TRUE COST FROM COSTS TO BENEFITS IN FOOD & FARMING

(TMG) ThinkTank for Sustainability Töpfer Müller Gaßner

soil & more impacts

TRUE COST ACCOUNTING AGRIFOOD HANDBOOK

Practical guidelines for the food and farming sector on impact measurement, valuation and reporting

Whitepaper, March 2022

Acknowledgments

This present True Cost Accounting AgriFood Handbook is the result of numerous individuals and organizations who provided their time and expertise in developing this work and to whom we are grateful. The close collaboration between Soil & More Impacts and TMG – Think Tank for Sustainability must be acknowledged for the leadership of the True Cost – From Cost to Benefit in Food and Farming Initiative. A special thank you to Tobias Bandel and Alexander Müller for their vision and to Olivia Riemer and Gyde Wollesen for steering the initiative.

Thanks to the members of the initiative and pilot participants – Eosta, GEPA, GLS Bank, HiPP, Lebensbaum, Martin Bauer Group, MISEREOR and PRIMAVERA – whose funding made this project possible; they developed and tested the true cost accounting methodology alongside TMG and Soil & More Impacts and in partnership with their suppliers. In addition, we would like to extend our appreciation to the highly valued participation and input in various workshops and working groups by the members' representatives Oliver Krafka, Almut Haase, Hubertus Doms, Dr. Johannes Knubben, Evi Weichenrieder, Christian Geis, Klaudia Strasda, Henning Osmers-Rentzsch, Dr. Laura Mervelskemper, Jan Köpper, Marianne Steinmeyer, Andrea Fütterer, Verena Albert, Markus Wolter, Lena Monshausen, Wilfried Wunden, Andrea Dahm, Hannah Schübel, Florian Klein, Sander Dijkslag and Gert-Jan Lieffering.

Our sincerest gratitude to the lead authors of this report Olivia Riemer, Sivan van Leerzem, StBin Dr. Janine von Wolfersdorff and Gyde Wollesen with contributions from Andrea Richter, Dr. Joost Vogtländer and Sarah Zitterbarth and, to our partners and project consultants including EY (Ernst & Young - Arno Scheepens, Rob Wortelboer and Alex Jöersen), Dr. Joost Vogtlander, StBin Dr. Janine von Wolfersdorff, Dr. Michael Hamm and Nadia El-Hage Scialabba. Their knowledge and expertise were indispensable and co-shaped the form and content of the true cost accounting methodology and pilots.

We would also like to take this opportunity to express our appreciation for the critical and inspiring comments of Sibyl Anwander (all chapters), Dr. Joost Vogtländer (Chapters 2-4) and Dr. Tobias Gaugler (all chapters) and Christian Heller and the team from Value Balancing Alliance (Chapter 6) on an earlier version of this document. Finally, thank you to the editor Reem Azzu as well as the designer Polina Korneeva who contributed to the final version of the Handbook.

Disclaimer

Scientific consensus on measuring the true cost of food is still evolving. The true cost accounting method proposed in this document contributes to an actionable framework towards a refined, (inter-) nationally agreed-on framework as the basis for food system impact accounting.

Suggestion for referencing: True Cost Initiative (2022). TCA Handbook – Practical True Cost Accounting guidelines for the food and farming sector on impact measurement, valuation and reporting. Available at: http://tca2f.org/wp-content/uploads/2022/03/TCA_Agrifood_Handbook.pdf

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TRUE COST
FROM COSTS TO BENEFITS
IN FOOD & FARMING

True Cost – From Costs to Benefits Initiative is an independent research project carried out by Soil & More Impacts GmbH and TMG – Töpfer, Müller, Gaßner GmbH and is financially supported by Eosta BV, GEPA Gesellschaft zur Förderung der Partnerschaft mit der Dritten Welt mbH, GLS Gemeinschaftsbank eG, Hipp-Werk Georg Hipp OHG, MB-Holding GmbH & Co. KG, Bischöfliches Hilfswerk MISEREOR e. V., PRIMAVERA LIFE GmbH and Ulrich Walter GmbH.

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Abbreviations & acronyms

C	Carbon
CH_4	Methane
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalents
CSRD	Corporate Sustainability Reporting Directive
Cu eq	Copper equivalents
DALY	Disability Adjusted Life Years
EC	European Commission
EU	European Union
EUR	Euro
FAO	Food and Agricultural Organization of the United Nations
GHG	Greenhouse Gas
GPG	Gender Pay Gap
GNI	Gross National Income
GRI	Global Reporting Initiative
IFRS	International Financial Reporting Standards
IIRC	International Integrated Reporting Council
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
KPI	Key performance indicator
NH_3	Ammonia
NO_x	Nitrogen oxides
N_2O	Nitrous Oxide
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
OECD	Organisation for Economic Co-operation and Development
PEFCR	The Product Environmental Footprint Category Rules
PO_4eq	Phosphate equivalents
SASB	Sustainability Accounting Standards Board
SDGs	Sustainable Development Goals
SO_2	Sulphur dioxide
SO_2eq	Sulphur dioxide equivalents
SOC	soil organic carbon
TCA	True Cost Accounting
TEEB	The Economics of Ecosystems and Biodiversity
TMG	TMG Think Tank for Sustainability
UNEP	United Nations Environment Programme
USD	United States Dollar
WB	World Bank

Executive Summary

The regulatory, financial, and societal pressure on companies regarding sustainable corporate governance has never been greater. Environmental disasters and a global pandemic are raising awareness of companies, investors, policy makers and the public for the urgency of bringing businesses on a sustainable path. More than ever, businesses must gain comprehensive insights into their own supply chains to develop future-proof business models that can withstand the increasing sustainability challenges and fulfil customer and legal requirements.

Soon, stakeholders will expect companies to report on sustainability impacts and risks with the same discipline and rigour as done for traditional financial information and, focus will be given on “double materiality”: the environmental and social impacts on companies' finances (risk) as well as companies' impacts on people and planet.

With the need for wider risk assessments and more transparent reporting comes the requirement for better quality, decision-relevant and comparable sustainability data and, a uniform approach for data collection, indicators and reporting of relevant sustainability issues. True Cost Accounting (TCA) can support in this matter, by providing businesses with a method to assess, value and report their environmental, social, and human impacts.

The here presented TCA AgriFood Handbook was developed by the True Cost Accounting Initiative and outlines a TCA methodology for the food and farming sector. The TCA methodology describes how agri-food businesses can measure, value and report the environmental, social and health externalities (“true costs”) of plant-based products with a focus on supply chain analysis. The methodology centres around three capitals – natural, social and human capital.

The TCA AgriFood Handbook offers:

- A TCA Methodology practically tested in 14 countries across 5 continents for 20 different supply chains.
- TCA indicators measuring material sustainability issues, including their formulas, recommended tools and models for computation, as well as their respective monetization factors.
- A data collection procedure for businesses' own operations and that of their suppliers; including guidance on data aggregation.
- An overview of the requirements for TCA results to be reported in a business's annual report under current international (e.g., International Financial Reporting Standards [IFRS]) and national financial (e.g., German Handelsgesetzbuch) and non-financial (e.g., Environmental, Social and Governance reporting and Corporate Social Responsibility reporting) reporting directives and accounting laws.
- Insights and practical tips from the pilot assessment on conducting TCA.
- Recommendations on the further development and upscaling of TCA along supply chains, within a company and across companies.
- A TCA methodology with the potential to develop into a standardised approach to TCA in the food and agricultural sector.

The TCA AgriFood Handbook includes concrete information on the implementation of TCA for food and agriculture companies (e.g. for those responsible for reporting, the procurement and sustainability department) as well as for business consultants supporting these businesses with the implementation of TCA.

Policy makers, particularly the European Commission (EC), Directorate-General for Financial Stability, Financial Services and Capital Markets Union, Directorate-General for Environment, national agricultural, environmental and financial ministries, accounting standards committees, financial regulatory authorities etc. will find this report relevant for reforming reporting frameworks and designing policies that incentivise and support sustainable businesses and farming practices.

The following TCA methodology contributes to the field of sustainability impact and risk assessment as well as sustainable business reporting and accounting and invites research to contribute to the future development of TCA as a sustainability and risk assessment and reporting tool for agriculture and food businesses.

Foreword

There is growing consensus that the global economy, and especially the world's food systems, urgently need to become more sustainable. We know that the agri-food sector is the primary driver of biodiversity loss globally. It is responsible for 70% of all freshwater withdrawals from the natural cycle, and 31% of human caused Greenhouse Gas (GHG) emissions. The world loses 24 billion tons of fertile soil every year. Moreover, we lose around 31 % of our food due to unsustainable production and consumption patterns: 14% of food produced globally is lost between harvest and retail, while a further 17% of food is wasted every year.

With the world population expected to reach 10 billion in 2050, providing adequate and healthy food under the conditions of climate change and remaining within planetary boundaries remains one of the greatest challenges facing humanity today.

We are good at describing this existential crisis. We have even agreed on targets and goals for sustainability that need to be achieved in the years, or even decades, to come. But we are not so good at explaining how to move from current state to the desired end situation, or elaborating the types of actions that will get us there. Even more fundamentally, our proposed solutions do not go far enough because we do not explicitly address the fact that it is the key driver of unsustainable development that needs to change. In other words, food systems transformation cannot happen unless we tackle the economic foundations of unsustainable development!

In the last few years, international scientific collaboration has started to analyse the "True Costs" of our economic systems and has started to challenge the belief that sustainability can be achieved with "economics as usual."[1]

We are convinced that the current economic system, and specifically how we count and measure value and costs, is fundamentally responsible for today's unsustainable and unjust food systems. It provides the wrong incentives and neglects crucial components when assigning economic value, and it makes negative externalities economically invisible. Put another way, our economic systems hide the true costs of food production and consumption. In reality, cheap food is very expensive. Our food bill is not only paid for at the market or supermarket, but in the additional – and largely unaccounted for – costs of climate change and biodiversity loss. Ultimately, our children will have to pay for the damage we have caused with our unsustainable economic system.

Several studies[2] have demonstrated that True Cost Accounting (TCA) is central to understanding the drivers of unsustainable development. It is therefore also a pre-condition for attaining sustainable development. It is no longer enough to measure food systems success by the amount of kilos produced per ha, the share of gross domestic product, or even as earnings before interest, taxes and amortization.[3] For the first time, the 2020 Global Risk Report of World Economic Forum included five climate and environmental issues in its assessment of the greatest global risks facing humanity. It is short-sighted and counterproductive to systematically ignore sustainability issues by still using misleading terms such as "non-financial" impacts. If we do not change the accounting than we will see serious business threats. Such an approach undermines the ability of our food system to feed future generations.

This TCA AgriFood Handbook builds on the concept of four capitals[4] that was advanced by the TEEBAgriFood framework and applies it to specific food value chains. Our aim is to provide concrete instructions on how to measure and value the hidden costs of food production. We do this by uncovering the environmental, social and human impacts of food products that so far have either been unknown, ignored, or considered to be a necessary trade-off. To put it simply, this handbook allows us to name the full price that we pay for seemingly cheap food.

The AgriFood Handbook goes beyond existing environmental, social and governance indicators by estimating the associated costs of damage from our food systems to the environment and people. Furthermore, it describes how sustainability information in the form of true cost accounting can find its way into companies' annual financial reporting. This is an important door opener for ensuring that sustainability information gains a foothold in the financial sector.

The handbook also represents the collective legacy of the True Cost Initiative, an alliance of agri-food businesses, financial institutions, researchers, business consultants, think tanks and non-governmental organizations. For almost three years, they have developed practical guidelines on how to carry out true cost accounting in the agri-food sector, and practically tested it across 20 supply chains in 14 countries. This multi-stakeholder approach stemmed from the realisation food system actors need to take not only responsibility for their own actions but also for their decisions and choices that determine the actions of others. In practical terms, this means, for example, that agri-food processors must not shift (environmental and social) costs to other actors, including in other nations.

This TCA AgriFood Handbook marks the beginning of the following:

First, it is an invitation to agri-food businesses to join the movement of responsible business leadership. The foundation has been laid for standardised true cost accounting and reporting; hence, businesses have no excuse to ignore the environmental, social and human damage that they cause.

Second, it is an appeal to the scientific and reporting community to further develop the TCA concept as well as its methodologies to support the integration of true costs into national and international business reporting.

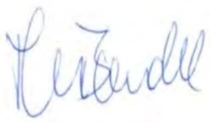
1 For example, see TEEB (2018). TEEB for Agriculture & Food: Scientific and Economic Foundations. Geneva: UN Environment and Dasgupta, P. (2021). The Economics of Biodiversity: The Dasgupta Review. London: HM Treasury
2 For example, see Sukhdev, P., May, P., & Müller, A. (2016). Fix food metrics. Nature, 540(7631), 33-34
3 Earnings before interest, taxes, and amortization (EBITA) is a common measure of company profitability used by investors.
4 Produced, natural, human and social.

Third, TCA approaches are relevant for ongoing and future policy making at different levels. Examples of potential policy applications include: the European Union (EU) taxonomy and EU Corporate Sustainability Reporting Directive (CSRD); reform of the EU Common Agricultural Policy to effectively incentivise sustainable farming practices; or the implementation and monitoring of national legislation such as the German Supply Chain Act.

Finally, the TCA AgriFood Handbook reminds us that our individual food consumption choices matter. As food consumers, we all need to demand that agri-food companies are transparent and accountable in their business practices, as well as in the information that they provide about the true costs and impacts of food.

Alexander Müller

Managing Director,
TMG – Think Tank for Sustainability



Tobias Bandel

Managing Director,
Soil & More Impacts

1

A business initiative for practical testing of true cost accounting

In early 2019, the True Cost – From Costs to Benefits Initiative was formed with the goal to increase the level of information and transparency of agricultural and food (from there after 'agri-food') supply chains regarding their impact on nature and people. The interest stemmed from agri-food businesses to:

- Better understand potential business threats due to risks such as the climate emergency, crossing planetary boundaries, (global) economic impact of diet-related diseases, etc..
- Make the beneficial effects of sustainable (agricultural) business practices transparent and understand the negative impacts of current destructive economic system(s) ('business as usual').
- Explore the newly evolving approach of TCA as a potential solution that can be upscaled by businesses for identifying, measuring and reporting sustainability issues in agri-food supply chains.
- Contribute to efforts to harmonise and standardise TCA in the agri-food sector.
- Inform ongoing national and international policy, and regulatory developments regarding the reporting of sustainability information.

TCA was developed by the United Nations Environment Programme (UNEP) and others (TEEB, 2018) to holistically assess the positive and negative impacts and their associated value and/or costs of food systems on nature, people and society. For businesses, TCA provides a method to assess, value and report environmental, social, and human impacts of businesses and their supply chains. The objective of TCA is to measure the total true costs of the companies' activities (include upstream and downstream activities in the value chain) and to integrate TCA consideration into strategic management and reporting of companies.

While the need to integrate information on non-financial capital into business strategies and the transformative potential of TCA to steer the agri-food system towards sustainability were increasingly recognized, there was a lack of practical guidance on TCA assessments and reporting in 2019 when the True Cost Initiative started. Although theoretical frameworks[5] and descriptive process reports[6] have laid the groundwork for TCA, concrete suggestions for indicators and metrics – specifically those adopted to the realities of the agriculture and food production – were scarce.

As a response, the True Cost Initiative combined a multi-stakeholder approach with a living lab application in order to develop and stress-test a TCA methodology, that estimates the true cost of agri-food products along their supply chain over the course of nearly three years.

As a first step, experienced agronomists, nutritionists, accountants, food economists and impact consultants came together and developed a zero draft of a TCA methodology to measure, value and report the environmental, social and health impacts of food and agribusinesses. As a second step, the method was applied to real value chains. More than 20 assessments across 5 continents in 14 countries were conducted in order to test the developed methodology. Based on the lessons from the living labs and the feedback from an audit readiness check performed by EY (Ernst & Young), the methodology was adapted to fit the reality of everyday business.

1.1 The added value of the document

- This document presents the TCA methodology developed and tested by the True Cost Initiative and, in a nutshell: the TCA methodology provides a detailed description of indicators, monetization factors, data collection and reporting of social, environmental and health impacts.
- The TCA methodology was tested and evaluated in real businesses. It works for all types of agricultural, plant based raw materials in many agricultural settings and for various types of value chains.
- The TCA methodology instructs businesses on how to measure today's impacts in order to manage tomorrow's risks and reduce tomorrow's costs.
- The TCA methodology provides a baseline for comparing business impacts and for establishing a standardised model for impact assessment and reporting.
- The TCA methodology supports closing the gap between financial and sustainability information allowing for reporting which captures all impacts of businesses.

1.2 Who this document is for

This document addresses top-level management as the default target audience. This follows from the emphasis on more holistically informed management accounting and internal decision making. For true cost information to be truly embedded in business decision making, it needs to be processed directly alongside financial and operational data.

This document presents a methodology intended to be used primarily by:

- Sustainability teams that are likely to bear the responsibility for conducting the assessments and supervise the data collection.
- Accountants within the finance, accounting and controlling function in businesses who bear the responsibility for documenting and reporting true cost results. They take the lead in communicating assessment results to different business functions.
- Recipients of true cost results such as the department for strategy, finance, sourcing, procurement, product development and others who need to be able to understand and interpret true cost results in order to formulate necessary action and responses.

Besides the target audience, other stakeholders may have interest in understanding and using the TCA methodology (see Figure 1).

True Cost Accounting

Evolving methodology to measure and value the positive and negative environmental, social, and health externalities in order to allow analyzing the costs and benefits of business and/or policy decisions

Baseline

State of environment or [other stock] against which changes in capital are valued

ISO14008 (ISO, 2019)
Natural Capital Protocol (Natural Capital Coalition, 2016)

Value chain

The full range of processes and activities that characterize the lifecycle of a product from production, to manufacturing and processing, to distribution, marketing and retail, and finally to consumption (including waste and disposal across all stages)

TEEBAgriFood (TEEB, 2018)

5 For example, see The Economics of Ecosystems and Biodiversity (TEEB) (2018). TEEB for Agriculture & Food: Scientific and Economic Foundations. Geneva: UN Environment.

6 For example, see Natural Capital Coalition (2016). Natural Capital Protocol. Available online at: www.naturalcapitalcoalition.org/protocol and Eigenraam, M., Jekums, A., Mcleod, R., Obst, C. & Sharma, K. (2020). Applying the TEEBAgriFood Evaluation Framework: Overarching Implementation Guidance. n.p.: Global Alliance for the Future of Food, 2020. Available online at: https://futureoffood.org/wp-content/uploads/2021/01/GA_TEEBAgriFood_Guidance.pdf

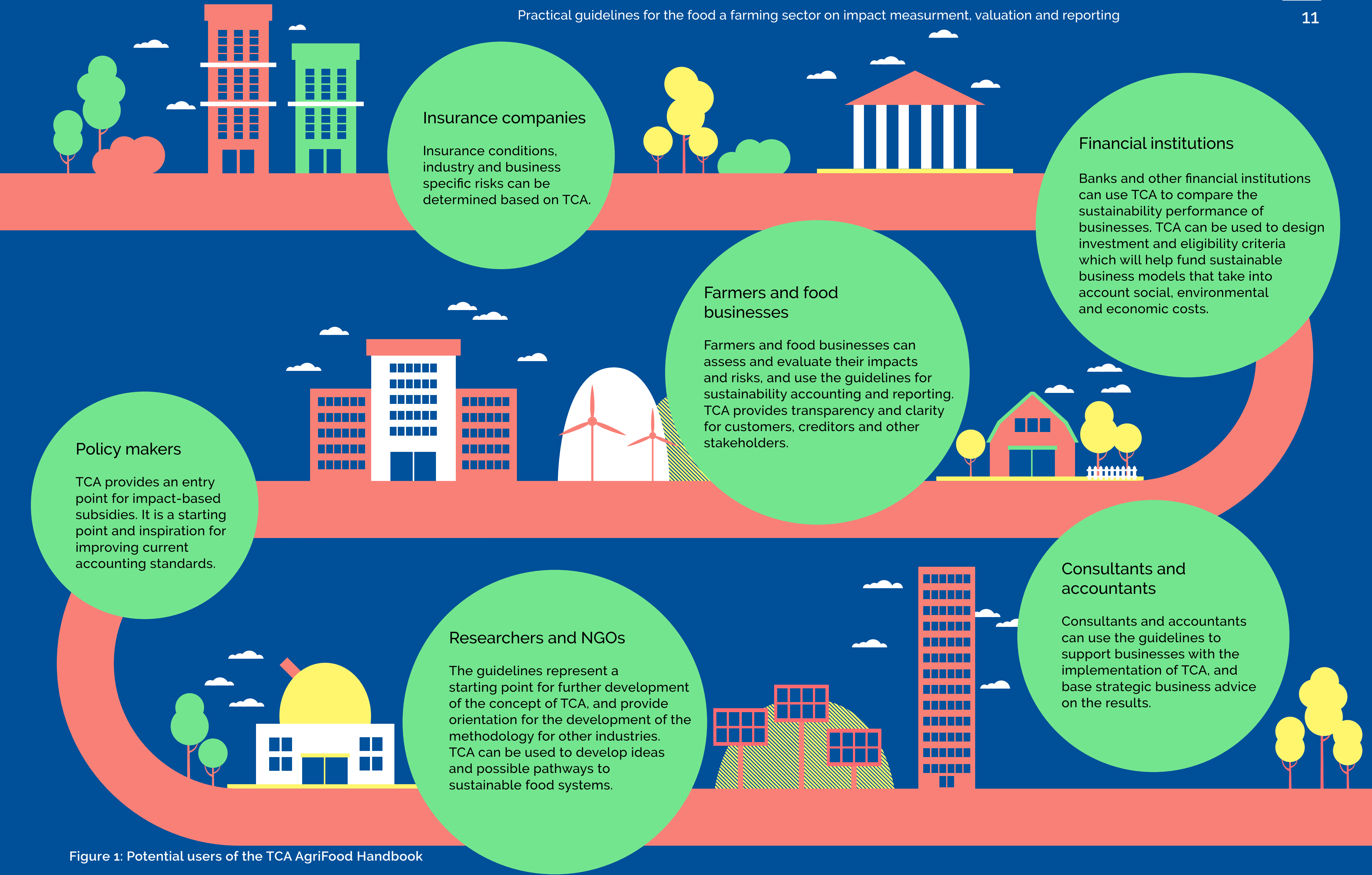


Figure 1: Potential users of the TCA AgriFood Handbook

1.3 The intended use of the document

TCA, as outlined in this document, enables better informed business decision making by providing a means of quantifying and understanding a business supply chain's impact on natural, human, and social capital.

Potential applications of the TCA methodology include:

- assessing environmental, social and human impacts and related business risks;
- identification of business opportunities leveraging sustainable value chains;
- feedback of performance data to farmers to enhance the development of farmer-centred services (e.g. extension services, finance, insurance, etc.); and
- reporting quantified business impacts internally.

With the further development of the accounting and reporting of true costs and the standardisation of the implementation of TCA across entities, TCA can further contribute to:

- sustainability accounting and reporting in businesses' annual reports;
- comparison of the sustainability performance of businesses;
- design of investment and eligibility criteria to help fund sustainable business models;
- determination of insurance conditions based on a better risk assessment;
- input in on-going changes of the regulatory framework for a better alignment of subsidies and other incentives with societal costs and benefits;
- design of policy on issues such as climate change, due diligence of sustainability in business supply chains or the improvement of reporting requirements to include the financial dimension of sustainability;
- transparency and communication with consumers on the actual value of sustainably produced goods; and
- development of a TCA methodology for other industries based on the inspiration and orientation provided.

2

Theoretical and practical principles of the True Cost Accounting methodology

This chapter describes the principles on which the TCA methodology is based.

2.1 Theoretically grounded on literature

The TCA methodology is grounded on the theoretical and conceptual foundation for TCA provided by the TEEBAgriFood evaluation framework (TEEB, 2018). This methodology endorses the holistic capital-based systems approach to evaluate the interconnections of natural, human, social and produced capital in eco-agri-food systems and to account for all externalities thereof as highlighted in TEEBAgriFood. Externalities (also: external effects or impact¬s) are defined as the positive or negative consequences of an economic activity or transaction that affects other parties without being reflected in the price of the goods or services transacted.

The TCA methodology was developed following the four stage process as described in the TEEBAgriFood Operational Guidelines by the Capitals Coalition (2020) and the Overarching Implementation Guidance published by the Global Alliance for the Future of Food (2020); these stages are:

1. framing;
2. describing and scoping;
3. measuring and valuing; and
4. taking action.

Data collection was based upon the Product Environmental Footprint Guidance by the EC (European Commission, 2018).

The selection of these frameworks and guidance documents was made through a comparative analysis of frameworks and standards which in turn were based on the following six key principles for good non-financial reporting by the EC (European Commission, 2017):

1 material (see requirement 3 below);
2 fair, balanced and understandable (see requirements 8, 9, 10 and 11 below);
3 comprehensive but concise (see requirements 5, 6, and 9 below);
4 strategic and forward-looking (see requirements 1 and 12 below);
5 stakeholder oriented (see requirement 2 below); and
6 consistent and coherent (see requirements 7 and 8 below).

Taking these principles into consideration resulted in the following selection requirements:

1 Alignment of the proposed methodology with EU regulatory developments and vice versa.
2 Defining the user group.
3 Does the framework say anything about how totality is ensured?
4 Does the framework say anything about how materiality is determined?
5 Does the framework say anything about the value chain scope that should be taken into account?
6 Does the framework say anything about the organizational boundaries?
7 Does the framework say anything about what should be considered when making estimates?
8 Does the framework say anything about the way information should be measured/valuated?
9 Does the reporting framework say anything about the presentation and disclosure of information?
10 Does the framework say anything about the balance of information?
11 Are the different steps that an organization should take in order to retrieve non-financial information well defined?
12 Is the framework integrated with other reporting frameworks?

2.2 Capitals-based

The TCA methodology conceptualises external impacts according to four capitals. These capitals are described as follows:

- Natural capital refers to physical and biological resources found on earth, such as air, water, soil, biodiversity and ecosystems which provide benefits to people in the form of ecosystem goods and services.
- Human capital includes an individual's health, knowledge, skills and motivation that are essential for productive work and facilitate the creation of personal, social and economic well-being.
- Social capital encompasses networks, institutions as well as societal norms and values which facilitate cooperation within and among groups.
- Produced capital refers to all manufactured (buildings, factories), built (roads, water systems), financial, and intellectual capital (technology, software, patents).

