Data for True Cost Accounting

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This paper provides an overview of the data and databases that can be used to calculate the true costs of food. True Cost Assessments can be based on a Life Cycle Analysis (LCA) methodologies that assesses environmental and social/human effects. Several databases have been developed to conduct environmental and social LCAs. Several other databases have been built to monetise these impacts. These databases can be used to support TCAs. However, depending on the goal of the TCA, awareness of the necessity of collecting specific, primary data is vital.

Key words: True Cost Accounting, food data, true pricing

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1 Introduction

True Cost Accounting can help achieve a more sustainable food system
Preliminary research estimates that societal costs that are currently not included in food prices are about to at least double (UNFSS, 2021; FOLU, 2019). True cost accounting can help all actors in the food value chain (e.g. governments, market actors, NGOs) to make decisions to create a more sustainable food system, based on insights into external factors caused by the production and consumption of food. As such, we see growing interest in the concept of True Cost Accounting (TCA).

Methodology TCA in development
Many approaches to calculating externalities have been proposed, such as in the report by Hendriks et al. (2023).[1] However, there is no harmonised methodology yet. The EU FOODCoST project aims to harmonise and integrate existing approaches (Proposal FOODCoST, submitted October 2020).

Insights into the data required to calculate true costs are necessary
Data are the key to calculating true costs. In addition to the development of a methodology to measure and value the externalities of food systems, the availability of good data is important. Only theoretically sound methodologies with good data are able to deliver the desired insights for decision making. An overview of the required data and databases and their availability for the calculation of true costs is necessary.

Aim of the paper
In this paper, we provide an overview of the data and databases required and available to calculate the true cost of food. We want to achieve two goals:
- To provide an overview of databases to give TCA implementers insight into where what data are available for calculating the true costs of food
- To provide directions for additional data collection by identifying data gaps.

Demarcation of the project
To calculate true costs, we need: (i) data on the impact of food production and consumption on the environmental, social/human and economic issues, and (ii) an overview of the monetisation factors that can be used to give a value to impacts on environmental, social/human and economic issues. This paper focuses on the first type of data. The second type of data is a limited list; if 30 issues are measured using two indicators, 60 monetisation factors are required. There are a few public databases available for these factors, including:
- SPIQ with marginal damage costs (SPIQ-FS Generic Dataset – FoodSIVI),
- Eco-cost with prevention costs (Download databases – Sustainability Impact Metrics (ecocostsvalue.com)),
- Ecosystem Services Valuation Database (esvd.info), and
- The Handbook of Environmental Prices (CE Delft), which has various costing methods (Handboek Milieuprijzen 2023. Methodische onderbouwing van kengetallen gebruikt voor waardering van emissies en milieu-impacts - CE Delft).

In addition to public databases, there are also monetised commercial databases available.

This paper focuses on the Dutch food system. Due to the international focus of the Dutch food system, international data and databases are considered as well.

Most external costs are location specific. For example, nitrogen emissions have location-specific effects on health and ecosystems. These effects depend on population density in terms of health effects. They also rely on the quality of nearby nature reserves, their sensitivity to changes in nitrogen deposition and dispersion, and the sensitivity of the ecosystem services to nitrogen in terms of biodiversity effects. Because of these location-specific properties, TCA requires location information and data (Woltjer et al., 2023 not published

[1] The True Cost of Food: A Preliminary Assessment | SpringerLink.

yet). A lot of available spatial data series could be helpful for this. However, the analysis of these databases needs to be considered in a separate comprehensive study, which is beyond the scope of this assignment. In the EU FOODCoST project, we focus on GIS databases as data sources for TCA.

Finally, we focus on the capitals that have been explored so far: natural capital and social/human capital. Economic capital in TCA analysis is much less developed at the moment. As such, it is not clear yet what data are needed.

Outline of the paper

We first discuss the concept of true cost accounting (Chapter 2) to provide an understanding of the methodology for calculating true costs. In the following chapters, we provide an overview of the data and databases available for calculating TCA for two separate purposes: (i) data related to external environmental factors and social/human externalities (Chapter 3), and (ii) data and databases related to assessing sustainability-related effects on farm level (Chapter 4). Finally, we draw conclusions about the extent to which we are able to calculate true costs and where we observed data gaps that complicate the true cost calculations (Chapter 5).

