6.5.1. provides more information on the moral valuation.
	The moral value that is applied to DALYs to monetise the impact of low animal welfare is built on the assumption that animals have a different moral value than humans and that the moral value differs per species. This is a human-centred approach and based on the expected intelligence relative to humans. This assumption is in line with the Framework for integrating animal welfare into life cycle sustainability assessment (Scherer, Tomasik, Rueda, & Pfister, 2018).
Zoonotic diseases	The quantified assessment for zoonotic diseases is limited to the impact of the zoonotic diseases Campylobacteriosis and Salmonellosis. Together these two diseases make up 92% of zoonotic diseases reported by the European Centre for Disease Prevention and Control. For other zoonotic diseases there is no available quantified data on the transmission pathway between animal sourced food production and consumption and the human population, therefore the impact cannot be quantified.
	EU data for 2021 is used to estimate the cases of foodborne diseases for 2022, as data for 2022 is not available. WHO data on the DALY/case of illness from 2010 is used to estimate the total human health burden in the EU. It is assumed that the DALY per case of illness in 2010 is the same for the year 2022.
Diet-related diseases	The most recent available data on the human health burden attributable to meat consumption is from 2019. It is assumed that this is a representative value for the year 2022.
	To allocate the impact of diet-related disease to the different animal sourced food categories, it is assumed that each type of meat is equally represented in processed meat in accordance with share of total meat consumption.
Air pollution	The impact indicators of air pollution (particulate matter formation and others) do not only result in air pollution but also in – for example – water pollution. In the Global

	Impact Database (GID), no distinction is made between the resulting impact in terms of air pollution and other forms of pollution. All is assumed to result in air pollution as it is likely that most of the impact must be accounted to air pollution.
Soil quality	To determine the toxicity factor for the human toxic impact of pesticides emitted to soils, it is assumed that pesticide use for wheat production is representative of all non-oilseed crops and that pesticide use for soy production is representative of all oilseed crops. Furthermore, it is assumed that when individual crops are not distinguishable, the soy toxicity factor is representative of all imported EU feeds. Finally, for the toxicity factor for the human toxic impact pesticides emitted to soils it is assumed that the data from 8 LCAs (6 soy and 2 wheat) are representative of all animal feeds.
	Assumption that all feed in the EU is consumed by beef cattle, dairy cattle, pork, broiler chickens, laying hens, sheep, and goats. This assumption does not affect calculation of total impacts of EU animal sourced food production and consumption, only per kg estimates. However, as these animal categories represent the large majority of animal feed consumption, the impact is minimal.
	When individual crops are not distinguishable, it is assumed the wheat toxicity factor is representative of all domestic EU Feed production.
	For pesticide use from EU animal sourced food imports, the value for land use/100g food product protein from Poore and Nemecek (2018) is assumed to be a representative value for the global average for 2022.
	It is assumed that imported animal sourced food products present similar erosion impact per kg of product as those produced in the EU.
	For the calculation of the impact of pesticide exposure for imported beef, it is assumed that 50% of impact is from the dairy herd and 50% from the beef herd.
	Impact of soil compaction does not address imports because soil compaction is calculated based on feed mix of imports and there is no data available on the global typical feed mix. Therefore, the impact of soil compaction from imports is left out of the analysis to maintain quality in results.
	The less scenario includes the impact of additional plant protein that is needed to replace the protein from animal sourced food. The impact of this additional plant protein is based on soy, for which it is assumed that this soy is produced conventionally.
	Impact of wind erosion, over-grazing, soil compaction of imports, and the likely positive impact of organic farming on soil erosion and ecotoxicity could not be calculated and were left out scope.

5.5 Details on selected impacts

The following section provides additional explanation on the quantification method for the impacts: low animal welfare, zoonotic diseases, diet-related diseases and soil quality. The remaining impacts (underpayment, air pollution, water pollution, contribution to climate change, land use) are based on data from the Global Impact Database (GID). Additional information on quantification and monetisation based on GID data is explained in Annex 5.6.

5.5.1 Low animal welfare

Animal welfare is about the mental and physical well-being of non-human animals. The 5 Domains Model (1 Nutrition, 2 Physical Environment, 3 Health, 4 Behavioural Interactions and 5 Mental State) has been applied internationally and focuses on acknowledging the sentience of farm animals, increasing animals' mental well-being, and opportunities for positive experiences for all animals in human care rather than solely minimising negative experiences (Mellor, et al., 2020; Eurogroup for Animals, 2021). Assessments of animals' well-being are based on the satisfaction of their needs since animal welfare cannot be measured directly.