The main focus of the TCA methodology lies in the first three capitals since they contain the externalities of an agri-food product. Produced capital (main production cost) is widely covered in current accounting standards and to a large extent is already reflected in the price of a food

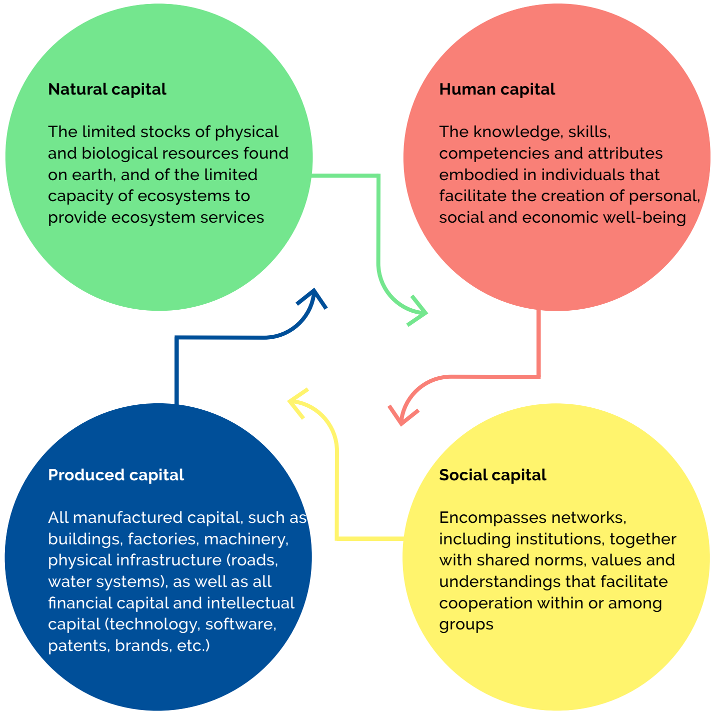


Figure 2: The 4-capital concept of True Cost Accounting

Value

The importance, worth, or usefulness of a good or service – including all relevant market and non-market values -determined by people's preferences and the trade-offs they choose to make given their scarce resources, or the value the market places on an item

TEEBAgriFood (TEEB, 2018)
Natural Capital Protocol (Natural Capital Coalition, 2016)

Capital

The economic framing of the various stocks in which each type of capital embodies future streams of benefits that contribute to human well-being

TEEBAgriFood (TEEB, 2018)

Eco-agri-food system

A descriptive term for the vast and interacting complex of ecosystems, agricultural lands, pastures, inland fisheries, labour, infrastructure, technology, policies, culture, traditions, and institutions (including markets) that are variously involved in growing, processing, distributing and consuming food

TEEBAgriFood (TEEB, 2018)

(Natural capital) dependency

A business reliance on or use of [..] capital

Natural Capital Protocol (Natural Capital Coalition, 2016)

Product

Agricultural raw material (e.g. apple) and processed materials (e.g. apple puree)

Production

The first of four stages in the value chain, including activities and processes occurring within farm gate boundaries (including the supply of ecosystem services, the supply of goods and services, and connections between producers)

TEEBAgriFood (TEEB, 2018)

Outcomes are informed by primary and secondary data

Stocks

are the available quantity (extent) and quality (condition) of capitals at a point in time, which may have accumulated in the past

Natural capital
The world's stock of natural resources and ecosystem services (e.g. soil & soil services such as nutrient cycle)

Human capital
The knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being

Social capital
Networks, including institutions, together with shared norms, values and understandings that facilitate cooperation within or among groups

Produced capital
Refers to all man-made assets, such as buildings, factories, machinery, physical infrastructure (roads, water systems) as well as all financial assets

→

Flows

are the changes over a period of time, such as ecosystem services or agricultural inputs and outputs

Use of capitals and ecosystem services
(e.g. water extraction)

Residues from production
(e.g. GHG emission due to land management practices)

Inputs and goods
(e.g. labour, synthetic fertilisers, electricity and fuel)

Agricultural outputs
(e.g. harvest, sales)

→

Outcomes

describe the changes in the extent or condition of the stocks of capitals due to value chain activities

Indicators

Natural capital
- Increase/Decrease of GHG emissions and carbon stock
- Increase/Decrease of soil eroded
- Increase/Decrease of soil organic matter
- Increase/Decrease of water stress and water pollution
- Increase/Decrease of acidification and eutrophication
- Increase/Decrease of eco-toxicity

Human capital
- Increase/Decrease of human toxicity
- Size of living wage gap
- Potential change in health conditions due to excessive working hours, work-related injuries and illnesses, etc.

Social capital
- Size of gender pay gap
- Increase/Decrease of forced labour and child labour

Produced capital
- Net income
- Depreciation/investment in e.g. agricultural machinery

→

Impacts

are longer-term and wider changes impacting human well-being and resulting from the outcomes

Environmental impact
E.g. slowing of climate change, reversing land degradation

Health impact
E.g. increasing food security, improving quality of life

Social impacts
E.g. reduction of inequalities, closing the gender pay gap

Economic impact
E.g. reduction of unemployment, less poverty

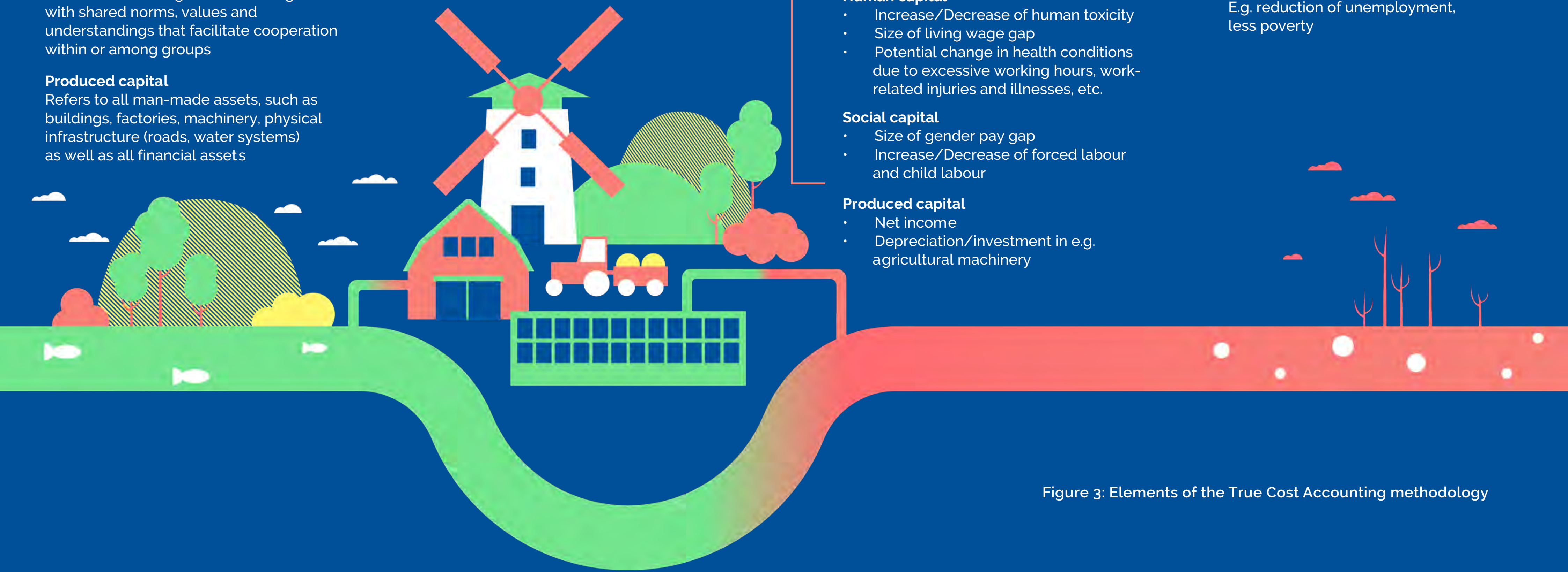


Figure 3: Elements of the True Cost Accounting methodology

product, quantified in monetary units. However, the TCA AgriFood Handbook focuses solely on the analysis of external cost (also referred to as "true cost") and does not follow a true pricing approach.[7]

The TEEBAgriFood framework distinguishes four key terms to describe the state, changes-in and interactions between the capitals and human well-being:

- Stocks are described through the four capitals and are accumulated over time.
- Flows are the changes over a period of time, such as ecosystem services or agricultural inputs and outputs.
- Outcomes describe changes in the stock of capitals.
- Impacts are the result of outcomes that impact well-being.

The indicators describe methods to measure or model the outcomes for the three capitals which are informed by primary (collected directly) and secondary data (obtained though [public] databases) on the flows and stocks. Using a monetization factor, the impact of these outcomes on well-being can be determined.

2.3 Cost-focused

The TCA methodology accounts for the negative impacts induced by business activities. Only two indicators – 'carbon stock' and 'soil organic matter build up' – account for positive impacts (i.e., long term carbon sequestration in agricultural soil and trees). For all other indicators, no positive impacts are considered as they either do not exist (e.g., Occupational Health and Safety – full health is the baseline and cannot be improved; Water Pollution – clean water is the baseline and cannot be improved) or do not occur for the same individual (e.g. Living Wage Gap, Gender Pay Gap [GPG] – paying someone else more does not improve the situation of the person who is underpaid).

To define the most appropriate approach for monetization of externalities within the context of the TCA methodology, among the main valuation approaches laid out by The Economics of Ecosystems, Biodiversity and Economics Foundations (TEEB, 2018) and the Social and Human Capital Protocol (Social & Human Capital Coalition, 2019), the following approaches were chosen:

- market-based
- cost-based
- revealed preference
- stated preference

The approaches were tested against four requirements:

1. Compatibility with the Life Cycle Assessment (LCA): Is the approach suitable to monetize LCA midpoints?
2. Methodologically applicable across both environmental as well as social externalities: Is the approach equipped to value externalities, and is the method applicable for both environmental and social aspects?
3. Pragmatism: Is there any data available, and is the valuation of the externalities straightforward?
4. Transparency: Would the monetary value be of meaning to the user and is that value (geographically) replicable?

The prevention costs approach was chosen primarily because it fulfils all four criteria since:

1. It is compatible with LCA (e.g. available in LCA software such as SimaPro and Open LCA);
2. It measures environmental externalities (and has potential to value social and human externalities);
3. It is pragmatic as it does not require extensive knowledge on impact pathways; and
4. It is transparent since data is already available and the valuation is based on marginal prevention costs of Best Practice techniques ('end-of-pipe' or 'system integrated').

The TCA methodology makes use of a prevention cost (also known as abatement cost or avoidance cost, sometimes also described as restoration costs)[8] approach whenever a prevention cost value is available. The marginal prevention costs refer to the costs per unit of emission that is required to contain a negative impact to a defined negligible effect level[9] that follows from scientific calculations, and results in emission reduction targets ratified by policy (e.g. 1.5 °C predicted by the Intergovernmental Panel on Climate

7 True pricing estimates a true price of a product. The true price consists of the market price including external costs. For more information on the true pricing approach see True Price Foundation (2019). A roadmap for true pricing. Vision paper – consultation draft. Available at: https://trueprice.org/wp-content/uploads/2021/12/True-Price-A-roadmap-for-true-pricing-v1.0.pdf. For information on the difference between true costs and true prices see Hendriks et al. (2021). The True Cost and True Price of Food. A paper from the Scientific Group of the UN Food Systems Summit. Available at https://sc-fss2021.org/wp-content/uploads/2021/06/UNFSS_true_cost_of_food.pdf

8 Restoration costs refer to the investment necessary to restore the capital stock to the original state or beyond (using artificial/manmade technologies) (compare with (TEEB, 2018)).

9 The negligible effect level (or no-effect level) refers to the amount of emission so small that it does not cause any significant impact. The marginal prevention costs of the last measure of the prevention curve to reach the no-effect-level.

Stock

The physical or observable quantities and qualities that underpin various flows within the system, classified as being produced, natural, human or social

TEEBAgriFood (TEEB, 2018)

Flow

A cost or benefit derived from the use of various capital stocks (categorized into agricultural and food outputs, purchased inputs, ecosystem services and residuals)

TEEBAgriFood (TEEB, 2018)

Outcome

A change in the extent or condition of the stocks of capital (natural, produced, social and human) due to value-chain activities

TEEBAgriFood (TEEB, 2018)

Impact

A positive or negative contribution to one or more dimensions (environmental, economic, health or social) of human well-being

TEEBAgriFood (TEEB, 2018)

Ecosystem services

The contributions that ecosystems make to human well-being (e.g. classified by CICES into provisioning, regulation & maintenance and cultural)

TEEBAgriFood (TEEB, 2018)

Data

Information, especially facts or numbers, collected together for reference or analysis and used as a basis for reasoning, discussion, or calculation

Prevention cost

Prevention expenditure incurred by a company (or household or government) to mitigate or avoid particular environmental impacts or risks

Table 1: Overview of the monetization methods used for the TCA indicators

Impact category	Impact indicator	Impact type	Valuation approach	Reference for monetization
Climate	GHG emissions	Cost	Prevention cost	Cost of replacing coal by offshore wind for electricity generation
	Carbon stock	Cost and benefit	Prevention cost	Cost of replacing coal by offshore wind for electricity generation
Soil	Soil erosion	Cost	Damage costs	On-site and off-site damage costs
	Soil organic carbon build-up	Cost and benefit	Restoration costs	Restoration costs for soil organic carbon build-up
Water	Water stress	Cost	Prevention costs	Costs of reverse osmosis of salt- or polluted water
	Water pollution	Cost	Prevention costs	The cost of sustainable manure treatment
Ecosystem	Acidification	Cost	Prevention costs	The cost of diesel desulphurization
	Eutrophication	Cost	Prevention costs	The cost of sustainable manure treatment
	Eco-toxicity	Cost	Prevention costs	The cost of water treatment (removal of heavy metals)
Human health	Human toxicity	Cost	Prevention costs	The cost of treating a kidney patient for one year
Worker remuneration	Living wage gap	Cost	None	No monetization necessary
Working conditions	Occupational health & safety	Cost	Prevention costs	The cost of treating a kidney patient for one year
	Excessive working hours	Cost	Prevention costs	The cost of treating a kidney patient for one year
Gender inequality	Gender pay gap	Cost	None	No monetization necessary
Human rights violation	Forced labour	Cost	Prevention costs	The cost of treating a kidney patient for one year
	Child labour	Cost	Prevention costs	The cost of treating a kidney patient for one year

Change, resulting in the targets of the Paris Agreement). In other words, true cost calculated based on marginal prevention costs express the necessary or made investment to reduce the emission to a level by which negative impacts are avoided.

The damage cost approach is used as an alternative valuation approach in case of lacking satisfactory studies on prevention costs for the concerned indicators. Damage costs are the estimated cost of all economic and 'non-market' damage that result from negative impacts (such as emissions). They indicate how much it is worth to society today to avoid the damage that is projected for the future. Calculating the damage costs requires estimating the impacts of a business's activity. The damage cost approach is being used for the indicators soil erosion and soil organic matter build-up.

The monetization factors presented in this document (see Table 1) can be applied universally.[10] This approach is chosen for its feasibility, as a study into the local costs for each origin would require a high amount of work for an agri-food company. An example is that a global value is recommended for the costs of desalinating water - a prevention cost of water stress. In practise, it would require different costs locally to desalinate water based on the concerning origin, the identification of which would be practically unfeasible. Also, an additional argument is that a global level playing field should be preferred in business reporting.

Impact pathway

Series of consecutive, causal relationships, ultimately starting at a stock, describing how an impact driver results in changes in [...] capital and what impact these changes have on different stakeholders

ISO14008 (ISO, 2019)
Natural Capital Protocol (Natural Capital Coalition, 2016)

Wage

Compensation for work that includes both monetary and in-kind payment

Living wage

Remuneration received for a standard work week by a worker in a particular place sufficient to afford a decent standard of living for the worker and her or his family

Global Living Wage Coalition (2018)

Worker

Waged employees hired to work including migrant, temporary, seasonal, sub-contracted and permanent workers

Delta Framework (2020)

2.4 Agriculture and food supply chain centred

The TCA methodology specifically focuses on the food and farming sector. In comparison to the secondary and tertiary sector, the primary sector strongly depends on and impacts environmental, human and social capital. For example, agriculture irrigation accounts for 70% of water use worldwide making the sector both responsible for and vulnerable to water scarcity. Assessing sustainability issues unique to the agriculture sector (e.g. eutrophication through fertilizer run-off) requires specific indicators (e.g. soil organic carbon (SOC) stock).

The TCA methodology expands the focus from a 'company only view' to a more holistic sustainability approach by including supply chains into TCA. This expanded view reflects

10 Values are not correct for purchasing power, because they represent global values.

ongoing trends to extend companies due diligence (for example, see the German Supply Chain Sourcing Obligations Act [Section 5 Absatz 1 Seite 1 LkSG]). The sourcing of raw material and pre-processed goods are an important, if not the most important, leverage to sustainable agri-food business models. Agriculture provides many solutions to pressing sustainability issues, including carbon farming, producing healthy food, providing decent livelihoods, etc.

The TCA methodology is intended to apply to any crop and farming system worldwide except for livestock farming, aquaculture and fisheries, which might be addressed in a future version of this document.[11] The focus lies on the assessment of agricultural and food supply chains.

For natural capital impacts, it was found that the majority of impacts in the life of agri-food products is caused during cultivation, processing and transportation towards the warehouse. This was evident in a broad range of agricultural products. Therefore, this TCA methodology focuses on all stages before the factory gate. Consequently, system boundaries of TCA studies should at least be determined on a cradle to gate basis. Non-material, internal transport like the use of forklifts may be excluded. Social and human impacts can be assessed for the farm and processing stage (it was not feasible to cover additional scopes during the pilot testing). Table 2 illustrates the application of the TCA indicators per supply chain stage in more detail.

2.5 Action-oriented

Different methods come with different levels of scientific consensus and precision, but also different levels of practical feasibility. The TCA methodology follows an action-oriented approach; and the use of tools and guidance documents that have proven their applicability in the pilot phases of the True Cost Initiative is suggested. Only an approach that is feasible to implement can be adopted by food/agricultural companies and initiate the needed action to reduce externalities in this sector.

2.6 Primary data-driven

Impact measurement approaches for the individual indicators described in Chapter 3 typically involve modelling approaches. This means that impacts are not directly measured in the field (e.g. taking soil samples in order to determine the amount of carbon stored in the soil); instead, primary data on the local conditions and management practices are obtained in order to predict the impact using models (e.g. the Cool Farm Tool in case of SOC stock).

The TCA methodology outlined in this document pays special attention to the good representation of farm specific practises (as opposed to input/output-based data). LCA models commonly neglect differences in impacts due to differences in farm management practices. Often, assumptions about farm management are made based on secondary databases, where sustainable efforts of individual farmers, such as the use of cover crops or erosion prevention measures are overlooked. Agricultural practises, such as those that involve conservation or circularity, have high potential to create positive outcomes for the four capitals. Only a method that recognizes these opportunities can help companies steer towards better practise.
When primary data cannot not be obtained, techniques that rely on secondary data are used. Common sources of secondary data include modelling techniques such as environmentally extended input-output models, LCA databases and published, peer-reviewed literature.

The following aspects of data quality should be considered:

- Geographical representation: Selecting datasets that are representative of the geographical and climate area.
- Timeliness: Choosing up-to-date or recently updated data from a recent period over a time frame that is representative for the average situation (e.g., a full year or multiple years to account for season and yearly variations).
- Technological representation: Taking data that are representative for the technologies and processes under assessment.
- Completeness: including all relevant data.
- Parameter uncertainty: accuracy of the data to the actual product and unit studied; it will be important to formalize uncertain data in the future by developing clear communications around this type of data (e.g. developing quality scores based on data quality).

The database section of the TCA Inventory (Soil & More Impacts & TMG Thinktank for Sustainability, 2020) offers a good (but not exhaustive) overview of relevant available secondary databases.

Indicator

Something that shows what a situation is like by depicting a value or a change

Cultivation

The action of preparing the soil and raising crops on agricultural land

Residuals

By-products of the cultivation and/or production processes that produce agricultural and food outputs

TEEBAgriFood Implementation Guidance (Global Alliance for the Future of Food, 2020)

Manufacturing and processing

Stages in the value chain, including the operations involved in converting raw materials into finished products

TEEBAgriFood Implementation Guidance (Global Alliance for the Future of Food, 2020)

2.7 Time bound

The TCA methodology set out in this document seeks to be compatible with the concept and principles of financial accounting. Hence, the duration for which true costs are estimated should be in line with the annual period typically used in financial accounts; this allows for sufficient accounting for seasonal differences. For example, in Germany the fiscal year for agricultural businesses runs from the 1st of July to the 30th of June in accordance with Section 4a of the Income Tax Act (Einkommensteuergesetz).

The TCA methodology accounts for all impacts associated with activities happening during the specified period (e.g. one financial year). This includes future impacts generated by activities occurring during the period defined in the scope of the assessment.

11 Other environmental issues (e.g. nitrogen pollution due to excrements) occur for livestock farming, aquaculture and fishery which are currently not included in the here presented models.

Table 2: Impact of the agri-food value chain stages covered (green) or not covered (red) by the true cost accounting indicators

Indicator	Input manufacturing	Cultivation	Transportation	Processing	Sales	Consumption	Disposal
GHG emissions					Methodologically possible, but was not feasible in the pilotswind for electricity generation	Thematically applicable, but requires additional data and tools; not feasible in the pilots	Thematically applicable, but requires additional data and tools; not feasible in the pilots
Carbon stock	Only applicable for inputs that are produced on farmland, such as seeds and seedlings; not feasible in the pilots		Thematically not applicable	Thematically not applicable	Thematically not applicable	Thematically not applicable	Thematically applicable, but requires additional data and method; not feasible in the pilots
Soil erosion	Only applicable for inputs that are produced on farmland, such as seeds and seedlings; not feasible in the pilots		Thematically not applicable (no agricultural land involved)	Thematically not applicable (no agricultural land involved)	Thematically not applicable (no agricultural land involved)	Thematically not applicable (no agricultural land involved)	Thematically applicable, but requires additional data and method; not feasible in the
Soil organic matter build-up	Only applicable for inputs that are produced on farmland, such as seeds and seedlings; not feasible in the pilots		Thematically not applicable (no agricultural land involved)	Thematically not applicable (no agricultural land involved)	Thematically not applicable (no agricultural land involved)	Thematically not applicable (no agricultural land involved)	Thematically applicable, but requires additional data and method; not feasible in the
Water stress	Methodologically possible, but was not feasible in the pilots		Thematically not relevant (this stage does not require any substantial water use)	Can be thematically applicable, but requires additional data and method; not feasible in the pilots	Can be thematically applicable, but requires additional data and method; not feasible in the pilots	Can be thematically applicable, but requires additional data and method; not feasible in the pilots	Can be thematically applicable, but requires additional data and method; not feasible in the pilots
Water pollution*	Methodologically possible, but was not feasible in the pilots		Thematically not applicable (no P and N run-off or leaching possible in this stage, other forms of water pollution are covered under the indicator "eutrophication")	Thematically not applicable (no P and N run-off or leaching possible in this stage, other forms of water pollution are covered under the indicator "eutrophication")	Thematically not applicable (no P and N run-off or leaching possible in this stage, other forms of water pollution are covered under the indicator "eutrophication")	Thematically not applicable (no P and N run-off or leaching possible in this stage, other forms of water pollution are covered under the indicator "eutrophication")	Can be thematically applicable, but requires additional data and method; not feasible in the pilots
Acidification			Methodologically possible, but was not feasible in the pilots		Methodologically possible, but was not feasible in the pilots	Methodologically possible, but was not feasible in the pilots	Methodologically possible, but was not feasible in the
Eutrophication			Methodologically possible, but was not feasible in the pilots		Methodologically possible, but was not feasible in the pilots	Methodologically possible, but was not feasible in the pilots	Methodologically possible, but was not feasible in the
Eco-toxicity			Methodologically possible, but was not feasible in the pilots		Methodologically possible, but was not feasible in the pilots	Methodologically possible, but was not feasible in the pilots	Methodologically possible, but was not feasible in the
Human toxicity			Methodologically possible, but was not feasible in the pilots		Methodologically possible, but was not feasible in the pilots	Methodologically possible, but was not feasible in the pilots	Methodologically possible, but was not feasible in the
Living wage gap	Methodologically possible, but not feasible within the framework of the pilot project, as this would have required much more data (which is probably not available)		Methodologically possible, but not feasible within the framework of the pilot project, as this would have required much more data (which is probably not available)		Methodologically possible, but not feasible within the framework of the pilot project, as this would have required much more data (which is probably not available)	Thematically not applicable	Methodologically possible, but not feasible within the framework of the pilot project, as this would have required much more data (which is probably not available)
Occupational health & safety	"		"		"	"	"
Excessive working hours	"		"		"	"	"
Gender pay gap	"		"		"	"	"
Forced labour	"		"		"	"	"
Child labour	"		"		"	"	"

* The only water pollution impact that is considered by the "water pollution" indicator is eutrophication due to leaching and run-off of nitrogen and phosphor, which is only applicable for inputs and outputs that are produced on farmland.
Legend: red = indicator was not used/tested for this supply chain stage; green = indicator was tested for this supply chain stage; within the framework of the study, the value chain stages were only partially covered.

When comparing true costs between years or in other currencies, exchange rates must be taken for the same evaluation year. The monetization factors should be adjusted to its base year, followed by adjustment to currency as described in International Organization for Standardization (ISO) 14008:2019, point 6.6.4 (International Standard, 2019). The use of currency exchange rates published by the World Bank (WB), International Monetary Fund or similarly recognized institutions is recommended.

It is not recommended to update monetization factors by the inflation rate only since monetization factors might decrease significantly because of technical learning curves, economies of scale, and increased efficiencies. In the past, recalculations were done every 5 years (2001, 2007, 2012, 2017, 2022) and scientific papers were checked at these intervals. An example (based on European data) of decreasing monetization factors is the eco-costs of carbon footprint: it was 0.135 euro (EUR)/kgCO2eq in 2012 and decreased to 0.116 EUR/kgCO2eq in 2022, because of better efficiencies of bigger windmills. Another example is the Disability Adjusted Life Years (DALY): for the past decade it has stayed at 80,000 EUR/DALY as improved efficiencies in hospitals have counteracted the inflation rate. However, for most end-of-pipe measures, the inflation rate appeared to be higher than the gains in efficiencies (e.g. indicators such acidification, eco-toxicity etc.).

2.8 Product-oriented

The TCA methodology assigns estimated true costs to a product.[12] Since the reference flows in TCA are agricultural bulk products, the approach of the Declared Unit is applied (see the International Reference Life Cycle Data System handbook "General Guide for LCA – Detailed guidance", Section 6.4.6 (Guinée & Lindeijer, 2002)]). The declared unit is simply the name of the product per unit of mass or volume (e.g. apples per tonne). Hence, the impact of a specific agricultural product is expressed in true costs per unit of mass or volume.

The general approach in LCA is to follow economic allocation in agri-food studies ("the broadest shoulders should carry the greatest impact-burden"). This is specifically relevant for animal products, which are not covered by the TCA AgriFood Handbook. A classic example of this issue is the impact of a sheep: which part of the impact is allocated to the wool, and which part is allocated to the meet? Here, TCA follows the common practice of economic allocation in LCA for agricultural products - in other words, when 55% of the revenues come from the wool and 45% comes from the meat, 55% of the eco-costs are allocated to the wool and 45% to the meat. An overview of other allocation systems for agri-food co-products is given in Ijassi, Rejeb, & Zwolinski (2021). Although economic allocation has some shortcomings,[13] it seems best in line with the goal and scope of TCA assessments.

Aspects that were not accounted for in the pilots, but should be considered for future TCA assessments are:

- Accounting of impacts of waste: If products do not meet desired quality standards and are wasted, the impact of waste management and treatment should be included in the true cost calculations of the original product. Whenever product waste (e.g. organic crop residues or organic waste treatment) is used for other products (e.g. animal feed) or in other value chains (e.g. production of biofuels based on organic waste), only the impacts related to their transportation to these other chains should be included in the true cost calculations of the original product.
- Accounting of impact in non-productive periods: For productions with an initial phase where no produce is generated (e.g. tree crop production where tree needs to grow for couple of years before they carry fruit) the impacts that arise during the non-productive period need to be allocated to the following productive years. A similar approach might be useful for perennial crops for which management practices differ substantially from year to year. In this case it might be useful to estimate the true cost for the entire production cycle and estimate the true cost per tonne of product at the end of the production cycle (e.g. collect the data of peppermint production over the course of three years).

Scope

The extent of the area or subject matter that something deals with or to which it is relevant

Dictionary (Lexico.com, 2021)

Monetization

The process of converting a metric or an impact into monetary terms

Disability-adjusted life years

(DALY) One DALY represents the loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of the years of life lost to due to premature mortality and the years lived with a disability due to prevalent cases of the disease or health condition in a population

WHO (2021)

Measurement

The process of determining the amounts, extent, and condition of capital and capital changes

2.9 Quantitative approach

The goal of the proposed TCA methodology is to provide quantitative results that represent the change in capital stocks caused by the production of agricultural materials and products. This is where it differs from qualitative research methodologies that provide more detailed and context specific insights into causes and solutions (e.g. by approaching agricultural value chains from a behavioural perspective). The advantage of a quantitative methodology is the scalability and universal comparability of outcomes. However, the results do not provide context specific insights into the likelihood of adoption or feasibility of solutions to reduce externalities.