2 Methods for True Cost Accounting

2.1 The concept of True Cost Accounting

True Cost Accounting (TCA) for measuring and valuing externalities
True Cost Accounting (TCA) is an evolving holistic, systemic approach to measure and value the environmental, social, human and economic costs and benefits for facilitating decision-making by businesses, consumers, investors and policy makers (UN Food Systems Summit 2021).

TCA distinguishes environmental, social/human and economic capitals
Table 2.1 shows the components of true price methodology for agri-food products: Valuation framework, Assessment method and Impact modules (Galgani et al., 2021a).

Table 2.1 *Components of the true price methodology for agri-food products*

	Content	Audience
Valuation framework	Theoretical framework, normative foundations, definitions and valuation guidelines based on the True Price principles	Experts and method developers
Assessment method	Steps and requirements for implementation (completeness, accuracy, data, reporting, etc.)	Experts and practitioners
Impact modules	Definitions, footprint indicators, monetisation factors and data guidelines for specific impacts (e.g. climate change, health and safety, water use)	Experts and practitioners

Source: Galgani et al. (2021a).

Different approaches are used distinguish between various capitals.[2] Some approaches work with three different capitals; others recommend working with six capitals. However, all approaches distinguish between environmental, social/human and economic capitals. We will work with these three types of capital.

List of external factors to be considered
As described in Chapter 1, we exclude the economic capital because TCA for this capital has not been developed yet. We focus on environmental and social/human capital.

A huge number of externalities can be involved in True Cost Accounting. Depending on the goal and scope of the study, particular externalities should be selected. Please refer to the descriptions of how to conduct TCA, e-LCA and s-LCA for further details. In all approaches, the externalities that have to be considered should be defined first.

In this paper, we focus on the most important externalities discussed in the EU project FOODCoST (see Table 2.1). It follows that not every potentially relevant externality is discussed here. However, most of these items can be categorised under the various headings in Table 2.2.

[2] The various capitals are important societal issues that can change. They are a way of categorising societal impacts.

Table 2.2 *Preliminary list of externalities to be considered for each kind of capital, as of spring 2023*

Environmental	Social and human
Climate Change	Labour rights and conditions
Acidification and eutrophication	Local community rights and wellbeing
Particulate matter	Equity
Water stress	Infectious diseases
Land use and land transformation	Food safety
Direct effects on biodiversity and ecosystems	Health effects of diets
Toxicity	Food security
Non-renewable resource depletion	Consumer rights
Ozone and radiation	Animal welfare
Noise, smell and visual disturbance	

Based on discussions in the EU project FOODCoST.

2.2 Methods for TCA

Methodology in development

TCA is still in development. A large number of different approaches have been developed. Von Braun and Hendriks (2023) and The Impact Institute (2023) have provided the latest overview of existing approaches. The differences in methodologies complicate comparing the results. This is one of the reasons the EU finances the FOODCoST project, which aims to harmonise and integrate methodologies.

Woltjer et al. (2024) argue that all methods should ideally have a welfare foundation if their goal is to estimate the loss of welfare from food production and/or consumption. Woltjer et al. (2024, to be published) also argue for the importance of causality. Consequently, they recommend applying a welfare based approach as a valuation methodology. The two other approaches – the abatement costs approach and the rights-based approach – are less suitable for TCA. Abatement costs may be necessary for some effects for which the value is particularly uncertain, and shadow prices can be used to estimate true costs. However, they can also be used to estimate damage costs. We follow these authors' recommendations.

