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True cost accounting applications for agrifood systems policymakers

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Background paper for *The State of Food and Agriculture 2023*

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Contents

Tables

Figures

Boxes

Abstract

Global agrifood systems have substantial hidden costs, contributing to climate change, ecosystem damage, the continued poverty of workers in agrifood systems and the occurrence of food-related health issues. At the same time, agrifood systems provide many benefits, not least food and livelihoods. It is a policymaker's task to balance these costs and benefits, which are typically borne and enjoyed by different stakeholders.

True cost accounting is an approach to measure and value the costs and benefits generated by agrifood systems in order to facilitate improved decision-making. The approach has grown substantially over the last ten years, although further harmonization of the field is needed to improve the comparability of different studies. The priority must be reaching agreement on a minimum list of indicators and a set definition of materiality (that is, how to assess which indicators are most important, so that they receive most attention in the analysis).

Against this background, this study analyses how true cost accounting can support agrifood systems transformation, and provides an overview of the different stages and steps that need to be done to undergo a true cost accounting study. Given that data collection is typically one of the hardest steps in true cost accounting, this study gives practical guidance on collecting (or estimating) different types of data. It concludes with recommendations for scaling the field of true cost accounting as a whole.

Keywords: True cost accounting, agrifood systems, policy, materiality, data collection.

JEL codes: C81, M41, M48, Q18, Q56.

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1 Introduction

1.1 Introducing true cost accounting

Agrifood systems are perpetually changing. Since 1960, agricultural production has been increasing both in absolute value – at a rate of 2.3 percent per year – and per capita terms (Alston and Pardey, 2014). Alongside the benefits of greater agricultural productivity, however, external (or hidden) costs from food production and consumption have become an increasingly significant problem. These costs are called external costs, as they are negative effects from market-based decisions that are not automatically included in the price. Market-based decisions are mainly based on financial costs and benefits, whereas external costs reflect natural, social and human capital values. Examples of external costs borne by society resulting from water pollution and unhealthy diets, for instance, include medical costs and reduced well-being.

A study by Lord (2023) covering 154 countries found that the global hidden (environmental, health and social) costs of agrifood systems in 2020 reached USD 12.7 trillion in purchasing power parity (ppp). Health costs constituted the largest part (USD 9.3 trillion),[1] followed by environmental costs (USD 2.8 trillion)[2] and social hidden costs (USD 0.5 trillion).[3] The estimated hidden costs are substantial, even when accounting for uncertainty, and in the same order of magnitude as the market-based added value of global food and land-use systems, at USD 10 trillion (The Food and Land Use Coalition, 2019).

The environmental drivers of external costs of the agrifood systems are significant (Ritchie and Roser, 2022): food production and agriculture are responsible for 26 percent of global greenhouse gas (GHG) emissions, 70 percent of freshwater withdrawals and 78 percent of global ocean and freshwater pollution (eutrophication). Social issues also persist, with approximately 8 percent of the global population (over 600 million people) living in extreme poverty in 2019 (World Bank, 2023a). Of these, 80 percent live in rural areas and rely partly on agricultural and natural resource-based livelihoods (United Nations, 2020b). Moreover, there are frequent examples of child labour and forced labour in the agrifood systems (ILO *et al*., 2022; ILO and UNICEF, 2021).

At the same time, many of the benefits of agrifood systems are hidden. Agrifood systems can preserve biodiversity, while regenerative agriculture can actively restore nature. Agrifood systems directly employ more than 1 billion people, so are key to preserving rural livelihoods and protecting innumerable cultural expressions (United Nations, 2020a).

Managing external costs and benefits is a crucial part of the job of policymakers in charge of agrifood systems at all levels, from global to local. Uncovering and reducing external effects is not always easy, given the wide range of external effects and the many different stakeholders affected. Trade-offs make policy decisions even more complicated, as interventions can reduce one type of external cost while increasing another. For example, promoting the use of agrochemicals might increase production and help lift people out of poverty, but at the same time lead to ecological degradation. See Section 2.1 for more on the “triple challenge” in agrifood systems.

[1] Human health costs consist of productivity losses from dietary choices (i.e. diets high in calories, sugars, salt and trans fats and low in nuts, seeds, fruits and vegetables).

[2] Environmental costs consist of GHG emissions, nitrogen emissions, water use and land-use change.

[3] Social hidden costs consist of extreme poverty costs and undernourishment.

1.2 What is true cost accounting?

TCA is a way to take different external effects into account in a structured way that could benefit decision-making. It can be used in commercial organizations, as well as for public policy purposes.

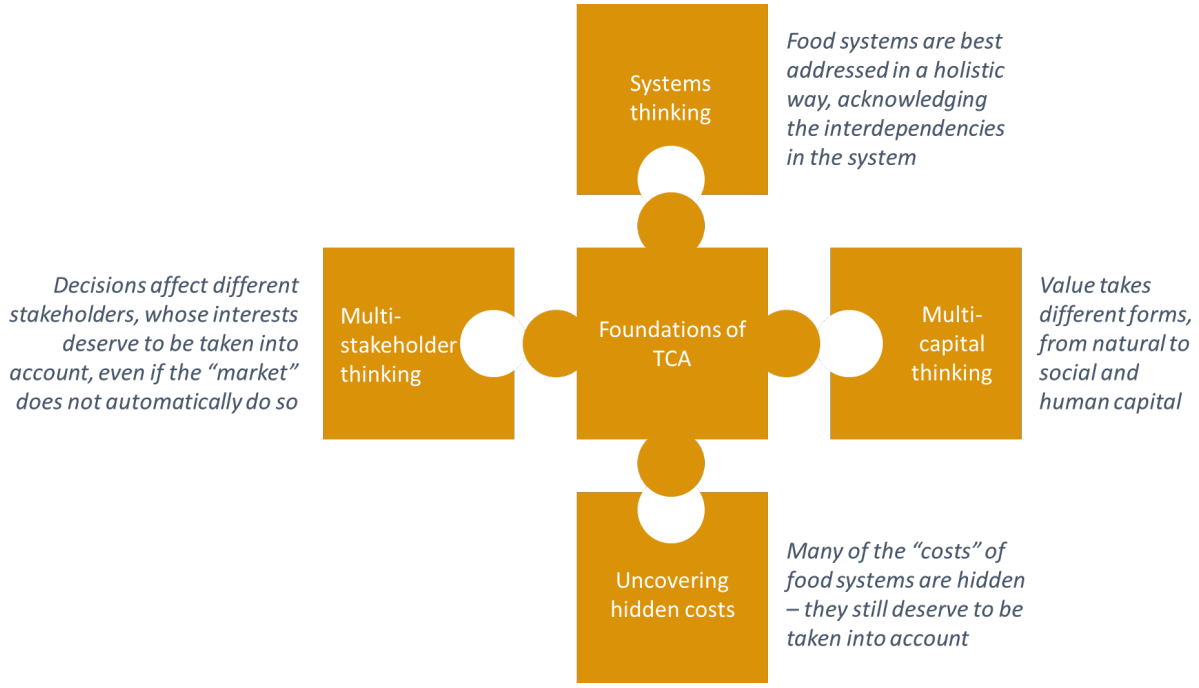
At its highest level, TCA is a philosophical approach. It involves a broader way of thinking beyond the purely economic. TCA makes different types of value explicit in a holistic manner, so that decisions can be made while taking each of these values properly into account.

TCA is an approach that can be applied to every sector of the economy. It is of particular relevance in the food and agricultural sector. As mentioned, external costs are substantial in the food sector and, for many of the poorest people on the planet, producing and consuming food is their primary source of income and main cost of living. Indeed, much of the development of TCA has historically been in the context of food.[4]

1.3 Key foundations of true cost accounting

TCA "borrows" concepts from different fields. It is a **systems-thinking approach** that includes **multicapital** and **multistakeholder thinking** and aims to **uncover hidden costs** so as to consider them in (policy) decision-making (Figure 1).

Figure 1. The foundations of true cost accounting



Source: Authors' own elaboration.

[4] See, for instance, TEEBAgriFood, the True Cost Accelerator funded by the Global Alliance of the Future of Food, and several publications, such as Hendriks (2021) and Gemmill-Herren, Baker and Daniels (2021).

1.3.1 Defining true cost accounting

Several definitions of TCA exist. Table 1 provides an overview. It also includes definitions of some concepts related to TCA, including full cost accounting (FCA), capital accounting, natural capital assessment, true pricing and cost–benefit analysis (CBA). FCA can be considered a synonym for TCA. There is a strong argument to be made that capital accounting, natural capital assessment and true pricing are specific manifestations of TCA. See Chapter 3 on how CBA gave rise to TCA and how the two relate.

Table 1. Definitions of true cost accounting and related topics in the literature

Defined concept	Definition	Source
True cost accounting (TCA)	An evolving holistic and systemic approach to measure and value the positive and negative environmental, social, health and economic costs and benefits to facilitate policy, business, farmer, investor and consumer decisions.	UNEP *et al*., 2021
TCA	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.	True Cost Initiative, 2022
TCA	System of accounting which ensures that the true costs and benefits of different industries and production processes are properly measured.	Sustainable Food Trust, 2019
TCA	New way of bookkeeping that includes the so-called "external costs" that are not included in the financial costs of our society.	Sustainability Impact Metrics, n.d.
Full cost accounting (FCA)	An approach that assesses the environmental, social and economic costs and benefits of food production and makes these costs and benefits "visible" so that decision-making processes can take them into account.	IFOAM Organics International & Sustainable Organic Agriculture Action Network, 2019
Capital accounting	Multiple capitals-based approach to systems thinking, which includes natural, human, social and produced capital. This integrated approach enables you to articulate and explore the full range of visible and invisible connections that agricultural and agrifood systems have with humans and the environment in eco-agrifood systems […]. Taking a capitals-based approach can strengthen the quality of an assessment and reveal pathways for addressing issues within eco-agrifood systems and agrifood value chains.	Eigenraam *et al*., 2020
Natural capital assessment	The process of measuring and valuing relevant ("material") natural capital impacts and/ or dependencies, using appropriate methods.	Natural Capital Coalition, 2016
True pricing	Calculation of true prices and the facilitation of paying true prices as an instrument of the remediation of harm to people and communities. The true price is the price paid to purchase a product that is either free of unsustainable external costs caused by its production and consumption, or where these costs are wholly remediated.	True Price Foundation, 2020a

Defined concept	Definition	Source
Cost–benefit analysis (CBA)	A tool that supports the policy process and political decision-making on a policy measure or policy alternative by presenting information about its effects, risks and uncertainties, the consequences of these for its costs and benefits and for social welfare, and information about who benefits and who experiences adverse effects.	Romijn and Renes, 2013

Source: Authors' own elaboration.

In a policy-focused context, this paper adjusts slightly the definition developed by a consortium of organizations including the Global Alliance for the Future of Food, the Capitals Coalition and the United Nations Environment Programme (UNEP), which hosts The Economics of Ecosystems and Biodiversity (TEEB) (UNEP *et al.*, 2021).[5]

Definition: TCA is a holistic and systemic approach to measuring and valuing the positive and negative environmental, social, health and economic costs and benefits generated by agrifood systems in order to facilitate improved decisions by policymakers, businesses, farmers, investors and consumers.