2.10 Material-focused

The indicators are expansive, but not exhaustive. They were prioritised based on the concept of materiality defined by the Global Reporting Initiative (GRI) and on the availability of scientifically acknowledged output models and monetization factors. According to the GRI Standards (GRI 3: Material Topics 2021) 'material' are those "topics that represent an organization's most significant

12 The total of all products of a farmer or company may be aggregated for annual reporting.
13 The main disadvantage of economic allocation is the strong price fluctuations in agriculture; this is addressed in the first comprehensive international LCA Handbook (J.B. Guinee (Ed.); Handbook on Life Cycle Assessment, Operational Guide to the ISO Standards, Kluwer Academic Publishers, 2002, pp 143-151; 505-522; Table 3.9.2.1).

impacts on the economy, environment, and people, including impacts on their human rights". Material impacts relevant to the food and farming sector were identified based on the GRI Standard G4 Processing Food Sector, UNEP's Guidelines for Social Life Cycle Assessment of Products, the Natural Capital Protocol, the Human and Social Capital Protocol and were cross checked with the sustainability topics named in UNEP's TEEBAgriFood Framework, the Food and Agriculture Organization of the United Nations (FAO) Sustainability Assessment of Food and Agricultural System Guidelines, the Social Hotspot Database, SASB - the Sustainability Accounting Standards Board Standards for the agricultural industry as well as several scientific research articles on the materiality analysis for sustainability reporting in agri-food sector and the Sustainable Development Goals (SDGs).

Selected indicators also adhere to the requirements of double materiality. On the one hand, the focus of the indicators is to measure the impacts that businesses have on the environment and people (inside-out); on the other hand, dependencies and thus risks for businesses can be derived from these impacts (outside-in) and can be included in their reporting.

3
True Cost Accounting indicators for agri-food supply chains

The six following steps explain how indicators for the TCA methodology were derived. To apply the TCA methodology to additional supply chains (other than those in the pilots performed by the True Cost Initiative), these steps do not need to be repeated. It is, however, important to mention that the methodology is expected to further develop with increasing scientific knowledge and data availability/accessibility on food system impacts.

1. Defining capitals: The framing according to TEEBAgriFood (2018) into four capitals was chosen: natural, human, social, and produced capital. Focus was given to the first three.
2. Prioritising impacts: Identification of priority impacts based on size/relevance of the impact, ease of quantification, feasibility, availability of intervention to modify the impact and expert feedback.
3. Forming impact categories: The identified food system costs (and benefits) were grouped into impact categories according to frequency mentioned across existing approaches to assessing the true cost of food and system level quantifications.

4 Collection and adoption of impacts and respective indicators/metrics: Over 100 indicators and metrics from existing approaches were collected in order to select or create formulars/models to qualitatively assess the impact of agri-food products.[14]

5 Identify monetization method and factor corresponding to the indicators: For each indicator a suitable monetization approach was chosen with the preference for prevention cost approach. For the estimation of the true cost of food and agricultural product's impact, monetization factors were assigned to each indicator in line with the chosen approach. A wide range of monetization approaches and factors exist – those here provided represent one option for monetization estimates.

6 Testing: The indicator and the collection of the respective data were tested in two iterative pilot phases and were adjusted according to the feedback and lessons learned. Table 3 provides a summary of the final indicators. Some of the tested indicators (e.g. health impacts from pesticide ingestion) were not included in the final list of indictors because of insufficient performance during the piloting (e.g. lack of accurate impact modelling, insufficient proof of causality).

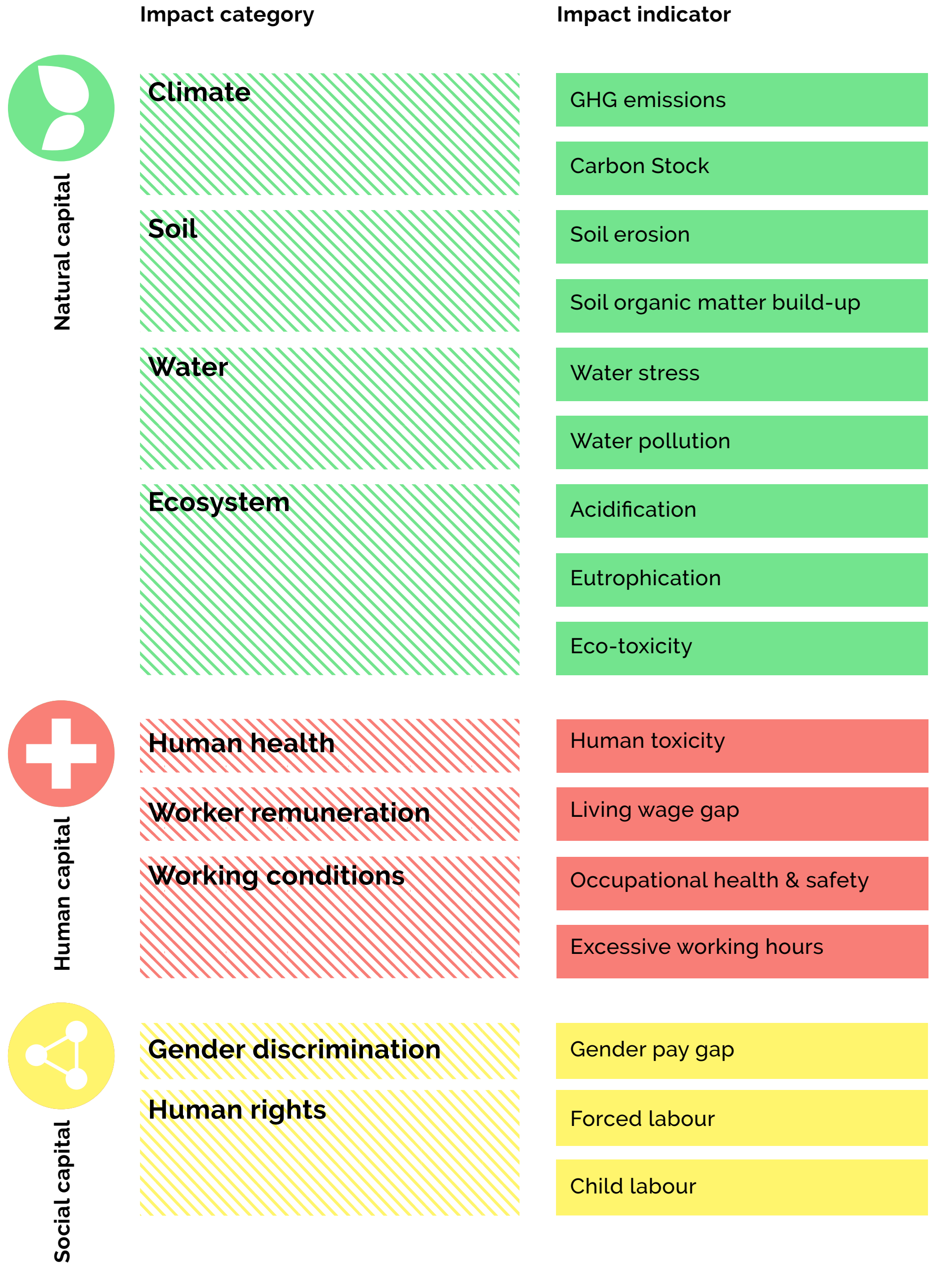


Figure 4: Capital, impact categories and impact indicators

14 Please note that the selected indictors do not cover all issues under each impact category. For example, gender discrimination entails gender inequalities beyond unequal pay in the context of farming and food processing, such as discrimination of woman with regard to access to land and water, credits, information, education, etc. Another example of a missing indicator is the issue of living income (the net annual income required for a household in a particular place to afford a decent standard of living for all members of that household), which is of particular importance in the agricultural context and would need to be include as an indicator under 'remuneration' to adequality cover the impact category.

Info box 1: Disability Adjusted Life Years (DALY)

Human and social impacts are measured using DALY, a standardised method employed by the United Nations World Health Organisation to compare the burden of different diseases. A DALY is equivalent to one lost year of "healthy" life. The sum of DALYs across a population affected by an impact driver (e.g. excessive work) measures the gap between the health status with and without the presence of the impact driver. DALYs for a disease or health condition are calculated as the sum of the years of life lost due to premature mortality in the population and the years lost due to disability for people living with the health condition or its consequences.

For the valuation of DALY, the True Cost Initiative follows the Eco-Cost Value approach (Sustainability Impact Metrics, 2020). Van der Velden and Vogtländer (2017) researched that in the United States the price of kidney dialysis ("the dialysis standard") is proposed as the maximum price for 1 DALY (Grosse, 2014) (King, 2005), at 82,000 United States Dollars (USD) in 2009 (United States Department of Health and Human Services National Institutes of Health, 2012). Although the DALY cannot be used as tool for medical decision making on the level of the individual patient (Cleemput, 2011), it is often used for general guidance for higher level policy decisions. The Dutch Council for Public Health and Care (Raad voor de Volksgezondheid en Zorg, 2006) proposes 80,000 EUR per DALY in Europe. Since a life should have the same value no matter the country someone is born in, 80,.000 EUR per DALY is applied universally.

Indicator	DALY*
Human toxicity	11.5
Occupational health & safety	Varies depending on type of injury or illness
Excessive working hours	0.5
Forced labour	0.5
Child labour	0.5

*The DALY value assigned per impact for the bottom three indicators are based on rough estimates and require further research. The issues are:

1 how can these impacts be classified in sub-categories of sufferings; and

2 how can these sub-categories be compared to the sufferings of diseases in the World Health Organization lists.

Performance reference point

Condition at which an indicator becomes zero

Impact driver

A flow (e.g. input or non-product output) which arises from the activities of agents (i.e. governments, corporations, individuals) in eco-agri-food value chains, resulting in significant outcomes and leading to material impacts

TEEBAgriFood (TEEB, 2018)
Natural Capital Protocol (Natural Capital Coalition, 2016)

Table 3: Overview of the true cost accounting indicators

Natural capital

Impact category	Impact indicator	Definition	Impact type	Used tool*	Monetization method	Monetization factor (at base year)**
Climate	Greenhouse Gas emissions	Emission and global warming potential of GHGs	Cost	Cool Farm Tool (no fee, registration required)	Cost of replacing coal by offshore wind for electricity generation	116 EUR/tonne CO_2eq
	Carbon Stock	Emission and global warming potential of CO_2 from soil and tree biomass	Cost and benefit	Cool Farm Tool (no fee, registration required)	Cost of replacing coal by offshore wind for electricity generation	116 EUR/tonne CO_2 or -116 EUR/tonne CO_2
Soil	Soil erosion	The erosion of soil due to precipitation	Cost	Revised Universal Soil Loss Equation (no fee)	On-site and off-site damage costs	27.38 USD/tonne soil
	Soil organic matter build-up	The emission and build-up of soil organic carbon (SOC)	Cost and benefit	Cool Farm Tool (no fee, registration required)	Restoration costs for SOC build-up	100 EUR/tonne SOC emission or – 100 EUR/ tonne SOC build-up
Water	Water stress	The withdrawal of fresh ground- and surface water compared to its availability	Cost	Aqueduct Water Risk Atlas (no fee), CropWat (no fee), CLIMWAT (no fee)	Costs of reverse osmosis of salt- or polluted water	1 EUR/m^3 water use under water stress
	Water pollution	The leaching and run-off of nitrogen and phosphorous and their eutrophication potential in ground- and surface water	Cost	Grey Water Footprint Guidelines, Water Footprint Network	The cost of sustainable manure treatment	4.70 EUR/kg PO_4eq
Ecosystem	Acidification	Considers the emissions of nitrogen oxides (NOx), sulphur dioxide (SO2) and ammonia (NH3), their atmospheric deposition and acidifying potential on water and soil systems	Cost	USEtox, (no fee, registration required), LCA Software (various software for free or at charge available)	The cost of diesel desulphurization	8.75 EUR/kg SO_2eq
	Eutrophication	Energy use, diesel combustion and production of non-organic fertilizers and their terrestrial eutrophication potential	Cost	USEtox, (no fee, registration required), LCA Software (various software for free or at charge available)	The cost of sustainable manure treatment	4.70 EUR/kg PO_4eq
	Eco-toxicity	The potential ecological risk to species by chemicals emitted to the environment	Cost	USEtox, (no fee, registration required), LCA Software (various software for free or at charge available)	The cost of water treatment in municipal facilities	340 EUR/kg Cu eq

Human capital

Human health	Human toxicity	Potential health risk of cancerous and non-cancerous health effects of chemicals emitted to the environment (mainly soil and air)	Cost	USEtox, (no fee, registration required), LCA Software (various software for free or at charge available)		80,000 EUR/DALY
Worker remuneration	Living wage gap	Difference between the living wage and the actual remuneration (earnings during a standard work week and includes wages, bonuses and in-kind benefits)emitted to the environment (mainly soil and air)	Cost	Described in this document, Anker Methodology (no fee); IDH Living Wage Matrix (fee)		-
Working conditions	Occupational health & safety	Work-related injuries, (long-term) illness and death	Cost	Eco-cost methodology (no fee)	The cost of treating a kidney patient for one year	80,000 EUR/DALY
	Excessive working hours	All hours worked more than the normal working hours	Cost	Eco-cost methodology (no fee)	Half the cost of treating a kidney patient for one year	80,000 EUR/DALY

Social capital

Gender inequality	Gender pay gap	The difference between male and female net earnings	Cost	Fully described in this document	-	-
Human rights violation	Forced labour	All work or service which is exacted from any person under the menace of any penalty and for which the said person has not offered himself voluntarily	Cost	Eco-cost methodology (no fee) (method was adapted)	Half the cost of treating a kidney patient for one year	80,000 EUR/DALY
	Child labour	Work performed by a child below 15 years old that is inappropriate for a child's age, preventing the child from going to school, or harming the physical and mental development	Cost	Eco-cost methodology (no fee)	Half the cost of treating a kidney patient for one year	80,000 EUR/DALY

* For references to the sources of recommended tools and guidance, see the detailed indicator tables in Chapter 3.
** For more Information on the respective base year see Table 4.
Note that a wide range of monetization approaches and factors exist – those here provided represent one option for monetization estimates.

3.1 Natural capital

Natural capital are the limited stocks of physical and biological resources found on earth, and of the limited capacity of ecosystems to provide ecosystem services (TEEB, 2018).

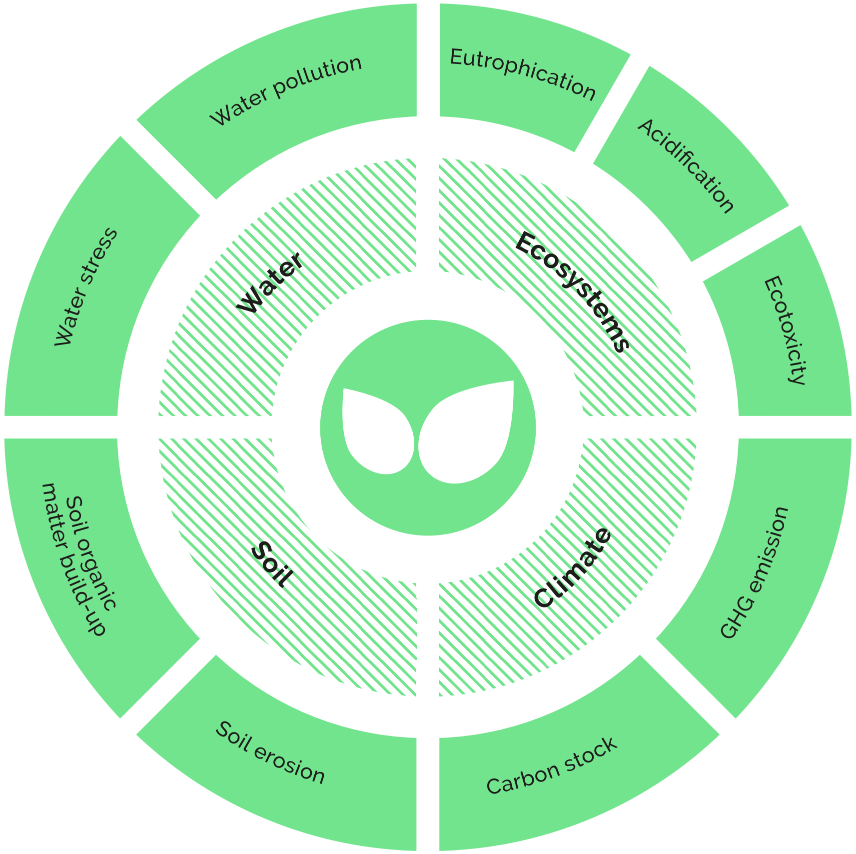


Figure 5: Natural capital: impact categories and impact indicators

Category 1	Climate
Background info	The emission of GHGs into the atmosphere causes global average temperatures to rise. This change in climate results in unpredictable weather circumstances and a higher chance of natural disasters such as floods and droughts. These events have economic and geopolitical consequences and may result in events such as famine, mass migration and war (FAO, 2014a).

Indicator 1.1	Greenhouse Gas emissions
Rational/Materiality	Agriculture is responsible for large portions of three of the most significant sources of GHG emissions. From 2007 to 2016, activities in the sector accounted for approximately 13% of carbon dioxide (CO_2), 44% of methane (CH_4), and 82% of nitrous oxide (N_2O) emissions from human activities globally; these figures totaled in 23% of total net anthropogenic emissions of GHGs. Crop production primarily causes GHG emissions through soil cultivation (with the largest discharges coming from soil tillage), soil decomposition, and burning vegetation and crop residues. Fertilizers, pesticides, and fossil fuels used to power machinery and vehicles also release GHG emissions. Crop residue decomposition and burning plant biomass are other direct sources of emissions, including CO_2, N_2O, and particulate matter (IPCC, 2007).
Definition	This indicator considers the emissions and global warming potential of the GHGs CO_2, N_2O and CH_4.
Scope: Impact drivers	Cultivation: emissions from crop residue, fertilizer production and application, pesticide use, paddy production, machinery use, energy use, transport emissions, seed production Processing: energy use Storage and transport: fuel combustion, other energy use
Performance reference point	Zero GHG emissions

Metrics	$TC_{GHG} = U_{GHG} * MF_{GHG}$ Where: TC_{GHG} = true costs of greenhouse gas (GHG) emissions U_{GHG} = total GHG emissions (tonne CO_2eq)
Required data	Cultivation: yield, fertilizer use, crop protection use, energy use, land use changes, crop residue management, tillage and green manure related practice changes Processing: energy use Storage and transport: fuel combustion
Recommended tool/ guidance for impact quantification	Cool Farm Tool (Cool Farm Alliance, 2021) For a complete technical description of the Cool Farm Tool methodology, please contact info@coolfarmtool.org
Monetization	Cost replacement of electricity from a coal fired power plant by renewable energy from an offshore windfarm
Monetization factor	MF_{GHG} = 116 EUR_{2017}/tonne CO_2eq (Sustainability Impact Metrics, 2020)
Verify data	Primary source: Energy bill, fuel bill Secondary source: satellite images for land use changes, Life Cycle Inventory (LCI) Databases (Ecoinvent, Agribalyse, Agri-Footprint)
Sustainable Development Goals	SDG 12 Responsible Consumption and Production, SDG 13 Climate Action

Indicator 1.2 Carbon Stock

Rational/Materiality	Agricultural production areas can remove vast quantities of carbon dioxide (CO2) from the atmosphere over long periods of time. However, when natural ecosystems are converted to other uses such as arable land (also known as deforestation), stored carbon can be released from the soil and tree biomass into the atmosphere. This contributes to GHG emissions and climate change.
Definition	This indicator considers the emission and global warming potential of carbon stored in soil and tree biomass.
Scope: Impact drivers	Cultivation: incorporated organic material, land use changes, tillage changes, cultivation of cover crops, additional biomass through tree crops Processing: not applicable Storage and transport: not applicable
Performance reference point	Carbon stock equilibrium
Metrics	$TC_{CS} = (C_{soil} + C_{tree\ biomass}) * 3.67 * MF_{CS}$ Where: TC_{CS} = true cost of carbon stock emissions C_{soil} = carbon emissions from soil (tonne C) $C_{tree\ biomass}$ = carbon emissions from tree biomass (tonne C) MF_{CS} = monetization factor of carbon stock emissions Note: One ton of carbon equals 3.67 tons of carbon dioxide. C_{soil} is derived by: $\Delta C_{20} = SOC_t - SOC_{t-20}$, $SOC_{t-20} = RC * BF * TF * IF * LA$ Where: RC = Reference carbon stock (tonne C) BF = Base factor (relative carbon storage compared to the native system) TF = Tillage factor IF = Input factor LA = Land area for a particular land use and management system
Required data – **Cultivation level**	Primary data: land use changes, crop residue management, changes in tillage and/or green manure use, organic fertilization
Recommended tool/ guidance for impact quantification	Cool Farm Tool (Cool Farm Alliance, 2021). For a complete technical description of the Cool Farm Tool methodology, please contact info@coolfarmtool.org

Monetization	Cost replacement of electricity from a coal fired power plant, by renewable energy from an offshore windfarm
Monetization factor	MF_{GHG} = 116 EUR_{2017}/tonne CO_2eq (Sustainability Impact Metrics, 2020)
Verify data	Primary source: photos Secondary source: satellite images
Sustainable development goals	SDG 13 Climate Action, SDG 12 Responsible Consumption and Production, SDG 2 Zero Hunger, SDG 1 No Poverty

Category 2 — Water

Background info	In the last century, water use has grown by nearly twice the rate of population growth. Challenges related to this increased water use are water stress, water pollution, degradation of water dependant ecosystems, climate change and cooperation within and across water basins. Billions of people worldwide live without access to clean drinking-water, sanitation and hygiene services (United Nations Economic and Social Council, 2021).

Indicator 2.1 — Water Stress

Rational/Materiality	The agriculture sector accounts for an estimated 70% of total water withdrawn globally. Withdrawn water is primarily used to irrigate land for crops. Water is also used for pesticide and fertilizer application, crop cooling, and frost control. Intensive water withdrawal can decrease aquifer levels, which reduces the long-term sustainability of water resources and increases access cost for all users (FAO, 2011).
Definition	This indicator considers the withdrawal of fresh ground- and surface water compared to its availability.
Scope: Impact drivers	Cultivation: local fresh-water availability and demand, irrigation Processing: local fresh-water availability and demand, water use Storage and transport: not applicable
Performance reference point	Zero water withdrawn
Metrics	$TC_{ws} = MF_{ws} * B_{ws} * (\text{Irri req} + W_p)$ Where: TC_{ws} = true cost of water stress MF_{ws} = monetization factor water stress B_{ws} = Aqueduct baseline water stress factor Irri req = CropWat irrigation requirements (m^3) W_p = water demand in processing phase p (m^3)
Required data — **Cultivation level**	Primary data: location, crop, irrigation (yes/no)
Required data — **Processing level**	Primary data: location, water use
Recommended tool/ guidance for impact quantification	Aqueduct Water Risk Atlas (https://www.wri.org/applications/aqueduct/water-risk-atlas/) Cropwat (http://www.fao.org/lan d-water/databases-and-software/cropwat/en/) Climwat for Cropwat (http://www.fao.org/land-water/databases-and-software/climwat-for-cropwat/en/)
Monetization	Cost for reversed osmosis of saltwater or polluted water
Monetization factor	MF_{ws} = 1 EUR_{2017}/m^3 water use under water stress (Sustainability Impact Metrics, 2020)
Verify data	Primary source: water bill, sales receipt Secondary source: local weather station report, soil map, certifications, LCI databases
Sustainable development goals	SDG 12 Responsible Consumption and Production, SDG 14 Life below Water, SDG 15 Life on Land, SDG 6 Clean Water and Sanitation

Indicator 2.2	**Water Pollution**
Rational/Materiality	Agriculture operations can also impact species that exist in areas surrounding natural ecosystems. Agricultural production can be a major source of surplus nitrogen and phosphorous pollution, which can lead to eutrophication in adjacent lakes and rivers, rendering them uninhabitable for aquatic biodiversity (FAO, 2011).
Definition	This indicator considers the leaching and run-off of nitrogen and phosphorous and their eutrophication potential in ground and surface water.
Scope: Impact drivers	Cultivation: Nitrogen (N) and Phosphor (P) application through fertilizer Processing: not applicable Storage and transport: not applicable
Performance reference point	Zero N and P leaching and run-off
Metrics	$TC_{WP} = N_{appl} * an * MF_{neu} + P_{appl} * ap * MF_{peu}$ Where: N_{appl} = amount of N applied (kg) P_{appl} = amount of P applied (kg) an = leaching-runoff fraction of N ap = leaching-runoff fraction of P TC_{WP} = True cost of water pollution MF_{neu} = Monetization factor of N eutrophication in EUR/kg pollution MF_{peu} = Monetization factor of P eutrophication in EUR/kg pollution
Required data | **Cultivation level**	Primary data: fertilizer application in units N and P
Recommended tool/ guidance for impact quantification	Grey water footprint accounting (Franke, Boyacioglu, & Hoekstra, 2013)
Monetization	The costs of sustainable manure treatment
Monetization factor	MF_{neu} = MF_{peu} = 4.70 EUR_{2017}/kg PO_4eq (Eco-cost Value, 2022) MF_{neu} = 1.75 EUR_{2017}/kg nitrogen (0.42 kg PO_4eq/kg) MF_{peu} = 12.76 EUR_{2017}/kg phosphorus (3.06 kg PO_4eq/kg)
Verify data	Primary source: Fertilizer bill Secondary source: N and P requirements by crop
Sustainable development goals	SDG 12 Responsible Consumption and Production, SDG 14 Life below Water, SDG 15 Life on Land, SDG 6 Clean Water and Sanitation

Category 3	**Soil**
Background info	Soil, particularly the 30 cm layer which is called the topsoil, provides many ecosystem services such as the production of food, filtering of water and recycling of organic waste streams. Cultivation, degradation, pollution and changes in land-use impact the ability of soils to deliver these ecosystem services (FAO, 2011).

Indicator 3.1	**Soil Erosion**
Rational/Materiality	Despite being a naturally occurring process, soil erosion can accelerate greatly through agricultural activities, including removal of vegetation cover, tillage, soil compaction, and overgrazing by livestock, particularly when these practices are conducted on steep slopes in areas subjected to intense rainstorms or wind events. In agriculture, original vegetation cover is removed to make land available for crop production or animal grazing. Agricultural crops rarely hold onto the topsoil as well as the original vegetation cover, increasing soil erosion and potentially reducing soil fertility over time. Estimates show that half of the topsoil globally has been lost in the last 150 years (FAO, 2011).
Definition	This indicator considers the erosion of soil due to precipitation.