In the food sector, an inventory of 35 initiatives has been made. The Impact Institute (2023) conclude (p23/24 of the current Field of True Cost Accounting):

> 'The field of True Cost Accounting is developing quickly. Unfortunately, the heterogeneous nature of this development has caused an incomparability in the results of TCA assessments - especially for those resulting from different initiatives. This is now serving as a barrier to building confidence in the field by potential users, decision-makers, advocates, and others. The process of harmonizing the field – either through the creation of one, overall framework and related methodologies and tools, through setting defined boundaries for TCA assessments, or through other harmonisation endpoints – will help to reduce this barrier. As harmonisation is slowly achieved, TCA initiatives will become more comparable and readily understandable. This will build trust in the methods used and in the sector overall.'

Harmonised approaches are efficient for practical applications and defining and gathering data. The fundamentals (economic approach versus rights-based approach) and the list of indicators are essential for harmonisation. In the Horizon project FOODCoST, researchers are trying to build a TCA framework based on damage costs. In cases damage costs are difficult to estimate, the next best alternatives are used.

As mentioned before, we prefer to take the developments and outcomes of EU project FOODCoST as starting point. This approach can be characterised by:

- Multi-capital scope: environmental, social/human, and economic capital
- Multi-stakeholder approach: agri-chain (product) & agri-food systems (economy)
- Having an economic basis with damage costs approach for determining monetisation factors

- Using materiality assessments while aiming for a full assessment of all externalities. Secondary data can be used to complete the analyses for less material, societal issues
- Transparency with regard to methodology and data used
- Application of the broad definition of welfare as the basis for defining the externalities and the indicators
- Relevant and suitable for different goals.

Same steps and stages in TCA as in E-LCA and S-LCA

According to Galgani et al. (2021a), the following steps and phases can be distinguished (see Figure 2.1).

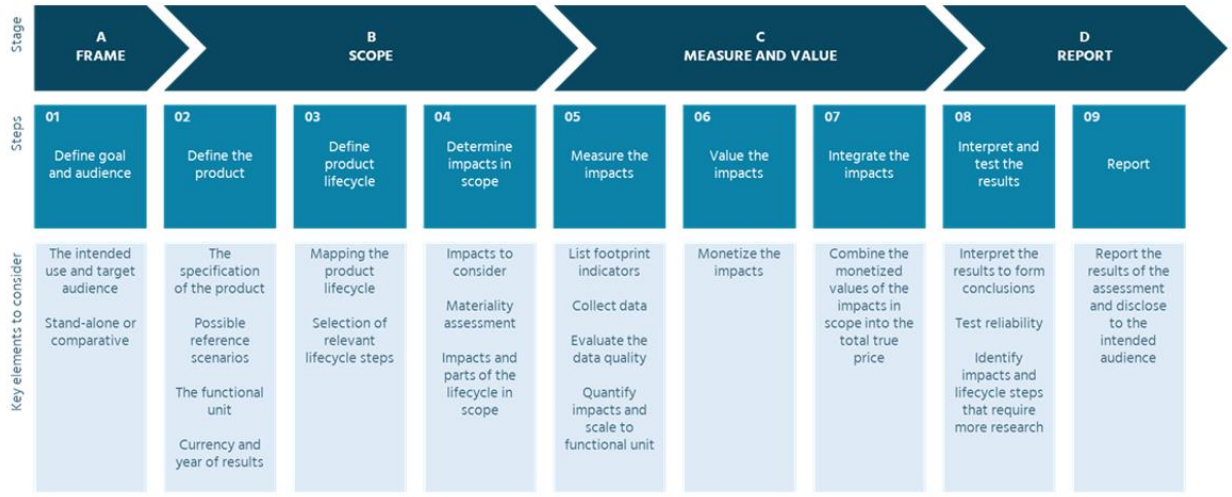

Figure 2.1 *The steps and stages of the True Pricing Assessment framework based on Natural Capital Coalition (2016) and Social & Human Capital Coalition (2019)*

As can be read in Chapter 3, to calculate TCA, the same steps and stages can be defined in the execution of Environmental Life Cycle Analyses (E-LCA) and Social Life Cycle Analyses (S-LCA). After all, for each monitoring system one has to find answers to four main questions (Boone and Ten Pierick, 2005):

- Why are we doing the study? Who are we doing it for?
- How do we demarcate the objective, subject and object of the study?
- How do we measure the results?
- How do we interpret and report the results?