This definition has a number of key elements that merit mention:

- **Holistic and systemic** – TCA studies full systems, accounting for interconnectedness between its elements, including through higher-order effects. It takes multiple capitals and stakeholders into account and always studies their interconnectedness.
- **Measuring and valuing** – Measuring and valuing effects are the main tools in the TCA toolkit. Valuation is, in this context, defined as making explicit the value of an effect to its stakeholders. This is necessary so it can be taken into account in decision-making. Note that valuation can take different forms, including qualitative, quantitative and monetary (see Sections 5.3 and 6.2).
- **Positive and negative; costs and benefits** – The inclusion of benefits (positive effects) seems contradictory to the very name of true *cost* accounting. Indeed, TCA uncovers both negative and positive (external) effects that are not sufficiently taken into account in traditional decision-making. Knowledge of both is required to make good decisions.
- **Environmental, social, health and economic** – These four dimensions reflect the broad view that TCA has in terms of scope effects, though this is not a binding segmentation. This broad view is also reflected by the four capitals (natural, social, human and produced) (see Section 5.2 and Annex 5).
- **To facilitate […] decisions** – The application of decision-making is key in TCA. Even though the name includes the word "accounting", it is about the proper use of that accounting information.
- **[Decisions by] policymakers, businesses, farmers, investors and consumers** – TCA can have a wide set of audiences that use its information to take decisions. In this

[5] The original definition is, ''true cost accounting (TCA) is an evolving holistic and systemic approach to measure and value the positive and negative environmental, social, health and economic costs and benefits to facilitate policy, business, farmer, investor and consumer decisions'' (UNEP *et al.*, 2021, p.12).

document, policymakers are the main audience, although all others can be considered a secondary audience (for example, if policymakers use fiscal incentives based on a TCA analysis, this targets businesses).

1.3.2 Structure of this paper

The report has eight further chapters in addition to this introduction. Chapter 2 analyses how TCA can support agrifood systems transformation. It reflects on policy goals and levers that professionals in the food sector face and describes how TCA can help them. Chapter 3 contains a literature review of the TCA approaches and provides an overview of the different stages and steps underlying TCA.

Chapters 4 to 7 hone in on specific phases of a TCA study. They reflect how TCA studies can be designed and executed and give guidance to practitioners on the key phases and what to do in each one.

Chapter 8 focuses on data. Data collection is typically one of the hardest steps in a TCA project, and many projects take place in a context where data scarcity is an issue. The chapter centres on the idea of a “reversed” data strategy, where all data points are roughly estimated and the most relevant ones later refined. It gives practical guidance on collecting (or estimating) different types of data. Chapter 9 provides an outlook.

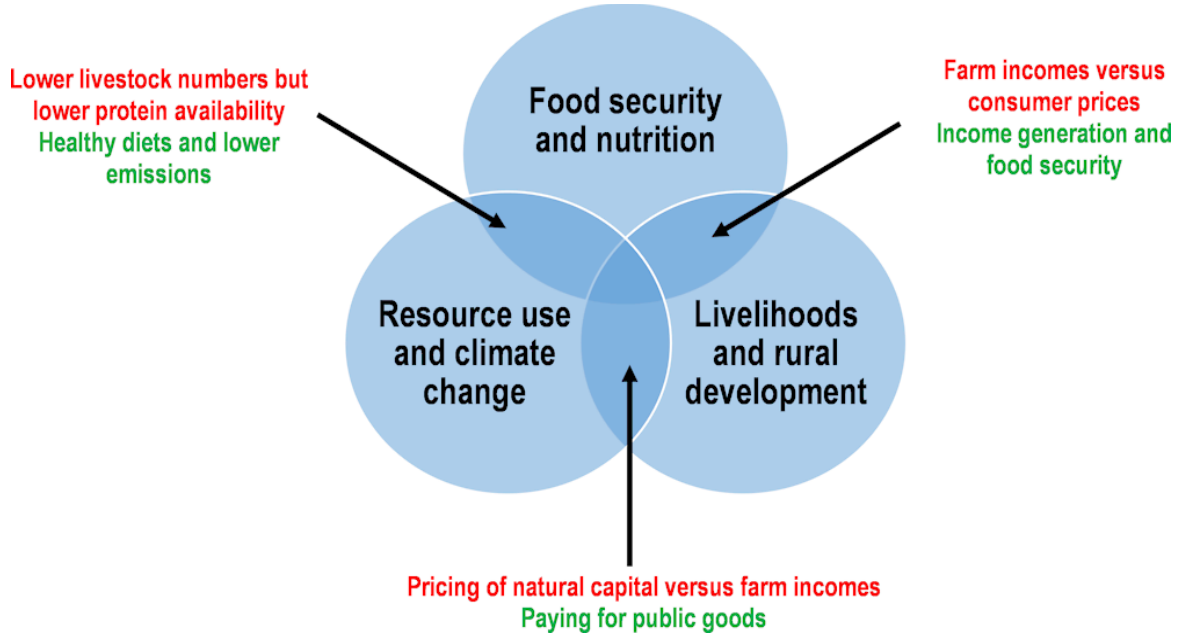
The recommendations in Chapters 2 to 8 provide practical advice for performing a TCA study. The recommendations in Chapter 9, in contrast, formulate a vision for the next steps in scaling up the field of TCA as a whole. These can be seen as recommendations for the TCA community.

2 How true cost accounting can support agrifood systems transformation

2.1 Food policy goals

Policymakers need to navigate a complex landscape of synergies and trade-offs in their decision-making when governing global, national, regional and local agrifood systems. On the one hand, the decision-making process should not be too arduous, while on the other, it must consider the interconnection between the different effects of decisions. The triple challenge of Figure 2 serves as a simplified framework for capturing the interactions between three key challenges (OECD, 2021).

Figure 2. Examples of synergies (green) and trade-offs (red) in agrifood systems when prioritizing specific combinations of agrifood systems challenges



Note: Trade-offs are simplified and need not always hold (for example, it may be possible to boost farm incomes while keeping consumer prices unchanged).

Source: OECD (Organisation for Economic Co-operation and Development). 2021. *Making Better Policies for Food Systems.* Paris. https://doi.org/10.1787/ddfba4de-en

Policies will be less effective and may waste resources when agrifood systems interactions are not taken into account. A single-objective policy may unintentionally come with side-effects in the case of a trade-off or may not realize all potential benefits of a synergy. For example, one programme that aimed to improve food security by providing greater access to food also led to more widespread obesity (Ruel, 2022).

Acknowledging that the trade-offs and synergies in Figure 2 are simplified, they nonetheless exemplify the interconnections between these three challenges of the agrifood systems. Take, for example, the red trade-off in the top left of the figure. Reducing livestock numbers can provide environmental benefits (for instance, directly through reduced methane emissions and indirectly through reduced water use). At the same time, this can limit the availability of protein.

Plant-based protein may have the potential to replace animal-based protein, but care should be taken that alternative local sources are available.

As a second example, consider the green synergy on the top right-hand side of the figure. Policies that reduce rural poverty can simultaneously improve food security and help to secure rural livelihoods. However, they can just as easily backfire if they do not properly take local culture and behaviour into account. The above examples show that policies should be coherent in the sense that "various policies are aligned so that efforts in one policy area do not undermine efforts in another area, and even reinforce those efforts where possible" (OECD, 2021, p. 58).

The current agrifood systems have direct financial costs and benefits to market participants (prices and incomes) and governments (taxes and subsidies), as well as hidden social, human and environmental costs and benefits. These affect those who have not chosen to incur those costs and benefits. TCA can help policymakers to (better) uncover hidden costs and benefits. This then provides input for decisions on a coherent policy mix that takes into account synergies and trade-offs. Moreover, TCA can provide policymakers with a common approach to assessing the effectiveness of policies in retrospect (Merrigan, 2021).

2.2 Policy levers

When it comes to agrifood systems policies, there are global and regional agendas, such as the Sustainable Development Goals (SDGs) and the African Union Agenda 2063, which guide decision-making and use different accountability mechanisms to track commitments. TCA can guide the planning and implementation of national pathways for agrifood systems transformation. Indeed, the United Nations Food Systems Summit (UNFSS) 2021 recognized TCA as a game-changing solution to agrifood systems transformation (UNFSS, 2021). It identified several pathways to "correct" policy failures that led to hidden costs, including mandatory transparency on the externalities of food and the incentivization of healthier and more sustainable food.

A wide range of policy levers is available to policymakers, ranging from a relatively narrow focus to support for a full redesign of the entire agrifood systems. This array of options reflects the differing mandates of policymakers (Table 2). Taxes and regulation are often the most cost-effective and powerful levers, but many others exist and can all be part of an effective policy mix (Sustainable Food Trust, 2019).

TCA has been used to evaluate agricultural land-use policies at country level. Unfortunately, few studies have resulted in concrete policy change. Positive examples are Brazil and India, which have used the TEEBAgriFood Evaluation Framework to consider the valuation of ecosystem services with a view to delivering more equitable and sustainable agrifood systems (TEEB, 2022). Another TEEBAgriFood study assessed the hidden costs and benefits of cacao agroforestry and monoculture in Indonesia. This contributed to cacao agroforestry being included in the country's 2020 five-year development plan (Gemmill-Herren, Baker and Daniels, 2021).

A further example of regulation as a policy lever is the use of different competition rules on cooperation between value-chain partners if cooperation benefits sustainability. The Dutch anti-trust authority recently allowed price agreements between farmers and their distributors,

provided they are necessary to achieve higher sustainability standards than those required by law (Netherlands Authority for Consumers and Markets, 2022).

An example of a policy with a narrower focus is a programme that encourages public agencies to use procurement that draws on non-financial metrics. For example, the voluntary United States of America-based Good Food Purchasing Program provides a metric-based, flexible framework that encourages large institutions to direct their buying power toward five core values (local economies, environmental sustainability, valued workforce, animal welfare and nutrition) (Center for Good Food Purchasing, 2023).

When it comes to synergies and trade-offs, TCA can help identify the most appropriate policy levers for different scenarios (more in Section 4.2). For example, governments often provide fiscal subsidies to producers to increase productivity and reduce production costs, but traditional analysis does not account for the trade-offs of increased costs to the environment and society (for example, more pollution and poorer health as a result of greater pesticide use). TCA makes the trade-offs explicit, so that policymakers can make a more informed choice on how to balance these interests.

TCA can support the implementation of subsidies, either coupled or decoupled from production, that aim to encourage environmentally and socially sustainable production. For example, a current study aims to reveal the hidden production costs of the Public Distribution System in India (which provides subsidized food grain to over 800 million people) and inform subsidy reforms to maximize the impact of government expenditure in five focus areas: health, environment, biodiversity, economy and livelihoods (Tata-Cornell Institute, 2022).