In order to quantify the impact of low animal welfare, the animal life years suffered as a result of stock breeding for animal sourced food were calculated, based on Scherer et al.'s *Framework for integrating animal welfare into life cycle sustainability assessment* (Scherer, Tomasik, Rueda, & Pfister, 2018). The factors taken into consideration here to determine the welfare loss per animal type are a) the animals' life quality, b) their lifetime until slaughtering, c) the slaughter duration (including transport time), and d) the number of animals affected per kg of output. The latter element allows for comparing different types of animal produce. With regards to a) life quality, one variable is selected as a proxy for the general life quality of each animal type. In the case of beef and dairy cows, that criterion is the number of days spent on pasture, for broiler chickens, laying hens and pigs it is the stocking density in kg/m^2. The formula applied to calculate animal life years suffered is:

(1) *Animal life years suffered = number affected * ((slaughter age - slaughter duration) * (1 - life quality) + slaughter duration)*

To express the impact of animal welfare in a monetary value, the animal life years suffered are multiplied with a morally adjusted monetisation factor of a (human) DALY (True Price Foundation, 2021). A DALY (disability-adjusted life year) is an indicator to measure the overall burden of disease and is comprised of years of life lost due to premature death (YLLs), and years of life lost due to living in states of less than full health (YLDs) (WHO, 2020). Here, the focus of the analysis is the duration of the animals' suffering (equivalent to YLDs). The animal equivalent to YLLs is disregarded, as death can be considered a salvation from said suffering. To morally adjust the value of an animal life year, as opposed to a human life year, a moral valuation factor is applied that allows to value the lives of various animal species according to their intelligence compared to human beings (Scherer, Tomasik, Rueda, & Pfister, 2018).

Table 7 Moral valuation of animal lives, based on (Scherer, Tomasik, Rueda, & Pfister, 2018).

Animal	*Moral Value*
Human	1
Cattle	0.035
Pig	0.027
Chicken	0.0038

The moral values are a result of comparing the intelligence of different animal species to humans, based on their brain mass, number of neurons, or number of cortical neurons (Scherer, Tomasik, Rueda, & Pfister, 2018). The formula applied to calculate the monetised value for low animal welfare is:

(2) *Low animal welfare = Animal life years suffered* (€/DALY* moral value)*

Figure 16 shows a simple visualisation of formulas (1) and (2).

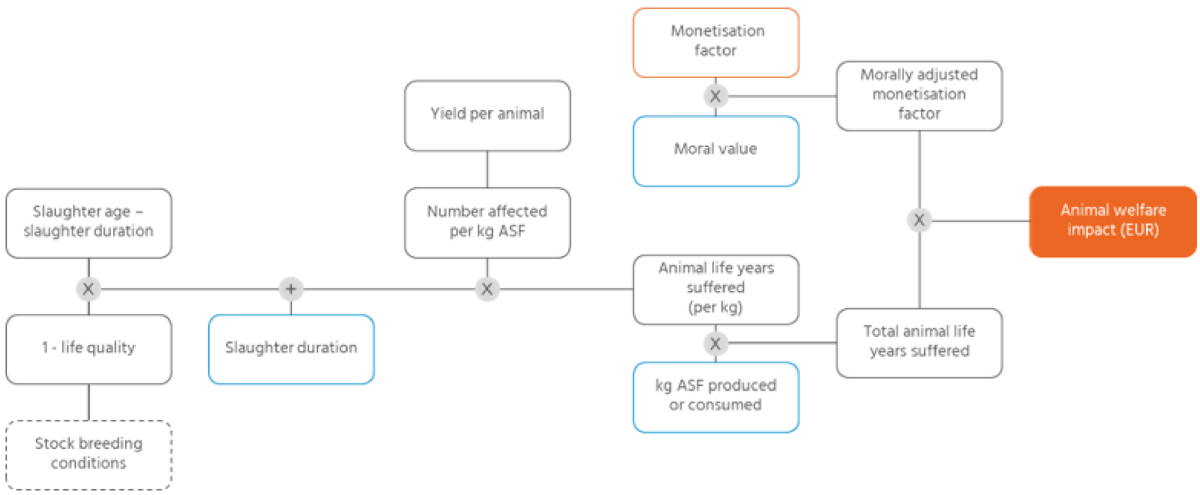

Figure 16 Visualisation of the formulas for the impact of low animal welfare.

