

True Costs of Food Database

Documentation and User Manual Version 1



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Table of Contents

Tables and figures	4
Abbreviations	4
Abstract	5
Introduction: Description of the database	6
1. Documentation of the True Cost Accounting methodology used	8
1.1. Data source	8
1.2. Impact assessment method	9
1.2.1. Greenhouse gas emissions	11
1.2.2. Water consumption	11
1.2.3. Marine eutrophication	11
1.2.4. Freshwater eutrophication	12
1.2.5. Ecosystem toxicity	12
1.2.6. Human health impact: human toxicity	12
1.2.7. Human health impact: particulate matter formation	12
1.3. Monetary valuation	13
1.3.1. Rights-based approach	14
1.3.2. Damage cost approach	15
1.4. Limitations of the database	16
2. User manual	17
Appendix	20
References	22

Tables

Table 1: Definition of the impact indicators	10
Table 2: Impact indicators and assessment method	11
Table 3: Monetization factors with application level, geographic scope, and source	13
Table 4: Monetization factors for environmental and human health impacts	14
Table 5: Overview of the database	17

Figures

Figure 1: Four steps of TCA	6
Figure 2: Boundaries of the database	7

Abbreviations

1,4-DCB-eq	1,4-Dichlorobenzene equivalent
CO ₂ -eq	Carbon dioxide equivalent
DALYs	Disability-adjusted life years
EFSA	European Food Safety Authority
GHG	Greenhouse gas emissions
GWP	Global warming potential
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
N	Nitrogen
NH ₃	Ammonia
P	Phosphorus
PM2.5	Particles that are 2.5 microns or less in diameter
SAFAD	Sustainability Assessment of Foods and Diets
SCBA	Social cost-benefit analyses
SUA	Supply utilization account
TCA	True Cost Accounting

Abstract

The [True Costs of Food Database](#) Version 1 (V1) is the first publicly available database worldwide to apply a True Cost Accounting (TCA) approach, providing comprehensive data on the environmental and health impacts and hidden costs of food products consumed in the European Union (EU). The database contains information on over 2,000 raw food items, representing more than 200 products sourced from over 80 countries.

This document accompanies the database and is structured in two parts: Chapter 1 explains the methodology used to derive the impact and hidden cost data for the various food products. Chapter 2 offers guidance on navigating and utilizing the database.

The True Costs of Food Database V1 is an innovative and ambitious project, the priority of which is to derive hidden cost estimates for typical food supply chains. This work builds upon the Sustainability Assessment of Foods and Diets (SAFAD) database v1.99 (SLU, 2024). It integrates established monetization factors from *Monetization Factors For True Pricing* by

True Price (Galgani et al., 2023) and the *Environmental Prices Handbook* by CE Delft (de Bruyn et al., 2023). The impact modelling aligns with the international life cycle assessment (LCA) guideline set forth in ISO 14040 and adheres to the ReCiPe 2016 LCA methodology (Huijbregts et al., 2016).

The True Costs of Food Database V1 was developed under the Horizon Europe research project PLAN'EAT, which runs from 2022–2026, with financial support from the European Commission. TMG Think Tank for Sustainability led the development of the database. True Price conducted the calculations for the environmental and health impacts and the corresponding hidden costs.



Access the database by clicking here: [True Costs of Food Database](#)

Introduction: Description of the database

Overview

The True Costs of Food Database V1, developed by TMG Think Tank for Sustainability in cooperation with the Netherlands-based social enterprise True Price, is an open-access database that provides comprehensive information on the hidden costs of food using the methodology of True Cost Accounting (TCA). This database details the environmental and health impacts of various food products, incorporating their associated hidden costs.

The database contains data on 208 raw food products from 81 countries, resulting in over 2,000 product-country combinations. They comprise the following food categories: berries, blue food, cereals, dairy, eggs, fruits,

novel foods, nuts, oil crops, pulses, red meat, root vegetables, seeds, spices, stimulants, sugar crops, vegetables, white meat, and other (see Chapter 1.1 for more details). The database focuses on products consumed in the EU but sourced worldwide. The impacts and hidden costs are estimated along the supply chain from cradle to farm gate. The environmental data used is broken down into to specific impact indicators by product and country of production. Impact indicators in the database were selected to be relevant to the agricultural sector and the target audience.

Purpose of the database

The primary purpose of the database is to derive hidden cost estimates for

True Cost Accounting (TCA) in a nutshell

True Cost Accounting (TCA) is a methodology used to evaluate the full environmental, social, health, and economic impacts of products, which are often not reflected in their market prices. It captures *hidden costs* such as damages to the environment and human health caused by pollution or resource depletion as a result of food production and consumption. By incorporating these externalities into the price of the food item, TCA aims to present a more accurate picture of the real cost of current food production and consumption, enabling consumers, businesses, and policymakers to make better-informed decisions. This approach highlights the broader consequences of food production on ecosystems and communities, encouraging practices that support sustainability and well-being.