Table 2. Overview of different policy levers for agrifood systems transformation

Policy lever	Description
Laws and regulation	For example, bans, permits, zoning and other land use regulations
Fiscal support	Subsidies, taxation and support to general services
Subsidies	Subsidies to producers (based on input, output, other production factors or decoupled from production) and consumers (e.g. food subsidies or vouchers)
Taxation	Production taxes on input or output or consumption taxes
General services support	For example, public expenditures on services such as infrastructure, public stockholding, research and development, inspection services, marketing and promotion
Price incentives	Through market price control or border measures (e.g. tariffs, quotas, bans on import and export)
Adopt targets	Encouragement to adopt societal targets, (e.g. food waste reduction, end hunger, both for government and private sector actors)
Voluntary standards	Encouragement of voluntary adoption of production standards for social, safety and/or environmental topics as a means for private sector actors to reduce externalities (and share information with consumers)
Other policies	Other policies not captured in the above categories (e.g. information provision)

Source: Based on FAO. 2023. *The State of Food and Agriculture 2023. Revealing the true cost of food to transform agrifood systems.* Rome.

2.3 Balancing goals in political decision-making

Policy design and political decision-making can lead to friction among stakeholders. According to the OECD (2021), this can be due to:

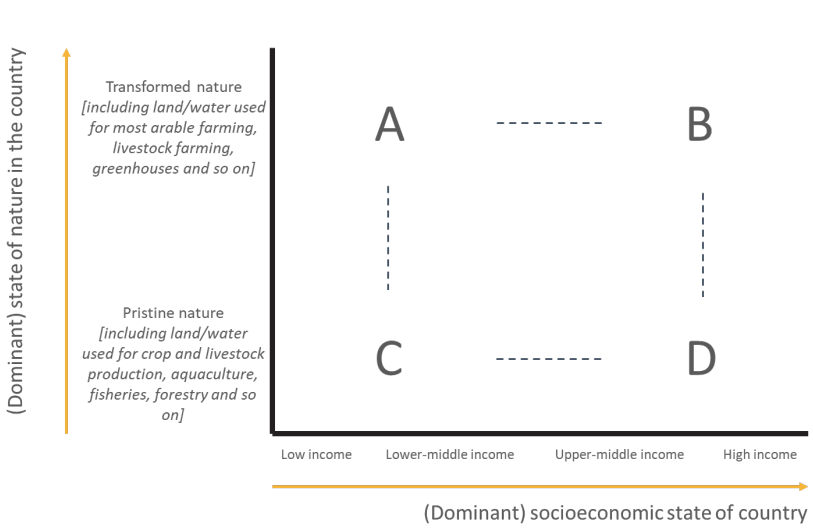
1. disagreement over facts;
2. diverging interests; or
3. differences over values.

If the problem is limited to a disagreement over the basic facts of a policy question, additional information can ease the friction in order to identify the best policy option or better communicate the existing body of evidence.

Conflicts of interest will require policymaking to bargain and/or to balance diverging interests. This, in turn, requires a level playing field (that is, without the disproportionate influence of one or more interest groups). When dealing with differences over values, disagreement as to what constitutes the public good may require deliberate approaches to help build societal consensus or compromise. The most difficult policy issues encounter frictions in all three areas (OECD, 2021).

Policymakers should balance the elements of the triple challenge in all contexts. However, in some contexts, one or two of the elements can receive more focus than the other(s). Figure 3 gives a high-level overview of this for policymakers in different socioeconomic and environmental situations. Figure 4 relates the different policy design questions of nine case studies (Table 3) to possible TCA support and policy levers and maps this to the matrix of Figure 3. Tables 8 and 10 provide information on nine selected TCA case studies.

Figure 3. High-level overview of the what the focus of food policymakers should be in different socioeconomic and environmental contexts



A
- **Food security**, mostly from the perspective of physical and economic access
- **Protecting livelihoods** of involved communities in the context of reducing poverty and related life quality consequences (more a matter of survival)
- Preventing further degradation of **nature** (including natural resource exploitation, such as fish stocks, arable land)
- Natural capital is also relevant through larger effects on health (for example, from pesticide use, water pollution)

B
- **Food security**, mostly from the perspective of healthy diets
- **Protecting livelihoods** of involved communities in the context of economic viability
- Preventing and mitigating degradation of **nature** (also globally) – ecosystem restoration where possible

C
- **Food security**, mostly from the perspective of physical and economic access
- **Protecting livelihoods** of involved communities in the context of reducing poverty and related life quality consequences (more a matter of survival)
- Protect existing **nature** (limit land use change, biodiversity loss and so on) as the country develops (including natural resource exploitation

D
- **Food security**, mostly from the perspective of healthy diets
- **Protecting livelihoods** of involved communities in the context of economic viability
- Protecting existing **nature** (also globally)

Notes: "Involved communities" refers to the active communities in the agrifood systems. An example of preventing and mitigating the degradation of nature for upper-middle to higher-income countries is the contribution to the GHG effect or deforestation elsewhere through imported food or feed. Those countries should typically have a more global focus, reflecting the common but differentiated responsibilities principle (that is, higher-income countries have more responsibility for mitigating global environmental degradation because of their higher historical contribution) (Matsui, 2004). An example of protecting livelihoods in terms of economic viability is providing support to some fishermen living around the local poverty line, even in high-income countries.

Source: Authors' own elaboration.

Table 3. Nine case studies used in this report and their link to policy

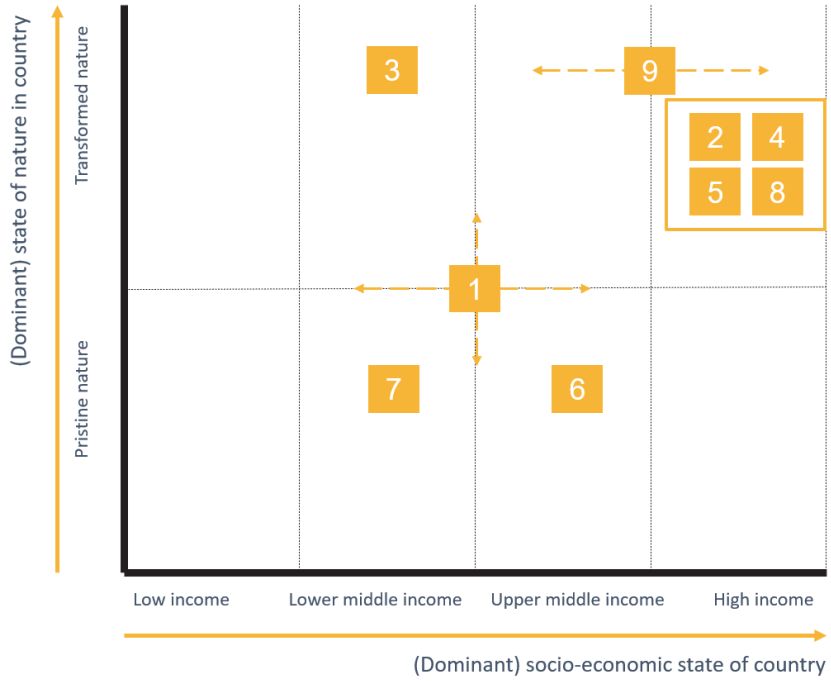
TCA study		Policy question	Link between policy goal and typology	Identified policy lever
1	True cost and true price of food (global)[i]	What are the external costs of the global food system? What are the potential reductions through different healthy, sustainable diets?	**Global** Global sustainability goals covering all definitions of food security, protecting all types of environment and livelihoods	Eliminating inefficient subsidies encouraging unhealthy food and installing a carbon tax
2	External costs and biodiversity effects of agriculture in Germany[ii]	Which types of impact does agricultural production have? What is the potential of sustainable practices within a European agricultural context?	**Germany agriculture** Focus on preventing degradation of nature, fair working conditions and social status of the farming profession	Fiscal support to internalize external costs
3	Organic rice production in Thailand (2018)[iii]	What are the hidden costs and benefits of rice production in Thailand? Which options for stimulating sustainable rice production on the long term can be identified?	**Thailand rice production** Preventing degradation of nature, improving livelihoods and human health	Fiscal support for organic farming, allowing farmers to ask higher prices for organic rice
4	True costs of the United States of America (US) food system[iv]	How can future economic and regulatory incentives for a sustainable food system be shaped?	**US food system** Preventing degradation of nature, food insecurity seen through unhealthy diets, protecting livelihoods (e.g. underpayment)	Fiscal support and guidelines to optimizing procurement policies, increased benefits to workers, policies to nudge behaviour of consumers
5	True cost of food: school meals case study[v]	What is the true value of public-school meal programs? Which drivers can be used to further increase its benefits and to stimulate investment?	**US food consumption** Preventing degradation of nature, food insecurity seen through unhealthy diets, protecting livelihoods, reducing social costs	Fiscal support and guidelines to optimize school meal procurement
6	Climate-smart agriculture (CSA) in coffee[vi]	What are the benefits of Climate-Smart Agriculture in the context of coffee farming in Colombia? How can further investment be stimulated?	**Colombia agroforestry** Preventing degradation of nature and protecting livelihoods	Support growth of CSA practices through investment
7	True price of cocoa[vii]	How can a chocolate company reduce external costs of own chocolate? And how can it change the sector?	**Ghana + Côte d'Ivoire agroforestry** Preventing degradation of nature, protecting livelihoods and protecting human rights	Adopting targets, providing transparency

TCA study		Policy question	Link between policy goal and typology	Identified policy lever
8	Genetically modified vs organic corn production in Minnesota[viii]	What are the external costs associated with genetically modified and organic corn production?	**US corn production** Preventing degradation of nature, food insecurity seen through unhealthy diets, livelihood of farmers	Decreasing subsidies on monocultural and increasing on organic production, procurement policies, stop cross-sector mergers and require full disclosure from companies (regulation)
9	The true price of cheap beef and pork[ix]	What is the gap between market prices and true costs of meat? How can we stimulate a shift of fiscal and regulatory policy to incentivize reduction and internalization of external costs?	**Germany + Argentina beef and pork systems** Preventing degradation of nature	Shift of fiscal and regulatory policy to incentivize reduction and internalization of external costs of meat

Notes: See Tables 8 and 10 for further detail on the nine case studies.

Sources: Authors' own elaboration based on [i] Hendriks *et al.* (2021); [ii] Kurth *et al.* (2019); [iii] TEEB (2018a); [iv] Rockefeller Foundation (2021a); [v] Rockefeller Foundation (2021b); [vi] Brounen *et al.* (2019); [vii] True Price (2018); [viii] Sandhu (2019); [ix] Bandel *et al.* (2020a).

Figure 4. Mapping the nine case studies in Table 3 to the matrix of Figure 3



Notes: The arrows for case study 1 indicate that the policy question covers many of the typical policymaker focuses. The arrows for number 9 indicate the different socioeconomic states of the countries in question (Argentina and Germany). The block with numbers 2, 4, 5 and 8 indicates that those case studies are similar in typology.

Source: Authors' own elaboration.

3 True cost accounting in the literature

Section 1.2 introduced the four key building blocks of TCA. The concept of externalities and **uncovering hidden costs** was initially described in the literature by Pigou and Marshall in the 1920s, providing the first key building block for TCA (Lusk, 2013). The formalization of **multistakeholder** and **multicapital thinking** accelerated with the development of sustainability reporting standards by the Global Reporting Initiative in the late 1990s (Global Reporting Initiative, 2022a).[6] Moreover, TCA has firm roots in CBA and lessons can be learned from its application and associated difficulties (see Box 1).