Scope: Impact drivers	Cultivation: soil coverage, crop, soil erosion prevention Processing: not applicable Storage and transport: not applicable
Performance reference point	Zero soil erosion by precipitation
Metrics	$TC_{SE} = A * MF_{SE}$ With $A = R * K * LS * C * P$ Where: TC_{SE} = True cost caused by soil erosion by water per hectare per year A = Soil loss in tonnes per ha per year MF_{SE} = Monetization factor soil erosion by water R = Rainfall-Runoff erosivity factor K = Soil erodibility factor LS = Slope length and steepness factor C = Cover-Management factor P = Support practice factor
Required data — **Cultivation level**	Primary data: slope, precipitation, soil erosion prevention management, coordinates
Recommended tool/ guidance for impact quantification	Based on farm management data: The Revised Universal Soil Loss Equation (USDA, 2021) Based on location: Global soil erosion map (Borrelli, et al., 2017)
Monetization	On-site and off-site damage costs (FAO, 2014a)
Monetization factor	MF_{SE} = 27.38 USD_{2014}/tonne soil lost
Verify data	Primary source: photos Secondary source: satellite images/data
Sustainable development goals	SDG 15 Life on Land

Indicator 3.2 — Soil organic carbon build-up

Rational/Materiality	Soil organic matter plays a vital part in enhancing soil fertility and quality. Soil organic matter improves soil structure. This ultimately helps to control soil erosion and improves water infiltration and water holding capacity, giving plant roots and soil organisms better living conditions. Soil organic matter is a primary source of carbon (C) which gives energy and nutrients to soil organisms. This supports soil functionality because it improves the activity of microorganisms in the soil and it can enhance biodiversity (Eip-Agri, 2015). Soil organic matter is also crucial factor for climate change. Depending on the soil management CO2 can be released from the soil into the atmosphere or can be sequestered in the ground (Ontl & Schulte, 2012).
Definition	This indicator considers the composition and decomposition of SOC.
Scope: Impact drivers	Cultivation: incorporated organic material, land use changes, tillage changes, cultivation of cover crops, additional biomass through tree crops Processing: not applicable Storage and transport: not applicable
Performance reference point	No increase/decrease in SOC
Metrics	$TC_{SOC} = C_{soil} * MF_{SOC}$ Where C_{soil} is derived by $\Delta C_{20} = SOC_{t} - SOC_{t-20}$ With: $SOC_{t-20} = RC * BF * TF * IF * LA$ Where: TC_{SOC} = true cost of SOC build-up C_{soil} = carbon emissions from soil (tonne C) MF_{SOC} = monetization factor of SOC RC = Reference C Stock (tonne C)

Required data – **Cultivation level**	Primary data: land use changes, crop residue management, changes in tillage and/or green manure use, organic fertilization
Recommended tool/ guidance for impact quantification	Cool Farm Tool (Cool Farm Alliance, 2021). For a complete technical description of the Cool Farm Tool methodology, please contact info@coolfarmtool.
Monetization	Restoration costs for SOC build up
Monetization factor	100 EUR_{2014}/tonne SOC emission (Ligthart & van Harmelen, 2019)
Verify data	Primary source: photos Secondary source: satellite images/data
Sustainable development goals	SDG 15 Life on Land

Category 4 Ecosystems

Background info	Ecosystems are natural systems in which organisms and their inorganic environment interact. Ecosystems provide services such as clean air, recreational value, weather mitigation, natural pollination, fresh water, purification and detoxification of water and aesthetic value. The emission of pollutants into ecosystems can lead to degeneration of these ecosystem services (FAO, 2011).

Indicator 4.1 Acidification

Rational/Materiality	Acidification is commonly associated with atmospheric pollution arising from anthropogenically derived air emissions of NH_3, NO_2 and SO_x. Few exceptions exist however for NO, SO_3. Anthropogenically derived pollutant deposition enhances the rates of acidification, which may then exceed the natural neutralizing capacity of soils. When acids are emitted, the pH factor falls and acidity increases, which for example can involve widespread decline of coniferous forests and dead species in lakes.
Definition	This indicator considers the emissions of nitrogen oxides (NO_x), sulphur dioxide (SO_2) and ammonia (NH_3), their atmospheric deposition and acidifying potential on water and soil systems by hydrogen ion concentration.
Scope: impact drivers	Cultivation: machinery use, non-organic fertilizer (organic fertilizers are considered a by-product of livestock) and crop protection Processing: energy use, substance use Storage and transport: fuel composition, energy use
Performance reference point	Zero acidification potential
Metrics	$TC_{AC} = U_i * A_i * MF_{AC}$ Where: TC_{AC} = True cost of acidification U_i = Use of substance i (unit) (e.g. fuel combustion, agricultural input application) A_i = Acidification potential of the use of substance i (kg SO_2 eq/unit) MF_{AC} = Monetization factor acidification
Required data – **Cultivation level**	Primary data: fuel use, fertilizer use, crop protection use
Required data – **Processing level**	Primary data: fuel use, material use
Required data – **Storage and transport level**	Primary data: fuel use
Recommended tool/ guidance for impact quantification	Life cycle analysis software, such as: Open LCA (OpenLCA, 2021) SimaPro (SimaPro, 2021)
Monetization	Cost of diesel desulphurization
Monetization factor	8.75 EUR_{2017} /kg SO_2eq (Eco-cost Value, 2022)
Verify data	Primary source: Energy bill, diesel bill, input material bill
Sustainable development goals	SDG 14 Life below Water, SDG 15 Life on Land

Indicator 4.1		Eutrophication
Rational/Materiality		In natural terrestrial systems, the addition of nutrients may change the species composition of the vegetation by favoring those species which benefit from higher levels of nutrients to grow faster than more nutrient efficient plants. This therefore changes the plant community from nutrient-poor (e.g. heath lands, dunes and raised bogs) to nutrient rich and more commonly, due to the widespread dispersion of nutrients, plant communities. The primary impact on the plant community leads to secondary impacts on other species in the terrestrial ecosystem. Terrestrial eutrophication is caused by deposition of airborne emissions of nitrogen compounds like nitrogen oxides (NO_x = NO and NO_2) from combustion processes.
Definition		This indicator considers energy use, diesel combustion and production of non-organic fertilizers and their terrestrial eutrophication potential.
Scope: impact drivers		Cultivation: machinery use, non-organic fertilizer use[15] Processing: energy use Storage and transport: fuel composition, energy use
Performance reference point		Zero acidification potential
Metrics		$TC_{eu} = U_i * A_i * MF_{eu}$ Where: U_i = Use of substance i (unit) (e.g. fuel combustion, agricultural input application) A_i = Eutrophication potential of the use of substance i (kg PO_4 eq/unit) MF_{eu} = Monetization factor eutrophication TC_{eu} = True cost of eutrophication
Required data	**Cultivation level**	Primary data: fuel use, fertilizer use, crop protection use
	Processing level	Primary data: fuel use, material/substance use
	Storage and transport level	Primary data: fuel use
Recommended tool/ guidance for impact quantification		Life cycle analysis software, such as: Open LCA (OpenLCA, 2021) SimaPro (SimaPro, 2021)
Monetization		These eco-costs of eutrophication in water are related to the costs of sustainable manure treatment
Monetization factor		4.70 EUR_{2017} kg PO_4eq (Eco-cost Value, 2022)
Verify data		Primary source: Energy bill, diesel bill, logfile fertilizer and crop protection Secondary source: LCI databases
Sustainable development goals		SDG 12 Responsible Consumption and Production, SDG 14 Life below Water, SDG 15 Life on Land, SDG 6 Clean Water and Sanitation

Indicator 4.3	Eco-toxicity
Rational/Materiality	Crop protection can have negative impacts on biodiversity, for example, those targeting insects or weeds can be toxic to birds, fish, and non-targeted plants and insects. Impacts from agriculture on biodiversity include air, soil, and water contamination.
Definition	This indicator considers the potential ecological risk to species by chemicals emitted to the environment (mainly water).
Scope: Impact drivers	Cultivation: crop protection use Processing: energy use, packaging Storage and transport: not applicable
Performance reference point	Zero hazard to species

15 The eutrophication effects of organic fertiliser application (and all other fertilisers) are taken into account under the water pollution indicator with a model that considers the context (e.g. rainfall, SOM content) to determine the run-off/leaching amount. Slight double counting of the eutrophication effect of non-organic fertilisers is possible but should be avoided in the TCA calculations.

Metrics		$TC_{ET} = U_i * T_i * MF_{ET}$ Where: TC_{ET} = True cost of eco-toxicity U_i = Use of substance i (kg) (active ingredient of crop protection product) T_i = Toxicity impact of use of substance i (kg Cu equivalent/kg) MF_{ET} = Monetization factor eco-toxicity
Required data	**Cultivation level**	Primary data: crop protection use
	Processing level	Primary data: energy use, material use
Recommended tool/ guidance for impact quantification		USEtox 2.1 (USEtox, 2021) Life cycle analysis software, such as: Open LCA (OpenLCA, 2021) SimaPro (SimaPro, 2021)
Monetization		The cost of water treatment costs in municipal water treatment facilities
Monetization factor		340 EUR_{2017}/kg Cu eq (Eco-cost Value, 2022)
Verify data		Primary source: Bill crop protection, picture storage, if applicable documentation reporting to responsible authority
Sustainable development goals		SDG 15 Life on Land, SDG 14 Life below Water, SDG 12 Responsible Consumption and Production

3.2 Human capital

Human capital encompasses the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being (TEEB, 2018).

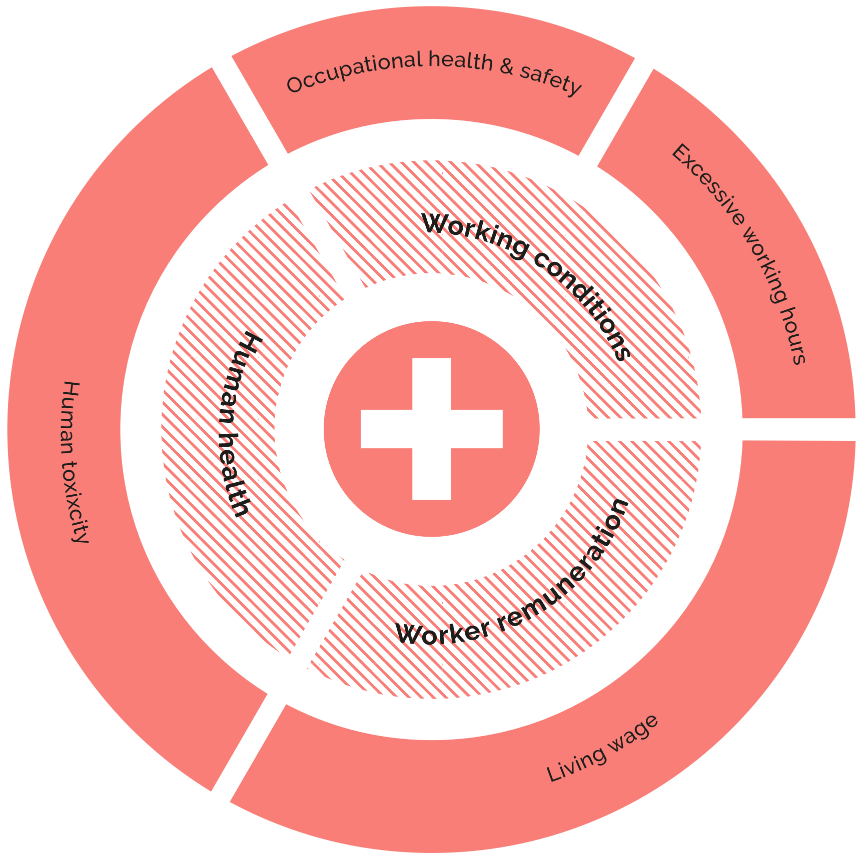


Figure 6: Human capital: impact categories and impact indicators

Category 5	Human health
Background info	Human health can be influenced by exposure to physical, chemical, biological, and radiological contaminants in the environment. People are exposed to contaminants in air, in water, and on land. Agricultural practices and food production can contribute to those contaminants. Public health goals seek to reduce the exposure to harmful contaminants (United States Environmental Protection Agency, n.a.).

Indicator 5.1	Human toxicity
Rational/Materiality	Heavy metals and persistent organic chemicals have deleterious implications for human health. Different body organs can be affected along with body systems. Potential health problems range from cancers (arsenic, asbestos, dioxins) to neurological damage and lower intelligence quotient (lead, arsenic), kidney disease (lead, mercury, cadmium), and skeletal and bone diseases (lead, fluoride, cadmium) (European Commission, 2013). Health impacts can be caused by short or long-term, low or high-level exposure to air and soil and water contaminants through ingestion, inhalation, and dermal absorption (United States Environmental Protection Agency, n.a.).
Definition	This indicator considers the potential health risk of cancerous and non-cancerous effects of chemicals emitted to the environment (mainly soil and air).
Scope: impact drivers	Cultivation: toxic substances including pesticides Processing: toxic substances Storage and transport: not applicable
Performance reference point	Zero disease cases
Metrics	$TC_{HT} = U_i * T_i * MF_{HT}$ Where: TC_{HT} = True cost of human toxicity (EUR) U_i = Use of substance i (kg) (active ingredient of crop protection product) T_i = Toxicity impact of use of substance i (Disease cases/kg) MF_{HT} = Monetization factor human toxicity (EUR/DALY)
Unit	Disease cases per kg emitted, where 1 disease case = 11.5 DALY
Required data – **Cultivation level**	Primary data: crop protection use, fuel use, fertilizer use
Required data – **Processing level**	Primary data: fuel use, material use
Recommended tool/ guidance for impact quantification	USEtox 2 (USEtox, 2021) Life cycle analysis software, such as: Open LCA (OpenLCA, 2021) SimaPro (SimaPro, 2021)
Monetization	The cost of medical treatment
Monetization factor	MF_{HT} = 80,000 EUR_{2017}/DALY (Raad voor de Volksgezondheid en Zorg, 2006)
Verify data	Primary source: Bill crop protection, picture of chemical storage, if applicable documentation reporting to responsible authority
Directly affected stakeholders	Local community
Sustainable development goals	SDG 3 Good Health and Well-Being (Target 3.9), SDG 6 Clean Water and Sanitation (Target 6.3, 6.6), SDG 12 Responsible Consumption and Production (Target 12.4)

Category 6	Working conditions
Background info	Agriculture is one of the most hazardous sectors in terms of work-related fatalities, non-fatal accidents, and occupational diseases. Workers in the food and agricultural industry face risks when operating heavy equipment and loud machinery, lifting weights or working with animals. Because farm workers are mainly working outdoors, they are exposed to harsh weather

conditions. Agricultural and food enterprises may experience periods with long working hours. Those working conditions which are unfavourable to health of the workers are considered as occupational hazards (International Labour Organisation, n.a.).

Indicator 6.1 Occupational health and safety

Rational/Materiality

Agriculture is one of the most hazardous sectors in terms of work-related fatalities, non-fatal accidents, and occupational diseases. Workers in the food and agricultural industry face risks when operating heavy equipment and loud machinery, lifting weights or working with animals. Because farm workers are mainly working outdoors, they are exposed to harsh weather conditions. Agricultural and food enterprises may experience periods with long working hours. Those working conditions which are unfavourable to health of the workers are considered as occupational hazards (International Labour Organisation, n.a.).

Definition

This indicator considers the health impact from work-related injuries, (long-term or chronic) illness and death of workers.

Scope: impact drivers

Cultivation: employment, working conditions, injuries, illnesses, and fatalities
Processing: employment, working conditions, injuries, illnesses, and fatalities
Storage and transport: not applied in pilots, but possible

Performance reference point

Zero injuries, zero fatalities, zero days of (long-term) illness caused from work (environment)

Metrics

$TC_{OHS} = OHS^{*}MF_{OHS}$

With

$$OHS = [\sum_{j=0}^{q} (F_j * DW_j)(LE-A_j)] + [\sum_{k=0}^{n} (IN_k * DW_k)(LE-A_k)] + [\sum_{l=0}^{m} (IL_l * DW_l) / 365$$

Where:
TC_{OHS} = true cost of occupational health and safety (EUR)
OHS = work related illness, injuries, and fatal accidents (DALY)
MF_{OHS} = monetisation factor (EUR/DALY)
q = number of fatal accidents per year
F = number of fatalities per killed worker j (is equal to 1)
DW_j = 1 (the disability weight given to death is 1)
LE = national life expectancy (year)
A = age of the worker j or worker k (year)
n = number of injuries per year
IN = number of injuries per injury type k per year
DW_k = disability weight (DW) of the injury type k (see table 2 in the source under recommended tool)
m = number of illnesses per year
IL = number of days with illness type l per year
DW_l = disability weight (DW) of the illness type k (see table 2 in the source under recommended tool)

And where the following definitions apply:

Occupational fatality: A fatality is a death caused by a work-related accident or other incidences related to the work.
Occupational injury: Any injury, such as a cut, fracture, sprain, amputation, and so forth, that results from a work-related event or from a single instantaneous exposure in the work environment.
Illness: Any abnormal condition or disorder caused by exposure to factors associated with employment, other than those resulting from an instantaneous event or exposure. It includes acute and chronic illnesses or diseases that may be caused by inhalation, absorption, ingestion, or direct contact (U.S. Bureau of Labour Statistics, 2020).

Unit

DALY

Required data — **Cultivation and processing level (same requirements for both levels)**

Primary data:
Injuries: number and type of injury, age of the worker, life expectancy in the country, the respective DW per injury
Illness: number and type of illness, the respective DW per illness, and the number of ill days per worker
Fatalities: number of deaths, age at death, life expectancy in the country
Secondary data:
Disability weights for the Global Burden of Disease (Salomon, et al., 2015)

Recommended tool/ guidance for impact quantification	With access to the required data, the above metrics provide enough information to calculate this indicator.
Monetization	The cost of medical treatment
Monetization factor	MF_{OHS} = 80,000 EUR_{2017}/DALY (Raad voor de Volksgezondheid en Zorg, 2006)
Verify data	Primary sources: record of accidents[16]
Directly affected stakeholders	Workers
Sustainable development goals	SDG 8 Decent Work and Economic Growth (Target 8.8)

Indicator 6.2 — Excessive working hours (under development)

Rational/Materiality		Long working hours can cause severe health and social issues. Excessive working hours negative health (e.g. 35% higher risk of a stroke and a 17% higher risk of dying from ischemic heart disease) and safety impacts (e.g. fatigue, stress, accidents); lead to difficulties in balancing work and family life, due to reduced time available for care work and domestic tasks; and reduced potential for job creation. The very first ILO convention, adopted in 1919 (Hours of Work [Industry] Convention, 1919 [No. 1]), limited hours of work and provided for adequate rest periods for workers. The concept of limited working hours as a human right is also addressed in both the Universal Declaration of Human Rights (Art. 24) and the International Covenant on Economic, Social and Cultural Rights (Art. 7). The number of people working long hours is increasing, and currently stands at 9% of the total population globally (Pega, 2021; International Labour Organization, n.a.).
Definition		This indicator measures the excessive working hours performed by the workers. Excessive working hours refers to overtime which is all hours worked in excess of the normal hours. The maximum standard working time (often called "normal hours") marks the point above which working time is considered as overtime.
Scope: impact drivers		Cultivation: employment, working hours management Processing: employment, working hours management Storage and transport: not applied in pilots, but possible
Performance reference point		No overtime, that is a maximum of 48 working hours per week[17]
Metrics		$TC_{EWH} = EWH * MF_{EWH}$ The formula for EWH with standard working hours: $EWH = \sum_{i=1}^{m}\sum_{j=1}^{n} (H^{j}_{EWH} - 48) / 48 * 0.5DALY$ if $H_{EWH} > 48$ hours per week $EWH = 0$ if $H_{EWH} \leq 48$ hours per week Where: TC_{EWH} = true cost excessive working hours (EUR) MF_{EWH} = monetisation factor (EUR/DALY) EWH = excessive working hour's impact (DALY) H_{EWH} = working hours per worker j per week m = number of working weeks n = number of workers
Unit		DALY
Required data	**Cultivation and processing level**	Primary data: working hours per week per worker, number of working weeks

16 Records of accidents are not likely to be sufficient as a source of information or proof. This same issue might appear for other indicators. In the case of occupation health and safety, primary data (e.g. information on the reason for an illness) might not be available (or even legally restricted) and hence it would be necessary to revert to secondary sources.

17 The performance reference point for over time is under development. A performance reference point on a monthly basis might possibly be more suitable. The ILO and some national laws allow in exceptional cases, that working exceed the maximum standard working time of 48 hours per week and eight hours per day, as long as daily working time remains not higher than ten hours, and weekly working time not higher than 56 hours. The European Union's Working Time Directive of 1993 sets the threshold of total working time, including overtime, at 48 hours per week on average over a 17-week period (Hamandia-Güldenberg, 2004).

Recommended tool/ guidance for impact quantification	With access to the required data, the above metrics provide enough information to calculate this indicator.
Monetization	The costs of medical treatment
Monetization factor	MF_{OHS} = 80,000 EUR_{2017}/DALY (Raad voor de Volksgezondheid en Zorg, 2006)
Verify data	Primary source: time recording, working hour sheets
Directly affected stakeholders	Workers
Sustainable development goals	SDG 8 Decent Work and Economic Growth, SDG 10 Reduced Inequalities

Category 7 Worker remuneration

Background info	For many people the most important aspect of a job is the wage it pays. For many workers, the wage is a primary source of income from which they need to pay for living essentials such as rent, food and water, clothing, health costs, etc. An adequate standard of living is a universally recognized basic human right, which in turn unlocks other rights, including access to health, food and nutrition, housing and education. Adequate wages provide the opportunity to reduce worker turnover and improve motivation and morale, creating a virtuous economic growth cycle (idh - the sustainable trade iniatitive, n.a.)

Indicator 7.1 Living wage

Rational/Materiality	Wage below living wage means that the income level from employment is so low that basic human needs cannot be met. As a consequence, workers and their families are lacking the financial resources and essentials for a minimum standard of living causing hunger and malnutrition, limited access to education and other basic services, social discrimination and exclusion, as well as the lack of participation in decision-making (United Nations Department of Economic and Social Affairs, n.a.).
Definition	This indicator measures the gap between the local (or national) living wage and the wages paid to a worker. Living wage refers to remuneration received for a standard work week by a worker in a particular place sufficient to afford a decent standard of living for the worker and her or his family. Elements of a decent standard of living include food, water, housing, education, health care, transport, clothing, and other essential needs, including provision for unexpected events.
Scope: impact drivers	Cultivation: employment, wages Processing: employment, wages Storage and transport: not applied in pilots, but possible
Performance reference point	The benchmark for a monthly net local living wage: • If an Anker and Anker living wage value or living wage benchmark with similar method for the area or at country level is available, this one is used. • If no Anker and Aner value or similar is available the living wage is calculated as follows: LW = (2 + FR) * (FC + LC) / (1 + FP) Where: LW = monthly net living wage in local currency FR = female fertility rate in the country FC = local cost for food in local currency LC = cost for living including cost for housing and other expenses in local currency FC is estimated using Numbeo.[18] In the Numbeo database, select the city nearest to the location under assessment while or the food basket select 'Food Prices, Asian Food' and subtract from it the costs for beef, apples and tomatoes.

18 Numbeo. Food Prices. https://www.numbeo.com/food-prices/

	LC is estimated as follows: 1.0 x the costs of food for WB low income countries (<= 1,035 Gross National Income [GNI] per capita) 1.5 x the costs of food for WB lower middle income countries (1,036 - 4,045 GNI per capita) 2.0 x the costs of food for WB higher middle income countries (4,046 - 12,535 GNI per capita) 4.0 x the costs of food for WB high income countries (> 12,535 GNI per capita)
Metrics	$TC_{LWG} = LWG * CER$ With $LWG = \sum_{i=1}^{n} (WG_i * H)$ With $WG_i = LW - W_i$ for $W_i < LW$ $WG_i = 0$ for $W_i \geq LW$ Where: TC_{LWG} = true cost of living wage (EUR) LWG = living wage gap (in local currency) CER = currency exchange rate into EUR n = number of workers WG = wage gap (in local currency) LW = local or national monthly living wage (in local currency) W_i = monthly net wage being paid to worker i (in local currency) H = standard working hours per worker i and month (on average ca. 155 hours/month that is ca. 1840 hours/year in Europe and up to 187 hours/month that is 2240 hours/year outside Europe)
Required data — **Cultivation and processing level**	Primary data: Monthly net wage per worker Secondary data: Anker and Anker local living wage or local food prices, female fertility rate, female participation rate, GNI per capita
Recommended tool for impact quantification	IDH Living wage matrix for data collection (https://www.idhsustainabletrade.com/living-wage-platform/salary-matrix/) Living wage benchmarks (https://www.globallivingwage.org/, https://www.idhsustainabletrade.com/living-wage-identifier-tool/) Local food prices (https://www.numbeo.com/food-prices/) Female fertility rate (https://data.worldbank.org/indicator/SP.DYN.TFRT.IN) Female labour force participation rate (https://data.worldbank.org/indicator/SL.TLF.CACT.FE.ZS) GNI per capita https://data.worldbank.org/indicator/NY.GNP.PCAP.CD
Monetization	Not necessary
Monetization factor	Exchange rate to EUR
Verify data	Primary source: wage statements
Directly affected stakeholders	Workers and their families
Sustainable development goals	Mainly SDG 1 No Poverty with effects for SDG 2 Zero Hunger, SDG 3 Good Health and Well-Being, SDG 4 Quality Education, SDG 8 Decent Work and Economic Growth, SDG 10 Reduced Inequalities

3.3 Social capital

Social capital encompasses networks, including institutions, together with shared norms, values and understandings that facilitate cooperation within or among groups (TEEB, 2018).

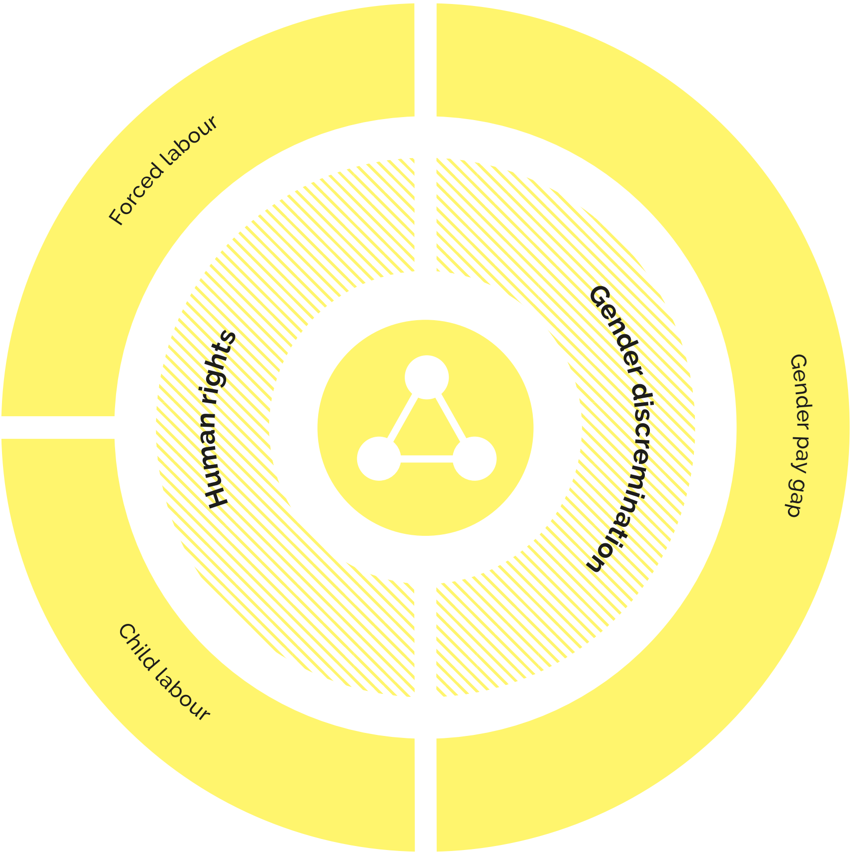


Figure 7: Social capital: impact categories and impact indicators

Category 8	**Human rights**
Background info	Workers' rights encompass a large array of human rights from the right to decent work and freedom of association, to equal opportunity and protection against discrimination as well as the prohibition of slavery, servitude, forced and compulsory labour. Businesses have a moral and legal obligation to protect workers' rights (The Danish Institute for Human Rights, n.a.).
Indicator 8.1	**Child labour**
Rational/Materiality	Worldwide more than 160 million children between 5 and 17 years are victims of child labour (International Labour Office and United Nations Children's Fund, 2021). Most child labour takes place in the agriculture sector (between 60-70%) (International Labour Organization, n.a.). Child labour in agriculture is not confined to developing countries; it is also a serious problem in industrialized countries. Not all children who work in agriculture work in "child labour". It is important to distinguish between different forms of work. Light duties that do no harm allow a child to acquire important livelihood skills and contribute to the child's survival and food security. However, work that interferes with compulsory schooling and damages health and personal development due to the hours and conditions of work, child's age, activities performed, and hazards involved, is child labour (FAO, 2020). Eliminating these worst forms of child labour should receive the most urgent attention, according to all 187 member States of the ILO who have ratified ILO Convention 182 (International Labour Organization, 2020).
Definition	Child labour refers to work performed by a child below 15 years old that is inappropriate for a child's age, preventing the child from going to school, or harming the physical and mental development. Light work is defined as work that does not harm children's health or development; does not stop children from attending school; and does not stop children from participating in vocational or training programmes approved by the national authority.