5.5.2 Zoonotic diseases

Zoonotic diseases are illnesses that can be transmitted between animals and humans via direct or indirect contact. Both wild animals and domesticated animals are a potential reservoir of zoonotic pathogens. These pathogens can be directly transmitted to humans through contact with animals and contaminated biological material or indirectly through the consumption of contaminated food products. Figure 17 presents the various transmission pathways in which the human population can get infected by zoonotic diseases. The impact attributed to EU animal sourced food consumption is based on foodborne transmissions, the impact attributed to EU animal sourced food production is based on the infections that result from direct contact with animals or contaminated biological material.

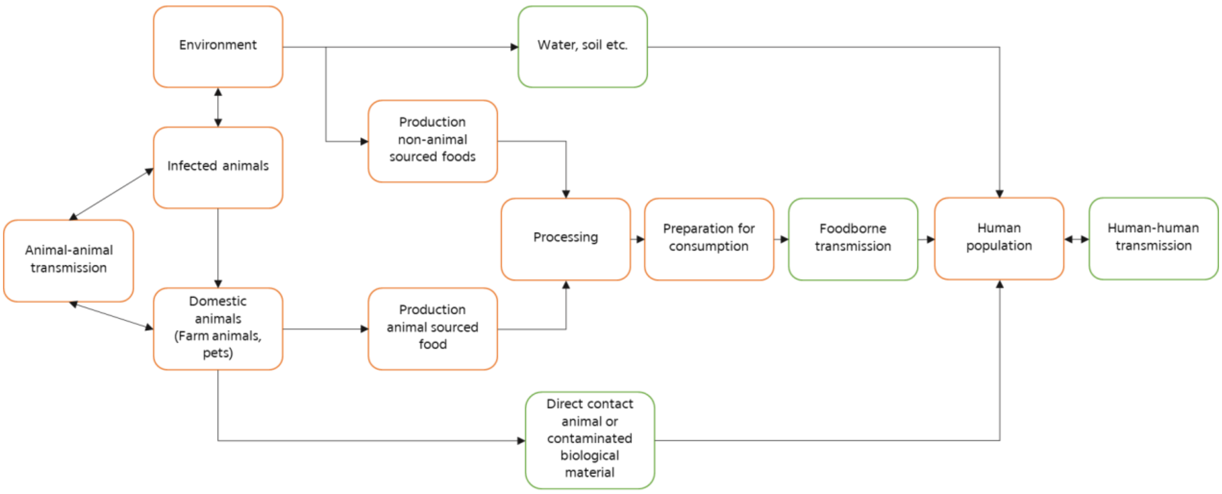

Figure 17 Transmission pathways of zoonotic diseases to human population.

The human health impact of zoonotic diseases is quantified based on the prevalence of the two most common zoonoses in humans in the EU. According to the latest European Union One Health zoonoses report of 2021, the diseases *Campylobacteriosis* and *Salmonellosis* accounted for 92% of reported zoonoses cases in the EU (European Food Safety Authority & European Centre for Disease Prevention and Control, 2022). In 2021, the EU reported 127,840 confirmed cases of Campylobacter and 60,050 confirmed cases of Salmonella. The impact is quantified based on the confirmed cases in 2021 of Campylobacteriosis and Salmonellosis and the corresponding Disability-Adjusted Life Years (DALYs) per case as estimated by the WHO (World Health Organization, 2017). DALYs are monetised based on a meta-analysis of the Value of Statistical Life (VSL) from 92 willingness-to-pay studies, carried out by the OECD (True Price Foundation, 2021). This compensation cost sets the value of a DALY at approximately €106,150 based on 2022 values.

As not all people who fall ill with zoonotic diseases seek medical care, the actual number of cases is believed to be much higher. Therefore, the resulting burden of zoonotic diseases based on confirmed cases inevitably also results in an underestimate of the incidence and burden of zoonoses. Furthermore, besides the impact on human health, there are other impacts resulting from zoonotic diseases. Zoonotic illnesses lead to healthcare costs for society as well as productivity loss. Moreover, zoonotic diseases not only cause a burden for human livelihood and the health sector, but can also result in animal illnesses and deaths and corresponding economic losses in the livestock sector. Due to a lack of data on these additional impacts of zoonotic diseases, the results in the main report solely refer to the impact on human health.

5.5.3 Diet-related disease

Diet-related disease is a major issue globally, with impacts resulting from malnourishment co-existing with impacts resulting from obesity. Two risk factors driving part of these diet-related disease impacts are red meat consumption and processed meat consumption. To assess the impact of diet-related disease from meat consumption in the EU, this analysis utilised data from the Global Burden of Disease (GBD) database (IHME, 2023). The GBD database is a highly respected and widely used tool by global decision-makers who wish to better understand what diseases are affecting relevant populations, what risk factors contribute to the incidence of given diseases, and what sort of impact they are having. The database is a collection of over a billion data points representing the most up-to-date scientific consensus on what drives disease where, and what the effects are.