Systems thinking is based on holistic thinking. In the context of hidden costs in the agrifood systems, systems thinking acknowledges the multidimensional and complex nature of the agrifood systems with all its interdependencies. Based on these four building blocks, TCA largely developed in the last decade.

Box 1. Cost-benefit analysis

A CBA is "a policy assessment method that quantifies in monetary terms the value of all consequences of a policy to all members of society" (Boardman, 2006, p. 1).[i] It informs policy decision-making aimed at increasing social value by assessing the net social benefit, an aggregated value of a policy's costs and benefits to society. However, as CBA has evolved from the assessment of national policies, its scope has historically been limited to the costs and benefits to the national population.

TCA can be seen as an expansion of CBA with wider scope, so it includes the (material) costs (and benefits) to all stakeholders affected on multiple capital levels. The purpose of TCA is not so much focused on increasing net social benefit, but rather increasing social value by reducing costs while improving benefits.

Even though differences exist, the concepts of TCA and CBA are closely related, and important lessons for TCA should be learned from the application of CBA. Some of these lessons are: filling knowledge gaps that surfaced in the use of CBA on how to account for specific costs and benefits; reducing their complexity to prevent the insights of TCA analyses remaining unused, thus allowing for reflection; and performing analyses in parallel with policy design (that is, as an integral part of design decisions), not as confirmation of the policy proposal.[ii]

Notes: [i] Boardman, A.E., ed. 2006. *Cost-benefit analysis: Concepts and practice* (3rd edition). Hoboken, USA, Pearson/Prentice Hall. [ii] Merrigan, K.A. 2021. Embedding TCA within US Regulatory Decision-Making. In: B. Gemmill-Herren, L.E. Baker & P.A. Daniels, eds. *True Cost Accounting for Food: Balancing the Scale,* 1st edition, pp. 179–188. London, Routledge. https://doi.org/10.4324/9781003050803

de Adelhart Toorop *et al.* (2021) describe the current state of TCA as "a paradox". On the one hand, the development of TCA is work in progress. Further development into application-level guidance is required to uncover its true potential.

On the other hand, TCA was developed autonomously and heterogeneously by multiple commercial and non-commercial organizations, with each application fit to their own purposes.

[6] The Global Reporting Initiative is an international, not-for-profit organization that developed a widely used standard for impact reporting.

The TCA Accelerator and Impact Institute (2023)[7] describe and compare 35 distinct initiatives in the literature that are all deemed to fit the definition of TCA, even though not all of them explicitly identify as TCA. Five of these were specifically developed for an agrifood context; the remaining 30 are more general, but are regularly used in the context of agrifood. This paper excludes approaches that cannot be used in an agrifood context or those that are only rarely used for this purpose.

Alongside the central TCA framework for agrifood systems, the TEEBAgriFood Evaluation Framework, there are seven approaches that are deemed most relevant to policymakers, as summarized in Table 4 and detailed in terms of focus, application and methodology in Annex 2.

Table 4. True cost accounting framework and leading approaches most relevant to policymakers

	Description	Source
True cost accounting (TCA) framework		
TEEBAgriFood Evaluation Framework	High-level framework that provides guidance on multicapital TCA for eco-agrifood value chains, and was developed by TEEB.	Eigenraam *et al.*, 2020; TEEB, 2018b
TCA approach		
Food System Impact Valuation Initiative (FoodSIVI)[i]	TCA approach that provides guidance in detailed multicapital impact measurement and valuation. It further lists the requirements for a non-financial capital accounting framework for the food sector.	Lord, 2020
Natural Capital Protocol	An approach developed by a predecessor of the Capitals Coalition (the Natural Capital Coalition),[ii] which provides guidance on how to measure and value natural capital, providing a widely accepted standardization.	Natural Capital Coalition, 2016
Social and Human Capital Protocol	An approach that provides widely accepted guidance on how to measure and value human and social capital, thereby complementing the strategy developed in the Natural Capital Protocol.	Social & Human Capital Coalition, 2019
Social Return on Investment (SROI)	An approach that provides guidance on calculating the social return on investment, developed by Social Value UK.[iii]	SROI Network, 2012
System of Environmental Economic Accounting (SEEA): Ecosystem Accounting	An approach that provides widely accepted guidance on capturing flows of environmental resources within systems, thereby reflecting how ecosystems are currently used.	United Nations, 2021
True Price: A Roadmap to True Pricing and valuation framework	Guidance on the assessment of true prices and an approach to the valuation of external costs developed by True Price[iv] with Wageningen University and Research. The true price is the market price plus the social and environmental costs of a product.	True Price Foundation, 2019; Galgani *et al.*, 2021a

[7] The TCA Accelerator is a global network advocating for the transition to just, sustainable and healthy agrifood systems through widespread adoption of true cost accounting.

	Description	Source
TCA Agrifood Handbook	Developed by the True Cost Initiative,[v] a methodological handbook for calculating external costs in the agrifood and farming sector. It focuses on environmental, social and health external costs in the supply chain of (plant-based) food products.	True Cost Initiative, 2022

Notes: [i] FoodSIVI is a collaborative initiative between academia, industry and civil society to promote the standardized and pre-competitive monetary valuation of environmental, social and health impacts of agrifood systems. [ii] The Capitals Coalition is a collaboration between organizations that aims to accelerate the use of capitals thinking and unites two pre-existing movements, the Natural Capital Coalition and the Social and Human Capital Coalition. [iii] Social Value UK is a membership organization (that originated from the SROI Network) that promotes the measurement of social impacts and using those results to guide decisions. [iv] True Price is a social enterprise aimed at realizing sustainable products that are affordable to all by enabling consumers to see and voluntarily pay the true price of products. [v] The True Cost Initiative is a broad network that generated a technical handbook for calculating the true costs of food and agricultural products.

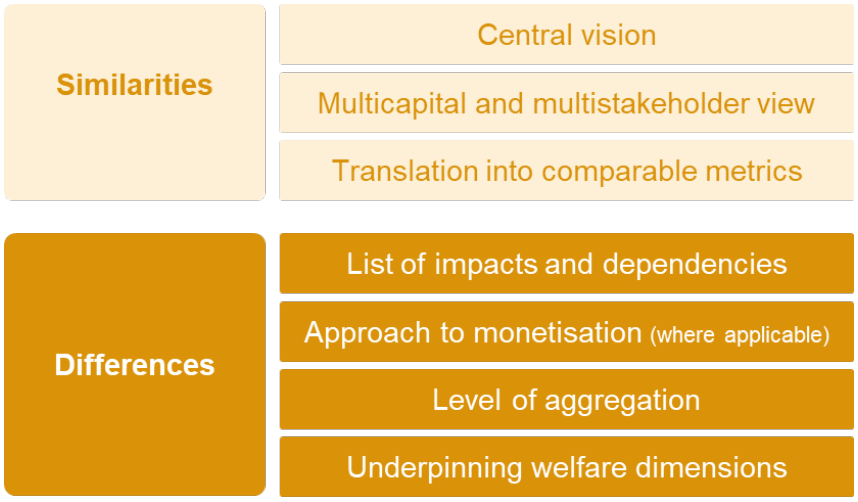
Source: Authors' own elaboration.

3.1 Similarities and differences between current approaches

The abundance of TCA approaches and related guidelines available may appear overwhelming for future TCA practitioners, including policymakers. The harmonization of the TCA field could help to encourage its potential use. The first step towards harmonization is assessing the similarities and differences between the TCA approaches.

de Adelhart Toorop *et al*. (2021) discuss similarities and differences between TCA approaches in the literature, as summarized in Figure 5.[8]

Figure 5. Similarities and differences in the 30 reviewed true cost accounting approaches in literature



Notes: Two additional differences in the original source are the visual presentation of results for publication and scope of the value chain. Furthermore, there is no agreement on the degree to which the value chain of an organization should be included in a TCA project. This is mostly an issue for TCA at organizational level and far less relevant when applying TCA to policymaking.

Source: Based on de Adelhart Toorop, R., Yates, J., Watkins, M., Bernard, J. & De Groot Ruiz, A. 2021. Methodologies for true cost accounting in the food sector. *Nature Food*, 2(9): 655–663. https://doi.org/10.1038/s43016-021-00364-z

[8] See also TCA Accelerator and Impact Institute (2023). The TCA Accelerator is a global network advocating for the transition to just, sustainable and healthy agrifood systems through widespread adoption of true cost accounting.

Obviously, all these TCA approaches share core properties that make them TCA, as reflected in Section 1.2. First, they have a central vision that the hidden costs should be revealed and be considered by decision-makers. Second, there is the multicapital (effects on economic/financial, environmental, social and human capital, including health) and multistakeholder view. This property means that TCA naturally requires a whole-of-government approach across ministries, administrations and agencies.

Third, TCA approaches translate the effects, expressed in their different or "natural" units (such as the amount of pollutants and disease burden), into costs and benefits to stakeholders. This translation is also known as valuation, representing the relative importance, worth or usefulness of externalities to people or society (TCA Accelerator and Impact Institute, 2023).

The review by de Adelhart Toorop *et al*. (2021) also revealed key differences. First, the indicators covered by the approaches vary substantially (see Section 5.2).[9] Second, there are differing views on why things are valuable. In some approaches, all value can be traced back to human well-being. In others, an intrinsic value of nature is acknowledged, or the respect of human rights is valued beyond the direct well-being of those affected.

The techniques available for (monetary) valuation differ according to the conceptual view on valuation in different TCA approaches. Through monetary valuation, hidden costs and benefits are expressed in monetary units. Transparency on the technique used is required to be able to assess its advantages and disadvantages (see Section 5.3).

Lastly, while most approaches include some type of aggregation based on capital or stakeholders, indicators are aggregated to varying degrees. Notably, approaches disagree as to whether to net positive and negative effects. A review of eight value accounting methodologies by the Capitals Coalition (2022b), not specific to agrifood systems, is recommended reading in this regard.

3.2 The path to scaling TCA

There are similarities and differences between the TCA approaches reviewed and these translate into advantages and drawbacks, as shown in Annex 2. Several approaches claim to be the (de facto) standard, having undergone extensive consultation. This background paper would refute those claims. High-level agreement can be observed, but a gold standard is (at the time of publication) lacking.

Specifically, every user of any TCA approach will have discovered that the devil is in the detail. TEEBAgriFood's Scientific and Economic Foundations Report (TEEB, 2018b) sets out high-level principles that all TCA studies should respect – and that all approaches in Table 4 follow. However, beyond this, the guidance in the sources diverge. It is highly likely that two researchers studying the same topic will come up with results that are substantially different, as users face many "microdecisions" in implementing a TCA project. Harmonizing TCA approaches is a way to mitigate this risk.

The following chapters focus on the different decisions a TCA practitioner has to make, such as: setting the boundaries of their assessment (Section 5.1); determining the materiality of

[9] Indicators are the fundamental building blocks of a TCA study. Examples include effects on climate change, food security and consumer health.

indicators and, as a result, putting some of them in and out of scope (Section 5.2); and estimating data points that are not readily available (Section 8.3).

The remainder of this paper is dedicated to providing additional guidance to aspiring TCA practitioners. Rather than suggesting a single "best" approach from the literature (for example, the one with the most advantages and fewest drawbacks, as in Annex 2), it provides an overview of the literature and suggests best practices. It describes issues a practitioner will face and provides direction on how to overcome them (based on the literature, experience and lessons learned from the leading voices of the TCA community).