Scope: impact drivers	Cultivation: employment of children, child labour policies and monitoring Processing: employment of children, child labour policies and monitoring Storage and transport: not applied in pilots, but possible
Performance reference point	Maximum of two hours of light and age-appropriate labour per day (that is 560 hours per year as an absolute maximum) under the condition that the child is not deprived of the opportunity to attend school
Metrics	$TC_{CL} = SC_{CL} * MF_{CL}$ $SC_{CL} = \sum_{i=1}^{n} (H_i^{CL} - 560) / 2240 * 0.5DALY$ for $H_i^{CL} > 560$ hours per year $SC_{CL} = 0$ for $H_i^{CL} \leq 560$ hour per year Where: TC_{CL} = true cost of child labour (EUR) MF_{CL} = monetisation factor (EUR/DALY) SC_{CL} = child labour (DALY) n = number of children working H_i^{CL} = working hours per child i per year
Unit	DALY
Required data – **Cultivation and processing level**	Primary data: Number of children working, working hours per child per year, type of work performed (light non-hazardous work not interfering with school vs. heavy hazardous work interfering with school)
Recommended tool/ guidance for impact quantification	With access to the required data, the above metrics provide enough to calculate this indicator
Monetization	The costs of medical treatment
Monetization factor	MF_{OHS} = 80,000 EUR_{2017}/DALY (Raad voor de Volksgezondheid en Zorg, 2006)
Verify data	Secondary source: social audits and certificates
Directly affected stakeholders	Working children
Sustainable development goals	SDG 8 Decent Work and Economic Growth (Target 8.7)

Indicator 8.2 Forced labour

Rational/Materiality	Since 1981, slavery has been prohibited by all individual states. However, slavery and forced labour remain prevalent. According to ILO, globally 40 million people were victims of modern slavery, including 25 million people in forced labour with 11% of victims working in agriculture and fishing (International Labour Organization, 2017).
Definition	Forced labour is any work that is performed involuntarily and under the threat of punishment (ILO Convention No. 29 on Forced Labour).
Scope: impact drivers	Cultivation: working relationship and conditions, protective safeguards and monitoring Processing: working relationship and conditions, protective safeguards and monitoring Storage and transport: not applied in pilots, but possible
Performance reference point	No forced labour
Metrics	$TC_{FL} = FL * MF_{FL}$ Forced labour can be measured along the eleven ILO indicators of forced labour (International Labour Organization, 2012). They include: • deception • restriction of movement • isolation • physical and sexual violence • intimidation and threats • retention of identity documents • withholding of wages • debt bondage

	• Abusive working and living conditions • Abusive of vulnerability • Excessive overtime According to ILO, the presence of a single indicator may in some cases imply the existence of forced labour. However, in other cases it may be necessary to look for several indicators which, taken together, point to a forced labour case. In the here presented methodology, a worker is classified as forced labour if three or more out of the eleven indicators apply. If less than three indicators apply the formular is FL = 0 If three or more indicators apply the formular is FL = h * 0.5DALY With $h = \sum_{i=1}^{n} h_i$ Where: TC_{FL} = true cost of forced labour (EUR) FL = forced labour (DALY) MF_{FL} = MF_{CL} = monetisation factor (EUR/DALY) h = total annual working hours worked per forced labourer i
Unit	DALY
Required data — **Cultivation and processing level**	Primary data: number of people in forced labour, working hours per person per year
Recommended tool/ guidance for impact quantification	With access to the required data, the above metrics provide enough to calculate this indicator; it is recommended to also refer to EU Guidance on due diligence for EU businesses to address the risk of forced labour in their operations and supply chains https://trade.ec.europa.eu/doclib/docs/2021/july/tradoc_159709.pdf
Monetization	The costs of medical treatment
Monetization factor	MF_{OHS} = 80,000 EUR_{2017}/DALY (Raad voor de Volksgezondheid en Zorg, 2006)
Verify data	Secondary source: Social audits
Directly affected stakeholders	Forced workers and their families
Sustainable development goals	SDG 5 Gender Equality (Target 5.2) and SDG 8 Decent Work and Economic Growth (Target 8.7)

Category 9 Gender discrimination

Background info	Gender discrimination at the workplace involves treating employees or job applicants differently or less favourably due to their sex, gender identity, or sexual orientation. Workplace gender discrimination comes in many different forms such as being insulted, harassed, paid less, denied a promotion, pay raise or training opportunity or not being hired because of the persons gender identity or sexual orientation. Gender inequalities can stem from different sources such as broader organizational structures, processes, and practices including leadership, structure, strategy, culture, organizational climate, as well as human resource policies. Gender discrimination, although predominantly an issue for women, can sometimes be directed towards men as well. Addressing gender inequality is essential to achieving sustainability in agriculture (for more information, see Chapter 6 of (OECD, 2021)).

Indicator 8.3 Gender pay gap

Rational/Materiality	Unequal pay is one form of gender discrimination. The GPG reduces women's lifetime earnings and affects their pensions - this is one of the significant causes of poverty in later life for women.
Definition	The GPG is the difference between male and female net earnings.

Scope: impact drivers	Cultivation: employment conditions, wages, human resource policies, discrimination policies Processing: employment conditions, wages, human resource policies, discrimination policies Storage and transport: not applied in pilots, but possible
Performance reference point	Equal pay for equal work (refers to the requirement that men and women are paid the same if performing the same job in the same organization)
Metrics	$TC_{GPG} = GPG * CER$ If both the wages of man and women are above the local living wage, the formula for GPG is $GPG = \sum_{i=1}^{n} [(S_H - S_L) * H]$ if $S_L > LW$ If one of the wages is above local living wage and the other below the local living wage, the formula is: $GPG = \sum_{i=1}^{n} [(S_H - LW) * H]$ if $S_H > LW$ and $S_L \leq LW$ If both wages are below the local wage, the formula is $GPG = 0$ if $S_H \leq LW$ With: $S_H = j_1 + j_2 + ... + j_m / m$ $S_L = i_1 + i_2 + ... + i_n / n$ Where: TC_{GPG} = true cost of gender pay gap (EUR) GPG = gender pay gap (local currency) CER = currency exchange rate to EUR S_H = average salary per hour of the sex with the higher salary (local currency/hour) S_L = average salary per hour of the sex with the lower salary (local currency/hour) W = local living wage (local currency) (see local living wage indicator for more information) H = standard working hours per employee and year; that is 1840 hours/year inside Europe and 2,240 hours/year outside Europe n = number of workers of the sex with the lower salary i m = number of workers of the sex with the higher salary j
Unit	Local currency

Required data	**Cultivation and processing level**	Primary data: monthly net wage per female worker and male worker Secondary data: local living wage
Recommended tool/ guidance for impact quantification		See living wage indicator
Monetization		Not necessary
Monetization factor		Exchange rate to EUR
Verify data		Primary source: wage statements
Directly affected stakeholders		(Mostly female) workers and their families
Sustainable development goals		SDG 5 Gender Equality

4 Monetization factors

In order to calculate the true costs of a product (or that of a whole company), the change in a capital stock due to a company's activities needs a monetary value to assess the impact on well-being. The monetary value assigned to environmental, social and human impacts are expressed as monetisation factors. Assigning monetary value allows for the comparison of different impacts; for example, the outcome of a social capital indicator can be compared to that of a natural capital indicator. See section 2.3 for more information on the monetisation approaches used.

Table 4 shows a list of monetization factors used in the TCA methodology. These factors are based on studies from different years and in different currencies. Here, they are presented in their original base year and currency.

Table 4: Monetization factors

Impact indicator	Source	Monetization factor (original)	Base currency	Base year	Unit
Greenhouse Gas emissions	(Eco-cost Value, 2022)	116.00	EUR	2022	tonne CO_2eq
Carbon Stock	(Eco-cost Value, 2022)	116.00	EUR	2022	tonne CO_2eq
Soil erosion	(FAO, 2014a)	27.38	USD	2014	tonne soil
Soil organic carbon build-up	(Ligthart & van Harmelen, 2019)	100.00	EUR	2014	tonne Soil Organic Carbon (SOC)
Water stress	(Eco-cost Value, 2022)	1.00	EUR	2022	m^3 water under water stress
Water pollution	(Eco-cost Value, 2022)	4.70	EUR	2022	kg PO_4eq
Acidification	(Eco-cost Value, 2022)	8.75	EUR	2022	kg SO_2eq
Eutrophication	(Eco-cost Value, 2022)	4.70	EUR	2022	kg PO_4eq
Eco-toxicity	(Eco-cost Value, 2022)	340.00	EUR	2022	kg Cu eq
Human toxicity	(Eco-cost Value, 2022)	80,000.00	EUR	2022	DALY
Living wage gap	The outcome of this indicators is a monetary value				
Occupational health & safety	(Velden & Joost G. Vogtländer, 2017)	80,000.00	EUR	2017	DALY
Excessive working hours	(Velden & Joost G. Vogtländer, 2017)	80,000.00	EUR	2017	DALY
Gender pay gap	The outcome of this indicators is a monetary value				
Forced labour	(Velden & Joost G. Vogtländer, 2017)	80,000.00	EUR	2017	DALY
Child labour	(Velden & Joost G. Vogtländer, 2017)	80,000.00	USD	2017	DALY

5

Calculation and aggregation of true costs

Chapter 3 has shown how to estimate the true cost per indicator. However, this information can further be aggregated for the purpose of broader analysis and reporting. This chapter describes examples of how true cost information can be aggregated at different levels and what needs to be considered when doing so.

The total true cost of a material or product at one stage in the supply chain is calculated as the sum of the true cost of all indicators:

$$TTC = TC_{GHG} + TC_{CS} + TC_{SE} + TC_{SOM} + TC_{WS} + TC_{WP} + TC_{A} + TC_{E} + TC_{ET} + TC_{HT} + TC_{LWG} + TC_{OHS} + TC_{EWH} + TC_{GPG} + TC_{FL} + TC_{CL}$$

Where:

TTC = Total true cost of a material/ product at one supply chain stages (EUR)
TC_{GHG} = True cost of GHG emissions
TC_{CS} = True cost of carbon stock
TC_{SE} = True cost of soil erosion
TC_{SOC} = True cost of soil organic matter build-up
TC_{WS} = True cost of water stress
TC_{WP} = True cost of water pollution
TC_{A} = True cost of acidification
TC_{E} = True cost of eutrophication
TC_{ET} = True cost of eco-toxicity
TC_{HT} = True cost of human toxicity
TC_{LWG} = True cost of living wage gap
TC_{OHS} = True cost of occupational health & safety
TC_{EWH} = True cost of excessive working hours
TC_{GPG} = True cost of gender pay gap (EUR)
TC_{FL} = True cost of forced labour (EUR)
TC_{CL} = True cost of child labour (EUR)

Table 5: Example of the true cost of an apple puree supply chain (imaginary numbers and values)

				Farm (apple)		Processing 1 (apple puree)		Total (over all supply chain stages)
Supply chain	**Capital**	**Impact category**	**Impact indicator**	**Main impact driver**	**true cost (in €/kg)**	**Main impact driver**	**true cost (in €/kg)**	**true cost (in €/kg)**
#3	Natural	Climate	GHG emissions	Diesel of farm machines	0.30		0	0.35
			Carbon Stock	Conversion from conventional to reduced tillage	-0.20			-0.24
		Soil	Soil erosion		0			0.00
			Soil organic matter build-up		-0.30			-0.35
		Water	Water stress	Irrigation in region with moderate water stress	0.23	Water use without recycling	0	0.28
			Water pollution		0		0	0.00
			Acidification		0		0	0.00
		Ecosystem	Eutrophication	Diesel of farm machines	0.10		0	0.12
			Eco-toxicity		0		0	0.00
	Human	Human health	Human toxicity		0		0	0.00
		Worker remuneration	Living wage gap	Wage gap for lowest wage class	0.15		0	0.18
		Working conditions	Occupational health & safety	Work in high temperature and direct sun	0.01	Accidents during operating machines	0.02	0.03
			Excessive working hours		0		0	0.00
	Social	Gender inequality	Gender pay gap	Lower pay of female employee	0.01		0	0.01
		Human rights violation	Forced labour	Work in high temperature and direct sun	0		0	0.00
			Child labour		0		0	0.00

Note: production ratio: 1.18 kg of apples for 1 kg of apple puree; empty cells: indicator not applicable for this supply chain stage

Disaggregated information on the impacts or true cost per individual supplier for a single product (see example in Table 5) is very useful for company-internal decision making. For example, as compared to other sustainability assessments, detailed TCA results can serve as a basis to derive supplier-specific recommendations for changes in production management practices or risk prevention.

In other cases, aggregated results are required or preferred. For example, this might be the case if a company is deciding whether to quit or change individual supply chains (e.g. change from conventional to organic pork) or the entire production of a specific input (e.g. change from animal-protein to plant-based protein). Another example is the reporting of TCA results in a business's annual report, where the company wants to inform about the overall company's impact on specific sustainability and business issues, as well as how they addressed these issues.

Since the TCA methodology of the True Cost Initiative follows a scope from cradle to gate for each product or supply chain that is being assessed, the TCA results obtained at farm and processing level need to be aggregated to derive the total impacts across all supply chain stages. Results can be aggregated on the basis of indicators, impact categories, products, regions, etc. depending on the information that the results shall provide. As shown in the horizontal calculations in Table 6, to derive the total true cost of a supply chain or product, the true cost per supplier tier must be added up along the supply chain as per the formula below:

$$TC_S = TC_{S1} + TC_{S2} + \ldots + TC_{SX}$$

Where:
TC_S = Total true cost of supply chain S (in EUR)
TC_{SX} = True costs at tier 1 till tier X supplier (in EUR)

From this also the true cost per tonne can be estimated:

$$tc_S = TC_S \,/\, (Q_{S1} + Q_{S2} + \ldots + Q_{SX})$$

Where:
tc_S = True cost of supply chain S per tonne (in EUR/tonne)
TC_S = Total true cost of supply chain S (in EUR)
Q_{SX} = Quantity of the material/product at tier 1 till tier X supplier

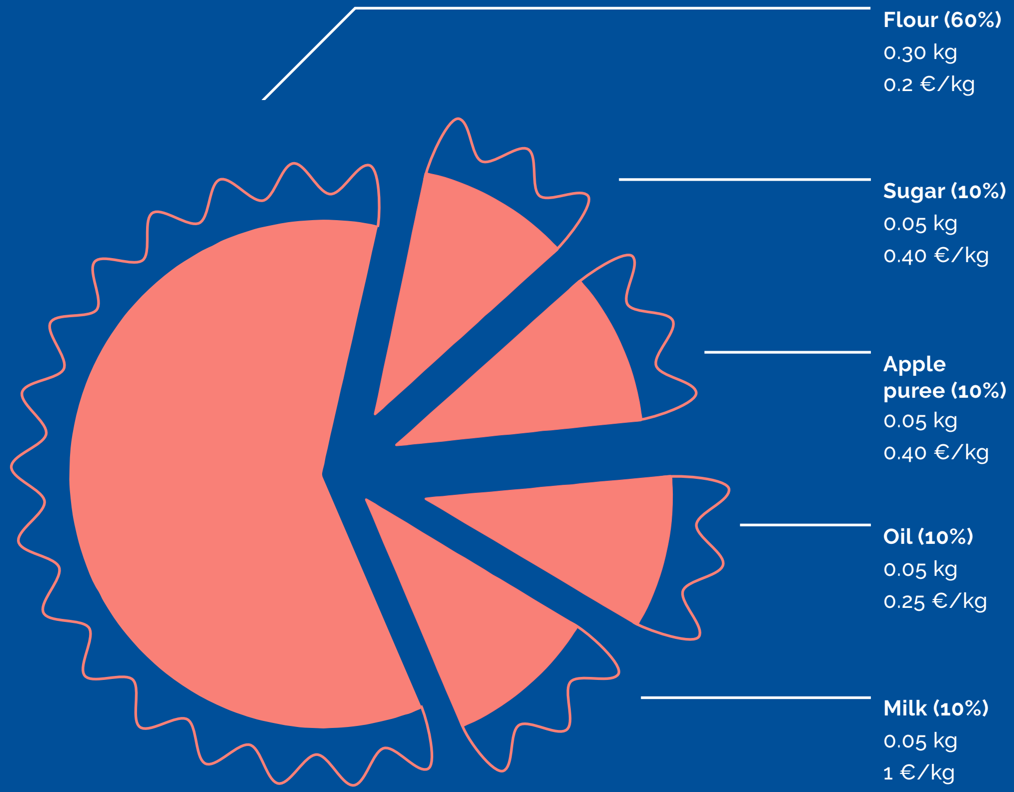
Table 6: Simplified example: True Costs of an apple pie (imaginary numbers and values)

		Farm tier 2 (apple)	Processing tier 1 (apple puree)	production ratio	Total (over all tiers)
Supply chain 1	Amount	100 kg	90 kg	1.11	90 kg
	True Cost per kg	0.10 €/kg	0.01 €/kg		0.12 €/kg
	Total Cost	10 €	0.90 €		10.90 €
Supply chain 2	Amount	1,000 kg	800 kg	1.25	800 kg
	True Cost per kg	0.20 €/kg	0.02 €/kg		0.27 €/kg
	Total Cost	200 €	16 €		216 €
Supply chain 3	Amount	10,000 kg	8,500 kg	1.18	8,500 kg
	True Cost per kg	0.30 €/kg	0.03 €/kg		0.38 €/kg
	Total Cost	3,000.00 €	255.00 €		3,255.00 €
Company's total apple procurement	Total amount	11,100 kg	9,390 kg	1.18	9,390 kg
	Total True Cost (per supply chain stage)	3,210.00 €	271.90 €		3,481.90 €
	Average true cost per kg	0.29 €/kg	0.03 €/kg		0.37 €/kg

Note: In the pilots, real data was used. Here in the example, fictitious figures were used due to confidentiality of the pilot results.

Average true cost for apples: 0.29 €/kg
Average true cost for apple puree: 0.37 €/kg
Average true cost for apple pies: 0.16 €/kg

In-house processing (apple pie)



Number of pies: 187,800 pies

Total amount: 272,310 kg

Total True Cost (for entire pie production): 43,852.93 €

Average true cost per pie: 0.16 €/pie

As shown in the vertical calculations in Table 6, the average true cost of a material or product can be estimated by assessing the true cost of all tiers of all the supply chains. In this case true costs are aggregated in two steps: first, the sum of true cost per tier is formed (e.g. tier 3: apple growers, tier 2: transportation, tier 1: puree makers) and second, the true costs of all tiers are added up. In some instances, it might not be feasible for a company to assess all its suppliers. In this case representative samples should be taken. See Appendix I for information on how representative samples can be formed.

Step 1: Aggregating the true costs of all suppliers (or sample of suppliers) per tier

The total true costs for a supplier tier (or sample of suppliers per tier) can be derived as follows:

$$TC_{tq} = \left(\sum_{i=1}^{n} TC_{sq}\right) / \left(\sum_{i=1}^{n} Q_{sq}\right)$$

Where:
TC_{tq} = True costs of tier t for product q (EUR/tonne)
TC_{sq} = True costs of supplier s for product q (EUR)
Q_{sq} = Total quantity Q of material/product q produced by supplier s (tonne)
n = number of suppliers in tier t (or sample of tier t)
The same procedure is repeated for all tiers.

Step 2: Aggregating the true cost across all tiers

It is important that the aggregation takes into account that a raw material/product changes in weight along the value chain- such as a product that is harvested fresh and dried in the processing stage. Below is an example of aggregating across supplier tiers the true cost per tonne of tier 1 product. Here the formula has been simplified to a two-tier supply chain:

$$TC_q = (TC_{fq} \times R_{fq} + TC_{pq}) / Q_{pq}$$

With

$$R_q = (P) / F$$

Where:
TC_q = True costs of tier 1 product q (EUR/tonne)
R_{fp} = ratio of product quantity P at tier 1 (processing level) p to material quantity F at tier 2 (farm level) f
TC_{fq} = Total true costs at tier 2 (farm level) f of material/product q (EUR)
TC_{pq} = Total true costs at tier 1 (processing level) p of /product q (EUR)
Qpq = Total quantity Q of material/product q at processing level p sourced by company (tonne)

6

Reporting

Through TCA, sustainability can find its way into economic and financial decision making. The external reporting of true costs is an elementary aspect of the transitional power of TCA. The reporting of true cost results will allow stakeholders such as shareholders and creditors, the financial administration and supervisory authorities as well as the interested public to include information on a business's impacts (inside-out perspective) and financial risks (outside-in perspective) in relation to the four capitals (natural, social, human and produced capital).

For TCA to become a key performance indicator (KPI) for credit ratings, insurance conditions or subsidies, true cost results need to be integrated into the annual report of businesses – the most important report to external stakeholders. Years of delineating Corporate Social Responsibility information in a separate, undefined sustainability report have shown that the separation has led to inadequate consideration of sustainability information in businesses' decision making. Long overdue, sustainability information is by now recognised as financially and business-relevant information and, according to the proposal of the EU CSRD, from 2023 onwards, this information must explicitly be integrated into annual business reports.

While several organisations (Capitals Coalition, Global Alliance for the Future of Food, Value Balancing Alliance) are working on the development of procedural guidelines for TCA assessments for businesses, this chapter contributes to the development of TCA by offering guidance on the reporting of true costs in businesses' annual reports. Firstly, the chapter presents the necessary principles and prerequisites of TCA to align with standard accounting rules. Secondly, a position for TCA reporting in General Purpose Financial Reporting (GPFR) – the management report – is suggested. It provides guidance on how to integrate the TCA report into management reports, using the example of German reporting. Finally, an outlook on TCA reporting under the new EU CSRD is offered.

6.1 Conditions and requirements for True Cost Accounting reporting

6.1.1 Objective and scope of True Cost Accounting

The objective of TCA is to provide information about a reporting entity's true costs and values in food systems through the measurement and monetization of hidden outsourced costs and benefits (i.e. 'externalities').

TCA is to be performed at the company/group level and at the product level. At the company/group level, TCA is intended to assist users of the information in assessing management's use of, and impact on, economic resources including natural, social and human capital and related risks and opportunities for the reporting entity's product ("double materiality"). TCA data are also expected to be integrated into the control and risk management systems of the reporting entity and their financiers, as useful information for decision-making.

At product level, TCA data provides useful information for suppliers and buyers (e.g. business-to-business procurement and supermarket customers). An example is climate TCA;[19] it displays the climate footprint and cost of a product thus informing not only business' procurement decisions, but also aims to inform and protect consumers.

This chapter focuses on the reporting of TCA information regarding the true costs in business' supply chains.

6.1.2 Target groups of True Cost Accounting reporting

Since TCA provides "double materiality" and concise information on the impact of and risks for an entity, TCA reporting forms part of an enterprise´s value and sustainability reporting. Depending on the reporting regulation to be applied, TCA reporting must be included in the entity´s financial reporting, especially in light of the upcoming EU CSRD. More specifically, for EU financial reporting, TCA must be included in the management report of GPFR.[20] End users of this report are considered to be shareholders and creditors, supervisory and enforcement authorities, employees, business associates and the interested public in general.

In addition to annual reports, TCA information on a product level addresses business clients and consumers. This relates to TCA data that is also requested by customers, such as climate TCA indicators/emissions data of delivered products in particular.

Furthermore, TCA information supports the discussion on necessary changes in the regulatory framework aiming at the transformation of today's non-sustainable food system worldwide. Public procurement in several countries is about to include initial steps of a climate TCA in the cost effectiveness calculations of public tendering.[21] TCA information therefore also addresses administration and politics.

19 See Chapter 2.
20 See section 6.2.2
21 See International Bank for Reconstruction and Development / The World Bank, Green Public Procurement: An Overview of Green Reforms in Country Procurement Systems, 2021; for Germany: Allgemeine Verwaltungsvorschrift zur Beschaffung klimafreundlicher Leistungen (AVV Klima), 2021.

6.1.3 Applying conceptual accounting and reporting elements for True Cost Accounting

An accounting and reporting framework that embraces basic accounting and reporting principles is a necessary supplement to the TCA Conceptual Framework, and to the technical/methodological procedure of conducting TCA (such as outlined in Chapters 2-4). This will allow TCA to meet decision usefulness requirements similar to those for GPFR, and also requirements for assurance engagement.

Having said that, to be of international relevance, the reporting framework for TCA presented in this chapter is primarily based on the IFRS Conceptual Framework. Therefore, the IFRS's underpinning principles must apply to the application and disclosure of TCA assessments and outline fundamental concepts for TCA reporting. This will provide guidance for the development of TCA standards. Applying these international standards to TCA includes qualitative and technical aspects such as:

- Guidance on what is to be reported;
- Guidance on the main of assessments;
- Definitions of metrics or other matters that are to be reported; and
- Measurement or evaluation bases to be used and other reporting policies, including those for presentation and disclosure.[23]

The application of international accounting and reporting principles to TCA is described below.

6.1.3.1 Relevance

Applying the TEEBAgriFood Evaluation Framework for a TCA assessment ensures that all relevant social, environmental, human, and economic elements along the entire value chain are included in TCA. Relevant TCA information is capable of making a difference in the decisions made by users. This is the case when TCA information has predictive value, confirmatory value or both. TCA indicators[24] also provide relevant information not only for users, but also for enterprise value reporting and risk management processes.

6.1.3.2 Materiality

Materiality is an aspect of relevance and refers to the importance/significance of impacts to which the information relates.

22 IFRS Conceptual Framework for Financial Reporting, 2021; further more Technical Readiness Working Group, General Requirements for Disclosure of Sustainability-related Financial Information Prototype, November 2021, ISAE 3000 rev; GRI 1: Foundation 2021; General financial reporting principles, Art 6 of the EU Accounting Directive 2013/34/EU; Art. 19b (2) of the draft CSRD.
23 Non-Authoritative Guidance on Applying ISAE 3000 (Revised), 169, on principle-based criteria assuring auditability.
24 See Chapter 3.

TCA reporting is considered to be material if omiting, misstating or obscuring TCA information could potentially influence decisions that users make on the basis of the reported information.[25] The materiality of each TCA indicator is specified in Chapter 3.

6.1.3.3 Comparability

Comparability is also an aspect of relevance. Comparability of TCA information enables users to identify and understand similarities and differences between entities and products, and to capture developments and performance of an entity or product over time. Consistency as regards accounting policies as well as reliability as sub-principles of comparability are to be respected.

Comparability of TCA reporting within financial reporting requires the disclosure of at least prior-year data of TCA, if available.

At the product level, comparability of TCA requires the reference object – the denominator – to be precisely defined. In question here is the quantity of the normal harvest or the actual harvest including possible crop failures. In accounting, idle costs[26] from underemployment are excluded from the manufacturing costs calculation. This also ensures comparability over time. TCA at a product level must accordingly be related to the quantity of the normal harvest of each supplier (hereafter referred to as 'normal TCA'). The concept of "normal harvest" – with normal variation – and irregular variation will need to be defined in further work on TCA.[27]

In order to compare products and entities with different sustainable supply chains regarding their true impacts over time, TCA information with reference to the actual harvest quantity must also be disclosed, if there is a significant deviation in the harvest quantity (hereafter referred to as 'actual TCA').

Comparability purposes require providing information on each individual TCA indicator even if TCA can be presented as a single or aggregate number for each of the three capitals. This is especially the case if TCA is not used as a concise single indicator for consumers in supermarkets at the price tag.

Furthermore, complementary contextual information must be given to enhance comparability of TCA data. This aims at helping users understand the root causes that contribute to differences between an entity's TCA data and the data of other entities, as well as TCA data for one entity or product over time. This is especially the case in the event of crop failures causing comparatively high TCA data related to the actual harvest quantity in this period. It also applies in the case of structural changes within the supply chain and changes to measures mitigating risks and adverse impacts within the supply chains, leading to significant changes in TCA data.