In this project, we focus on the data needed for the third stage: measuring and valuing results.

2.3 Need for data

Primary and secondary data differ in accuracy, availability and the resources needed to collect them

A distinction can be made between primary and secondary data. In terms of TCA, primary or internal data are data gathered from the value chain being studied directly, according to Zampori and Pant (2019). In the case of environmental data, primary data may be obtained through meter readings, purchase records, utility bills, direct monitoring, material/product balances, engineering models and other methods for obtaining data from specific processes in the value chain of the user. In the case of social data, surveys, are methods to collect the required data. Primary data are site, company or supply chain specific.

Secondary data are data that are not gathered from a specific process within the supply-chain of the company performing the study. These data are not directly collected, measured or estimated by the company or the TCA practitioner but sourced from a third party. Examples include data in the Life Cycle Inventory (LCI) database and data collected by NGOs. Secondary data include industry average data (e.g.

published production data, government statistics and industry associations), literature studies, engineering studies and patents. They can also be based on financial data and contain proxy and other generic data. Aggregated primary data are considered as secondary data.

A specific group of data within the secondary data are public data that are made available through general research. Open access databases are provided through national and international statistics offices and public reports from NGOs, news providers and advocacy groups.

In general, primary data are more accurate for specific situations. However, secondary data based on a large number of observations are more accurate if an average of a group is required. Primary data are also more time consuming to collect and are thus more expensive. Secondary data can be less costly, and they can be licensed. Another advantage of using secondary data is that we have much more secondary data to work with than primary data. The availability of primary data is somewhat low.

In conclusion, data collection should ideally be tailored to the purpose of the TCA. If the goal is to examine a specific company or type of product, it is often best to collect primary data. If this is too expensive, the TCA practitioner can use secondary data. Conversely, if they want to analyse something about a group of companies, an entire country or about a product group, secondary data is often the best alternative, if available and reliable. If these are not available, researchers can still collect primary data, however, good methods must be developed to extrapolate them to the total of the group.

The required data and their quality depend on the study's aim

The type of data that need to be collected depends on the goal and scope of the study, the TCA framework being applied, the type of TCA assessment method and the corresponding LCA methodologies. Depending on the goal of the analysis, the data may need to be more specific to support the argument decision or claim being made. The TCA practitioner has to decide what data should be primary and secondary, considering the appropriate guidelines.

For general decisions and claims, average sector level data can be sufficient. For example, to assess what sustainability items are the most relevant for Dutch apples, generally, one can use average data from apple chains in the Netherlands. However, if businesses want to develop a brand based on sustainability factors, one has to look for specific data in that specific value chain. The same is true for insights into differences in the sustainability impact of two products that differ in terms of production method, region or variety. Specific data are needed to underpin claims, while general data are helpful for assessing hotspots for example. As such, we need an overview of the availability of general data and specific data. Finally, the framework to calculate Product Environmental Footprint (PEF framework) and the corresponding Product Environmental Footprint Category Rules (PEFCR) define what data are primary and secondary if the study needs to be done in a PEF compliant way.

3 Method and required data to assess impact

3.1 Method and required data to assess impacts on natural capital

Life Cycle Analysis (LCA) is an important underlying method for TCA

- TCA calculations related to natural capital can be based on Environmental Life Cycle Analysis (E-LCA).
  - LCA and TCA both focus on the environmental impact of the production and/or consumption of a product or service.
  - At the moment of writing, a relatively good match can be made between TCA and LCA with regard to the monetary valuation: TCA method *PPS Echte en eerlijke prijs* and LCIA method ReCiPe 2016.
- However, one has to consider that there are still methods currently in development. For example, the valuation methods for certain toxicities need to be further elaborated.

Data needed in the inventory phase

- In the inventory phase of the LCA, data about the physical, material and environmental characteristics of production have to be collected.
- Depending on the TCA and underlying LCIA method, there are specific requirements for the data, such as the requirements prescribed in the PEF Guideline and PEFCFRs. These LCA guidelines defines what data should be collected.