The GBD presents results in DALYs, an indicator of the overall burden of disease. In order to monetise this impact, the analysis used a compensation cost that expresses the value of a Disability-Adjusted Life Year (DALY) based on a meta-analysis of the Value of Statistical Life (VSL) from 92 willingness-to-pay studies, carried out by the OECD (True Price Foundation, 2021). This compensation cost sets the value of a DALY at approximately €106,150 based on 2022 values.

The largest animal sourced food consumption related health impact in the EU is that of cardiovascular disease (CDV). The most significant health impacts of CDV are ischemic heart disease and stroke, although medical conditions such as hypertensive heart disease and myocarditis also create significant societal health impacts. While the connections between diet and heart health are complex, studies have found that those who consume more red and processed meat tend to have smaller ventricles, poorer heart function, and stiffer arteries – all indicators of decreased cardiovascular health (Raisi-Estabragh, et al., 2021). The second largest impact related to animal sourced food consumption in the EU is that of diabetes and kidney disease. While there is no clear consensus on what aspects of red and processed meat consumption lead to diabetes and kidney disease, increased consumption of these foods is often tied to increased consumption of saturated fat, cholesterol, iron, salt, and acids, to which some studies attribute a greater risk of kidney disease (Mafra, et al., 2018).

Cancers, also known as malignant neoplasms, are the third major impact of animal sourced food consumption in the EU. Both red meat and processed meat consumption are linked to increased risk of colon and rectum cancer, while some evidence also suggests links to prostate and pancreatic cancer. Again, there is no clear scientific consensus on how red meat and processed meats influence cancer risk, although some explanations include high iron and fat contents in red meat and salt and/or nitrate/nitrite contents of processed meats. There is also some suggestion that when meat is cooked at high temperatures, cancer causing substances are formed (National Center for Health Statistics, 2022).

5.5.4 Soil quality

The soil quality impact encapsulates a number of sub-impacts that refer to physical, chemical, and biological decline in soil quality and functioning, as well as the human toxic impact of human interaction with these soils. The sub-impacts that cumulatively comprise soil quality are soil erosion, soil compaction, and the human health impact of pesticides emitted to soils. All three sub-impacts are calculated based on the impact of growing animal feed for animal sourced food production and consumption. It is important to note that other processes, such as over-grazing and the ecotoxic effect of pesticides emitted to agricultural soils, likely result in significant impacts to soil quality. However, due to the difficulty in reasonably estimating the impact of these processes, they were left out of scope. These are addressed qualitatively later in this section. Similarly, this estimate does not include the impact of the production of grass for roughage, as it was not possible to determine what portion of grass feed was farmed for animal feed and what represented (unfarmed) pasture forage. However, grass represents approximately 52.1% of EU feed. The results of the soil quality impact assessment are therefore almost certainly an underestimation.

5.5.5 Soil erosion

Erosion is a naturally occurring process where factors such as water, wind, and gravity displace soil. However, intensive farming practices such as tilling and extensive fertiliser and pesticide use can accelerate this natural process, harm natural vegetation, and dry out soils, destroying the natural diversity of microorganisms typically found in healthy soils. Once the structural integrity of soils is degraded, inclement weather factors like wind and rain displace topsoil, reducing soil stability and fertility. While both wind and water erosion occur as a result of agriculture, water erosion is likely the more significant impact.

To calculate the impact of EU animal sourced food production and consumption on soil erosion, a model was built to estimate the erosion impact of agri-food inputs consumed by animals as part of animal sourced food production in the EU. The model utilised European Commission data on animal feed inputs as an indication for feed produced for consumption by EU animals (European Commission, 2022). Approximate land use per feed input was estimated based on FAO yield efficiency data for the EU (FAO, 2023a). An average soil erosion value for the EU was calculated based on country average soil erosion values published by the European Soil Data Centre (ESDAC) (ESDAC, 2023). The total impact was then attributed to the different product categories based on estimates of the percentage of total feed consumed per animal based on Eurostat Livestock Unit values and FAO estimates of EU livestock counts (Eurostat, 2023; FAO, 2023c). Values of impact per kg retail meat produced per product were then applied to animal sourced food imports to estimate their impact. The assumption that the erosive impact per kg of imported meat is similar to the impact per kg of meat produced in the EU is a reasonable one, as the factor used to calculate erosion in the EU was an average of EU erosion, which has a wide range and whose values cover a number of soil types and climates. For more information, please see Annex 5.4 for all assumptions and limitations.