25 Conceptual Framework CF 2.11; Technical Readiness Working Group, General Requirements for Disclosure of Sustainability-related Financial Information Prototype, November 2021, 10.
26 Idle cost is the opportunity cost (benefit foregone from the next best alternative) occurred due to a status of non-production or various disruptions in the business operation.
27 See section 6.1.3.4.

6.1.3.4 Connectivity and alignment with General Purpose Financial Reporting

TCA assessments with the objective of providing TCA data for annual reporting must be aligned to GPFR. This includes connectivity that allows users to understand the interrelationships, dependencies and trade-offs that exist between TCA disclosures and other information in GPFR.[28] Furthermore, alignment with GPFR includes generally accepted accounting principles applicable also to TCA.

Connectivity requires the entity to disclose TCA data for the same reporting period on which the entity's GPFR are based.

If possible, TCA assessments should be conducted in a timely manner to the procurement of the respective products; all relevant information on reasonably required corrections, for example due to missing reliability or accuracy of data known at the time of the preparation of the financial statements, must be taken into account.
If procured inventories are stored beyond the balance sheet date, the TCA values that were originally measured must be attributed to them also in the subsequent period. A numerical reconciliation especially of the acquisition and production costs of food inventory and the turnover must be made.

Materiality

An impact or dependency on [...] capital is material if consideration of its value, as part of the set of information used for decision

Natural Capital Protocol (Natural Capital Coalition, 2016)

Materiality assessment

The process that involves identifying what is (or is potentially) material in relation to the true cost accounting assessment's objective and application

Purchasing power parity (PPP)

Currency exchange rate that equalises the purchasing power of different currencies. This means that a given sum of money, when converted into US dollars at the PPP exchange rate (PPP dollars), will buy the same basket of goods and services in all countries. Thus, PPP is the rate of currency conversion which eliminate the differences in price levels among countries

UNESCO Institute for Statistics (2021)

Concerning generally accepted accounting principles, the concept of accrual accounting must also be applied in order to be comparable with TCA reporting. Similarly, this applies to financial accounting when events occur in one period but economically relate to other or several reporting periods. For example, for TCA, this is the case when the useful life of crops and means of production whose impacts are included in TCA span more than one reporting period. In this case, the allocation for TCA must be made on an accrual basis.

Especially in the case of perennial crops and tree crops, from sowing or planting to the last harvest, harvest volumes are not equally distributed each year. In order to achieve comparability of TCA data in the case of 'normal TCA', it is necessary to estimate the total normal harvest quantity over the lifetime of the crops and to define the average annual harvest quantity as the reference quantity of TCA on a product basis. In the case of 'actual TCA' the real annual harvest quantity is used for the TCA calculations.

28 As this regards connectivity, see also Technical Readiness Working Group, General Requirements for Disclosure of Sustainability-related Financial Information Prototype, November 2021, 21.

Also, the process of currency translation of the monetization data and inflation correction must be considered, as they are also issues of financial reporting. With TCA data that can be defined as monetary items, the currency translation procedure in the financial statements also for TCA is referred to.

Concerning inflation adjustments, financial accounting today follows a nominal capital maintenance concept. Only in the event of hyperinflation, adjustments are made for inflation effects in order to express the values of financial statement items in terms of the purchasing power at the balance sheet date. However, it is recommended to follow ISO14008:2019[29] for inflation adjustments and indexing every three years for better comparability of internationally measured TCA data adjusted for inflation.

6.1.3.5 Connectivity to Sustainability and Enterprise Value Reporting

Connectivity of TCA to various forms of Sustainability and Enterprise Value Reporting can be ensured by applying international accepted accounting and reporting principles as outlined in this TCA Handbook.

Once technical criteria for the implementation of the EU Taxonomy framework to facilitate sustainable investments in the food and agriculture sector are approved, the taxonomy alignment of agricultural measures can be included in the measurement of TCA natural capital indicators.

The disclosure of turnover and capital expenditures (CAPEX) as well as operational expenditures (OPEX) ratios in accordance with Article 8 of the EU Taxonomy Regulation will also form part of TCA reporting. Higher operational expenditures, for example those stemming from sustainable procurement of agricultural products, must also be included.

Science-based GHG emission reduction targets and the measurement of their achievement through climate TCA indicators[30] can also be anchored in TCA assessments and reports.

With regards to the new enterprise value reporting that is emerging worldwide on the basis of Task Force on Climate-related Financial Disclosures reporting,[31] climate TCA data can be used for the GHG emissions reporting and as a baseline indicator for climate-related risks within the food supply chain.

There also can be several interconnections with regulations on due diligence in supply chains. For example, as of the 1st of January 2023, in accordance with the German Act on Corporate Due Diligence in Supply Chains, companies are required to comply with human rights due diligence requirements in their supply chains in an appropriate manner. Among others, the due diligence requirements include:

29 Point 6.6.4, International Standard, 2019.
30 Consistent with the level of decarbonization required to limit warming to 1.5°C or well-below 2°C.
31 For example, the development of new enterprise value reporting standards by the newly announced International Sustainability Standards Boards (ISSB).

- The establishment of a risk management system and complaints procedure designed to identify human rights risks from direct and indirect suppliers;
- An event-driven implementation of due diligence with regard to risks at indirect suppliers in the event of knowledge of risks of violations of human rights due diligence obligations; and
- The documentation and reporting on related governance and processes.

As these due diligence obligations contain issues such as child and forced labor, work safety, antidiscrimination and appropriate remuneration, there are large thematic overlaps of risk management procedures under the Due Diligence Act and TCA assessments on human and social capital.

The data generated for TCA assessments will impact the level of due diligence that can be effectively implemented in the supply chain, while in turn risk management data for due diligence as such can be used to verify the reliability of the corresponding TCA data.

6.1.3.6 Practicability

Cost-benefit-considerations for TCA assessments have to be made. A simplification of the evaluation is permissible under cost-benefit considerations. If there are several suppliers – and TCA values – for a product, an average evaluation (also applied in financial accounting) can be carried out for TCA at product level. The rules for 'average evaluation' will need to be further defined in future work on TCA.

Practicability also guides the application of sampling procedures.[32] Typically, an entity does not know all suppliers in its supply chain; with regards to cost-benefit-considerations, a TCA assessment for each individual supplier cannot be carried out. Nevertheless, in order to be able to carry out a complete assessment in the supply chain, it is recommended that TCA averages values. For example, climate TCA data for potatoes procured must be used for each TCA indicator in accordance with an official TCA database that needs to be set up if no individual assessment is carried out. Further work on this (e.g. by developing a database for TCA averages) must be done.

If TCA is to be implemented by law, then mainstreaming it can be implemented as a process. For example, one can start with readily-available indicators (e.g. climate), and add more indicators as they become available.

6.1.3.7 Faithful presentation

Like traditional financial information, TCA needs to be neutral, accurate and complete in order to be useful. As is the case for GPFR, the objective for TCA is to maximize those qualities to the extent possible.

32 See section 6.1.3.8.

Neutrality is supported by the exercise of prudence and diligence. Yet, faithful presentation does not mean accuracy in all respects. The use of reasonable estimates is an essential part of the preparation of TCA reporting. This does not undermine the usefulness of the information if the estimates are clearly and accurately described and explained. Part of a TCA reporting therefore has to be the disclosure of reasonably applied estimates.

Completeness means that no relevant factors that could affect the decisions of intended users be omitted.[33] Furthermore, a complete depiction includes all information necessary for a user to understand the scenario, including all necessary descriptions and explanations. Therefore, the sub-principle of completeness also leads to the need for numerical TCA data to be supported by contextual information.[34]

Completeness of information requires completeness of the definition of TCA assessment criteria, such as the definition of which suppliers are to be included in a TCA assessment.[35]

6.1.3.8 Reliability and verifiability

Reliable criteria for TCA assessments allow for a reasonably consistent outcome when used in similar circumstances by different entities. Applying the principle of reliability typically results in TCA information that is capable of being audited because sufficient evidence can be obtained based on the information.[36]

In order to meet practicability requirements, a sampling procedure aligned with Product Environmental Footprint Category Rules (PEFCR) 7.5 (European Commission, 2018) should be used for TCA assessments rather than simply conducting additional individual assessments. With the objective of forming reasonable sub-populations of suppliers/products for each indicator which meet reliability requirements, it is recommended to first conduct an initial TCA assessment for every supplier/product. Thereafter, depending on the comparability of the respective indicators, sub-populations can be formed for each indicator, and within these sub-populations, sampling methods can be applied in the following years. Further work has to be done to specify and simplify the formation of sub-populations especially where secondary data is concerned.

To ensure the accuracy and transparency of TCA reporting, TCA assessment procedures have to be documented. These include stating which governance and oversight structures, systems, processes and controls are in place to prevent or to detect and correct misstatements, taking into account their potential causes. This forms a precondition for audit, as in both limited and reasonable assurance engagements, the auditor aims to obtain evidence to respond to risk considerations.[37]

For natural capital indicators, integration of satellite imagery (and its preferably AI-supported analysis) is strongly recommended, as well as that of GPS-linked photographs as evidence for specific measures digitally provided by the supplier.

For human and social capital indicators, it is essential to also include secondary risk data like international child labor risk maps as well as data obtained through complaint procedures and information systems; by law, these have to be implemented to secure care standards in supply chains.[38] Further work on the verification of natural, social and human capital data has to be done.

6.1.3.9 Understandability

Understandable criteria result in subject matter information that can be understood by the intended users. Applying understandability should typically result in TCA information that will enable the intended users to readily identify the main points being made and to infer whether they are sufficiently significant to affect their decision-making. This is likely to be assisted by a clear layout and presentation of TCA information in a way that effectively summarizes and draws attention to these points.[39]

As such, the concept of TCA serves to capture the complex sustainability impacts and risks within food supply chains. Additional information on each included capital and indicator must be given to ensure the understandability of TCA data.

6.1.3.10 Reporting channel and format

An entity shall disclose TCA information as a part of their GPFR. Subject to regulations or other requirements that apply to an entity, there are various possible places in GPFR where TCA information may be disclosed.

Depending on the regulation, TCA can or must[40] be included in an entity's management report where this forms part of an entity's GPFR. For example, individual reporting of items such as the acquisition costs of raw materials could be explained in the notes with reference to TCA in order to supplement the information content of the balance sheet and income statement with sustainability aspects. However, if this information contains insights on risks, opportunities and sustainability aspects, it is recommended to report TCA information collectively and solely in the management report and, if applicable, just with a reference to this in the notes.

If extensive documentation (that includes governance and oversight structures, systems, processes and controls) on the procedure of TCA needs to be provided as a precondition for the audit of TCA information, a full and comprehensive TCA report is also recommended. The report should also disclose all contextual information, data, governance and procedures on TCA.

33 The definition is based on the IFRS Conceptual Framework.
34 See section 6.1.3.3.
35 See section 6.1.3.8.
36 Non-Authoritative Guidance On Applying ISAE 3000 (Revised), 191 ff.
37 Non-Authoritative Guidance On Applying ISAE 3000 (Revised), 270
38 For example, see the German Law on Supply Chain Due Diligence, Section 8,9.
39 Non-Authoritative Guidance On Applying ISAE 3000 (Revised), 198 ff.
40 See section 6.2.

Future European Sustainability Reporting will have to be prepared in a machine-readable format and be digitally published. For this reason, it is recommended that TCA data be tagged as highly financially relevant, and tagged for providing sustainability impact-related information on food supply.

6.2 Reporting of True Cost Accounting indicators in General Purpose Financial Reporting

The following explains the function of TCA indicators within the traditional management report; in addition, the recommendations for TCA Management Reporting given also take into account the EU draft of the CSRD.

6.2.1 True Cost Accounting in today's management reports

The double materiality of TCA indicators predestines them as core elements for enterprise value as well as sustainability reporting. TCA indicators display sustainability issues that are of financial relevance. In the near future, these sustainability issues are likely to have an impact on the balance sheet and profit and loss account, for example due to increasingly higher purchase prices, provisions for probable losses, impairments or necessary investments. Therefore, TCA indicators should – or, depending on the regulation, must – already be reported in an entity's management report today.

For the management report, TCA indicators first of all can be classified as relevant quantitative "non-financial" KPIs. Financial KPIs are key figures that can have a direct impact on financial accounting data in terms of amount, and represent circumstances that are relevant to competition and success. Since TCA data typically move in the opposite direction to procurement prices in the short term but can be linked to increasing medium and long-term resilience - risk minimization, cost–reduction, earnings increase - in the supply chain, they are to be classified also as financial KPIs, relevant for enterprise value reporting.

6.2.2 Example for True Cost Accounting management reporting: Germany

In Germany, if TCA assessments are carried out and the indicators are reasonably used for business steering, they must be reflected and reported on in the management reports of a company.[41] Significant changes in the TCA indicators compared to the previous year must be presented and explained. If relevant, also information comprising also medium and long-term horizons must be given.

The calculation of financial KPIs must also be presented and if possible, a reconciliation to the figures of the financial statements must be included. If the reporting is based on a generally accepted framework, this should be stated.

41 See German Accounting Standard No. 20

Forecasts are to be provided on the most significant financial and non-financial KPIs; point forecasts (estimated data), interval forecasts or qualified comparative forecasts (e.g.: "We expect TCA indicators to decrease slightly in the 2022 financial year") are permissible. As there are financial and non-financial KPIs with regards to food supply chains, forecasts of TCA indicators should be included here.

The risk section of the management report must present and assess the effects of risks on the business, as well as the measures taken to limit these. Significant changes in risks compared to the previous year must be presented and explained. This risk section of the management report should include TCA reporting.[42]

Conversely, if TCA is not included in the management report of food companies, it should be clear that there are no effective measures in place measuring and tackling sustainability-related risks in the supply chain.

Recommendations for a TCA Management Reporting recognize not only this reporting example but also the detailed regulation within the draft for a CSRD as described in the following section.

6.2.3 True Cost Accounting in management reports under the European Union Corporate Sustainability Reporting Directive

In April 2021, the EC published the draft of the CSRD, paving the way for a new level of sustainability reporting within the management reports in the EU. The obligation to publish a "non-financial statement" – including taxonomy reporting obligations – which has so far only applied to listed companies and financial institutions with more than 500 employees, is thereby extended to all large[43] non-listed as well as all listed companies. According to the proposed directive the extended reporting obligation for large non-listed companies would be applied to financial years beginning after 1 January 2023 and for small and medium-sized listed companies starting 1 January 2026.

The current reporting content of the non-financial statement will also be significantly expanded by the Sustainability Directive and concretized for specific sectors. In this respect, a separate reporting standard including sector-specific indicators should also be expected for the agri-food sector; TCA should – or must[44] - be incorporated here.

In light of the EU CSRD, recommendations for disclosing TCA information in management reporting in the food sector comprise:

1. **Integration of TCA indicators on natural, social and human capital in the management report. At a minimum, TCA information aggregated on a company level has to be disclosed.**

42 However, if TCA is used for internal steering, this section must include TCA reporting.
43 Defined by Article 3 of the Accounting Directive 2013/34/EU, small, medium-sized and large undertakings are distinguished by reference to balance sheet total, net turnover and the average number of employees during the financial year.
44 See section 6.2.2.

2 **Disclosure of elementary information on the TCA methodology, process and governance including references to the TCA Framework used, and a statement on the time horizon applied - which has to include at least the next five years.**

3 **Reporting TCA information for each capital and indicator. This includes the disclosure of the monetized costs, a description of the double materiality, a presentation of the main impact drivers, the relative change compared at least to the previous year including effects on the financial risk position of the entity, if applicable, and an explanation of the current TCA values and their development.**

Explanations are especially required in a change of application of the TCA methodology; in the event of crop failures (or similar) causing comparatively high TCA results in comparison to years with 'normal' harvest amounts; in structural changes within the supply chain; and measures to mitigate risk and adverse impacts within the supply chains, leading to significant changes in TCA data.

4 **Estimated forecasts for TCA indicators at least for the next five financial years and at least as a qualified comparative forecast,[45] including an explanation of this.**

5 **TCA target plans, especially for the climate indicator, to ensure that the entity´s supply chain strategy is compatible with the transition to a sustainable economy and limiting global warming to 1.5 °C in line with the Paris Agreement. If target plans do not exist, include an explanation why.**

This must be done as a point forecast (estimated TCA indicators) or at least an interval forecast (range of estimated impact TCA indicators). The annual progress the entity has made towards achieving those targets must be reported with reference to climate TCA data.

6 **Commodity risk and opportunity report that present current and forecasted sustainability-related opportunities, risks and related strategic or mitigation measures for the supply chain (commodity risk and opportunities report), linked with TCA indicators, have to be reported for the most significant sustainability-related risks and opportunities within the supply chain.**

The sustainability-related root causes of supply chain risks such as drought, floods, storms, transport restrictions due to low water levels in rivers, lack of employees due to strikes or pandemics and, the planed and reached targets of risk mitigation, for example enhanced harvest security and reduction of crop failure risks, lower price fluctuations or better compliance with regard to supply chains due diligence requirements, must be reported. A special feature arises through connection with TCA data insofar as, for example, good climate or water stress TCA values also represent quantitative indicators for correspondingly lower natural capital risks and increased resilience in each case, to which descriptive references should be made.

Current and forecasted opportunities related to a sustainable supply chain strategy, mirrored in low TCA data, include enhanced quality and the development of potential new revenue streams such as from carbon accounting or the sale of sustainable food.

A concluding statement on the present and forecasted resilience of the supply chain, including information on price volatility, significant price increases and supply chain failures with references to TCA, has to be made.

7 **References and reconciliation of TCA indicators and related business transactions – like investments in sustainability-related supply chain resilience or amounts of sustainability -linked supply chain finance - to accounting; that means the figures of the balance sheet, income statement, the notes, the cash flow statement and statement of equity changes. In particular, a connection to the procurement prices paid shall be made for example, by disclosure of a surge/reduction of procurement costs relating to sustainable/unsustainable procurement of agricultural commodities and reduced/increased TCA indicators. Also, a reconciliation to the turnover relating to sales of products containing agricultural commodities with mitigated TCA indicators, and to guarantees or contingencies from supply chain due diligence duties shall be reported.**

45 See section 6.2.2.

7

Piloting approach

The TCA methodology was developed through an iterative process. The TEEB AgriFood Evaluation Framework served as a starting point, whence TCA indicators were developed and shaped into a comprehensive methodology. The TCA methodology was then tested with agri-food companies and their suppliers to ensure that the methodology is practical and relevant.

Pilot assessments were conducted in two consecutive and iterative phases. The first phase took place from May 2020 to August 2020 and focused on the assessment of impacts at farm level. The second phase took place from January 2021 to August 2021 and included the analysis of impacts at farm and processing levels as well as the impacts occurring during the transportation of the products. Twenty supply chains ranging from different types of plant-based products, such as fruits, vegetables, nuts, tea and coffee, to more exotic agriproducts, such as medical herbs and essential oils, were analysed. The pilot implementation was led by Soil &More Impacts and TMG with the support of member companies of the True Cost Initiative.

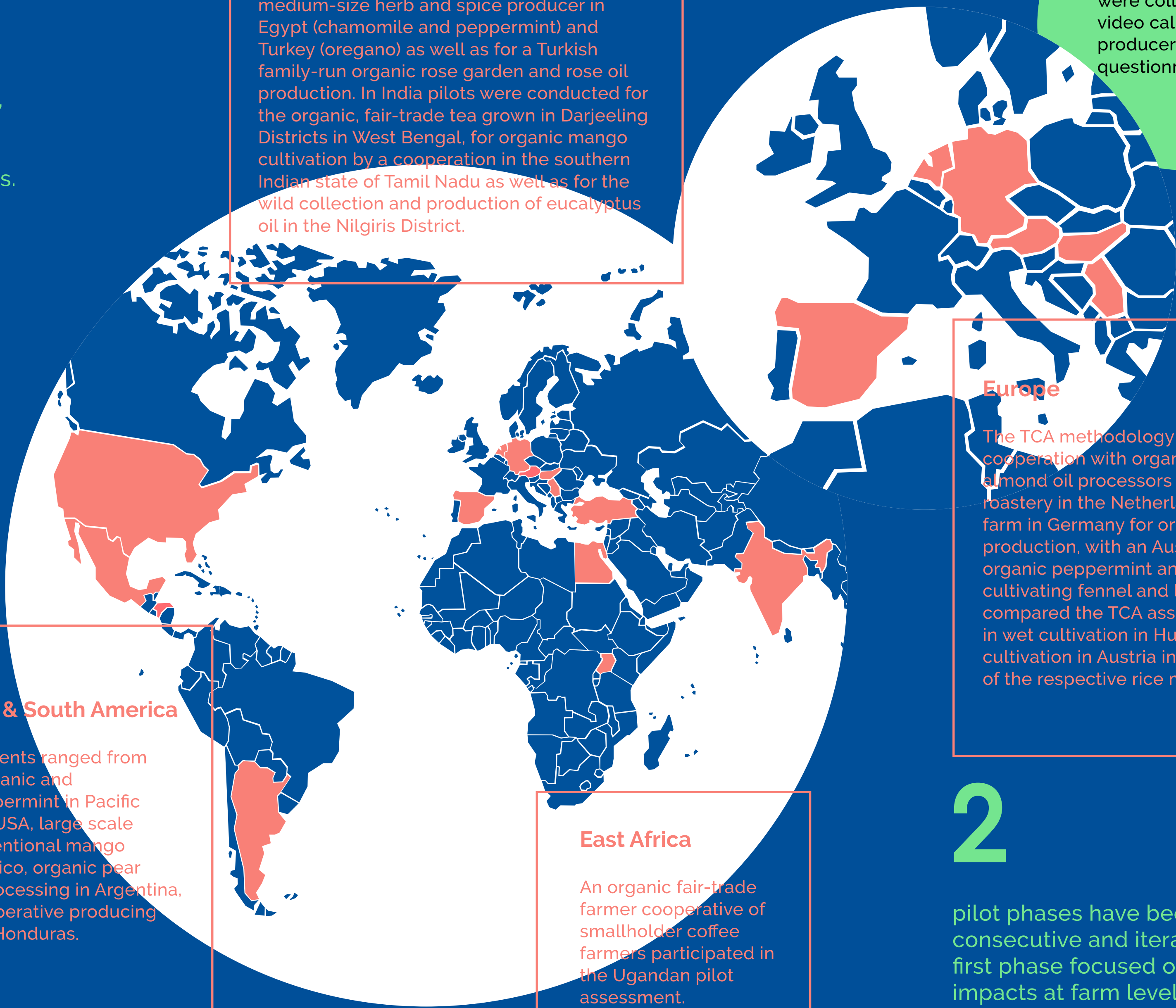
The pilots served to test the methodology and receive feedback from farmers, ranging from smallholder farmer's cooperatives to large scale farms, food processors and traders as well as different departments from food businesses such as procurement, finance and sustainability. The indicators and methodology were adopted based on the feedback and results; the TCA AgriFood Handbook is the outcome. The procedure undertaken for the pilots consisted of six phases; each phase contributed valuable insights to the development of the methodology. What follows is a detailed description of the six phases which serves to provide guidance for the implementation of future TCA pilots or assessments in agricultural supply chains.

20

different types of plant-based products have been assesed, such as fruits, vegetables, nuts, tea and coffee, as well as more exotic agriproducts, such as medical herbs and essential oils.

14

value-chains have been assessed. Based on the lessons from the living labs, the methodology is adapted to fit the reality of everyday business and undergoes an audit readiness check.



The data for the pilots were collected during video calls with the producers using digital questionnaires.

Middle East & South Asia

The pilots were conducted for an organic medium-size herb and spice producer in Egypt (chamomile and peppermint) and Turkey (oregano) as well as for a Turkish family-run organic rose garden and rose oil production. In India pilots were conducted for the organic, fair-trade tea grown in Darjeeling Districts in West Bengal, for organic mango cultivation by a cooperation in the southern Indian state of Tamil Nadu as well as for the wild collection and production of eucalyptus oil in the Nilgiris District.

Europe

The TCA methodology was tested in cooperation with organic almond farmers and almond oil processors in Spain, with a coffee roastery in the Netherlands, with a part-time farm in Germany for organic parsnip production, with an Austrian farm growing organic peppermint and a larger Serbian farm cultivating fennel and lemon balm. We also compared the TCA assessment of organic rice in wet cultivation in Hungary with that of dry cultivation in Austria including the assessment of the respective rice mill in both countries.

North America & South America

The pilot assessments ranged from family-farmed organic and conventional peppermint in Pacific Northwest of the USA, large scale organic and conventional mango production in Mexico, organic pear cultivation and processing in Argentina, to a women's cooperative producing Arabica coffee in Honduras.

East Africa

An organic fair-trade farmer cooperative of smallholder coffee farmers participated in the Ugandan pilot assessment.

2

pilot phases have been conducted in a consecutive and iterative process. The first phase focused on the assessment of impacts at farm level, while the second phase also assessed the impacts during the processing and transportation stages.

Figure 8: Countries and supply chains covered in the pilots of the True Cost Initiative

7.1 Phase 1: Develop a questionnaire

1 Identify data requirements based on indicators

A method for the estimation of each impact was selected (as shown in Chapter 3). Each of the tools and models that are part of the indicator's methodology come with a list of required data points. Many of these data points overlap - particularly for the natural capital indicators. Therefore, a list of all required data points was compiled based on which a questionnaire was designed that avoids double surveying of data points.

For some data points, several alternative questionnaire structures were designed to accommodate differences in data availability among respondents. An example is energy use, where no single best approach could be identified to make sure that the energy use would be allocated properly to the assessed raw material/product. Some suppliers can only provide the total energy use of the production site, while others can provide energy use for the processing of raw materials/products specifically.

2 Develop questionnaire format

For a higher expected efficiency in data management from respondents spread out over the globe, digital questionnaires were used. Exchanging the questionnaires digitally, auto-filling information, skipping irrelevant questions and auto-aggregating the data, considerably reduced the required time. The following applications were selected for data collection:

- Enketo:[46] an open source application for offline data collection developed to be compatible with xlsform - a programming language that is specifically designed for the authoring of digital questionnaires and implementable by users that are not schooled in information technology.
- ODK Aggregate:[47] an application for the storing, analysing and presenting of survey data. ODK Aggregate is part of the Open Data Kit[48] universe.

Enketo and ODK Aggregate (which are similar to other tools from the ODK universe), can be modified, hosted from a server of choice and no third party has access or control over the collected data. However, it requires support from information technology specialists to be set-up and maintained.

Tips

For a company without IT competence, ample data collection tools are available such as Google forms, Survey Monkey etc. The following features are recommended:

- Question types: The application should support at least text, numerical, multiple-choice questions and geographical coordinates. Other recommended question types are: Likert scales, dates, file uploading, photo uploading, digital signatures and the ability to collect metadata in the background such as auto-filling date, location and username.
- Dynamic: The form can respond dynamically to actions of the user, for example: If answer to question A is "tree crop", then present question B, otherwise continue to question C. Applications come with different degrees of complexity regarding dynamic features.
- Device and operating system: The application is compatible with a diverse range of devices (desktop, tablet, smartphone) and operational systems (Microsoft, Apple, Android).
- Data security: Application and database can be hosted from a server of choice (e.g within the EU).
- Language: Multi-language compatibility.

It should be noted that many tools cannot be operated offline. This can be a problem when agricultural producers want to collect data in the field, for example to take pictures for verification purposes, or if the suppliers are based in rural areas where internet connection is not available. The drawback of offline forms is that they are stored on the user's device and cannot be shared between different users (such as people with different responsibilities in a company) before submission.

Experience from the pilots showed that higher quality data can be obtained through live interviews with suppliers. If interviews are not performed on site in person, but are held remotely through a conference call, an internet connection is required; here, offline operability loses its relevance. In this case, a tool where the questionnaire can be operated jointly with the suppliers is preferable.

The average age of farmers worldwide is high[49] and their digital competencies cannot always be taken for granted. For this reason, the use of digital tools is currently not a perfect solution. Soil & More Impacts' longstanding experience with primary data collection on farms showed that printing, scanning and emailing of forms is still a preferred method for some suppliers, making many features of the selected digital tools irrelevant. Data collection that is fully digital and automized is therefore unlikely to be achieved. A flexible approach is necessary and allowing for additional time for technical support, communication and manual entry of data into the database is recommended.