LCI databases are well developed and useful for LCA and TCA

- Data can be found in LCI databases. LCI databases can provide environmental data for conducting the LCA/TCA. Data in LCI databases are defined on the supply chain level.
- The harmonised European LCA guideline PEF and its corresponding sector-specific PEF Category Rules (PEFCRs) are involved in the LCI and EF databases.
- Generally, LCI databases publish sector and country average data. If the study requires product, company or region specific data, primary data should be collected.

Additional data are necessary – primary data

- Currently, certain environmental issues cannot be monetised using LCIA methods because life cycle inventory data are missing, life cycle impact assessment methods do not include these issues and no monetisation factors for these issues have been developed as of yet.
- There are currently no LCI databases that include data on noise, smell, visual disturbances, marine plastic pollution, overfishing, litter or antibiotic use. Some of these data can be collected from non-LCI databases. Otherwise, primary data should be collected from the source. Monetisation is possible as soon as monetisation factors for these issues have been developed.

3.2 Method and required data to assess impacts on social capital

TCA calculation related to social/human capital can be based on Social Life Cycle Analysis S-LCA, but some important notes have to be made

- The S-LCA methodology is still under development. The most used methodological guidelines for S-LCA are ISO 14040/44 Environmental Management – Life Cycle Assessment standard, the United Nations Environment Programme (UNEP) Guidelines for Social Life Cycle Assessment of Products and Organisations 2020, and the Social LCA Guidelines and Product Social Impact Assessment Handbook (PSIA).

- The monetisation of S-LCA is in its infancy. There is also debate amongst S-LCA researchers regarding whether S-LCA performance should be valued or monetised and, if so, how, because positive social impacts may not make up for unacceptable negative ones.
- There is a lot of flexibility for stakeholder groups and impact categories from the 40 in the UNEP guidelines to become more flexible in S-LCA. Positive impacts can also be included when relevant while in TCA (FOODCost), the impact categories are fixed and cover negative externalities. From the perspective of S-LCA, a justification is needed for the choice of impact categories (justification, consequences and limitations).
- The health effects of diets as considered in the FOODCoST project are not covered by S-LCA. Noise, smell and visual disturbance are not specifically mentioned in S-LCA, but they may be covered by the impact category 'safe and healthy living conditions'. Living wage as considered in the UNEP guidelines can be included under equity in social impacts in FOODCoST. Simultaneously, S-LCA covers other issues than the TCA externalities selected in FOODCoST, which is chosen as starting point.

The two main approach types in S-LCA can provide a basis for assessing social capital
- The Reference Scale approach can assess actual social performance or indicate potential social risks.
- The outcomes of the Impact Pathway approach show the relevance and size of effects of separate social impacts.

The Social Hotspots Database (SHDB) and the Product Social Impact Life Cycle Assessment (PSILCA) database are designed to use in S-LCA can identify potential social risks.
- SHDB covers 25 social impact categories. PSILCA covers 19 impact categories. Neither covers all 40 of the social impact categories from the UNEP (2020) guidelines.
- The agricultural sector in the SHDB has no subsectors. Many sectors are included in the PSILCA, but they may not be complete for all sectors. The availability of data with respect to different sectors and products is currently being investigated.

Results of Reference scales approaches cannot be monetised directly.
- SHDB and PSILCA provide medium or high risk hours/working hours for sectors. This can be used as a reference scale, but the outcomes cannot monetised straight away. Whether there is a solution to this needs to be studied.
- The result of reference scale approaches that assess the actual performance cannot be valued easily. The underlying data may be needed for monetisation, but they may not available or suitable. The underlying performance indicators can be of qualitative, semi-quantitative or quantitative nature.

Ample data is available, but there are no databases that cover all social impact categories, countries or sectors
- A lot of data sources that can be used in a S-LCA have different characteristics, as discussed in Section 4.3.3. Experiences have shown that S-LCA practitioners need both primary data and secondary data (Goedkoop, 2020).