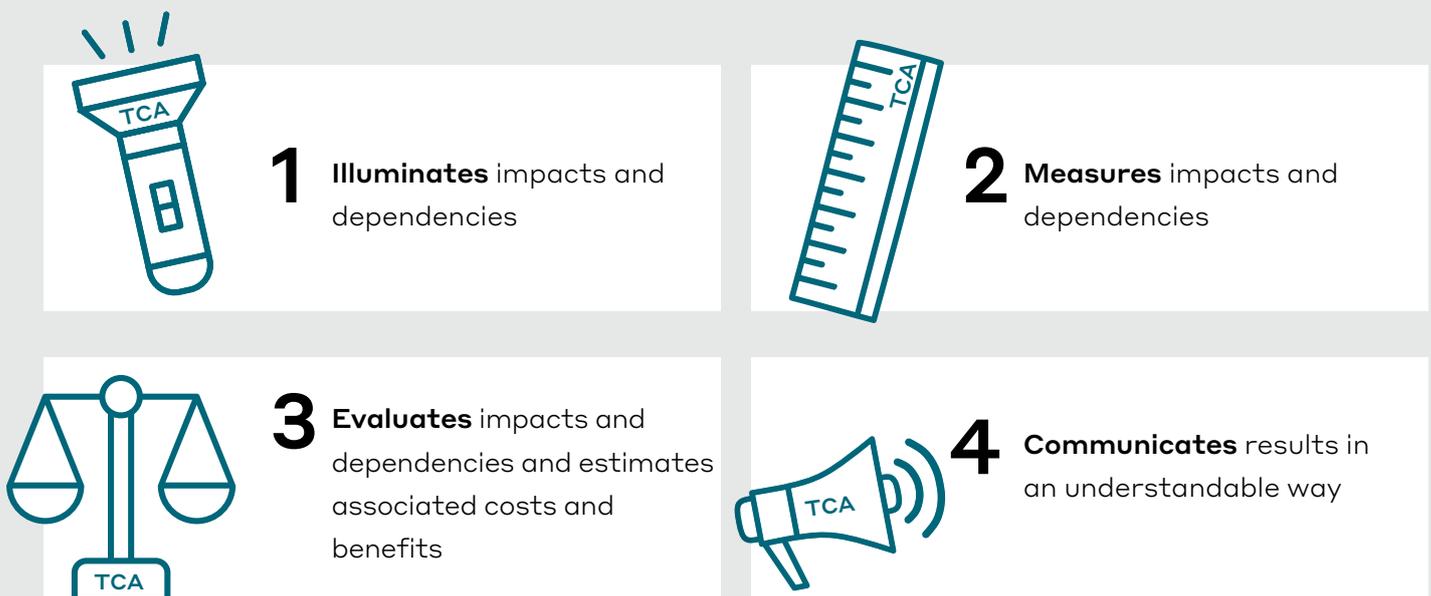


Figure 1: Four steps of TCA

typical food supply chains and thus allow for a comparison of hidden costs across different products. This information is intended to inform sustainability assessments of EU diets and support the transition to more sustainable and healthy diets. The database also aims to promote the wider application of TCA for holistic decision-making in line with the ambitions of the PLAN'EAT project.

Data sources

The True Costs of Food Database V1 was developed using the SAFAD V1.99 (SLU, 2024) database and incorporates established monetization factors from True Price (using a rights-based valuation approach) and CE Delft (employing a damage cost approach). The methodology of the database adheres to the international life cycle assessment (LCA) guidelines of ISO 14040 (ISO, 2006).

Scope

The coverage provided varies across indicators, with several focusing on

on-farm impacts only, thus excluding waste up to the farm gate (SLU, 2024). The value chain scope includes input manufacturing (e.g. fertilizer production), cultivation, and production. Processing and transportation activities are not in scope. The database includes environmental and human health impacts at the farm gate (see Chapter 1.2). These impacts are monetized based on two distinct approaches: the rights-based and damage cost approaches (see Chapter 1.3). Figure 2 visualizes the applied system boundaries.

About this document

Chapter 1 of the document outlines the methodology used to create the True Costs of Food Database, detailing the data sources, modifications to the data, how the impact and hidden cost data for various food products were derived, and limitations of the database. Chapter 2 offers users a guide to navigating and utilizing the database effectively.