In Chapter 9, this paper addresses the community as a whole in identifying next steps for scaling up TCA through harmonization. A first step is the observation that all approaches follow the principles that TEEBAgriFood provides as a framework for TCA. However, this framework is merely high level, while further guidance to ensure valid and robust results is needed. There are two main ways to achieve this (see TCA Accelerator and Impact Institute, 2023). The first is harmonization by integrating methodologies. The second is harmonization by adopting shared principles (beyond the highest level), ideas and/or requirements.

The first path can bring about harmonization if the collaboration of multiple initiatives leads to a dominant approach. The TCA Accelerator lists no fewer than nine such attempts: FoodSIVI, the Impact-Weighted Accounts Framework, the Natural Capital Protocol, the Public-Private Partnership for True Pricing, the Social and Human Capital Protocol, further development of TEEBAgriFood, the TCA Agrifood Handbook, the Transparent method and the Value Balancing Alliance method.

The second path is to create a shared core among the key approaches in the market by adopting shared principles, ideas and/or requirements and trying to expand the application of shared practices. The TCA Accelerator sees a role for itself, as well as for the Valuing Accounting Network, curated by the Capitals Coalition in partnership with the Impact Management Project and the Impact Management Platform, hosted by the Impact Management Project (TCA Accelerator and Impact Institute, 2023).

This background paper does not necessarily promote one path over the other. Still, at times, it provides input to the TCA community in the hope that harmonizers will take note.

3.3 Stages and steps of TCA studies

Conducting a TCA study in a structured way can help ensure that a TCA study is fit for purpose. A TCA study typically consists of several stages in which the practitioner performs a set of specific activities (steps). These stages are sequential, but the process is iterative in nature, meaning that previous stages will need to be revisited to apply recent insights. The de facto standard is an analysis comprising four stages, per the Natural Capital Protocol – frame, scope, measure and value, and apply (Eigenraam *et al*., 2020; IEF, 2022b; Natural Capital Coalition, 2016; True Cost Initiative, 2022).[10]

In each of the steps, a TCA study must balance the validity and robustness of results with keeping resources manageable. The OECD acknowledges this balancing act in policy design,

[10] The setup in Eigenraam *et al.* (2020) is similar: frame, describe and scope, measure and value, and take action.

noting that “there is a risk that striving for perfect coherence [of the policy] might lead to slow decision-making or even paralysis, and it might therefore be more feasible to strive instead for ‘good enough’ coherence. Such an approach would imply identifying and dealing with the most important synergies and trade-offs” (OECD, 2021, p. 59).

Recommendation:

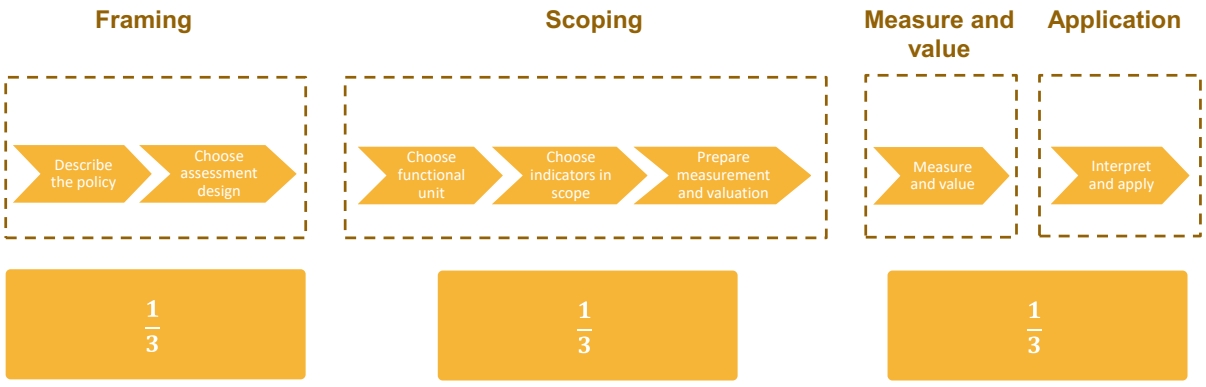
Use the guidance available for conducting a TCA study (Eigenraam *et al*., 2020; IEF, 2022b; Natural Capital Coalition, 2016).

3.3.1 Key design decisions

Figure 6 shows the stages and corresponding steps of a TCA study, adjusted for policy context. A clear frame and scope are essential to ensure a TCA study is fit for purpose. Relevant questions in the first two stages include: how to ensure that the study considers all relevant costs and benefits? How to assess the relative importance of external costs while ensuring that the costs to all stakeholders are equally well represented? For example, if the TCA study involves two stakeholder groups, does the study sufficiently represent the benefits/costs of smallholder farmers compared with large-scale agriculture?

The time and resources required for the framing and scoping stages should not be underestimated, as it is not unlikely for each stage to take up one third of the resources. Salman Hussain (Coordinator of TEEB) formulated the distribution of resources in equal thirds, based on experience with TCA studies where the TEEB AgriFood Evaluation Framework was applied. The authors acknowledge this distribution from their own experience with TCA studies.

Figure 6. Decisions in the framing and scoping phases of a true cost accounting study



Note: Suggested resource distribution over different stages of a TCA study in equal thirds.

Source: Authors’ elaboration based on Natural Capital Coalition. 2016. *Natural Capital Protocol.* The Hague, Capitals Coalition. https://capitalscoalition.org/capitals-approach/natural-capital-protocol/?fwp_filter_tabs=training_material

Five decisions are key when clarifying the frame and scope of a TCA study, shown as the first five arrows in Figure 6. The time spent on the first two stages will free up the last third of the resource investment for the assessment and interpretation stages to ensure results of sufficient quality.

Each of the four chapters that follow focuses on one of the stages. Most of the guidance is based on integrating insights provided by multiple TCA approaches ("intelligent mix and match"). The nine case studies introduced in Table 3 illustrate how design choices have worked in real situations.[11]

[11] See Tables 7 and 9 and, for more detail, IEF (2023).

4 Guidance on conducting a true cost accounting study: framing stage

The framing stage is the first phase of conducting a TCA study and includes two key decisions: i) describing the policy and ii) choosing an assessment design.

4.1 Describe the policy

Policymakers can use TCA to include elements of hidden costs in their decision-making that would otherwise not have been available. As discussed in Chapter 2, policymakers have to balance the challenges of food security and nutrition, resource use and climate change, and livelihoods and rural development. As discussed at the end of Chapter 2, policymakers typically have different focuses depending on the dominant socioeconomic state of their country and the dominant state of nature. A TCA study can inform decisions by showing who bears the costs and who gains the benefits, but also by holding stakeholders accountable for the role they play (Reinhardt *et al*., 2021).

Policy interventions typically change the financial picture (as some of those directly involved gain and others lose). They also affect social, human and environmental value, namely, who benefits and who bears the costs without having chosen to incur those effects. A policy description provides the required context to justify a TCA study. A policy description should address the policy goal(s), those likely to be affected by the policy, and the shifts in externalities deemed justified to achieve the policy goal(s).

Recommendation:

Explicitly address the following key questions when describing the policy underlying a TCA study:

What is the policy goal?

Which stakeholders are (likely to be) affected?

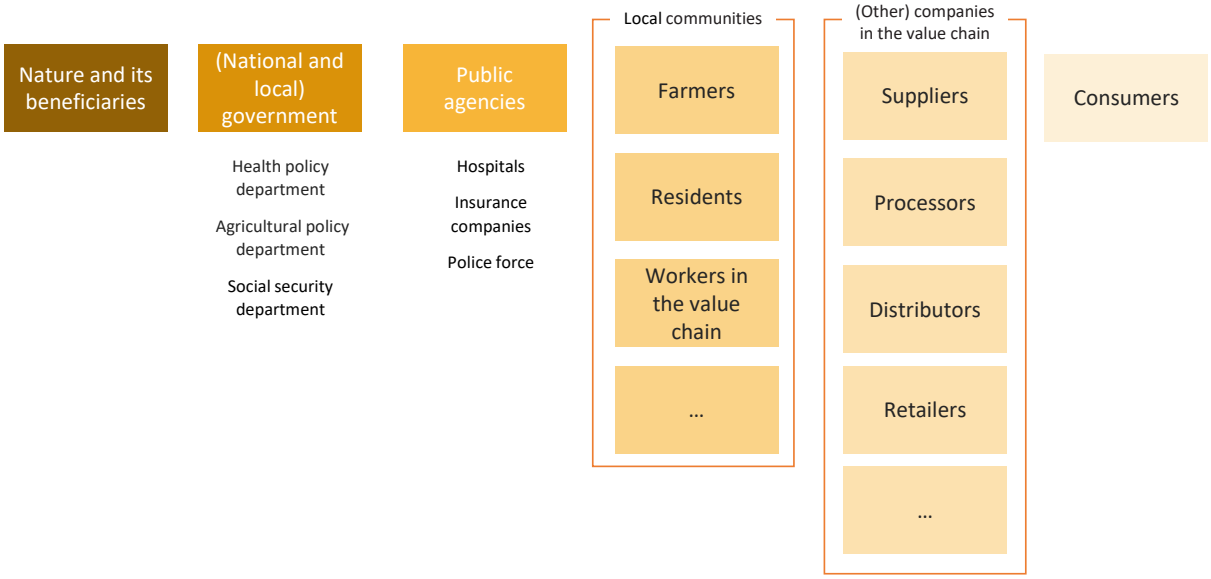
If hidden costs and benefits (are expected to) shift, what shifts are justified?

Whether a shift in externalities, including spillover effects, is justifiable should be assessed with a holistic view. The effects of policy decisions should be assessed for multiple stakeholders and different costs here and now, but should also consider transboundary and intergenerational effects (see 7.2).

4.1.1 Stakeholder groups

Figure 7 provides a possible list of stakeholder groups. Externalities generated by agrifood systems relate to both stakeholders within and outside the value chain. Practitioners are free to add, remove or split and further specify stakeholder groups to make the TCA study more fit for purpose.

Figure 7. A stakeholder classification that can be used in true cost accounting studies



Source: Authors' own elaboration.

4.2 Choose an assessment design

The design of a TCA study depends on the user and their intended application of TCA (Sandhu *et al*., 2021). TCA can be applied at different stages of the policy cycle, from problem definition and analysis of different policy design options to monitoring and evaluation. When the TCA study is part of the policy design phase, it should be used to inform and shape the policy design rather than to justify an already drafted design (Merrigan, 2021). When the study is monitoring or backward-looking, it is crucial to ask what the most relevant starting and ending points are. The following three design categories are often encountered.

4.2.1 Baseline assessments

Baseline assessments typically take a historical reference point to take stock of the hidden costs of the situation as it is now. They can thus help policymakers to identify areas of focus. An example is an estimation of the true costs of the United States of America agrifood systems (Rockefeller Foundation, 2021b) (see also Table 8).

A frequent application is to compare the performance of two or more alternatives (for example, other production methods, products, businesses, countries, cities and so on). This can then be used to promote the better performance of the alternative or to implement elements of it into the others. An example of this type of analysis is the comparison of the true price of different kinds of meat (Bandel *et al*., 2020a) (see also Table 8).