There is a need for additional data to assess the social/human capital, especially for assessing the social performance of particular products, companies and chains
- For assessing the social performance of specific companies or product supply chains, primary data often need to be collected at the company level along the supply chain, including at the farm level.
- The relevant stakeholder groups and impact categories should be identified in the materiality assessment. The SHDB can provide an initial hotspot analysis. Primary data collection can be more targeted this way.

4 Data about farm production

Accurate, recent data on farm level are key

Based on the discussion in Chapter 3, it can be concluded that we need detailed data collected at farm level to calculate TCA. Furthermore, we concluded that the LCA and S-LCA databases are important for calculating TCA, but additional data collected at farm level can be very helpful or even essential to measure sustainability and to support company-specific actions.

One of the sources of farm level primary data is the Farm Accountancy Data Network (EU-FADN). Currently, the Dutch FADN is much broader than the EU FADN, but the EU FADN will be extended in the near future (2025)[3] to become FSDN and to include several environmental and social indicators. In this chapter, we discuss the current and potential role of FADN plays in supplying data on farm level that could be used in TCA.

The Dutch Farm Accountancy Data Network provides insights into the economic, environmental and social effects of farming practices

The Dutch Farm Accountancy Data Network (FADN) is an integral part of the wider EU FADN system, which gathers comprehensive financial and economic information on 70,000–80,000 farms across Europe (as of 2021). While the EU FADN collects some technical data (e.g. yield per hectare, milk production per cow) and limited environmental data (quantities of N, P and K, and their use),[4] the Dutch FADN goes beyond financial indicators by incorporating a broader range of sustainability indicators.

With a focus on agricultural and horticultural holdings, the Dutch FADN gathers detailed data on 1,500 farms in the Netherlands, providing valuable insights into the environmental and social impact of farming practices. This data collection has been ongoing for over two decades, driven by the need to respond to evolving policy priorities and societal concerns.

Given the importance of environmental issues in Dutch agricultural policies, the Dutch FADN places particular emphasis on data related to manure, nutrient balances (including nitrogen and phosphorus), energy use, renewable energy production and pesticide use.

The Dutch FADN recognises the importance of social variables in agriculture, particularly with regard to farm succession, paid and unpaid labour input, and education. Furthermore, data are collected on a range of issues, including household income, innovation activities, and involvement in other gainful activities (e.g. care farming, farm tourism and direct farm sales). The Dutch FADN also places a strong emphasis on animal welfare. Information is gathered on stable systems, the use of antibiotics and more. These insights can be used to inform policy decisions and promote sustainable and socially responsible farming practices.

The FADN focuses on the farm level. In certain applications, it can focus on the product level. This requires the allocation of financial, material and environmental flows to the different products. At the moment, this is only done for a few important products.

Bookkeeping serves as a base for the data collection in Dutch FADN

The collection of data for the Dutch FADN relies on a variety of sources, with systematic bookkeeping serving as a common starting point for both economic and environmental data. Farm invoices are a particularly valuable source of information, offering insights into the cost, type and quantity of inputs used. For example, the recording of pesticide use goes beyond the total amount spent: complementary data on the specific

[3] The current proposal foresees the first FSDN data delivery in 2026 with data on the 2025 accounting year. See https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-farm-sustainability-data-network for a short description of the process and https://data.consilium.europa.eu/doc/document/ST-12194-2023-INIT/en/pdf for the text of the trilogue agreement.

[4] Not all those data are publicly available, but they can be assessed for research purposes. Analysis can be done at the farm level, but privacy restrictions require the publication of results at an aggregated level.

types and the quantities of pesticides used are also collected. This level of detail is essential for accurately measuring environmental performance and identifying opportunities for improvement.

To streamline the data collection process and reduce the administrative burden on farmers, other sources of information are also used where possible (see Vrolijk et al., 2016). Whenever feasible, access to existing data sources is sought to minimise duplication and ensure efficiency. All data collection is conducted in accordance with privacy regulations, with farmers providing explicit authorisation for the use of any relevant information.

Added value of an integrated data collection for use and assessment of quality

Linking the environmental and economic data provides advantages for the efficiency of data collection, quality assurance and the scope of analysis. Financial and material flows are collected simultaneously. This makes data collection much more efficient because the supporting documents and information flows are the same and only need to be processed once. It also allows for checking the completeness of material flows. The resulting material flows are factual flows that go in and out of the farm, confirmed by financial transactions.