5.5.6 Soil compaction

Soil compaction is a decrease in soil volume or change in soil form that affects soil pore functions, leading to reduced aeration, water infiltration, and drainage. Modern agriculture contributes to soil compaction through the use of heavy machinery, which compacts the soil upon each pass. These changes can simultaneously reduce crop yields and soil fertility, while increasing the incidence of run-off. This can be a particularly noxious combination on farms with extensive fertiliser or pesticide use, as greater quantities of hazardous or detrimental chemical substances run off into waterways and contribute to eutrophication or toxicity impacts.

As with soil erosion, a model was built to estimate the compaction impact of agri-food inputs consumed by animals as part of animal sourced food production and consumption in the EU. The model utilised European Commission data on animal feed inputs as an indication for feed produced for consumption by EU animals (European Commission, 2022). Based on the quantity of crops used as inputs, the amount of land dedicated to these crops was calculated based on FAO yield efficiency data for the EU (FAO, 2023c). Particular care was taken in the case of soya bean meal inputs as it is almost exclusively imported from Brazil, Argentina, and the United States. Average yield efficiencies for these countries were used to calculate the impact of soy products. The approximate impact of these inputs was estimated based on driving force values found in True Price's soil degradation module, which indicates approximate compaction impact per hectare of agricultural land dedicated to a given crop resulting from the use of machinery (True Price and Wageningen Economic Research, 2021). The total impact was then attributed to the different product categories based on estimates of the percentage of total feed consumed per animal based on Eurostat Livestock Unit values and FAO estimates of EU livestock counts (Eurostat, 2023; FAO, 2023c).

The impact of imported animal sourced food products on soil compaction could not be estimated, as compaction impact depends on context dependent factors including animal feed mix and yield efficiencies.

5.5.7 Human health impact of pesticides emitted to soils

The soil-related impacts of animal sourced food production are not purely environmental. In 2022, an estimated 280 million kg of pesticide were used to grow crops destined for feed in the EU, with over 450 individual active ingredients approved for use in the region (Heinrich Böll Stiftung, Friends of the Earth Europe, and Bund, 2021). Many of these pesticides present a danger to humans who come into contact with them, with both carcinogenic and non-carcinogenic toxicity at certain doses being common in legal substances. While the EU does have legislation which regulates both which chemicals may be used and in what quantity, there is often a lack of agreement in the scientific community on which substances and what those levels are. This estimate does not include the impact on the production of grass and is therefore likely an underestimation.

To calculate the human health impact of pesticides emitted to soils from EU animal sourced food production, a model was built to estimate the average toxicity per hectare of land dedicated to growing agri-food inputs to feed EU animals and EU animal sourced food imports. In order to do this, average toxicity factors were calculated depending on the crop input. Estimating average toxicity is challenging as it is highly dependent on country of crop origin, pesticide mix, and quantity of pesticide used. To make reasonable estimations, average toxicity factors were calculated for two representative crops – wheat and soy. The wheat toxicity factor was applied to cereals, roughages (excluding grass), and forage inputs as these typically require less pesticides to protect them from insects, fungi, and other pests. The soy toxicity factor was applied to oilseeds, as these are typically more pesticide intensive – particularly in the countries of origin for most soy products, Brazil, Argentina, and the United States. The toxicity factors were calculated using LCA data found in the Ecoinvent database. The wheat toxicity factor was based on an LCA study of wheat production in France and wheat production in Spain. The soy toxicity factor was calculated based on 6 LCA studies: one from the United States, one from Argentina, and four from different regions of Brazil.

All pesticides used in the foundation LCAs were converted to 1,4-DCB eq. for chemicals emitted to agricultural soils based on conversion factors found in the LCIA ReCiPe model, a life cycle impact assessment method published by RIVM, the Dutch National Institute for Public Health and Environment (RIVM, 2018). A weighted average toxicity factor for both the carcinogenic and non-carcinogenic toxicity of each product was calculated and then converted to DALY/kg 1,4-DCB eq. This output was then scaled to the average kg 1,4-DCB eq. output per kg of crop produced as calculated from the LCAs. Resulting carcinogenic and non-carcinogenic toxicity factors were then multiplied by human toxicity midpoint to endpoint conversion factors found in True Price's Air, Water, and Soil Pollution module and aggregated, resulting in DALY/kg pesticide emitted to agricultural soil per crop for both wheat and soy (Heinrich Böll Stiftung, Friends of the Earth Europe, and Bund, 2021).