4.2.2 Repeated measurements

Baseline assessments measure the state of a system at one point in time. If measures are taken as a result of the baseline assessment, it is important to track whether these, indeed, lead to progress. There are relatively few TCA studies that repeat measurements over time.

The true price of cocoa for Tony's Chocolonely is one (True Price, 2018) (see also Table 8). It presents two years of results to track progress.[12]

4.2.3 Scenario analysis

Scenario analysis inherently includes a forward-looking or predictive component. Based on policy choices, two or more scenarios for the future are projected (one of these is typically a "business-as-usual" scenario, where no additional policy is implemented). The costs and benefits of each scenario are determined, including any investments required to get there. Results of scenario analysis can be used to propagate the best-performing scenario. See the Natural Capital Protocol for more guidance on selecting scenarios (Natural Capital Coalition, 2016). An example is the TEEB AgriFood Evaluation Framework study (Faculty of Economics, Khon Kaen University, 2022; TEEB, 2018a) (see also Table 8), which compares four future scenarios of sustainable rice production in Thailand.

[12] As the methodology to assess true prices was developed between the two years in scope, the results for the first year had to be re-assessed in the second year. This required a substantial additional time effort. When TCA approaches (including data collection practices) are further developed, these extra costs will be much lower.

5 Guidance on conducting a true cost accounting study: scoping stage

Once the frame is set, the second phase of a TCA study can begin: the scoping stage. It consists of three key decisions: i) which functional unit(s) to choose; ii) which indicators fall within the scope of the assessment; and iii) which valuation approach to choose.

5.1 Choose the functional unit

TCA can help to identify potential courses of action towards an agrifood systems transition and shows where areas such as domestic production, agricultural practices or supply chains need to be amended (TMG Think Tank and WWF, 2021). Likewise, the policy goal behind a TCA study automatically points to the most suitable unit of analysis, as the case studies at the end of this chapter illustrate. Such a functional unit describes what is assessed and measured by a TCA study, thereby defining its boundaries (de Adelhart Toorop *et al.*, 2021). Selecting the right functional unit to effectively answer the policy question is one of the most crucial steps in the scoping phase.

Table 5 provides an overview of five commonly used functional units in the context of agrifood policy. These range from agrifood systems to products, describing what each one entails and their relevance for policymakers.

Table 5. Five often-used functional units, with a description and relevance for policymakers

Functional unit	Description	Relevance	Example
Agrifood systems	Encompass the entire range of actors, and their interlinked value-adding activities, engaged in the primary production of food and non-food agricultural products, as well as in storage, aggregation, post-harvest handling, transportation, processing, distribution, marketing, disposal and consumption of all food products including those of non-agricultural origin.	Crucial to holistically assess policies, accounting for multi-dimensional, complex, and interconnected nature of the agrifood sector. Most complete and thus most desirable.	See study 1–4, Table 8
Diet	Captures different diet forms (e.g., carnivore, vegetarian) or examines policy interventions towards a healthier diet based on the effects of a population's current dietary patterns	Important to understand and influence dietary patterns of the population since diets are a crucial condition for health and thus human activity and overall welfare	See study 1, 5, Table 8
Investment	Typically refer to investments made by organizations or investors. For policy makers, it refers to public investments or expenditures of public financial means	Simultaneously constitutes a policy goal and a functional unit. Relevant to answer the question: How can public spending decrease social and environmental costs, thereby contributing to an improved agrifood systems overall?	See study 5, 6, Table 8

Functional unit	Description	Relevance	Example
Organization	Describes the impacts of an entity, typically used for commercial organizations.	Only relevant for policy makers if commercial actors are part of the theory of change behind a policy intervention, e.g., public-private collaborations. Private corporations often do their own TCA assessments that policy makers can tap into.	
Product	Looks at the impacts caused by a product, ideally covering its full production process and end-of-life.	Often crucial to understand the levers with which the system can be improved.	See study 7–9, Table 8

Sources: FAO. 2021. *The State of Food and Agriculture 2021. Making agrifood systems more resilient to shocks and stresses.* Rome. https://doi.org/10.4060/cb4476en; TEEB. 2018b. *TEEB for Agriculture & Food: Scientific and Economic Foundations*. Geneva, Switzerland; de Adelhart Toorop, R., Yates, J., Watkins, M., Bernard, J. & De Groot Ruiz, A. 2021. Methodologies for true cost accounting in the food sector. *Nature Food*, 2(9): 655–663. https://doi.org/10.1038/s43016-021-00364-z; TMG Think Tank & WWF. 2021. *True Cost Accounting and Dietary Patterns: An Opportunity for Coherent Food System Policy*. Berlin. www.wwf-scp.org/wp-content/uploads/2022/03/WWF_TGM_Report_Full-version.pdf

Annex 4 provides further guidance to help policymakers in their decisions on an appropriate functional unit.

5.1.1 Understanding the scope of application

As the overview in Table 5 indicates, the five units of analysis translate into different scopes of the TCA study and come with implications that should be considered when choosing the functional unit.

Generally, units of analysis that cover a wide scope of the agrifood systems, including various actors, are most suitable for policymakers, as they are more holistic and consider the potential to steer impact (de Adelhart Toorop *et al.*, 2021). This suggests that "system" and "diet" are the best functional units to consider in this case. At the same time, levers for change are usually on a more granular level and nested systems require greater scrutiny. Hence, choosing "product" or "investment" as a functional unit often becomes necessary to inform concrete decision-making.

As the systems level offers the potential to account for the multidimensional nature of the agrifood sector most holistically, it is also the most complex. This requires clear guidance for practitioners on how to describe systems appropriately. At the same time, it does not provide a great level of detail. Describing the global system typically exceeds the scope of policymakers. Nevertheless, it can provide valuable information for international and multinational decision-making processes and advocacy purposes, as illustrated by the TCA study prepared for the UNFSS (see Table 8, case study 1). If national or regional policymakers are interested in insights into the agrifood systems within the geographical area for which they have a mandate, the system can be described within that area (see Table 8, case studies 2–4). The next section elaborates on this.

When the policy focus lies in ensuring a healthy and sustainable diet for all, it is usually most appropriate to use "diet" as the functional unit. How the comparison of different dietary patterns provides valuable insights is shown in case studies 1 and 5.

At the same time, TCA can serve as a decision-making tool to inform incentives and disincentives at product level, for instance, comparing genetically modified and organic corn (case study 8) or different types of meat (case study 9). Studies at product level, however, run the risk of ignoring any second-order effects that inhibiting or advancing the use of certain products might have, jeopardizing a beneficial outcome of a policy intervention. Such circumstances make it crucial to link the results back to the systems perspective, as the examples also show.

Similarly, the use of "investment" as a functional unit comes at the risk of ignoring systems-level effects, which are crucial when assessing investments as a policy tool. While it can be useful to assess whether it is worth investing in certain areas – as the study on climate-smart agriculture (CSA) coffee (see case study 6) and the United States of America school meal programme (see case study 5) depict, it is important not only to compare different investment options, but also how an investment can contribute to better overall agrifood systems (see Annex 4).

Depending on the theory of change, choosing the "organization" as a functional unit may also be suitable in certain cases. While this is mostly used for commercial organizations, it can yield valuable insights if the policy goal is to identify areas in which businesses need (most) support to either conduct TCA themselves or to reduce their hidden costs. As corporations usually conduct TCA on their own, providing results that policymakers can tap into, this paper does not elaborate on it further.

Recommendation:

Make sure to match the functional unit with the policy question, so the outcomes of the TCA study can be acted upon.

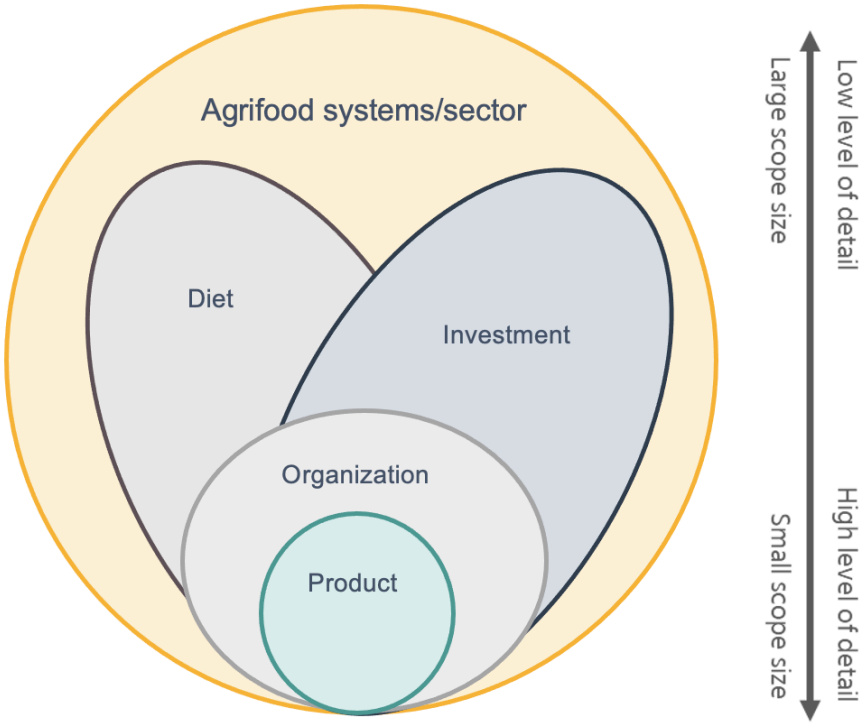
When navigating these different functional units, it is important to note that they are not mutually exclusive and can also be deployed in parallel. This will be illustrated further in the next section and in more detail in Annex 4.

5.1.2 Setting boundaries

Establishing boundaries keep the scope of a TCA study feasible, while allowing it to meet its goal. It is, therefore, important to bear in mind that "the true cost … will inevitably be only an approximation, or an incomplete snapshot, limited by a given set of boundaries over a given period of time'' (Figeczky *et al*., 2021, p. 99).

Starting with the **boundaries set by the chosen functional unit**, Figure 8 conceptualizes how these boundaries can be understood in relation to each other. Showing the embeddedness of diet, investment, organization and product within the agrifood systems, it reinforces the high relevance of considering systems-level effects, regardless of the chosen functional unit, as outlined in this paper.

Figure 8. Five commonly used functional units for policymakers and their scopes



Notes: de Adelhart Toorop *et al.* (2021) included geography as a functional unit. As this unit of analysis considered elements beyond the (agrifood) sector, it was excluded for the purpose of this paper. Simultaneously, a functional unit was added that was not covered in de Adelhart Toorop *et al.* (2021).

Source: Adapted from de Adelhart Toorop, R., Yates, J., Watkins, M., Bernard, J. & De Groot Ruiz, A. 2021. Methodologies for true cost accounting in the food sector. *Nature Food*, 2(9): 655–663. https://doi.org/10.1038/s43016-021-00364-z

Alongside the boundaries that are automatically set when choosing a functional unit – for example, looking at the true cost of selected diets – there are **geographical and temporal boundaries** that must be considered for each functional unit.