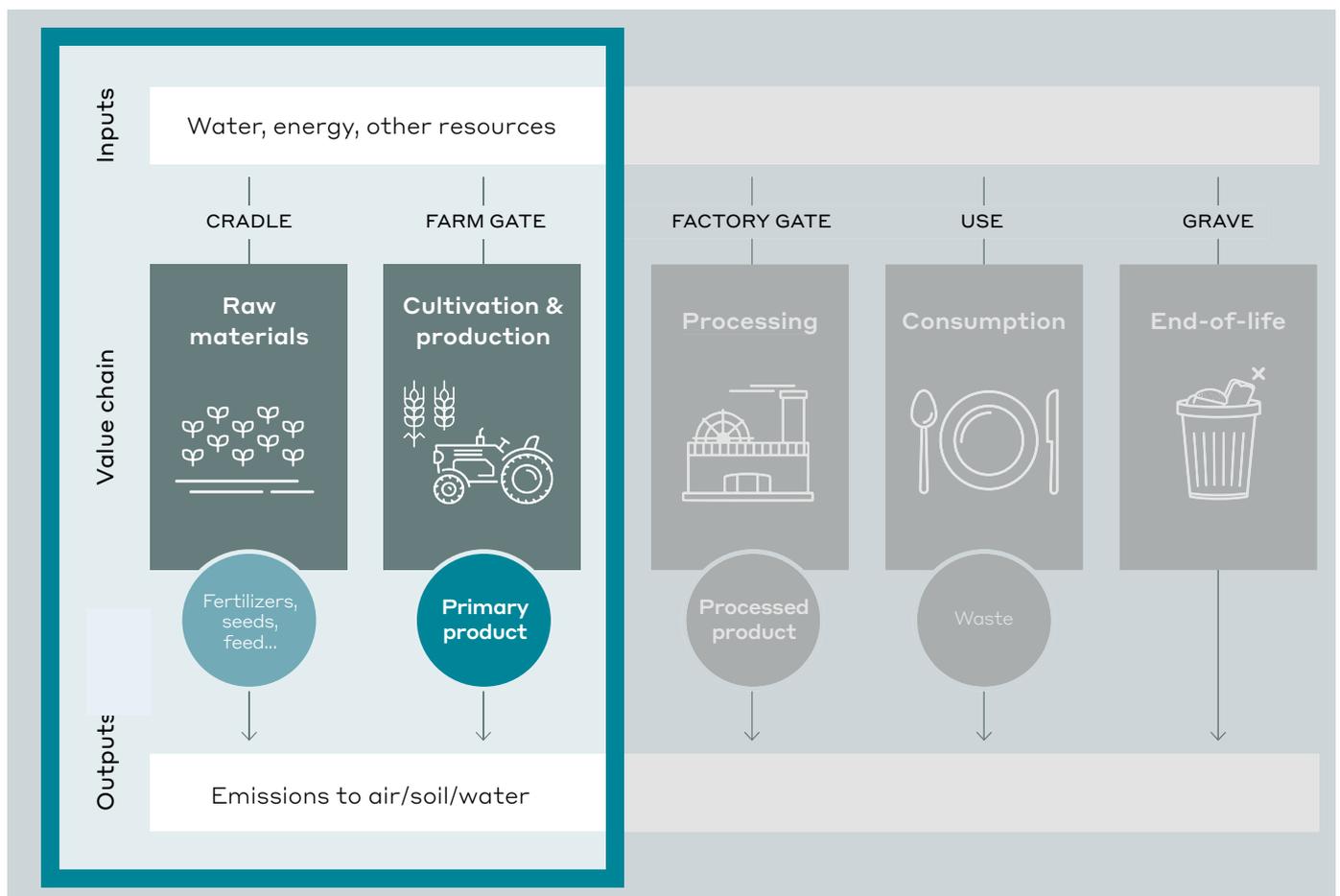


Figure 2: Boundaries of the database

1. Documentation of the True Cost Accounting methodology used

This chapter outlines the detailed methodology behind the development of the True Costs of Food Database V1. It begins by describing the underlying data source, SAFAD v1.99 (SLU, 2024), and then gives a detailed explanation of the impact assessment method, impact indicators, monetization methods, and monetization factors.

1.1. Data source

The True Costs of Food Database V1 is based on the Sustainability Assessment of Foods and Diets (SAFAD) database (Version 1.99), which was developed by the Swedish University of Agricultural Sciences (SLU) (SLU, 2024.) This data source was chosen based on a set of selection criteria that included the suitability of indicators, transparency of the underlying method, and the scope of the data coverage. A description of these criteria can be found in the Appendix.

The SAFAD database was built by SLU to evaluate the environmental performance of the Mapped Dietary Patterns developed in Work Package 1 of the PLAN'EAT project for eight European Living Lab countries.¹ It represents a novel development creating a diet-based sustainability assessment database at European level with transparent documentation of the methodological approach, data sources, and calculation model (Röös et al., 2025).

The database includes a wide geographical coverage for production countries, based on imports by eight countries participating in the PLAN'EAT Living Lab project. The countries of origin for products consumed were determined based on the trade matrix from Schwarzmüller and Kastner (2022) (Röös et al., 2025).

The SAFAD database contains data at various levels including impact data at midpoint level, as well as data at output and input levels. For example:

- Climate change impacts are provided at midpoint level based on the well-recognized IPCC method.²
- Water consumption is calculated using blue water footprint, equivalent to midpoint level.
- Ammonia emissions are provided at output level.
- Data on nitrogen, phosphorus, and pesticide impacts are provided at input level.

A total of 2,613 product-country combinations are available from the SAFAD database. These are organized into 22 main food categories (SAFAD data makes no distinction between production methods; i.e. organic vs conventional):

- Berries (140 product-country combinations)
- Blue food (54 product-country combinations)
- Cereals—millet, rice, sorghum (47 product-country combinations)
- Cereals incl. animal feed—barley, maize, oats, rye, wheat (112 product-country combinations)
- Dairy (67 product-country combinations)
- Eggs (56 product-country combinations)
- Fruits (415 product-country combinations)
- Novel foods (27 product-country combinations)
- Nuts (93 product-country combinations)
- Oil crops (112 product-country combinations)

¹ These are France, Germany, Greece, Hungary, Ireland, Italy, Spain, and Sweden. Poland also participated in the PLAN'EAT Living Lab project but dietary data for Poland are not available.

² Compatible with ReCiPe 2016 LCIA method.

- Oil crops, tree-derived (19 product-country combinations)
- Other (6 product-country combinations)
- Pulses (231 product-country combinations)
- Pulses incl. animal feed—broad beans and horse beans, peas (52 product-country combinations)
- Red meat (64 product-country combinations)
- Root vegetables (127 product-country combinations)
- Seeds (30 product-country combinations)
- Spices (20 product-country combinations)
- Stimulants (264 product-country combinations)
- Sugar crops (34 product-country combinations)
- Vegetables (552 product-country combinations)
- White meat (91 product-country combinations)

transparent impact assessment method for the respective indicator

- possibility to apply monetization to the respective indicator

The Life Cycle Impact Assessment (LCIA) method ReCiPe 2016 was used to model the impact indicators described in Table 1 using the inventory data from SAFAD (with the exception of the indicators “water consumption” and “GHG emissions,” which were already at the impact level in the SAFAD database).

ReCiPe 2016 (Huijbregts et al., 2016) is a complete and well-accepted impact assessment method with a high degree of geographical detail, providing country-specific mid- and endpoint characterization for relevant indicators, for the whole world.³ We decided against using the Product Environmental Footprint (PEF) methodology because it does not allow for separate accounting of marine and freshwater eutrophication impacts, nor for freshwater and terrestrial ecosystem toxicity impacts, in line with the SAFAD data. Additionally, rights-based monetization factors for PEF are not readily available.

1.2. Impact assessment method

This section presents the quantification methods of the impact in the True Costs of Food Database V1, describing the impact indicators and outlining the approach. The list of chosen indicators and their definitions are presented in Table 1. These indicators were chosen based on the following criteria (for more details see Appendix):

- availability of the indicators in the data source
- relevance of the indicators to agricultural and food production
- relevance of the indicators to the audience (i.e. primarily researchers, agrifood policy-makers, agrifood businesses, and consumers)
- availability of a well-recognized and

All indicators were calculated using midpoint characterization factors, except for “human toxicity” and “health effects due to ammonia emissions.” These two indicators were calculated based on their endpoint damage; i.e. their effect on human health measured in disability-adjusted life years (DALYs)—a standard metric for human health impacts in monetary valuation. For human toxicity, midpoint results (measured in kg of 1,4-DCB equivalents) were calculated as an intermediate step and then converted to endpoint values using mid-to-endpoint conversion factors from ReCiPe 2016. DALYs from ammonia emissions were determined using country-specific or regional endpoint characterization factors.

Table 2 provides an overview of all indicators and respective impact assessment methods used.