Once these toxicity factors were calculated, the amount of pesticides applied in the EU for animal feed were estimated by taking total applications of pesticide and multiplying by the percentage of agricultural area dedicated to animal feed in the EU (Heinrich Böll Stiftung, Friends of the Earth Europe, and Bund, 2021; Greenpeace, 2019). Total pesticide applications for 2022 were estimated by adjusting 2018 data based on the percentage growth of animal feed consumption in that time, based in turn on EU feed consumption change during that period (European Commission, 2022). Total human toxicity per animal sourced food product and value chain (imports, exports, or produced and consumed domestically) were attributed based on the percentage of total feed consumed per animal and EU production, consumption, import, and export data values found in Eurostat respectively.

5.5.8 Unquantified aspects of soil quality – impacts resulting from animal sourced food production

Soil-related impacts of the animal sourced food industry are not limited to the processes described above. One activity that contributes to additional impact is over-grazing, while the pesticide application discussed above has further consequences for soil ecotoxicity. Despite not being quantified in this report, these factors threaten the ability of soil to carry out vital ecosystem services and are thus relevant for further consideration.

Soil ecotoxicity from intensive pesticide use is an important factor leading to the degradation of soil quality within the EU (Stolte, et al., 2016). Soils contain an abundance of diverse living organisms, which recycle nutrients, decompose organic matter, maintain soil structure, filtrate water, provide habitat support, regulate pests and diseases, and sequester greenhouse gases (Gunstone, Cornelisse, Klein, Dubey, & Donley, 2021). However, this microscopic biodiversity is threatened by the accumulation of toxic pesticide residues from agricultural production, which adversely affect non-target species and the ecosystem services that they support (Gunstone, Cornelisse, Klein, Dubey, & Donley, 2021).

Previous research has identified that soil biodiversity is under pressure on 50% of European land, with 14% of soils being at high-risk (Gardi, Jeffery, & Saltelli, 2013). Furthermore, in Europe in 2015 more than 80% of agricultural topsoil examined in 11 Member States contained pesticide residues (Silva, et al., 2019). The EU Soil Thematic Strategy and the FAO have recognised the overuse of chemical control mechanisms for agricultural production as a driving force behind the loss of soil biodiversity (FAO, ITPS, GSBI, SCBD, and EC, 2020). Given that approximately 70% of European agricultural activity comes from animal feed production, it is probable that the livestock industry is an important contributor to the soil ecotoxicity resulting from pesticide use.

5.6 Details of Global Impact Database (GID) and GID impacts

This section provides a description of the Global Impact Database used to estimate the impact of underpayment, air pollution, water pollution, contribution to climate change and land use. This is followed by a description of the approach for measuring the impact *biodiversity* using the Global Impact Database Biodiversity dataset.

5.6.1 Global Impact Database

The Global Impact Database (GID) was officially launched in 2019 by Impact Institute to help organisations understand and make decisions based on a wide range of impacts covering economic, social, and environmental impacts. The GID includes 24 impact metrics across natural, social, human, manufactured, and financial capital – including climate, water, biodiversity, human rights, and living wages – and provides impact data for over 3,500 listed companies and country-sector data for 9,100 global sectors (65 sectors x 140 countries), including direct, upstream, and downstream value chain impacts without double counting.

The development of the GID is based on multiple internationally recognised frameworks and frameworks published by Impact Institute. GID incorporates several data sources from leading academic institutions and private data suppliers. The main data sources used include company reported data, trade data, economic data, environmental and social impact indicators, and impact valuation factors, including Exiobase, GTAP, Eora, FAOSTAT and more.

The GID provides the average impact per euro of economic activity for companies and sectors, it values the impacts in monetary units to make them easy to understand and to compare directly. To calculate the external cost per product, the values of the GID need to be attributed to products or product groups. In the true cost assessment, the impact is attributed to the product groups red meat, white meat, dairy or eggs. This attribution is based on production and consumption data from Eurostat and the FAO, as well as other secondary data sources.

5.6.2 Global Impact Database - biodiversity

GID includes a biodiversity impact dataset. It can be used to assess the biodiversity impact of investment portfolios and funds, as well as large supply chains, regions, countries and sectors. GID estimates the impact on biodiversity by modelling the pressures of land occupation, contribution to climate change, air pollution and water pollution.

Data is combined to model biodiversity impact using GLOBIO and ReCiPe, resulting in the metrics Potentially Disappeared Fractions (PDF) and Mean Species Abundance (MSA) loss. PDF captures the fraction of species that has a high probability of no occurrence in a region due to unfavourable conditions caused by various environmental problems. MSA, on the other hand, is the percentage of biodiversity lost under current usage compared to a natural ecosystem, both in terms of species number and species abundance. Both can be used to approximate the relative loss of pristine biodiversity. They are used to model biodiversity loss expressed as loss of hectares of natural ecosystem (biodiversity ha) for a year.