46 https://enketo.org/
47 ODK Aggregate (https://docs.getodk.org/aggregate-intro/) is no longer maintained and ODK Central (https://docs.getodk.org/central-intro) should be used instead.
48 https://docs.getodk.org/

49 Only one in ten EU farm managers (11 %) were under the age of 40 years old in 2016 (Eurostat, 2021). In the USA, the average age of primary producers increased from 58.3 in 2012 to 59.4 in 2017 and for all producers from 56.3 to 57.5 years during the same period (USDA, 2019). In Kenya and for Africa on the whole, the average farmer is 60 and in Japan, with the highest average age for a farmer, it is 67 (FAO, 2014b) (Henriques, 2019). However, when not only considering the household heads but also including all individuals who spent some time on their own/family farm are considered, however, the average age goes down to 34 in the developing countries (Arslan, 2019).

3 Translate into other languages

The pilot took place with suppliers across different countries and language areas. Therefore, the questionnaire was translated, and units were adjusted to regional common systems where necessary, to allow for using both metric and imperial systems.

4 Test run questionnaire

The questionnaire was tested with a diverse range of people with different backgrounds (such as agriculture, other agri-food supply chain phases, LCA or corporate sustainability) to find out if so far the surveyed data points are clear and if the returned data was of sufficient quality.

Tips

This revealed that, due to the unavoidable complexity of many of the indicators and assumably also due to the total length of the questionnaire, many data points were still interpreted incorrectly, hints were not read, or answers misspelled. Seeing that a small detail can make a big difference, it was decided that alongside the digital questionnaires, supportive video calls between the research/data collection team and the respondents, and at best with an agrarian consultant who is familiar with the local or farm-specific context would take place. These calls served to get a better understanding of the context in which the respondent operates and to double check information.

7.2 Phase 2: Select supply chains

1 Select a material/product of interest

The participating agri-food companies were asked to specify one or more materials/products, of which they were interested to learn more about the true costs. Preference for a specific materials/product was either based on the quantity or volume sourced or thoughts on the sustainability performance of these materials/products.

Tips

Generally, it is recommended to choose materials or products based on the principle of (double) materiality.

2 Select individual supply chains and respective suppliers

While the purpose of the pilots was to test the methodology rather than to measure the TCA of a product, no sampled or randomized process was applied to select a representative group of suppliers. Instead, the participating companies were asked to select a variety of suppliers with different supply chain structures in order to test the TCA methodology in different contexts.

Tips

The selection of products, supply chains and supplier heavily depends on the reason why a TCA assessment is being performed. When wanting to report true cost at a company-basis (to project a realistic picture of the true cost and risk regarding all supply chains a company relies on), a sampling method that creates representative results should be used to select supply chains and respective suppliers to safeguard the accountability of results. See Appendix I.

3 Contact direct supplier and identify tier 2, tier 3, etc. suppliers

After selecting materials/products, supply chains and respective suppliers, tier 1 suppliers were contacted by the participating agri-food companies to examine the supply chain structure. In some cases, the tier 1 supplier is an agricultural producer and processor, while in other cases supply chains were more complex with additional tier 2 or higher tiered (tier 2+) suppliers involved. In the latter case, a selection was made for which of these tier 2+ suppliers were surveyed.

Tips

See Appendix I for instructions on a more generalised procedure of data collection for the purpose of deriving representative samples of the supply chains of an entire company. These were developed by one of the working groups of the True Cost Initiative.

7.3 Phase 3: Collect data

1 Inform suppliers

After the direct and indirect suppliers were selected, they were approached by the participating agri-food companies. Within each supplier company, a suitable contact person for the data collection was identified. Based on previous experience with the collection of primary data, these are usually 1-3 people in senior management positions such as production, human resources, or in the case of smaller organisations, the owner.

The contact person was informed about the study and asked for their willingness to provide the required data. Not all suppliers agreed – for various reasons (e.g. COVID-19 complications, lack of time) – after which an alternative supplier was searched for. The suppliers were informed on:

- The concept of TCA
- Information on the True Cost Initiative, including description of objectives
- Specific description of the pilot phase and respective objectives
- Estimate of time needed
- Data points requested
- Method of data collection
- Benefits of participation
- Planning
- Data privacy regulations

Tips

If the study is performed by a third party, it is recommended that the agri-food company approaches suppliers to ask for participation in the study. Data collection is a matter of trust so it should be clear to the suppliers why, how and where data is used and who has access to it. Clarity is also important - a supplier who is sufficiently informed before committing to participate is more likely to make the necessary efforts to provide data of good quality. The pilot showed that suppliers for whom the requested efforts and data requirements were not clear at the start, pulled out halfway during the surveying phase.

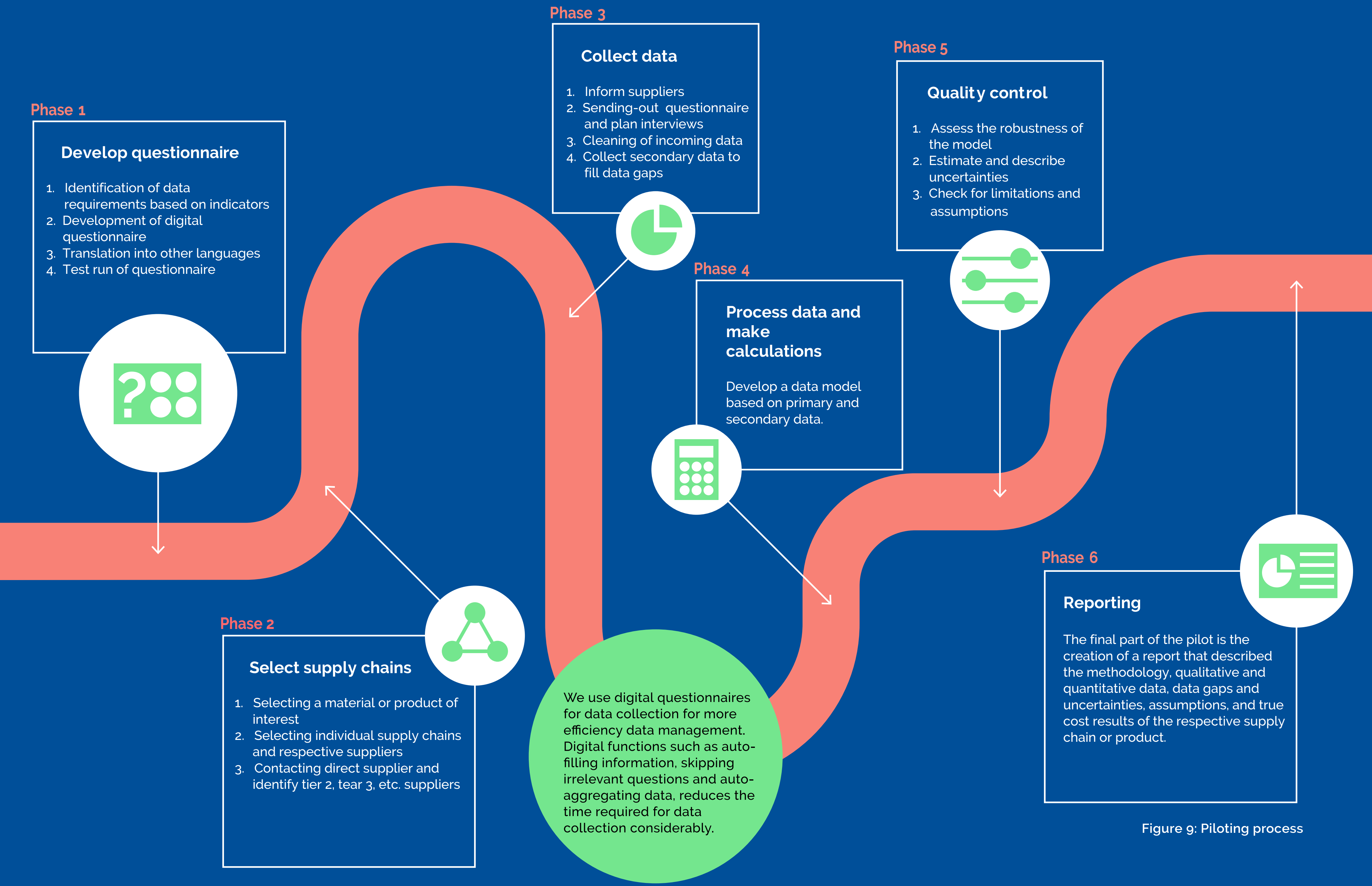


Figure 9: Piloting process

This can be avoided by providing sufficient information beforehand. It is not recommended to allow suppliers to choose which indicators they provide data on as this may create a data bias towards some indicators.

Due to seasonal peaks in the time requirements of their business, some suppliers did not agree to participate in the given period. It is therefore recommended to consider the seasonal characteristics of the chosen supply chain and plan on conducting the study during quieter periods.

2 Send out questionnaire and plan interviews

Once all suppliers were informed and agreed to participate, emails were sent out with a URL link to the questionnaire for preparation purposes, and a doodle[50] to plan a date and time for the digital interview. The participating agri-food companies were then asked to further coordinate the communication process with the suppliers.

Tips

It is recommended to book several time slots since agricultural producers in particular have an unpredictable work schedule and may need to cancel on short notice.

3 Clean incoming data

While some suppliers could be surveyed sooner than others, the data cleaning phase started in parallel with data collection. Incoming data was checked for unexpected or unrealistic observations. Even though the interviews had taken place through a conference call, this still proved to be a necessary process. Suppliers were contacted for confirmation or corrections of values so that the data collection phase could be closed with as little data gaps as possible.

Tips

A frequent mistake made by suppliers is that they provide data that is not disaggregated to the level of the assessed material/product. For example, the total energy use of a cereal dryer which processes several grain types is reported. However, for the assessment of the one specifically selected grain type, only the energy fraction used to process this one grain is of interest. By calculating the per unit (e.g. tonne) energy use and comparing it to reference data (such as Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL) data collections[51]), it can be determined if the reported data is accurate or if additional investigation/double checking is necessary. Similarly, for agricultural management, the per hectare or acre use of an input in comparison to reference data can reveal if allocation was performed correctly.

Follow up of missing data points or confirmation of the accuracy of data provided is best performed shortly after the interview while there is still momentum in the communication with suppliers and the submitted data is still fresh in their memory. Therefore, it is not recommended to wait on data cleaning until the data collection phase is closed. Moreover, learnings from the surveying of one supplier can lead to learning that will improve the process with other suppliers.

4 Collect secondary data to fill data gaps

Despite conference calls and a thorough data cleaning process, data gaps still had to be filled. Secondary data was used for this. As described in section 2.6, several criteria were used to ensure appropriate quality of secondary data: geographic, time, technological representativeness, completeness and parameter uncertainty.

7.4 Phase 4: Process data and make calculations

Separate datasets were compiled from reference data (e.g. the nutrient content of different types of animal manure, the living wage in certain countries, exchange rates and the monetization factor for each indicator). Based on this, a data model was developed. Lastly, algorithms were programmed to derive the outcomes and impacts for each indicator.

Tips

The important advantage of a data model over deriving the results manually is that the input data, reference data, and algorithms are made transparent and can still easily be adjusted without having to redo other steps of the process. Also, it avoids mistakes during the calculation process. Additionally, this data model can be used in subsequent assessments to load new data, repeatedly reducing time and resource requirements.

7.5 Phase 5: Quality control (not undertaken in the pilots)

The aim of the pilots was to test and learn from the process, rather than derive the TCA of materials/products – hence, no formal data quality control process took place. Instead, a simplified approach including plausibility checks on raw/primary data and calculated results was adopted, and an internal review of the modelled data performed. Additionally, an audit readiness check was conducted.

Tips

There is no specific comprehensive guidance on quality control of results, but ISO 14040 and PEFCR specify the following elements:

- assessment of the robustness of the model (completeness, sensitivity and consistency);
- estimation of uncertainty: statistical methods, worst/best case scenario modelling and/or qualitative description of uncertainties; and
- check for limitations and assumptions.

50 A free advertising-financed online service for creating appointment polls, see https://doodle.com/
51 https://www.ktbl.de/themen/datensammlungen

Info box 2: example – verification needs for natural capital data

Based on the experiences from the TCA Initiative pilots, it is recommended to verify the following natural capital data:

- Crop residue: quantity and treatment
- The use of soil conservation practises, such as soil cover, buffer zones and terracing
- Meteorological data: precipitation, temperature, humidity
- Geographical data: slopes and soil type
- Use of inputs: type and quantity (including organic fertilizers such as manure and compost)
- Energy use: fuels & electricity
- Irrigation use: volume, method and timing
- Changes in carbon stocks (soil and plant based)
- Transportation: quantities and distances

7.6 Phase 6: Report

1. True Cost Report

The final part of the pilot was the creation of a report that described the methodology, qualitative and quantitative data, data gaps and uncertainties, assumptions, and true cost results of the respective supply chain or product.

True costs were displayed in tables and bar charts showing true costs per indicator and supply tier (see Figure 9 and Table 7).

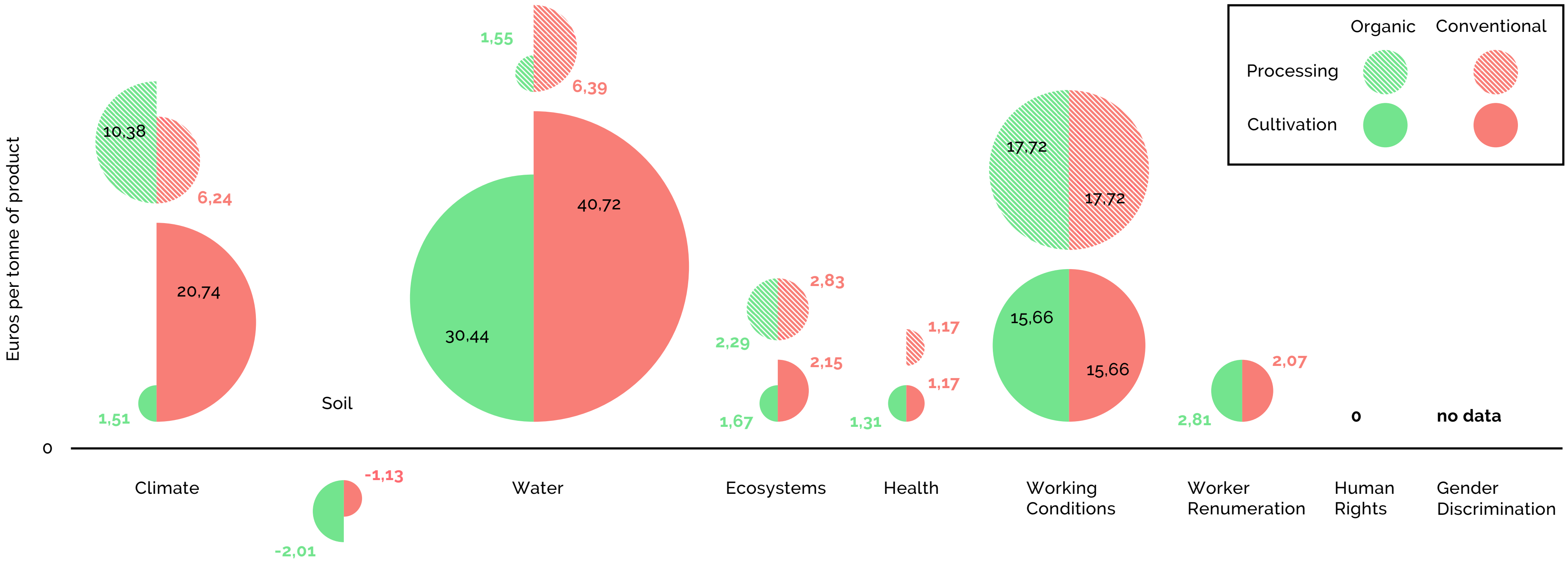


Figure 10: Example for displaying true costs (Fictitious figures for illustrative purposes only)

Table 7: Sample form of true cost display for a supply chain

Supply chain stage	Tier 2 (cultivation)			Tier 1 (processing)		Total	
True costs	€/tonne	€	€/ha	€/tonne	€	€/tonne	€
GHG emissions							
Carbon stock							
Soil erosion							
Soil organic matter build-up							
Water stress							
Water pollution							
Acidification							
Eutrophication							
Eco-toxicity							
Human toxicity							
Living wage gap							
Occupational health & safety							
Excessive working							
Gender pay gap							
Forced labour							
Child labour							
Total							

The true cost results can be of interest to different stakeholder groups such as:

- Different departments within the own company;
- Suppliers; and
- Externals, for example shareholders and creditors, financial administration and supervisory authorities, and the interested public.

For each stakeholder group a different type of reporting might be necessary or at least useful.

8

Requirements for scaling up true cost accounting in agri-food companies

The selective examination of impacts for specific supply chains can be very useful to a company, for example, to optimise the sustainability of those products with an extremely high negative impact. However, for TCA to unfold its full potential as KPIs for strategic management, to inform decision making of external stakeholders and to be included in GPFR, it needs to be scaled up:

- Along supply chains (assessing all stages of a product's lifecycle including downstream activities);
- Within a company (assessing up to 100% of all products and respective supply chains); and
- Across companies (ideally with all companies applying TCA).

An important prerequisite for external reporting to be meaningful and powerful is that the underlying calculation and presentation of true costs is standardised among businesses - or at least in a specific sector. This implies that uniform procedures are undertaken and hence results are easily interpretable and comparable. Only under the condition of standardisation can TCA become a KPI for credit ratings, insurance conditions, subsidies, etc.

Table 8 highlights technical and practical challenges that need addressing in order to pave the way for expansive adoption of TCA by agri-food business, as potential solutions to these barriers are within reach.

Table 8: Challenges and possible solutions for scaling up TCA

Area of concern	Barriers	Potential solutions
Methodology	**Inconsistency and opacity:** • TCA methods are under development by different (business) organisations. Consequently, TCA methods and results vary widely (e.g. regarding the impacts included or the stages of the value chain covered or the valuation method deployed). Lack of transparency and/or inadequate documentation of the applied TCA method make it even more difficult to interpret and understand TCA results of different organisations. • Sampling is a necessary approach to reduce resources for the annual data collection. However, existing guidelines on the sampling of agri-food suppliers for sustainability, such as the PEFCR (European Commission, 2017), do not specify what data to stratify on. This leaves much room to simplify the sampling process to an extent where the outcomes are unlikely to be representative.	**Consistency and transparency:** • The standardisation of TCA methodology including standardised reporting of TCA results in business annual reports could potentially enable transformative change of the agri-food sector. • Developing a standardised sampling approach specifically for TCA in agricultural value chains would allow to reduce data volumes and to make results more reliable and comparable across companies by impeding greenwashing. Appendix I provides a simplified sampling strategy as developed by the working group 'Suppliers' of the TCA initiative.
	Incompleteness: • Current TCA methods have scientific weaknesses. Appendix II shows the methodological weaknesses of this TCA methodology. • While the approach described in this report adopted 16 indicators, the agri-food sector is the source of a wider range of externalities which are currently inadequately covered. An example would be the many ways in which ecosystems are affected such as changes in the diversity of vascular and non-vascular species. • The TCA methodology by the True Cost Initiative (and that of many other organisations) is too narrow in its scope. However, it at least covers the major impact areas of crop cultivation, processing and transportation.	**Completeness:** • Additional research and development for impact modelling and measurement, monetisation factors and the design of indicators are required to overcome current methodological shortcomings. • Research and development of additional indicators that cover additional relevant sustainability topics such as impacts on biodiversity, the cocktail effect of different chemicals on human health, living income, etc. are essential for TCA to provide a holistic view. • Further development of TCA to expand the scope of assessment, including downstream activities and waste management, would be ideal ('cradle to grave'). Also, a methodology for animal production (e.g. dairy and meat production, aquaculture) needs to be further developed.
Implementation	**Time/human resource requirements:** • Involving suppliers in the collection of high-quality data requires considerable time/human resource investment from both the company conducting the assessment as well as participators in the value chain. Particularly for agri-food companies with a broad range of materials/products from diverse origins, the level of effort and resources needed to monitor first-tier suppliers (let alone upper-tier ones) can be very costly and time consuming. • In the case of lack of primary data, secondary data sources are often insufficient to fill in missing true cost information.	**Time/human resource requirements:** • Directing existing data flow, such as results from audits, certification, geo-information and benchmark databases, into data collection tools for TCA can help to considerably reduce data collection efforts. • Making use of newest technologies such as remote sensing and data warehouses can substantially reduce time requirements. • When a harmonized Standard for TCA has been established, a database should be developed that contains the average true cost of products and activities. This allows to benchmark TCA results of companies and offers a reliable source for secondary data if primary TCA data is not available. The database would also contribute to reducing primary data requirements.

	Lack of verification: • A transparent TCA assessment should be based on verifiable data, so that TCA results are trustworthy and can serve as an input or form the basis of decision making. Since value chain partners are economically dependent on their buyers, the provided data cannot be considered objective. At present there is no consensus on adequate verification methods of TCA data from agri-food supply chain data.	**Verification:** • A research project could address the issue of verification, for example by identifying critical data that needs verification as well as analysing different formats for verification (such as digital solutions, overlaps with certification schemes, etc.) and testing those approaches in living labs.
Communication	**Inaccessibility:** • The sensitivity, jargon and level of abstraction involved in TCA stands in the way of adoption by the non-scientific community of practise and agri-food sector. Additionally, the right implementation of TCA depends on a broader understanding of basic research methodology (interview techniques, sampling, weighting averages, uncertainty estimation, etc.). • At present, TCA results are very difficult for agri-food companies and their suppliers to interpret; starting with the definition of 'prevention costs' to the processes that affect the measured indicators, the measurement, as well as the action based upon these measurements must be scaled up. If action based on TCA results is to be scaled up, these actors are crucial for supporting quantitative data with qualitative interpretation derived from the knowledge of local contexts.	**Accessibility:** • Terms and considerations of TCA assessments can be harmonised to contribute towards a common understanding. Harmonisation processes are currently being undertaken by organisations such as the TCA Accelerator under the sponsorship of the Global Alliance for the Future of Food. • Stronger and more communication beyond the research community is necessary to inform businesses, policy makers and the wider public of the concept of true costs. • Actors, most importantly agri-food supply chain partners (including consumers), must be able to interpret the results of TCA assessments to formulate action. When TCA results can be presented in a way where both the meaning and drivers of results become clear, targeted action can be formulated together with local actors.

Appendix I – Data Collection: Prioritization and Sampling

For TCA information to be effective a large amount of primary and secondary data is required.[52] There are several advantages and disadvantages to using just one of these data types. A TCA assessment built upon primary data is more resource intensive but provides in-depth and more accurate information on the sustainability performance of the individual company. Using secondary data for the assessment is less resource intensive but only depicts the general or average situation at the sector level. Therefore, primary data better serves the creation of actionable guidance on sustainability performance in a food or agricultural company; it is recommended to use primary data as much as possible, complementing it with secondary data[53] where necessary.

To have complete transparency and representative information on the overall true cost of an agri-food company, the true costs of all materials and products should ideally be assessed. For the assessment of companies' supply chains this means that data from all supply chains and the respective suppliers needs to be collected.[54] This is especially important for the assessment of the cultivation of food and agricultural products since this step most often creates the highest impacts.

However, retrieving data from each farm and supplier is often not feasible or practical for large companies with large (and often long) numbers of supply chains. To make the assessment of true costs feasible for all agri-food companies, the True Cost Initiative explored sampling procedures for supply chain data with the aim of deriving a representative TCA result for a company's supplied materials (inputs). The developed procedure focuses on crop and plant-based agri-food products only. The proposed approach could eventually form the basis of standardised rules for agri-food companies; by considering how many and which suppliers need to be directly assessed, the available data can then be extrapolated to form an accurate assessment of true cost at a corporate level.

The developed sampling procedure mainly builds on the work of the GHG Protocol (Greenhouse Gas Protocol and Carbon Trust, 2013; Greenhouse Gas Protocol, 2011) and the PEFCR Guidance (European Commission, 2018). These are widely applied and reviewed documents which have proven to be useful in the standardization of foot printing and life cycle assessment. For process-oriented guidance, the TEEB For Agriculture and Food: Operational Guidelines for Business (Capitals Coalition, 2020) was referred to.

Step I: Prioritisation – Selecting (raw) materials

If it is not possible for a company to conduct TCA assessments for all the materials used in its production, it is necessary as a first step to decide for which materials TCA assessments will be performed. The methodology can be applied both to raw materials, (such as apples), and materials that have already been processed to some degree (such as apple juice). This can be done in two steps.

I.I: Categorising (raw) materials according to genus

First, all the different kinds of agricultural materials a company procures must be listed. To reduce the number of entries and facilitate the next steps crops or plant-based materials can be grouped according to their genus.[55]

> Example 1: If a company buys different types of mint such as peppermint, spearmint, nana mint, they can be grouped under their genus mentha.
> Example 2: If a company sources different types of citrus plants, such as orange, clementine, grapefruit, they can be combined under the genus citrus.
> If a procured material consists of multiple genera the different ingredients should be considered separately.
> Example: If a company sources apple puree (ingredients: beet sugar, apples), it should single out the ingredients and assign them to their group according to their genus ('beta' and 'malus').

Table 9: Template for grouping (raw) materials

Genus	(Raw) material
Mentha	Peppermint
	Spearmint
	Nana mint
Citrus	Orange
	Grapefruit
...	...

I.II: Selecting material genera

The decision of which agricultural material a company needs to assess should be made on the basis of the genus and according to the selection criteria recommended by the GHG Protocol (Greenhouse Gas Protocol and Carbon Trust, 2013) (p. 12). The recommendations originally relate to the identification of relevant scope 3 activities causing greenhouse gas emissions and are therefore suitable to determine the materiality of supply chains.

52 Primary data refers to internal business data or data collected from suppliers or customers for the assessment being undertaken. Secondary data is not collected directly from the assessed parties, but is instead derived from literature, past assessments or models.

53 For information on secondary data source for True Cost Accounting refer to the annex A of the TEEBAgriFood framework (TEEB, 2018) which provides a comprehensive overview of resources from which secondary data can be derived.

54 A TCA assessment does not necessarily have to take place every year. An assessment once every several years can already provide useful insights on progress made. It can therefore be decided to collect data from different products or suppliers each year, using previously collected data as secondary data in following years.

55 A genus is a taxonomic category ranking used in biological classification that is below family and above species. Species exhibiting similar characteristics comprise a genus. (Source: https://www.biologyonline.com/dictionary/genus).

Section criteria:

1 Spending analysis – a company buys a significant volume/mass (e.g. tonnes) of a material/product or at a significant cost (e.g. €)

> Example 1: A company (e.g. juice producer) decides to conduct TCA assessments for the 30 materials they buy the most of (in tonnes).
> 1. Malus – 1000 tonnes
> 2. Citrus – 900 tonnes
> ...
> 25. Punica – 10 tonnes
>
> Example 2: A company (e.g. juice producer) decides to conduct TCA assessments for the most expensive (total spending – not unit costs) materials that make up 50% of their purchase costs.
> 1. Citrus – 7% of total purchasing costs
> 2. Malus – 6 % of total purchasing costs
> ...
> 20. Mentha – 2% of total purchasing costs

2 Impact size – The material contributes significantly to the overall true cost (impact) of the company. This can be determined through initial TCA assessments of all supply chains or through estimates for each TCA indicator and their variables based on secondary data, expert opinions, or industry benchmarks (though the latter are currently only sparsely available).

> Example 1: Based on the initial TCA assessments, a juice producer decides to focus its TCA assessments on the materials that together make up 80% of the total true costs.
> Example 2: Based on expert advice, a juice producer will analyse in the first year the top 10 materials among the ingredient list with the expected highest true costs.

3 Influence – The material entails promising and realistic potential to reduce its true cost and is therefore prioritised.