³ This applies to marine and freshwater eutrophication. Characterization factors for GHG emissions, water use and ecosystem toxicity are consistent across all countries (global factors).

Table 1: Definition of the impact indicators

Indicator	Unit	Definition
Greenhouse gas (GHG) emissions	kg CO ₂ -eq	Emissions of greenhouse gases (GHG) increase their atmospheric concentration (measured in parts per billion or ppb), which increases the radiative forcing capacity and consequently increases the global mean temperature. Ultimately, extreme weather patterns, reduced agricultural yields, and increased frequency of natural disasters can result in damages to the economy, human health (e.g. increased risk of diseases), natural disasters, and ecosystems (Huijbregts et al., 2016).
Water consumption	m ³	The volume of “blue water” (i.e. the surface and groundwater consumed primarily for irrigation of crops) (Mekonnen & Hoekstra, 2011).
Marine eutrophication	kg N-eq	Emissions to water (kg N-eq to marine water) contributing to marine eutrophication. Eutrophication occurs due to the runoff and discharge of nutrients, for example from leaching of plant nutrients into soil and bodies of water and the subsequent rise in nutrient levels, i.e. of phosphorus (P) and nitrogen (N).
Freshwater eutrophication	kg P-eq	Emissions to water (kg P-eq to freshwater) contributing to freshwater eutrophication. Eutrophication occurs due to the runoff and discharge of nutrients, for example from leaching of plant nutrients into soil and bodies of water and the subsequent rise in nutrient levels, i.e. of phosphorus (P) and nitrogen (N).
Human health impact - human toxicity	DALYs*	Emissions to air, soil, or water contributing to human toxicity (carcinogenic and non-carcinogenic).
Human health impact - ammonia emissions (NH ₃)	DALYs	Represents impacts of ammonia in the formation of particulate matter that can be harmful to human health. Emissions of NH ₃ pollutants to air constitute secondary PM2.5** aerosols causing human health problems when inhaled (Huijbregts et al., 2017).
Ecosystem toxicity - terrestrial	kg 1,4-DCB-eq	Emissions to air, soil, or water contributing to soil ecotoxicity.
Ecosystem toxicity - freshwater	kg 1,4-DCB-eq	Emissions to air, soil, or water contributing to freshwater ecotoxicity.
Ecosystem toxicity - marine	kg 1,4-DCB-eq	Emissions to air, soil, or water contributing to seawater ecotoxicity.

* Disability-Adjusted Life Years

** Fine particulate matter is defined as particles that are 2.5 microns or less in diameter.

Table 2: Impact indicators and assessment method

Indicator	Unit	Impact assessment method
GHG emissions	kg CO ₂ -eq	GWP100 (IPCC, 2021)
Water consumption	m ³	Blue water footprint (Mekonnen & Hoekstra, 2011)
Marine eutrophication	kg N-eq	ReCiPe 2016 - hierarchic midpoint Scope: only accounts for new N inputs in fields, i.e. synthetic fertilizers, N fixed in legumes; does not account for N inputs through manure
Freshwater eutrophication	kg P-eq	ReCiPe 2016 - hierarchic midpoint Scope: only accounts for new P inputs in fields (i.e. mined P), does not account for P inputs through manure
Ecosystem (terrestrial, freshwater, marine) toxicity	kg 1,4-DCB-eq	ReCiPe 2016 - hierarchic midpoint Scope: only accounts for pesticides
Human health impact - human toxicity (carcinogenic and non-carcinogenic)	DALYs	ReCiPe 2016 - hierarchic endpoint Scope: only accounts for pesticides
Human health impact - ammonia emissions	DALYs	IPCC (2019) + ReCiPe 2016 - hierarchic endpoint

1.2.1. Greenhouse gas emissions

Greenhouse gas (GHG) emissions from agricultural activities are quantified based on global warming potential within a 100-year time frame (GWP 100) to account for their contribution to climate change. Carbon footprints were similarly estimated using the GWP metric to aggregate the impacts of different GHGs—primarily carbon dioxide, methane, and nitrous oxide—on a common scale, expressed in CO₂-equivalents. SAFAD applies GWP100 factors from the 2021 IPCC report, which are 27 kg CO₂-equivalent/kg for biogenic methane, 29.8 kg CO₂-equivalent/kg for fossil methane, and 273 kg CO₂-equivalent/kg for nitrous oxide.

1.2.2. Water consumption

Water consumption was estimated using blue water footprint data from SAFAD and calculated based on the

water footprint method by Mekonnen and Hoekstra (2011). While blue water footprint and water consumption are similar concepts, they differ methodologically. SLU's SAFAD database provides pre-calculated data for water consumption as blue water footprints, which accounts for water sourced from surface or groundwater resources. This water either evaporates, is incorporated into products or taken from one body of water and transferred to another, or is discharged elsewhere later. Irrigated agriculture, industry and domestic water users can each have a blue water footprint (Water Footprint Network, n.d.).

1.2.3. Marine eutrophication

Nitrogen (N) inputs can leach into groundwater or run off into marine water, contributing to marine eutrophication. The LCIA method ReCiPe 2016 was used to quantify marine eutrophication. SAFAD data calculates the amount of N

input on an area of land and its impact on the product produced. The calculation includes only new N input through synthetic fertilizers and N fixed in legumes, excluding N inputs from manure. Characterization factors for emissions to agricultural soil from N inputs (kg N-eq/kg N) by ReCiPe 2016 were used to calculate marine eutrophication. These characterization factors are continent-specific (Huijbregts et al., 2016).

1.2.4. Freshwater eutrophication

Phosphorus (P) can leach into groundwater or run off into freshwater bodies, contributing to freshwater eutrophication. The LCIA method ReCiPe 2016 was used to quantify freshwater eutrophication. As with N inputs, SAFAD data calculates the amount of P input on an area of land and its impact on the product produced. The indicator accounts for P added to a field while excluding P inputs from manure application. Characterization factors for emissions to agricultural soil from P inputs (kg P-eq/kg P) from ReCiPe 2016 were used to calculate freshwater eutrophication. For countries not included in ReCiPe 2016 but covered by SLU's SAFAD data, the characterization factor for "Rest of the World"⁴ was used. The characterization factors for freshwater eutrophication are country-specific.