In the attribution step, the biodiversity impact of companies, countries or sectors is attributed through value chains, using trade data from the GTAP model (Global Trade Analysis Project) and input-output analysis. Thanks to GID's innovative approach, it is possible to estimate how economic activity creates biodiversity effects both up- and downstream, without double counting when aggregating many estimates.

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Additional annex

Scenario analysis: effect on human health from animal welfare measures

This annex contains a scenario analysis of the potential for true cost reduction attributable to animal welfare measures. Key aspects of the relationship between specific animal welfare measures and human health are discussed in the following sections. More research into the relationship between measures aimed at improving animal welfare and Indicators of human health are vital to better understanding the potential for true cost reduction discussed in this annex.

Background information

The assessment of human health impacts resulting from zoonotic diseases transmitted from animals to humans (either through direct contact with infected animals or through the consumption and preparation of animal-sourced food) is accounted for in the scenario for two zoonotic diseases:

- Campylobacteriosis
- Salmonellosis

These diseases are representative of the broader spectrum of zoonotic disease, accounting for 92% of all reported cases in the European Union (European Food Safety Authority & European Centre for Disease Prevention and Control, 2022) (see Section 5.5.2 of main report). Both Campylobacter and Salmonella are included within the framework of the European Union directive 2003/99 for the monitoring of zoonoses and zoonotic agents, as causal agents for the most prevalent zoonotic illnesses in Europe (Iannetti et al., 2020).

Campylobacteriosis, as reported by the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control (ECDC) since 2005, is the predominant zoonotic pathogen, accounting for approximately 70% of all confirmed human cases of zoonotic diseases (EFSA/ECDC, 2018). Several studies have established a generally linear correlation between the prevalence of Campylobacter infections within animal flocks and

Methodology

The model presented in this Annex constitutes an extension of the methodology used in the main report. The analysis is based on the True Price method, an application of True Cost Accounting to quantify and monetize the adverse externalities arising from the production and consumption of animal-sourced food on human health (True Price Foundation, 2020). This method provides quantifiable, comparable insights into the human health costs attributed to the transmission of zoonotic diseases through animal-sourced food.

The impacts of zoonoses are quantified across various stages of the food chain, namely, the initial production (*i.e.*, harvest/slaughter), processing, and consumption stages (for an in-depth methodology description, see Section 2 of main report). The inclusion of direct means of transmission, namely farming and slaughter activities, as potential sources of zoonosis risk is reported by several studies. These studies highlight distinctive characteristics of farms and slaughterhouses that facilitate the shedding of pathogens (Alpigiani et al., 2017; Iannetti et al., 2019; Wesley et al., 2009).

To estimate the indirect zoonosis transmission pathways, a meta-analysis of population-attributable factors (PAFs) from case-control studies, such as the ones presented by Hald and Mughini-Gas (2022a, b), has been considered. The indirect transmission pathways include the consumption of meat, tripe, and undercooked/raw meat. Activities easing the transmission such as grill/barbecue usage and the consumption of raw meat, as well as preparation practices like eating out, picnics, and street food consumption, are also accounted for in the analysis.

the consequent risk to human health (Nauta et al., 2009). This means that a specific reduction percentage in flock prevalence corresponds to a proportionate reduction in associated risks. However, this linear relationship is not observed in the concentration of Campylobacter. Lowering the levels of contamination within affected flocks usually results in a nonlinear decrease in the incidence of infection (EFSA Journal, 2011).

The second most recurring zoonotic disease in Europe is Salmonella, with a pronounced association with the poultry sector, particularly meat and eggs (EFSA/ECDC, 2018; Iannetti et al., 2020). The decreasing trend in EU Salmonella-confirmed cases (which persisted until 2008) ended in 2013-2017, with a rise in its transmission to humans. Among the total food-borne outbreaks reported by EFSA/ECDC (2018) as part of their zoonosis monitoring estimates for 2017, Salmonella occurrences in eggs, meat, and meat products are reported as the highest risk agent/food combinations. However, in contrast to the beforementioned correlation between Campylobacter infection in animals and disease prevalence in humans, the direct correlation between Salmonella Infections In animals and risk to human health Is less pronounced.