Greenhouse gas emissions, ammonia emissions and other environmental impacts can be established by combining general calculation rules and farm-specific characteristics (e.g. stable systems, feed ratios, manure storage systems). Using farm-specific characteristics provides a more realistic estimation of the environmental performance of a farm and therefore more useful data for benchmarking.

A single set of data provides the advantage that the impact of policy measures on different objectives can be assessed, and trade-offs between conflicting policy objectives can be measured. It also allows for the analysis of trade-offs in social aspects.

However, currently the EU FADN can only play a limited role in providing information for TCA calculations

Compared to the Dutch FADN, the EU FADN provides much less information. It also mainly collects data on the economic performance of farms (farm income, productivity, farm subsidies etc.). It provides little information on the environmental and social impacts of farming. Its value for LCAs and TCAs is therefore still limited. This issue will soon be solved by the extension of EU FADN into FSDN.[5]

Future developments make the FADN a better source of data about the economic, environmental and social/human impact of farming practices

The European FADN is being transferred into a Farm Sustainability Data Network (FSDN). This will increase the costs involved in data collection but significantly increase the value of the collected data (Vrolijk and Poppe, 2021). The Farm to Fork Strategy presents clear ambitions with respect to the reduction of pesticide use, nutrient surpluses, antibiotics use and greenhouse gas emissions. The legislation to start collecting these data in 2025 is in development. On 29 June 2023, the council and the European Parliament reached an agreement on the basic act to introduce FSDN. Topics such as nutrient balances, pesticide use and antibiotic use are included in the basic act. The topics mentioned in the basic act are largely already covered in the Dutch FADN. The Belgian Flanders region, Ireland and Italy already have more extensive data collection in place. The exact definition of the variables to be collected is still to be decided and will be described in the implementing acts. These will be discussed after the formal adoption of the basic act.

Digitalisation will make sustainability monitoring more efficient

As described in this chapter, integrated data collection depends heavily on the processing of invoices. Currently, these invoices are still largely on paper. When these invoices are available digitally, the data recording and processing can be automated to a large extent. This kind of a use of robotic accounting could provide data for a range of sustainability initiatives (Poppe et al., 2022), including the FSDN, True Cost Accounting, KPIs for circular farming, labelling and certification.

[5] See https://www.pacioli.org/28/3-4.pdf for the current status of the legislative process and an overview of the proposed topics of data collection.

Furthermore, digitalisation and the availability of new technologies to be implemented at farm level will generate a lot more data. Examples of these technologies include precision farming with variable rate application, different types of sensors and earth observation. All these technologies generate a lot of data, which could be useful to monitor the sustainability performance of farms (Poppe et al., 2023).

FADN is a potential valuable source of data on farm level to calculate TCA

The Dutch FADN and the future EU FSDN data could be important sources of data for use in LCA (E-LCA as well as S-LCA) for TCA. These systems contain or will contain information on farming practices and sustainability results at the farm level. An example of a data point that could be directly applied in E-LCA is yield per hectare for main and co-products, and the environmental impacts of pesticide and fertiliser use. The Dutch FADN contains more mass related, product specific and production specific data and, as a result, will be more directly applicable in E-LCA and S-LCA. It is expected that the FSDN will follow the developments of the Dutch FADN.

LCA guidelines contain requirements on the use of primary data and emission modelling. As a result, depending on which LCA guideline is applied, an assessment should be made regarding whether the Dutch FADN and EU FSDN meet these criteria and whether changes in the data collection and processing can be implemented to fulfil the criteria.

Table 4.1 *Potential role of FADN for data required in the different domains to be considered in TCA*

	Issues	Remarks
Environmental domain	• Pesticide use • Mass balance of feed and other inputs • Nutrient balance • Ammonia emissions • Energy use • GHG emissions • Water use	• Most are specific to Dutch FADN. Several will be included in the EU FSDN
Social domain	• Animal welfare, stable system, grazing and antibiotics use • Labour, education, gender issues	• Several specific for Dutch FADN. • FSDN will include a broader range of social indicators

5 Conclusion

TCA calculations can be based on LCA to calculate the impact of food production and consumption on natural, social and human capital.