1.2.5. Ecosystem toxicity

Pesticide application and emissions of toxic compounds, such as heavy metals, contribute to ecosystem toxicity. The ReCiPe 2016 LCIA method was used to quantify ecosystem toxicity. This assessment covers terrestrial, freshwater, and marine ecotoxicity impacts. SAFAD impact data accounts for ecotoxicity impacts solely from pesticides, excluding a broader range of activities and substances that contribute to toxic emissions, such as fossil fuel combustion and emissions from industrial processes throughout the life cycle.

SAFAD data on pesticide application refer to the national average amounts of active ingredients used (kg/ha) to produce the products under study. However, SAFAD does not specify the types of pesticides⁵ applied, only the total amounts used. To estimate ecotoxicity for the SAFAD data, the composition of a global average pesticide mix was taken from AGRIBALYSE and applied to all products in the SAFAD-based database.⁶ Midpoint characterization factors from ReCiPe 2016 were then applied to estimate the ecotoxicity impacts based on the amounts of pesticides used.

1.2.6. Human health impact: human toxicity (carcinogenic and non-carcinogenic)

Pesticide application and emissions of toxic compounds, such as heavy metals and organic pollutants, contribute to human toxicity. The ReCiPe 2016 LCIA method was used to quantify human toxicity. The human toxicity impact was quantified using the same approach as for ecotoxicity. As noted under ecosystem toxicity, SAFAD data provides only the total amounts of active ingredients used. Therefore, data on the composition of a global average pesticide mix were taken from AGRIBALYSE to estimate human toxicity impact. Midpoint characterization factors for human toxicity, both carcinogenic and non-carcinogenic, were available in ReCiPe 2016. Subsequently, human toxicity midpoint results were converted to endpoint results expressed in DALYs, also using ReCiPe 2016.

1.2.7. Human health impact: particulate matter formation (ammonia emissions)

Ammonia release (e.g. from manure and other fertilizers) contributes to particulate matter formation, which adversely affects human health. The impact was quantified as DALY-loss, combining data on ammonia emissions with country-specific or

⁴ This corresponds to World Weighted Average in ReCiPe 2016.

⁵ I.e. active ingredients.

⁶ For more information on the pesticide data used see Nemecek et al. (2015, p.32).

regional endpoint characterization factors from ReCiPe 2016. In SAFAD, ammonia emissions are provided at output level. Ammonia emissions were converted to DALYs using endpoint characterization factors.

1.3. Monetary valuation

Several frameworks exist for the monetary valuation of social, human, and environmental impacts. However, True Cost Accounting is a relatively young methodology and there is no consensus on which factors to use for specific applications; therefore, monetary estimates always carry some uncertainty. To address this, two distinct frameworks were used side by side for the True Costs of Food Database V1: the rights-based approach and damage cost approach.

For the right-based approach, we applied the monetization factors from *Monetisation Factors for True Pricing* by the True Price Foundation (Galgani et al., 2023). These factors estimate the remediation costs associated with environmental and human health impacts, encompassing restoration, compensation, prevention, and retribution. For the damage cost approach, we referenced CE Delft's *Environmental Prices Handbook* (de Bruyn et al., 2023), which develops environmental prices using the damage cost approach to reflect the social cost of environmental pollution. The handbook uses an abatement cost approach for the impact of GHG emissions, similar to the rights-based approach (rather than a damage cost approach as used by CE Delft for all other indicators). Both monetization approaches are described in detail in Chapters 1.3.1 and 1.3.2.

Table 3: Monetization factors with their application level, geographic scope, and source

Impact category	Application level	Geographic scope	Source**
GHG emissions (kg CO ₂ -eq)	Midpoint	Global	CE Delft and True Price ^a
Marine eutrophication (kg N-eq)	Midpoint	Global	CE Delft and True Price ^b
Freshwater eutrophication (kg P-eq)	Midpoint	Global	CE Delft and True Price ^b
Ecosystem (terrestrial, freshwater, marine) toxicity (kg 1,4-DCB-eq)	Midpoint	Global	CE Delft and True Price ^b
Water consumption (m ³)	Midpoint	Global	CE Delft
Water consumption (m ³)	Midpoint	Country-specific*	True Price ^c
Human health impact - human toxicity (carcinogenic and non-carcinogenic) (DALY)	Endpoint	Global	CE Delft and True Price ^b
Human health impact - ammonia emissions particulate matter formation (kg PM _{2.5} -eq or DALY)	Endpoint	Global	CE Delft and True Price ^b

* "Country-specific" refers to water scarcity multiplied by a "scarcity" factor derived from Physical Water Risk ratings by the WWF (2020).
 ** For the methodology of the monetization method by CE Delft, refer to de Bruyn et al. (2023). For the monetization factors by True Price, refer to Galgani et al. (2023). For the detailed methodology of the respective monetization factors by True Price refer to a) Galgani et al. (2021a), b) Galgani et al. (2023b) and c) Galgani et al. (2021b).

Table 4: Monetization factors for environmental and human health impacts

Approach	Rights-based		Damage cost*		
	Impact	Interpretation	Value	Interpretation	Value**
GHG emissions	Restoration cost***/marginal abatement costs	0.168	Marginal abatement costs	0.144	EUR/kg CO ₂ -eq
Water consumption	Restoration costs (country-specific)	1.437	Compensation costs	0.452	EUR/m ³
Marine eutrophication	Restoration costs	15.7	Compensation costs	15.8	EUR/kg N-eq
Freshwater eutrophication	Restoration costs	226	Compensation costs	4.15	EUR/kg P-eq
Freshwater ecotoxicity	Compensation costs	0.0451	Compensation costs	0.0232	EUR/kg 1,4-DCB-eq
Marine ecotoxicity	Compensation costs	0.00206	Compensation costs	0.00355	EUR/kg 1,4-DCB-eq
Terrestrial ecotoxicity	Compensation costs	0.000281	Compensation costs	0.000711	EUR/kg 1,4-DCB-eq
Human health (toxicity and ammonia)	Compensation costs	115,000	Compensation costs	94,400	EUR/DALY

* Central values are used for all impacts.