Geographical boundaries constrain the chosen functional unit to a defined geographical area, for example, looking at different diets only the population within Latin America alone, analysing meat produced in Germany or studying rice production in Thailand. A very common and useful application for policymakers is to choose the system as a functional unit and then set geographical boundaries in line with their area of influence and capability to act on the results. This way, a TCA can focus on the area most relevant to a policymaker while accounting for the agrifood systems as a whole. Case studies 2, 3 and 4 illustrate such cases and are further elaborated on in Annex 4.

The **temporal boundaries** in a TCA study refer to the time period covered by the results when presented in their functional unit. Those boundaries are also closely linked with the chosen assessment design, as presented in Section 4.2. Another question that merits consideration is whether it is relevant for the TCA study to include the value of costs/benefits to future generations (see Section 6.2.2 on the discount rate).

Table 6 provides an overview of the different kinds of boundary that can be set for a functional unit.

Table 6. Boundaries for functional units of a true cost accounting study

Functional unit	Geographical boundaries	Typical temporal boundaries	Further specific boundaries
Agrifood systems	Global, multinational, national, regional or local	One year	Subsystems according to markets and agricultural products (for example, the dairy system or the meat market) Context-dependent definition of what the system entails (for example, maize systems are differently defined in different countries)
Diet	Defined by the population whose diet is analysed	Diet per day	Specific dietary forms (for example, carnivore, Mediterranean, vegetarian)
Investment	Typically where the investment occurs	Lifetime of the investment	Direct money flows and/or indirect expenditures, such as bureaucratic costs and research
Product	Typically where the product is produced (and/or consumed)	n.a. (but fixed time)	Selected life-cycle stages of a product that are included (for example, own operations, upstream, downstream)
Organization	Operating location of the organization	One year	Selected parts of the organization's value chain (own activities and/or down- and upstream activities)

Sources: de Adelhart Toorop, R., Yates, J., Watkins, M., Bernard, J. & De Groot Ruiz, A. 2021. Methodologies for true cost accounting in the food sector. *Nature Food*, 2(9): 655–663. https://doi.org/10.1038/s43016-021-00364-z; Social & Human Capital Coalition. 2019. Social & Human Capital Protocol. The Hague. https://capitalscoalition.org/capitals-approach/social-human-capital-protocol; TMG Think Tank & WWF. 2021. *True Cost Accounting and Dietary Patterns: An Opportunity for Coherent Food System Policy*. Berlin. www.wwf-scp.org/wp-content/uploads/2022/03/WWF_TGM_Report_Full-version.pdf; Gemmill-Herren, B., Baker, L.E. & Daniels, P.A. 2021. *True Cost Accounting for Food: Balancing the Scale* (first edition). London, Routledge. https://doi.org/10.4324/9781003050803

5.2 Choose indicators in scope

Indicators are the fundamental building blocks of a TCA study. Examples are the effects on climate change, food security and consumer health. A single study can contain a dozen or more indicators. Once the relevant indicators are selected, based on materiality, each is measured and valued in the subsequent stages.

When aiming to scale the application of TCA, there is a greater need to improve the comparability of different study results. A potential pathway to such harmonization is for the TCA community to agree on standardized indicators (and the underlying methods to measure the impacts these indicators capture). These indicators can serve as a longlist to guide the selection of indicators within the scope of each study. Such a standardization effort would serve the need for application-level guidance on TCA use (as mentioned in Chapter 3).

An analysis of 35 TCA initiatives (within and beyond the food context) showed that 20 of them provided a list of indicators that could be assessed when conducting a TCA (TCA Accelerator and Impact Institute, 2023). Even though they were mostly developed for the "product" and "organization" functional units, the indicators are relevant to policymaking beyond these scopes of TCA as well.

Table 7 shows 15 indicator categories that can be considered most relevant for TCA analysis of agrifood policies because of their frequent use in a multitude of TCA frameworks (TCA Accelerator and Impact Institute, 2023) and/or particular relevance to the agrifood sector. The indicators are typically grouped according to their relevant capital. More details are provided in Annex 5.

Table 7. The 15 most relevant and frequently used indicator categories per capital

Natural capital	Social capital	Human capital and health	Produced capital
Effect on climate change	Food security	Health effects from food consumption	Taxes and subsidies
Land occupation and land transformation	Effects on poverty	Employee compensations and earnings in the value chain	
Air, water, and soil quality and pollution	Effects on local communities	Employee health and safety	
Water scarcity	Diversity, equality and inclusion	Employee career and skill development	
Recycling and waste management	(Other) effects on human rights		

Source: Adapted from TCA Accelerator and Impact Institute. 2023. *The Current Field of True Cost Accounting: an Analysis of the similarities and differences of True Cost Accounting frameworks*. Amsterdam. https://tcaaccelerator.org/wp-content/uploads/2023/03/The-Current-Field-of-True-Cost-Accounting-Final.pdf

5.2.1 Materiality

Materiality can generally be defined as "a measure of how important a piece of information is when making a decision" (Cambridge Dictionary, 2023). As TCA is a multi-stakeholder and multicapital approach, TCA studies can potentially contain a lot of information, such as a large number of indicators to be measured and valued. The principle of materiality helps focus the scope of a TCA study on those pieces of information that matter – in other words, the elements that can make a difference to the decision the TCA study aims to facilitate in the end.

A key application of the principle of materiality is in choosing indicators within the scope of the TCA study. Constraints in terms of time, resources and available data typically mean that only a limited number of indicators can be included (TCA Accelerator and Impact Institute, 2023). All indicators that are material to the decision on the policy objective should be included – and only those indicators.

5.2.2 Assessing materiality

Determining materiality is complex and prone to human bias (WBCSD, 2021). There is no consensus on how to determine materiality and most of the currently published guidance on assessing materiality is aimed at businesses rather than policymakers (see, for example, Capitals Coalition, 2022a; Global Reporting Initiative, 2022; True Cost Initiative, 2022). Still, the available guidance provides selection criteria useful to materiality assessments and their main underlying principles.

A few criteria for selecting material indicators relevant to policymakers include, but are not limited to: indicator size (scale, scope), likelihood, ease of quantification, risk level, feasibility, availability of interventions to modify the indicator, and expert feedback (Global Reporting

Initiative, 2022b; True Cost Initiative, 2022). Practitioners should be careful to ensure that all existing indicators affecting different stakeholders are equally represented.

Engagement with stakeholders is, therefore, a central element of a materiality assessment, to identify the most relevant areas on which an analysis should focus (Capitals Coalition, 2022; Global Reporting Initiative, 2022b; True Cost Initiative, 2022). There is no prescribed way of doing this and it depends on the situation in which policymakers find themselves. The general principles, however, can be applied in a similar way to the process described for businesses, such as the guide on materiality by the Global Reporting Initiative (Global Reporting Initiative, 2022). For instance, policymakers may have a hypothesis on which indicators are most material based on their experience, expertise or the results of previous studies/statistics, most likely identified together with researchers/advisers.

In a second step, the team – politicians and/or researchers – discusses these suggestions with stakeholders to make sure the materiality assessment reflects the needs of all. According to lessons from evidence-based policymaking for impact measurement by Nicholls and Yee (2022), it is not only crucial that stakeholders participate in the process, but also that the hierarchy of evidence be taken into account when selecting material indicators in the first place.

For relatively straightforward indicators, a “back-of-the-envelope” calculation can be done based on quickly estimated datapoints. Following a time-boxed literature review, data points from different contexts, such as other systems or geographies, can give an indication as to what an analysis should include. For instance, when the interest lies in the effects of mango cultivation in Malaysia, values from studies in other geographical contexts, such as Thailand and Indonesia, could be used to make a rough first estimate of the effects. The results will obviously carry a very high degree of uncertainty, but some indicators are sure to be much larger than others and, as such, will carry more weight in the decision to which the TCA analysis leads. In other words, these are estimated to be most material.

This is, then, an argument for focusing most of the time available on further analysis of the (assumedly) most material indicators. Those of lower (assumed) materiality can be left out of the scope entirely or be assessed only at the highest level (given lower priority in data collection and refinement).

The final step in assessing the materiality of indicators is presenting the results, for example, through a materiality matrix (Capitals Coalition, 2022). A materiality matrix provides structured insight into the degree of materiality (namely, not material, low, medium or high) for different aspects of a TCA study (Figure 9). In summary, this results in the following recommendations for assessing materiality:

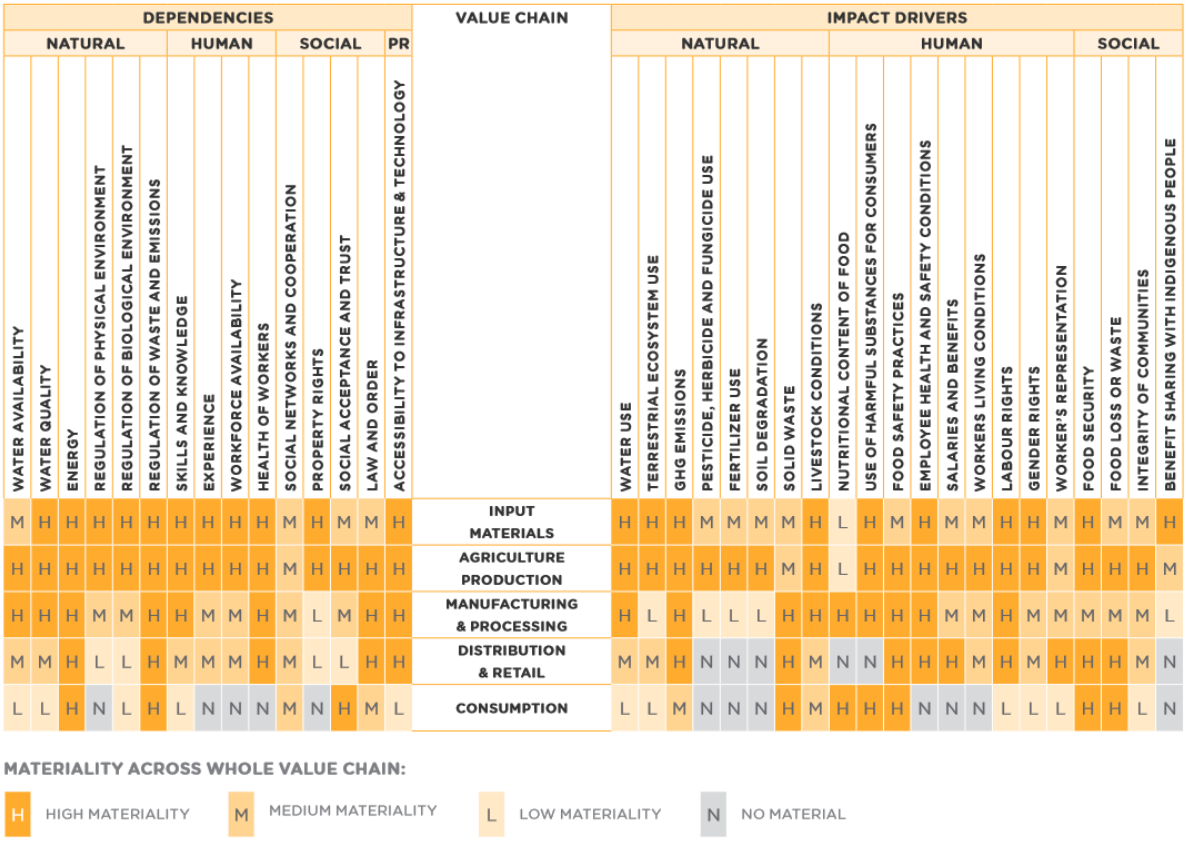
Recommendation 1:
Include relevant stakeholders in materiality assessments for the selection of indicators.