TCA calculations related to natural capital can be based on E-LCA, while TCA calculations for social/human capital can be based on S-LCA, because:

- They all employ a chain approach.
- They focus on the impact of the activity through midpoints.
- The impact assessment (via ReCiPe 2016) fits within the TCA framework, especially for E-LCA.

However, some important notes have to be made:

- The TCA methodology is still very much in development.
- The E-LCA methodology is still under development, although it has a longer history than the S-LCA methodology. Impact assessment methods are being improved, environmental indicators are being added, databases are being developed and the LCA methodology is being harmonised.
- The S-LCA methodology is still under development, and the monetisation of S-LCA is in its infancy. The most-used methodological guidelines for S-LCA are the United Nations Environment Programme (UNEP) Social LCA Guidelines, Product Social Impact Assessment (PSIA) Handbook and ISO 14040/44 Environmental Management – Life Cycle Assessment.
- In the FOODCoST project, new harmonised methods are being developed to measure and value social/human impacts. These methods are sometimes aligned with S-LCA guidelines. When social and human impacts are considered from an LCA viewpoint, alignment with S-LCA is recommended. However, the valuation of social impacts requires a consistent analytical framework and corresponding data, which are currently unavailable. The databases explored in this study can only partly deliver the data required for calculating the true costs of food production and consumption with respect to social and human effects.
- Whether the methods for valuing the outcomes of the S-LCA fit with the principles and starting points of the welfare and damage costs approaches that we have chosen as a starting point needs to be further examined.

A well-argued decision has to be made to choose primary or secondary data to calculate true costs

- The type of data that need to be collected depends on the goal and scope of the study, the TCA framework that is being applied as well as the type of TCA assessment (and correspondingly LCA methodologies) that is being undertaken
- For general decisions, such as with regard to hotspots for product groups, average data on the sector level can be sufficient to support decisions and claims. However, specific data are necessary to underpin claims, while general data are helpful for assessments.
- Primary or 'internal data' are data taken directly from the value chain being studied. Primary data are site-specific, company specific or supply chain specific.
- Secondary data refer to data not generated from a specific process within the supply chain of the company that performs the study. This refers to data that is not directly collected, measured or estimated by the company, but sourced from a third party.
- In general, primary data are more accurate for specific situations, although they could be sensitive to a number of factors (e.g. seasonal fluctuations). However, they are more time consuming to collect and are therefore more expensive. Secondary data can be cheaper to collect, although they can be licensed.

There are a few databases available for conducting E-LCA, S-LCA and TCA

Table 5.1 presents an overview of the relevant databases for assessing impact on natural capital and social/human capital. The databases with monetisation factors are also presented.

Table 5.1 *Relevant databases for TCA*

	Relevant databases
For the assessment of the impact on natural capital	• Several LCI databases
For the assessment of the impact on social/human capital	• SHDB and PSILCA are most important • Other databases
For monetising	• SPIQ with marginal damage costs (SPIQ-FS Generic Dataset – FoodSIVI), • Eco-costs with prevention costs (Download of databases – Sustainability Impact Metrics (ecocostsvalue.com)) and • *The Handbook of Environmental Prices* (CE Delft) contains various costing methods (Handboek Milieuprijzen 2023. Methodische onderbouwing van kengetallen gebruikt voor waardering van emissies en milieu-impacts - CE Delft).

Additional data are necessary to achieve certain goals – primary data

- Additional data are required, especially when it comes to company-specific applications. Think of the substantiation of claims or communications.
- FADN can play a role in the agricultural production phase. It cannot currently play that role adequately, but with upcoming developments to collect more sustainability-related data at EU level (FSDN), its role to calculate E-LCA, S-LCA and TCA can grow.

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The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 7,600 employees (6,700 fte) and 13,100 students and over 150,000 participants to WUR's Life Long Learning, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.