** All values are in €₂₀₂₃ per unit.

***Due to the severe impact of GHG emissions, restoration costs should be prioritized over compensation costs when technically feasible.

The monetization factors are applied at midpoint and endpoint levels depending on the respective type of the impact indicator and they are either at global or country-specific scale (Table 3). Table 4 shows the monetization factors for environmental impacts at the midpoint level and for human health impacts at the endpoint level.

1.3.1. Rights-based approach

The method developed by True Price (Galgani et al., 2023a) employs a rights-based approach to monetary valuation. This approach was first introduced in 2020 with the initial version of the *Monetisation Factors for True Pricing*. The most recent version (3.0), published

in 2023, was applied in this project.

Over the past decade, True Price has established principles and a methodology for monetizing a broad range of social, environmental, and human health costs. Essentially, a food product is considered sustainable if the production and consumption processes respect the basic rights of all individuals, including future generations. Internationally recognized rights, such as those outlined in the Universal Declaration of Human Rights, serve as the foundation for defining what are termed *unsustainable* externalities of food production and consumption.

True Price's monetization factors represent the remediation costs associated

with a negative social, environmental, or health impact. Remediation costs are the costs of restoring stakeholders harmed by violations of basic rights to the level of wellbeing they would have enjoyed had the violation not occurred. As described in the *Valuation Framework for True Price Assessment of Agri-food Products* (Galgani et al. 2023a), the concept of remediation is derived from human rights law. Remediation costs are calculated as restoration, prevention, compensation (also known as damage costs), or retribution costs, depending on a decision tree that considers the type of impact to be addressed. For example, in cases of severe, reversible environmental damage, restoration costs are deemed appropriate.

In contrast, for damage that cannot be reasonably reversed, compensation costs—entailing reimbursement for the incurred damage—are considered appropriate (Galgani et al. 2021; True Price Foundation & Impact Economy Foundation, 2020). This approach allows True Price monetization factors to reflect two welfare categories: respect for rights and wellbeing, with the latter referring to what is intrinsically valuable to the stakeholders concerned (Schoenmaker & Schramade, 2023).

For the impacts considered in the True Costs of Food Database V1, restoration costs are applied to GHG emissions, eutrophication, and water consumption, while compensation costs are applied to human health and ecotoxicity impacts. All human rights-based monetization factors in the True Costs of Food Database V1 are global representatives, except those related to water consumption, which are country-specific to reflect variations in water scarcity.⁷ For the water consumption monetization factor, a global restoration cost⁸ is multiplied by a water scarcity factor derived from Physical Water Risk ratings by the WWF (WWF, 2020). The WWF factors used in this study

can be found in the Scarce water use impact-specific module for true price assessment (Galgani et al., 2021).⁹ For more information about the sources used to derive each monetization factor, see *Monetisation Factors for True Pricing* (Galgani et al., 2023).

1.3.2. Damage cost approach

The *Environmental Prices Handbook*, published by CE Delft (de Bruyn et al., 2023) updates the *Shadow Prices* handbooks, which CE Delft has published since 2010 (de Bruyn et al., 2010). In addition to midpoint prices for the Netherlands, the 2023 publication (in Dutch) also provides midpoint prices for all 27 EU Member States (de Bruyn et al., 2023). The environmental prices reflect the loss of economic welfare that occurs when one additional kg of a pollutant is released into the environment. This is mainly estimated using a damage cost approach, with the exception of climate change (GHG emissions), for which an abatement cost approach is employed.

To account for the uncertainties in deriving monetization factors, CE Delft's *Environmental Prices Handbook* (de Bruyn et al., 2023) provides lower, central, and upper values rather than a single monetization value. CE Delft recommends using central values for corporate social responsibility reporting by companies and as weighting factors in LCA. The upper and lower value estimates are used in social cost-benefit analyses (SCBA) in accordance with the Dutch General SCBA Guidelines. In the context of corporate social responsibility reporting and life cycle assessments, central value estimates are applied.

CE Delft's EU values are used for all products, production countries, and impacts, based on the assumption that these values serve as proxies for global monetization factors.¹⁰ The 2021 CE Delft monetization factors have been inflated

⁷ Note that geographical differences for other impact categories are accounted for in the impact assessment method (see Chapter 1.3).

⁸ The monetization factor represents a restoration cost that reflects the annualized expenses of desalination, including operational and maintenance costs, as well as electrical and thermal energy costs, and the expenses associated with covering and repaying initial capital.

⁹ Galgani et al. (2021) recommend applying this scarcity adjustment to the quantification of a footprint indicator known as the "scarcity-adjusted blue water footprint." In this case, however, we apply it to the monetization factor, which yields the same result.

¹⁰ Note that country- and region-specific characteristics are also accounted for in the impact assessment method (see Chapter 1.2).

to 2023 levels using consumer price indices (%) from the Euro area.¹¹

1.4. Limitations of the database

Users of the True Costs of Food Database V1 should be aware of several limitations. These relate to the underlying modelling and impact assessments choices, data sources, and the monetary valuation of impacts used to derive hidden costs.

Limitations related to modelling

Choice of impacts: While the impacts included in the True Costs of Food Database V1 are significant drivers of environmental and health externalities in the agri-food sector, the selection is not exhaustive. Important indicators, such as consumer health, land use, land use change, biodiversity loss, and soil degradation are notably missing.

Toxicity: Human toxicity factors (both carcinogenic and non-carcinogenic) for several pesticide active ingredients are absent from ReCiPe 2016, potentially resulting in an underestimation of health impacts. This absence affects the toxicity results, especially as SAFAD includes only the toxicity effects of pesticides in its assessment.

Pesticide mix: A typical mix of pesticides is constructed to model the toxicity impact of pesticides in SLU's SAFAD database. This pesticide application model serves as a global proxy for pesticide application, assumed to be applied uniformly across all product-country combinations. However, different crops require different pesticide combinations during cultivation and regulations concerning permissible pesticides differ from country to country.