> Note: This criterion can only be chosen if average true cost reference data is available for the respective genus or if a previous assessment of all materials has taken place, based on which reasonable

4 Risk – The material is suspected to contribute to the company's risk exposure (physical or transition risks).

> Note: This criterion requires a risk assessment. Assessing the true cost gives insights into the magnitude of the risks and identifies potential to reduce the external costs and risks. Information on region or crop-specific risks should also be consulted.

> Example: The cultivation of which crops bear high risks of injuries and illnesses? Which regions are subject to a lot of water stress? Which countries are prone to child labour and which for low wages?

It is recommended that the selection criteria are prioritised in the order presented here, with criteria 3 and 4 employed only if criteria 1 and 2 are not possible. The selection criteria and process for identifying materials for data collection should be justified and made transparent in the reporting (e.g. in a supplement or paragraph in an annual report as part of the reporting criteria).

Step II: Sampling – Identifying points for primary data collection

Once it is clear which materials need to be assessed, it needs to be determined from which supply chains[56] data should be collected. Priority for primary data collection efforts is given to primary production (step 2.1), followed by processing, transportation, and storage (step 3.1). The following steps need to be repeated for all material genera of a company's supply chain.

II.I: Identify primary producer for each supply chain per material genus

The TCA pilots conducted by the True Cost Initiative confirm the findings of existing literature that environmental (and to some extent also social and human) impacts are largest at farm level. This also holds true in terms of risks, such as crop failure through weather extremes caused by climate change, or breaches of human rights laws. Hence, for most indicators, the majority of data is needed from the cultivation stage of a raw material. This implies that agri-food companies need to be committed to investigating their supply chains and identifying the last tier supplier: the farm where the raw material is produced.

Table 10: Template for an overview of supply chains

Genus	(Raw) material	Supplier tier 1	Supplier tier 2	Supplier tier X
Mentha	Peppermint	Egyptian herb farm	-	-
		US-American herb farm	-	-
	Spearmint	Egyptian herb farm	-	-
	Nana mint	Indian farms	Indian wholesaler	Indian farm
Citrus	Orange	Spanish cooperative	Member farmers of the cooperative	-
	Grapefruit	Dutch wholesaler	Farm in the USA	-
...	...			

Note: Supplier = subject for data collection ("last supplier")

56 The term 'supply chain' refers to the number of suppliers involved in supplying a specific material or good and is defined by the sequence of processes involved in the production of that material or good.

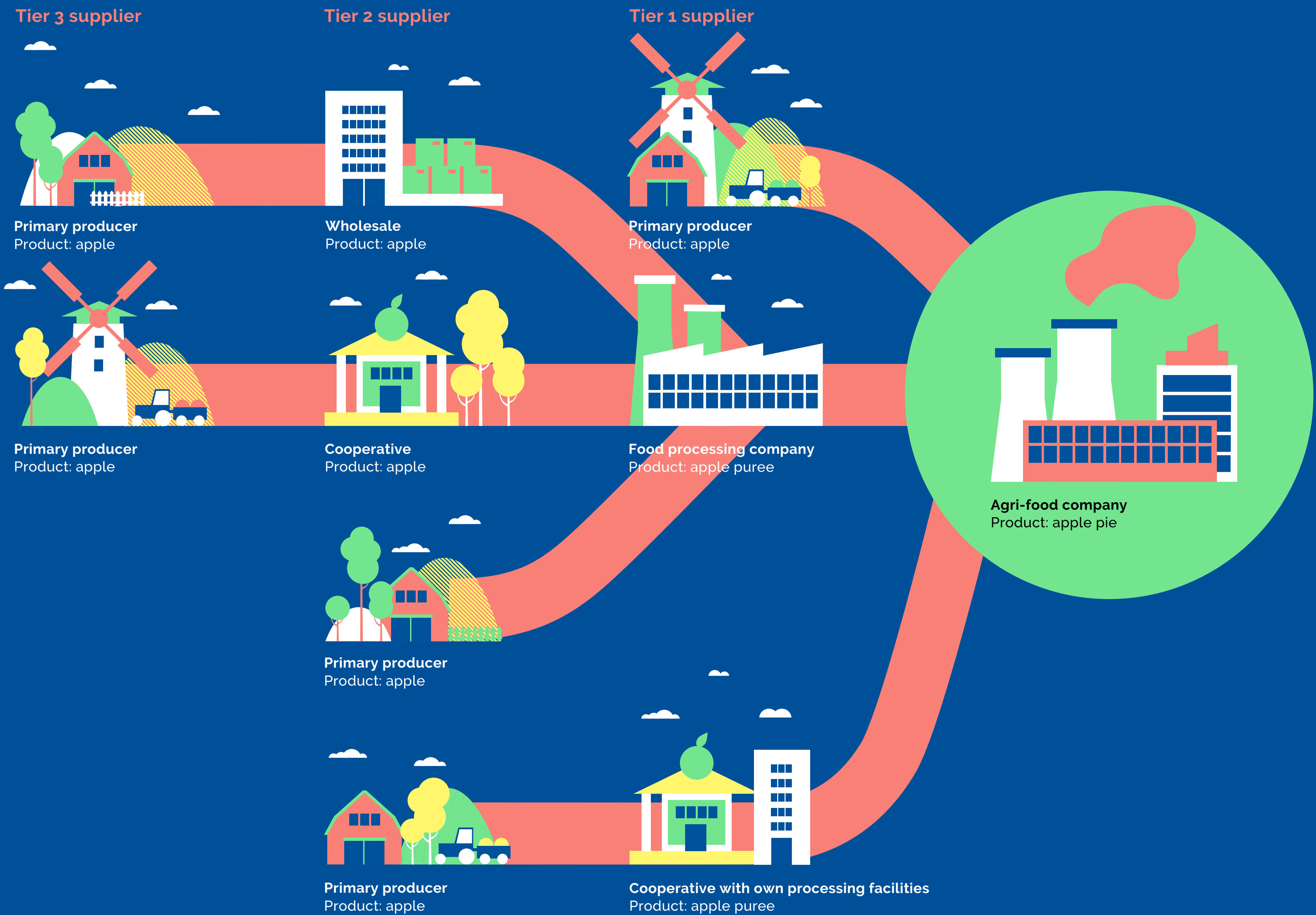


Figure 11: Examples of different supply chain structures

This may be relatively easy in cases where a direct business relationship to the farmer or a farming cooperative exists. It will be more difficult when materials are sourced through traders or from the world market (see Figure 6). Hence the first step a company needs to undertake for a TCA assessment is to map its supply chain structure and identify access point to the primary producers.

II.II: Identify sub-population for each genus

From here a company needs to determine whether data can be collected from all supplier farms. The total number of farms is usually the determining factor in assessing whether data collection is feasible or not.

If data can be collected from all primary producers, companies can skip the following steps and continue to section II.III.

If it is not possible, a company can reduce the number of farms that are assessed by applying the sampling procedure presented in PEFCR 7.5 (European Commission, 2018). This procedure allows for estimations of the true costs of a material based on their genus by collecting the data from only a subset of farms.

When a (raw) material is sourced from sites that differ in terms of geographical characteristics, farm management practices, or scale, a stratified sampling procedure is necessary to account for the variability in true costs between farms. A stratified sampling procedure ensures that farms from each sub-population are included in the final sample.

The following shows three relevant characteristics to define a sub-population per genus. They are based upon the PEFCR (European Commission, 2018):

1. The number of countries from which the product is sourced.
2. The number of different farming practices (this can be interpreted differently and could simply mean the distinction between organic and conventional, or more specific classifications such as agroforestry systems, or farms practicing regenerative agriculture).
3. The number of different production sizes of farms that the company sources from classified by production amount.

It is recommended to use primary data to extrapolate homogenous sub-populations if available; for example if it can be provided by supply chain partners. Otherwise, extrapolate homogenous subpopulations based on information gained indirectly. For example, farming practices can be inferred based on country information and certifications; the production quantity per farm can be used as an indicator of farm size.

Table 11: Example for the identification of sub-populations

Genus	(Raw) material	Last tier supplier	Country	Farming practice	Production capacity(tonne)
Mentha	Peppermint	Egyptian herb farm	Egypt	Organic	Medium
		US-American herb farm	USA	Conventional	Large
	Spearmint	Egyptian herb farm	Egypt	Organic	Medium
	Nana mint	Indian farms	India	Conventional/ organic	Large
	...	...	...	...	...
Citrus	Orange	50 member farmers of the cooperative	Spain	Agroecological	Small
	Grapefruit	Farm in the USA	USA	Organic	Medium
	...	Cooperative with 4 members	Morocco	Organic	Small

The number of sub-populations can be reduced by aggregating the classification per characteristics. For example, dividing farms into only two categories of farming practices (organic and conventional) or distinguishing geographical location according to larger regions (North America, East Europe, Sub-Saharan Africa, etc.).

III.III: Define the sub-sample size at sub-population level

According to the PEFCR (European Commission, 2018), for each sub-population the size of sample (the sub-sample size) can be determined in two ways:

1. By taking the square root of the sub-population size
   $N_{SS} = \sqrt{n_{SP}}$

   N_{SS} = sub-sample size
   n_{SP} = sub-population size

   In case rounding is necessary, the general rule used in mathematics shall be applied.[57]
2. By selecting farms that together make up at least 50% of the production (mass, e.g. tonne, or volume, e.g. litre)

57 If the number you are rounding is followed by 5, 6, 7, 8, or 9, round the number up. If the number you are rounding is followed by 0, 1, 2, 3, or 4, round the number down.

II.IV: Selecting primary producers for data collection

When selecting the actual farms from the sub-sample population, use a random sampling approach (randomizing tools are widely available.)[58] If the square root method was chosen, companies should randomly select the required sub-sample size (e.g. 7 farmers out of 50 citrus farmers in Western Europe). If the 50% approach was chosen, a company must randomly select farms until at least 50% of the production volume is reached.

Table 12: Example of stratified sampling using the square root approach

Genus	Sub-population	Country	Farming practice	Size	Nr. of farms in sub-population	Nr. of farms in sub-sample (square root)
Malus	1	Western Europe	Organic	Small	50	7
Malus	2	Western Europe	Organic	Medium	2	1
Malus	3	North America	Organic	Small	0	0
Malus	4	North America	Organic	Medium	3	2

If the farm size is homogenous, approach 1 usually leads to the lower (sub-)sample size. However, if the production of several farms is higher, approach 2 can be more practical. Both approaches can still lead to large (sub-)sample sizes that are not feasible. Particularly when dealing with smallholder farmers, the number of farms within a sub-population can be very high. It is important to make transparent when and how a smaller sample is selected to assess the TCA of a number of farms.

58 https://www.randomizer.org/

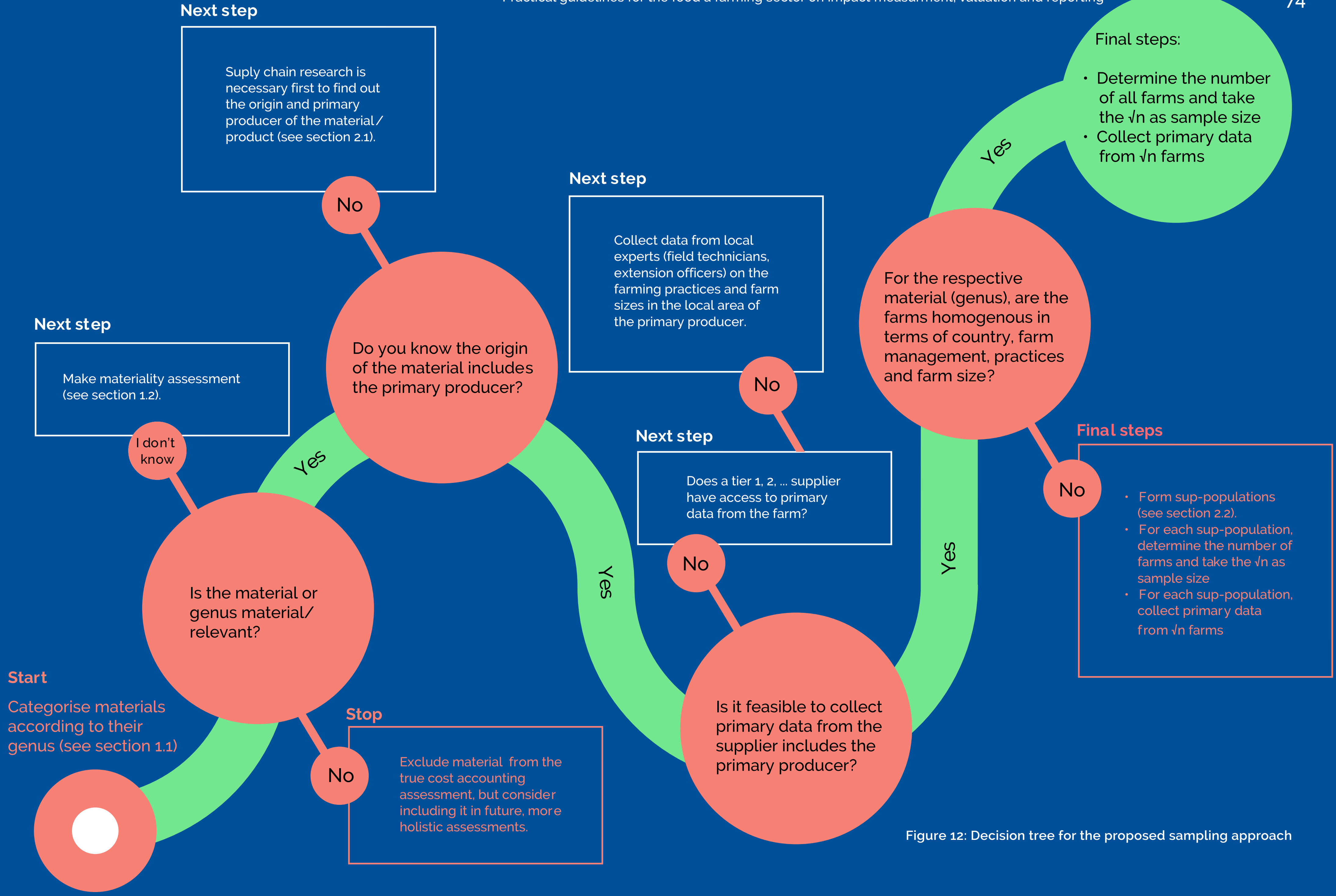


Figure 12: Decision tree for the proposed sampling approach

II.V: Identify and sample processors

Before (raw) materials are shipped to the country of destination, they often pass one or more stations where they are processed (e.g. graded, washed, aggregated or simply stored) for which several transportation trips might be needed. These activities contribute to changes in capital stocks (impacts) as well. For the indicators that are not restricted to the farm level, such as GHG emissions and water pollution, data will also have to be collected from the supply chain steps other than the farm.

Usually, the number of processors is lower than the number of primary producers in agri-food supply chains. Therefore, the efforts needed to cover sufficient intermediate stations will be lower.

The same technique as described under step II.II-II.IV can be used to select a sample of processing stations.

It is recommended to include transportation in the assessment of the previous supply chain step. For example: the fuel combustion of transportation from farm to processor are included in the farm level assessment, while transportation from the processor to port is included in the processing assessment. No separate sampling procedure is then necessary for the transportation phases.

Appendix II – Shortcomings of the TCA indicators

Table 13: Shortcomings of the TCA indicators

Indicator	Shortcomings
Greenhouse Gas emissions	• Incomplete: Currently, there exists a gap between "accessible but simple" farm GHG footprint models such as Cool Farm Tool which are used for this indicator and "complicated but extensive" approaches such as LCA software-based approaches. An ideal tool that is "accessible and complete" is currently missing. The Cool Farm Tool only provides a limited range of emission factors for fertilizers and crop protection products. However, LCA models and software also lack emission factors such as for organically certified inputs (e.g. organic nitrogen, phosphorus, and potassium fertilisers).
Carbon stock & soil organic matter build-up[59]	• Lack of primary data: Primary data on changes in carbon stocks through measurements such as periodic soil sampling or tree trunk diameter are often not available. • Lack of comparability: Comparability between measuring carbon stock changes and GHG emissions is not yet fully possible since LCA-models on measuring carbon stock changes are still being developed. • Scientific dissent: In practise, there are many carbon farming practises such as different types of green manure, fertilizers, tillage practises and inclusion of woody vegetation in cultivation systems where no consensus exists on their exact carbon stock potential.
Soil erosion	• Inaccuracy of estimates: Since direct measurement of soil erosion is unfeasible, models are used to determine soil erosion based on wind/rainfall intensity, terrain elevation and soil conservation practises. The pilot, in which the Revised Universal Soil Loss (RUSLE) model was used, revealed that the average slope of a field is often difficult to assess for agricultural producers while this estimate has a big effect on the soil erosion outcome. A method based on field-level satellite observations could provide improvements in accuracy. • Missing impact: For the pilot, no practical models could be identified to assess wind erosion. Such a model would add to the completeness of the soil erosion indicator.

59 In contrast to other LCA models, this indicator includes and accounts for carbon stock changes and hence decision makers can see the effect of different farm management practices on carbon stock changes.

Water stress	• Neglecting on-farm water management practices: The water stress indicator requires an estimate of the farm-level blue water footprint. The evapotranspiration volume determines the eventual blue water footprint. This is unfeasible to measure and therefore requires a model, for which CropWat by the FAO was used in the pilot. This tool predicts the irrigation requirements based on climatic data, but does not take into account water conservation practises on farm, such as mulching or deficit irrigation. This means that the effects of water conservation on the farm cannot be assessed.
Water pollution[60]	• Missing impact: This indicator is currently limited to the leaching and run-off of nitrogen and phosphorous from fertilizer application of which the eutrophication outcomes are monetized. The impact of the leaching and run-off of other pollutants such as chemical substances or metals is missing. • Missing research: Only the nutrient content of fertilizers has been assessed, but not the type of fertilizers. A much-heard critique is that specific fertilizers, in particular organic fertilizers such as compost, have a slower release of nutrients and therefore a lower run-off or leaching rate. More research should be done to obtain concrete answers to this critique, thus providing insights into the effects of organic fertilization on the water pollution indicator. • Double counting: While water pollution is an indicator name that is recognizable to the public and considered important by the agri-food sector, it would be scientifically more correct to include it as a sub-category of the indicators acidification, eutrophication and eco-toxicity. It should be made sure that there is no double counting of emissions.
Acidification, eutrophication, eco-toxicity & human-toxicity	• Double counting and missing impact: Since acidification, eco-toxicity and eutrophication consider partially similar substances as for example nitrogen-compounds, avoiding double counting can be challenging when applying the prevention cost approach. Understanding those mechanisms, can be challenging and difficult for users. Besides, region-specific background-pollution has an important role for those categories and is not being considered so far in the current TCA-methodology.

Living wage gap	• Secondary data missing: Once reliable living wage benchmark vales for a majority of countries and region values are available, the indicator will become more consistent. • Missing impact: The indicator only covers the issue of low earnings regarding wages, disregarding the income of smallholder farmers or family farmers. This neglects a huge part of the issue since 30% of food is produced by smallholder farms and 80% by family farms (FAO, 2021).
Occupational health & safety	• Missing primary data: Some of the required data might be subject to confidentiality.
Excessive working hours	• Missing primary data: The collection of primary data on working hours per employee proved to be very difficult in the pilots. On the one hand, there can be a lack of sufficient and credible documentation and on the other hand, if data is available, it can be difficult to handle. • Research gap: The assigned DALY requires further research.
Gender pay gap	• Wiggle room: It was difficult to predefine uniform job categories according to which the gap between genders can be measured. Hence it is up to each company or supplier to define those categories appropriately – which can potentially lead to inconsistency among TCA results. • Missing impact: The indicator does not show if one of the genders is not at all represented in a job category (e.g. if all senior managers are male). • Missing context: The indicators insufficiently consider potential reasons for wage differences (e.g. employee's experience). • Discrimination: It is a binary indicator and hence neglects people who identify outside the gender binary.
Forced labour	• Lack of verification: The here presented TCA methodology does not cover the verification of data. However, it is highly recommended to verify information on forced labour. • Research gap: The assigned DALY requires further research.
Child labour	• See forced labour

60 During the pilot, the grey water foot printing guidelines by the Water Footprint Network were used to derive the run-off and leaching of applied nutrients. This method accounts for factors such as farming practises that affect the run-off and leaching rate. Models such as this help the agri-food sector to assess the role that farmers can play in reducing water

Appendix III: Glossary

Term	Definition	Source
Baseline	State of environment or [other stock] against which changes in capital are valued.	ISO14008 (ISO, 2019) Natural Capital Protocol (Natural Capital Coalition, 2016)
Capital	The economic framing of the various stocks in which each type of capital embodies future streams of benefits that contribute to human well-being.	TEEBAgriFood (TEEB, 2018)
Human capital	The knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being.	TEEBAgriFood (TEEB, 2018)
Natural capital	The limited stocks of physical and biological resources found on earth, and of the limited capacity of ecosystems to provide ecosystem services.	TEEBAgriFood (TEEB, 2018)
Produced capital	All manufactured capital, such as buildings, factories, machinery, physical infrastructure (roads, water systems), as well as all financial capital and intellectual capital (technology, software, patents, brands, etc.).	TEEBAgriFood (TEEB, 2018)
Social capital	Encompasses networks, including institutions, together with shared norms, values and understandings that facilitate cooperation within or among groups.	TEEBAgriFood (TEEB, 2018)
Cultivation	The action of preparing the soil and raising crops on agricultural land.	Author's own elaboration
Data	Information, especially facts or numbers, collected together for reference or analysis and used as a basis for reasoning, discussing, or calculating.	Author's own elaboration
Primary data	Raw data or original data that are directly obtained during an observation, a measurement or a data collection specifically undertaken for the True Cost Accounting assessment.	Author's own elaboration
Secondary data	Data that were originally collected and published for another purpose or a different assessment.	Author's own elaboration
Qualitative data	Non-numerical, descriptive and conceptual findings collected through questionnaires, interviews, or observation; it describes qualities or characteristics.	Author's own elaboration
Quantitative data	Numerical data expressing a certain quantity, amount, value or range.	Author's own elaboration
Disability-adjusted life years (DALY)	One DALY represents the loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of the years of life lost to due to premature mortality and the years lived with a disability due to prevalent cases of the disease or health condition in a population.	WHO (2021)
Dependency (natural capital)	A business reliance on or use of [..] capital.	ISO14008 (ISO, 2019) Natural Capital Protocol (Natural Capital Coalition, 2016)
Eco-agri-food system	A descriptive term for the vast and interacting complex of ecosystems, agricultural lands, pastures, inland fisheries, labour, infrastructure, technology, policies, culture, traditions, and institutions (including markets) that are variously involved in growing, processing, distributing and consuming food.	TEEBAgriFood (TEEB, 2018)
Ecosystem services	Ecosystem services The contributions that ecosystems make to human well-being (e.g. classified by Common International Classification of Ecosystem Services into regulation and maintenance, provisioning, and cultural).	TEEBAgriFood (TEEB, 2018)
Externality	A positive or negative consequence of an economic activity or transaction that affects other parties without this being reflected in the price of the goods or services transacted.	TEEBAgriFood (TEEB, 2018)
Flow	A cost or benefit derived from the use of various capital stocks (categorized into agricultural and food outputs, purchased inputs, ecosystem services and residuals).	TEEBAgriFood (TEEB, 2018)

Impact	A positive or negative contribution to one or more dimensions (environmental, economic, health or social) of human well-being.	TEEBAgriFood (TEEB, 2018)
Impact driver	A flow (e.g. input or non-product output) which arises from the activities of agents (i.e. governments, corporations, individuals) in eco-agri-food value chains, resulting in significant outcomes and leading to material impacts.	TEEBAgriFood (TEEB, 2018) Natural Capital Protocol (Natural Capital
Impact pathway	Series of consecutive, causal relationships, ultimately starting at a stock, describing how an impact driver results in changes in [...] capital and what impact these changes have on different stakeholders.	ISO14008 (ISO, 2019) Natural Capital Protocol (Natural Capital Coalition, 2016)
Indicator	Something that shows what a situation is like by depicting a value or a change.	Author's own elaboration
Manufacturing and processing	Stages in the value chain, including the operations involved in converting raw materials into finished products.	TEEBAgriFood Implementation Guidance (Global Alliance for the Future of Food, 2020)
Materiality	An impact or dependency on [...] capital is material if consideration of its value, as part of the set of information used for decision making, has the potential to alter that decision.	Natural Capital Protocol (Natural Capital Coalition, 2016)
Materiality assessment	The process involving the identification of what is (or potentially is) material in relation to the true cost accounting assessment's objective and application.	Author's own elaboration
Measurement	The process of determining the amounts, extent, and condition of capital and capital changes.	Author's own elaboration
Monetization	The process of converting a metric or an impact into monetary terms.	Author's own elaboration
Outcome	A change in the extent or condition of the stocks of capital (natural, produced, social and human) due to value-chain activities.	TEEBAgriFood (TEEB, 2018)
Performance reference point	Condition at which an indicator becomes zero.	Author's own elaboration
Prevention cost	Prevention expenditure incurred by a company (or household or government) to mitigate or avoid particular environmental impacts or risks.	Author's own elaboration
Product	Agricultural raw material (e.g. apple) and processed materials (e.g. apple puree).	Author's own elaboration
Production	The first of four stages in the value chain, including activities and processes occurring within farm gate boundaries (including the supply of ecosystem services, the supply of goods and services, and connections between producers).	TEEBAgriFood (TEEB, 2018)
Purchasing power parity (PPP)	Currency exchange rate that equalises the purchasing power of different currencies. This means that a given sum of money, when converted into US dollars at the PPP exchange rate (PPP dollars), will buy the same basket of goods and services in all countries. Thus, PPP is the rate of currency conversion which eliminates the differences in price levels among countries.	UNESCO Institute for Statistics (2021)
Residuals	By-products of the cultivation and/or production processes that produce agricultural and food outputs.	TEEBAgriFood Implementation Guidance (Global Alliance for the Future of Food, 2020)
Scope	The extent of the area or subject matter that something deals with or to which it is relevant.	Dictionary (Lexico.com, 2021)
Stock	The physical or observable quantities and qualities that underpin various flows within the system, classified as being produced, natural, human or social.	TEEBAgriFood (TEEB, 2018)
True cost accounting	Evolving methodology to measure and value the positive and negative environmental, social, and health externalities in order to analyse the costs and benefits of business and/or policy decisions.	Author's own elaboration

Value	The importance, worth, or usefulness of a good or service - including all relevant market and non-market values - determined by people's preferences and the trade-offs they choose to make given their scarce resources, or the value the market places on an item.	TEEBAgriFood (TEEB, 2018) Natural Capital Protocol (Natural Capital Coalition, 2016)
Value chain	The full range of processes and activities that characterize the lifecycle of a product from production, to manufacturing and processing, to distribution, marketing and retail, and finally to consumption (including waste and disposal across all stages).	TEEBAgriFood (TEEB, 2018)
Wage	Compensation for work that includes both monetary and in-kind payment.	Author's own elaboration
Living wage	Remuneration received for a standard work week by a worker in a particular place sufficient to afford a decent standard of living for the worker and her or his family.	Global Living Wage Coalition (2018)
Worker	Waged employees hired to work including migrant, temporary, seasonal, sub-contracted and permanent workers.	Delta Framework (2020)
Migrant worker	A person who moves from one area within her or his own country or across the borders to another country for employment.	International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families (OHCHR, 1990)
Permanent worker	Person who works at a company on a regular, long-term basis and does not have a predetermined end date to employment.	Author's own elaboration
Seasonal worker	A worker whose work by its character is dependent on seasonal conditions and is performed only during part of the year.	International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families (OHCHR, 1990)
Temporary worker	A person who works at a company on a non-regular, short term basis; a temporary worker may be a seasonal worker.	Delta Framework (2020)

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Members of the True Cost Initiative

TMG – Think Tank for Sustainability
EUREF Campus 6-9
10829 Berlin

Soil & More Impacts GmbH
Address: Buttstrasse 3
22767 Hamburg