Scenario analysis

An increased physical and mental animal welfare, as accounted for by the Five Domains model (see Section 1.1.1 of main report), is expected to significantly reduce the transmission of zoonotic diseases from animal-sourced food to humans. Noticeably, scientific literature (EFSA, 2011; Elliot et al., 2012; Iannetti et al., 2020) suggests that a more effective strategy for decreasing the reservoir of zoonotic diseases should include not only improved safety measures during the consumption and preparation phases of animal-sourced food but also improved animal welfare throughout the production phase. Such a comprehensive approach is likely to yield more significant results in curbing zoonotic disease transmission.

To obtain first insights into the true cost reduction (from lower costs to human health) which may potentially result from selected animal welfare measures, a scenario analysis was performed. This section discusses the data used for the scenario analysis and its respective results and conclusions.

Key data sources

The scenario analysis builds on the existing method for quantifying the human health costs from zoonotic disease as described in Section 2.3.6 (see main report). To determine the potential true cost reduction from selected measures for improving animal welfare, additional data is required specifying the change in infection per illness.

Given the lack of existing literature and studies on the causal relationship between specific animal welfare measures and infection rates, changes in zoonotic infections for selected policies to improve animal welfare are based on assumptions developed by experts in epidemiology who were consulted by the Eurogroup for Animals in the context of calculating the impact of a potential new animal welfare legislation. The control policies include improving mutilations and breeding practices such as increasing space allowances, regulating litter sizes for piglets, adjusting growth rates for chickens, and determining the onset of laying for hens. The collective adoption of these policies would positively influence immunocompetence by mitigating susceptibility, stress levels and other associated risk factors.

Notably, the lack of existing literature on the relationship between the respective infection rates and animal welfare measures poses an important limitation to this analysis.

The assumed reduction rates for the spread of Campylobacteriosis and Salmonellosis among humans are:

- Animal welfare measures can reduce campylobacter infections within broiler flocks by 20%. In turn, this would correspond to a 15% reduction in Campylobacter infections among humans. Estimates of Campylobacter infections are proven to be significant for white meat, specifically poultry meat, production, and consumption (EFSA 2022; Iannetti et al., 2020; ICF Report, 2012).
- The animal welfare measures can reduce salmonella infections within animals from the poultry sector (comprising eggs and broilers) as well as pigs by 50%. Human infections originating from both direct contact with animals and the consumption of contaminated animal-sourced food are assumed to decrease by 20%.

Results

Point of contact	Animal sourced food		Expected human health costs			
Value chain	**Animal sourced food category**	**Unit**	**Original value from main report (without new measures)**	**Expected value with measures**	**Absolute change (EUR)**	**Relative change (%)**
Production	Red meat (Beef, Lamb, Pork)	EUR/kg	€ 0,0003682	€ 0,0003682	€ 0,0000000	**0%**
	White meat (Poultry)	EUR/kg	€ 0,0001539	€ 0,0001326	€ 0,00000214	**-14%**
	Dairy	EUR/kg	€ 0,0000257	€ 0,0000257	€ 0,0000000	**0%**
	Eggs	EUR/kg	€ 0,0003044	€ 0,0003044	€ 0,0000000	**0%**
Preparation & consumption	Red meat (Beef, Lamb, Pork)	EUR/kg	€ 0,0042731	€ 0,0038090	€ 0,0004641	**-11%**
	White meat (Poultry)	EUR/kg	€ 0,0081086	€ 0,0081086	€ 0,0006063	**-7%**
	Dairy	EUR/kg	€ 0,0000086	€ 0,0000086	€ 0,0000000	**0%**
	Eggs	EUR/kg	€ 0,0043482	€ 0,0034785	€ 0,0008689	**-20%**

Results of scenario analysis. *The results are based on the assumption that – with the implementation of selected measures to improve animal welfare – the spread of two zoonotic diseases (i.e., Campylobacteriosis, Salmonellosis) among humans, both as a result of direct contact with livestock and the consumption of contaminated animal-sourced food, will decrease as follow: Campylobacter, -20% infection in broiler flocks and -15% in humans; Salmonella, -50% in animals (eggs, broilers, and pigs) and -20% in humans.*

Conclusion

This scenario analysis, albeit based on strong assumptions, shows the potential for true cost reduction attributable to animal welfare measures. The changes in true costs are observed for both production and preparation & consumption of white meat as well as in preparation & consumption of red meat and eggs.

To better understand this potential for true cost reduction attributable to animal welfare measures, it is recommended to invest in more quantitative research on the relationship between animal welfare measures and effects on society (specifically social, environmental, and human health impact).

References

This additional annex contains references additional to the ones stated in the main report. Please find the additional references listed below.

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