Limitations relating to impact assessments

GHG emissions: SLU's SAFAD uses GWP100 factors from the 2021 IPCC

report, which are 27.0 kg CO₂-equivalent/kg for biogenic methane, 29.8 kg CO₂-equivalent/kg for fossil methane and 273 kg CO₂-equivalent/kg for nitrous oxide. These values are lower than the GWP100 factors in ReCiPe 2016 based on IPCC 2013.

Data gaps: Not all necessary process data were available in SLU's SAFAD source. As a result, certain products lacked process data, which prevented the calculation of hidden costs for all indicators. Indicators that could not be calculated are indicated as NA values.

Extrapolation of data for foods within the same category: This resulted in identical hidden cost estimates for different products within the same food category. For example, goat milk and cow milk show the same results because the same underlying data were used. Similarly, eggs from hens and other birds have the same hidden cost results due to being assigned the same impact data.

Limitations related to monetary valuation

Local vs global monetization factors: When evaluating the monetary value of impacts, global monetization factors are used for both the rights-based and damage cost approaches, except for water use in the rights-based approach, which is provided at the country level.¹²

EU27 averages serve as global averages: In the damage cost approach, EU27-average values are used as proxies for global average damage costs and applied universally, even in countries outside the EU27. Given that the EU generally has a higher income level than the global average, this may lead to an overestimation of damage costs for non-EU countries, particularly those in the Global South, where costs are typically lower. Nevertheless, until more specific values are available, using EU costs as a proxy for global costs remains a consistent approach for estimating hidden costs.¹³

¹¹ Inflation factor (1.11) sourced from World Bank's World Development Indicators.

¹² Under the rights-based approach, regionally adjusted eutrophication factors could be derived for future iterations of the database.

¹³ In the case of human health, global monetization factors are preferred to avoid assigning different values to people's health based on their geographic location.

2. User manual

This section provides a detailed description of the structure and format of the True Costs of Food Database V1. It explains the different tabs in the Excel file and the

columns within the tabs, offering guidance on how to use the database effectively. Table 5 provides a summarized overview of the database.

Table 5: Overview of the database

Category	Details
VALUE CHAIN INFORMATION	
Type of products	Raw products
Value chain scope	Cradle to farm gate
Number of geographies	81
Number of product-country combinations	2613
IMPACT ASSESSMENT	
Greenhouse gas emissions (kg CO ₂ -eq)	GWP100 (IPCC, 2021) aggregated effects of different greenhouse gases (i.e. carbon dioxide, methane and nitrous oxide)
Water consumption (m ³)	Blue water footprint (i.e. surface and groundwater consumed, primarily for irrigation of crops) (Mekonnen & Hoekstra, 2011)
Marine eutrophication (kg N-eq)	ReCiPe 2016 - hierarchic midpoint Only new N inputs in fields (i.e. synthetic fertilizers, N fixed in legumes)
Freshwater eutrophication (kg P-eq)	ReCiPe 2016 - hierarchic midpoint Only new P inputs in fields (i.e. mined P)
Ecosystem (terrestrial, freshwater, marine) toxicity (kg 1,4-DCB-eq)	ReCiPe 2016 - hierarchic midpoint Only pesticides
Human health impact - human toxicity (carcinogenic and non-carcinogenic) (DALY)	ReCiPe 2016 - hierarchic endpoint Only pesticides
Human health impact - ammonia emissions particulate matter formation (DALY)	IPCC (2019) + ReCiPe 2016 - hierarchic endpoint

MONETIZATION

Monetization approach	Two distinct valuation approaches are used: rights-based and damage cost
GHG emissions	Global midpoint
Marine eutrophication	Global midpoint
Freshwater eutrophication	Global midpoint
Ecosystem toxicity (terrestrial, freshwater, marine)	Global midpoint
Blue water footprint	Global midpoint (damage cost) Country-specific midpoint (rights-based)
Human health impact - human toxicity	Global end point

Database structure

The Excel worksheet The True Costs of Food Database V1 consists of four sheets:

1. Info: This sheet provides general information on the database.
2. SAFAD-based database: This sheet provides the environmental and human health impacts and associated hidden costs of food products estimates based on the SAFAD data.
3. Key: This sheet gives definitions of some of the terms used in the database.
4. Monetization factors 2023: This sheet presents the monetization factors used in the database for the rights-based and damage cost approach, adjusted for inflation for 2023.

The database itself (sheet 2) is divided into five sections:

1. Product information: Columns A-J contain product details, including the product name and its classification

according to both the European Food Safety Authority (EFSA)¹ and supply utilization account (SUA),² standards. These columns also include the product category, which groups food products based on their characteristics (see Chapter 1.1 for a comprehensive list of product categories), as well as the country of origin, place of cultivation and processing, production method, agricultural practices, and any additional production details if provided.

2. Impact results: Columns K-S present the environmental and human health impacts associated with each product, as outlined in Table 1.
3. Monetization factors: Columns T-AK contain the monetization factors applied to each impact indicator, applying both the rights-based approach by True Price and the damage costs approach by CE Delft (see Table 3 for details).
4. True costs: Columns AL-BC show the calculated hidden costs per impact indicator for each monetization approach. Hidden costs are calculated

¹ EFSA has developed a comprehensive food classification and description system that serves as a standardized method for classifying and describing food items across various food safety domains in the EU.

² SUA is a statistical framework used by FAO to organize food and agricultural data. The SUA system classifies food items into groups and subgroups.

by multiplying the impacts by the respective monetization factors.

5. Total true costs: Columns BD-BE present the aggregated hidden costs for each product and monetization approach across all impact categories.

The impacts and hidden cost information of each food product is provided per kilogram of product.

as fruits, vegetables, cereals, and meats, and create comparisons to understand the hidden costs associated with different food categories, helping them identify categories with problems that require intervention. Such analysis can help encourage shifts in diets from high-impact to low-impact food categories, promoting more sustainable consumption.

How to use the database

Users can download the True Costs of Food Database V1 in Excel format from the [TMG website](#). Potential uses include but are not limited to the following:

- Businesses, researchers, and consumers can utilize the database to compare the environmental and health impacts of food production,³ as well as the associated hidden costs of various food products.
- Consumers can estimate the hidden costs of a dish or diet based on the quantities of food used in their recipes.
- The database can be used to inform consumers about the hidden costs of food products and diets, allowing them to make more sustainable food choices.
- It can also be used by researchers and data analysts for further studies on the hidden costs of food.
- The data offers numerous ways to make meaningful comparisons. For example, researchers can analyse products to identify those with the highest and lowest overall hidden costs, highlighting often-overlooked externalities of food products.
- Additionally, the database allows for comparison of how different impact categories contribute to the total hidden costs of various products. This allows researchers to pinpoint the areas where improvements are needed to reduce impacts. Researchers and analysts can also examine the hidden costs across different food categories, such

³The database does not cover consumption-related health impacts (such as Type 2 diabetes).

Appendix

A.1 Selection criteria for the impact indicators

This section outlines the criteria for evaluating databases and selecting indicators for the True Costs of Food Database. The focus is on agriculture and food production. The criteria include the following:

Relevance to the audience: The concepts should be easily understood and relevant for public discourse on sustainability. A long list of indicators that could diminish consumer and stakeholder interest or understanding should be avoided.

Relevance for agriculture and food production: The focus should be on covering the most significant environmental indicators for agriculture and food production and, where possible, incorporating human or social impacts (desired indicators). Selected indicators based on materiality include:

- Contribution to climate change (GHG emissions)
- Land use and biodiversity
- Water use
- Soil degradation
- Eutrophication/nutrient emissions to water
- Ecosystem toxicity
- Human toxicity
- Particulate matter health effects
- Nutrition costs and benefits¹

We did not conduct a thorough assessment of social impacts as part of this scoping exercise because the selected databases focus on environmental data. It was difficult to include all materials and the indicators listed, so we had to be flexible in our final selection. Nonetheless, the database does include several of the desired indicators.

¹It should be noted that scientific consensus on the impact of nutrition is lacking in relation to Life Cycle Assessment (LCA).

²An example of such a method is the characterization of human toxicity using the ReCiPe impact assessment method. In this case, the endpoint characterization is based on DALY's (Disability-Adjusted Life Year), a measure of health burden. The monetary values for DALYs can be found in the literature or easily calculated, making it possible to compare them to the value of 1 kg 1,4-DCB-eq (midpoint characterization for human toxicity). This allows for a calculation of a monetized value for the impact of human toxicity of the products being considered.

Well-recognized and transparent impact assessment method: A well-recognized and transparent impact assessment method is a systematically developed approach for evaluating impacts. It should provide a structured framework for quantifying impacts. Transparency in this context refers to the method's accessibility and the reliability of its data and assumptions. These methods are typically backed by scientific evidence or peer-reviewed research.

Possibility of applying monetization within the scope of this project: Monetization factors for the indicators that are available and consistent with each other should be used. Monetization factors can be developed within the project timeline. For example, if the available impact assessment method allows for evaluation at the endpoint (i.e. environmental and human health damage), established damage costs (e.g. for environmental and human health) can be utilized.²

A.2 Selection criteria for the underlying data sources

The following criteria were used to identify the most suitable life cycle inventory (LCI) data sources for developing the True Costs of Food Database V1:

- **Suitable indicators:** The data source must allow for the derivation of appropriate TCA indicators, as defined in Appendix A.1.
- **Transparency:** Detailed information regarding the data sources, general methodology, assumptions, and limitations should be accessible.
- **License:** The data of the data source should be reusable, modifiable, and publishable.
- **Data coverage:** An optimal combination of the following data

coverage characteristics should be present:

- **Product diversity:** The data source should cover a wide range of products and include different production methods.
- **Geographical coverage:** Preferably, data should cover a large geographical area. Both production countries inside and outside the EU are relevant for the database. The primary goal is to cover as many products as possible, along with their respective countries of origin, as part of the diets in the PLAN'EAT Living Lab countries.
- **Relevance to the audience:** The data should cover products widely consumed in Europe, such as pork, beef and poultry meat, dairy products and eggs, cereal-based products, vegetables, and oils (Crenna et al., 2019).

The following data sources were reviewed during the database selection process:

- AGRIBALYSE database
- SLU SAFAD database
- The Netherlands National Institute for Public Health and the Environment (RIVM) database on Environmental Impact of Food Products
- Idemat 2023 Midpoints
- FAOSTAT Climate Change Domain
- Publication: Reducing food's environmental impacts through producers and consumers (Poore & Nemecek, 2018)
- Publication: Estimating the environmental impacts of 57,000 food products (Clark et al., 2022)
- PLAN'EAT Internal Report 4: Food system-related health impacts

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About the project

PLAN'EAT is a Horizon Europe project that seeks to facilitate the transition towards healthy and sustainable dietary behaviour through an in-depth understanding of the underlying factors and drivers and the development of innovative, effective recommendations, tools, and interventions addressing different agri-food system actors.

PLAN'EAT aims to implement a systemic approach at the macro (food system), meso (food environment), and micro (individual) levels. Various socio-cultural and geographic contexts across Europe will be considered by implementing nine living labs in different European areas, five pan-European food value chain consultation and working groups, and national and pan-European policy labs.

As part of a consortium of 24 partners, TMG is leading work on True Cost Accounting (TCA) to analyze the environmental, socio-economic, and health impacts of European diets and their associated costs. This component of the project includes:

- analyzing the availability of TCA data
- developing a database of the impacts and true costs of 2,000+ food products consumed in Europe
- assessing the true costs of three different European dietary patterns
- providing recommendations for using TCA for holistic food systems policy and the development of national dietary guidelines

Building on this work, TMG will also be involved in developing a roadmap for the establishment of a proposed European Food Policy Council, as well as setting up a methodology framework to design easy-to-understand healthy and sustainable food-system-based dietary guidelines at the national level, for various population groups. Find out more on the TMG [project page](#) and the [PLAN'EAT website](#).



TMG Think Tank for Sustainability

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