Recommendation 2:
Use clear selection criteria and the same selection criteria throughout a TCA study. Aim to include indicators that reflect costs and benefits to all stakeholders.

Recommendation 3:
Building on recommendation 2, communicate clearly which selection criteria were used.

Recommendation 4:
Once selection criteria have been selected and applied, present the materiality assessment using, for example, a materiality matrix (Capitals Coalition, 2022).

Figure 9. Example of a materiality matrix



Notes: The columns show the dependencies (such as water quality) and impact drivers (such as water use) divided over the capitals for different parts of the value chain (such as input materials and agriculture production). For each of the dependencies and impact drivers, materiality is assessed and scored according to a high–medium–low–no scale. For example, energy is a highly material dependency at the consumption stage, but water quality is not.

Source: Capitals Coalition. 2022a. *TEEB for Agriculture & Food: Operational Guidelines for Business*. The Hague. https://capitalscoalition.org/wp-content/uploads/2020/08/DRAFT-TEEBAgriFood-Operational-Guidelines.pdf

5.3 Choose the valuation approach

5.3.1 The why of valuation

Choosing the valuation approach is another essential aspect of TCA. The valuation of indicators involves estimating their worth or usefulness to people or society (TCA Accelerator and Impact Institute, 2023). Valuation is the step in which measured indicators are translated into information understandable to the users of TCA studies (Bandel *et al*., 2020b; TCA Accelerator and Impact Institute, 2023), for example, the translation of an amount of methane emissions or other GHGs into CO_2 equivalent. Valuation is related to a materiality assessment, as both steps involve an estimation of the importance or worth of indicators. However, a materiality assessment is done to scope relevant indicators, whereas valuation involves applying value to the relevant indicators and using this to compare them.

There is broad consensus on the usefulness of valuation (TCA Accelerator and Impact Institute, 2023). Approaches use qualitative, quantitative or monetary valuation, as well as a combination of different approaches (Eigenraam *et al*., 2020; TCA Accelerator and Impact Institute, 2023). For example, monetary valuation can be applied to all or some indicators. By reflecting the worth of an indicator from a stakeholder's perspective, all types of valuation can inform decision-making (IEF, 2022a; TMG Think Tank and WWF, 2021).

5.3.2 The use of qualitative valuation

Valuation does not necessarily need to be numerical, but can also be done qualitatively (Natural Capital Coalition, 2016). Its application is especially useful when many different perspectives must be considered, if strong moral or ethical stances are involved, or if there are not enough data for quantitative valuation. On the downside, quantitative valuation is prone to bias and is inherently problematic when it comes to validation and reproduction. In the same vein, it does not facilitate comparison as well as the other methods of valuation. If quantities or monetary values are difficult to understand or challenge, however, qualitative valuation can serve as an alternative or as clarification (Social & Human Capital Coalition, 2019). Examples of valuation in non-numerical terms could be an "increase in air emissions" or a "decrease in social benefits of recreation" (Natural Capital Coalition, 2016, p. 82).

5.3.3 The use of quantitative valuation

Assessing values quantitively can draw both from direct and proxy measures. This method allows the evaluation of whether progress has been made and can be useful if monetization is either not accepted or too challenging. At the same time, it can be difficult to understand or compare, especially when the units and/or context are unclear. When it comes to elements with an ethical dimension – such as the significance of health – quantitative valuation can also face acceptance challenges among stakeholders (Social & Human Capital Coalition, 2019). An example of quantitative valuation that is deemed important to policymakers is the Happiness Index by Heilwell *et al*. (TMG Think Tank and WWF, 2021).[13]

5.3.4 The use of monetary valuation

One of the largest benefits of monetary valuation is the translation of indicators assessed in various units into one comparable unit (TCA Accelerator and Impact Institute, 2023). Thus, monetary valuation allows for the integration and comparison of non-financial capital with inherently monetized financial capital (United Nations, 2021). For example, when expressing results in a common monetary unit, the cost of GHG emissions (natural capital) can be compared with the cost of unhealthy foods (human capital). Hence, if done correctly and consistently, it enables the assessment of trade-offs between different capitals (Social & Human Capital Coalition, 2019).

Despite the benefits of monetization, monetary valuation is not a replacement for measuring indicators in their natural units (Value Balancing Alliance, n.d.). For some TCA study objectives related to policy, assessing indicators in their natural units already reflects normative desirability and sufficiently informs decision-making, for example, when comparing the GHG emissions of two scenarios.

[13] See, for example, Heilwell *et al*. (2022).

Recommendations:

Use monetary valuation when it fits the TCA study objective, that is, where the comparison of indicators between capitals in one comparable unit is desirable.

Never use monetary valuation to hide negative indicators by netting the monetary value of positive and negative indicators.

Furthermore, monetary valuation is not a one-size-fits-all solution. Indeed, it is argued that it cannot be used as a valuation approach in some cases, for example, when it comes to aspects of human rights. While strong objections exist to the monetary valuation of human rights (TMG Think Tank and WWF, 2021), others do attempt to monetize them by, for example, estimating the costs of providing remediation (Galgani *et al*., 2021a; IEF, 2022a). In addition, questions have been raised over the use of monetary valuation, as reflecting a societal norm of money as the standardized measure of value.

Illustrating the key decisions of the framing and scoping phase of a TCA study, Table 8 shows which assessment design, policy goal, functional unit and indicators were selected for different policy goals of nine TCA studies.

Table 8. Selection of true cost accounting studies with policy goals, framework used, assessment design, chosen functional unit and indicators in scope

Study		Policy goal	Framework/ approaches used	Assessment design	Chosen functional unit	Rationale behind chosen functional units and boundaries	Indicators in scope
1	True cost and true price of food (global)[i]	Showcasing the external costs of the global agrifood systems and the potential reduction in these when adopting different healthy, sustainable diets	Parts of the methodology underlying the True Price approach were used, for example, the valuation/monetization factors. The extensive scoping and materiality assessment method was not followed.	Baseline assessment and scenario analysis (intervention)	System and selected diets	In the context of the SDGs and in broader terms of planetary and social boundaries, insights into the costs of the global agrifood systems are key. In addition, the "diet" functional unit is used to compare how different diets could potentially reduce external costs of the global agrifood systems. Specific boundaries: Food consumption and production in the full (global) value chain were included. Transportation, processing and food preparation were excluded.	Impacts scoped by both materiality and practical considerations (modelling time requirements and data availability). Six impacts focusing on environmental and health effects were included.
2	External costs and biodiversity effects of agriculture in Germany[ii]	Showcasing the types of impact that agricultural production has, as well as the potential of sustainable agricultural practices within a European agricultural context	Ecosystem services derived from SEEA with reference to TEEB AgriFood	Baseline assessment and scenario analysis (intervention)	System with geographical boundaries (Germany)	The agricultural system is assessed for the case of Germany, thereby setting geographical boundaries. Specific boundaries: Imported products in the agricultural value chain (such as fertilizers) and exports of agricultural produce were included. Indirect effects were not taken into account.	Six environmental impacts: climate change, air, water, soil, livestock farming and the loss of ecosystem services were included.
3	Organic rice production in Thailand (2018)[iii]	Measuring and making visible the hidden costs and benefits of rice production in Thailand; also identifying options for stimulating sustainable rice production in the long term	TEEBAgriFood Evaluation Framework	Baseline assessment and a scenario analysis (intervention)	System (rice production) with geographical boundaries (Thailand)	Focus is on the rice production agroecosystem in north-eastern Thailand at landscape level to capture the full ecosystem and biodiversity effects. By choosing a (sub)system – rice production – as functional unit and setting geographical boundaries (defined landscapes), gains can be shown to be very substantial (up to several USD billion). Total rice production is relatively constant in the region, hence the choice of hectares or kilograms as a unit.	The study included two environmental, two human, tree social and two financial impacts. The selection of material impacts was based on interviews with stakeholders and expert input.

Study		Policy goal	Framework/ approaches used	Assessment design	Chosen functional unit	Rationale behind chosen functional units and boundaries	Indicators in scope
						Specific boundaries: The focus within the value chain is on production, processing, milling and domestic consumption. Some secondary products, such as rice straw, were excluded.	
4	True costs of the United States of America (US) food system[iv]	Understanding how to shape future economic and regulatory incentives for a sustainable agrifood systems	Self-developed framework (true cost of food) based on definitions by TEEBAgriFood and the metrics of several frameworks, such as TEEBAgriFood, True Price and the Capital Coalition	Baseline assessment	System with geographical boundaries (United States of America)	The functional unit of the system was chosen with a view to understanding its cost for the United States of America, the latter constituting geographical boundaries. Further specific boundaries: All the food produced (including exports at production level) and consumed (including imports at consumption level) in the United States of America is included.	There was a quantitative assessment of 14 impacts in 5 areas: human health, environment, biodiversity, livelihoods and economy. Three additional indicators – animal welfare, resilience and antimicrobial resistance – were also assessed quantitatively.
5	True cost of food: school meals case study[v]	Measuring the current benefits of public school meal programmes and assessing three drivers to further increase their benefits to stimulate investment therein	Self-developed framework (True Cost of Food) based on definitions by TEEBAgriFood and the metrics of several frameworks, such as TEEBAgriFood, True Price and the Capital Coalition	Baseline assessment against the alternative scenario of not having a programme at all; scenario analysis for the assessment of three drivers	Investment and diet	It aimed to identify the current return of investment on school meal programmes, thereby identifying the costs and benefits that public expenditure on this programme creates. To analyse drivers of further increased benefit, the functional unit of "diet" was deployed to look at dietary patterns. Specific boundaries: For investment, the annual federal budget for two specific programmes; for dietary patterns, the United States of America population.	Quantitative assessment of 19 impacts in 6 areas: environment, biodiversity, livelihoods, economy, human health and poverty alleviation.
6	Climate-smart agriculture (CSA) in coffee[vi]	Stimulating additional investment in CSA, specifically in the context of coffee farming in Colombia	True Price	Baseline assessment: comparison between conventional and CSA coffee production. In addition,	Investment (to transform one farm from conventional farming to farming with CSA). A secondary part	Starting farming with CSA requires substantial investment – without financial support, this is not feasible for most farmers. The study shows that there is both a financial business case as well as an "impact business case". By focusing on investments in single farms, the investments are most tangible.	Eight environmental and four social externalities were included, in line with the True Price methodology. Social indicators for which there was no indication that they would be

Study		Policy goal	Framework/ approaches used	Assessment design	Chosen functional unit	Rationale behind chosen functional units and boundaries	Indicators in scope
				a baseline assessment was designed in combination with projecting information into the future to inform current decisions	of the study – but excluded from this case study summary – was the True Price assessment using the functional unit of a kilogram of parchment coffee	Specific boundaries: The parts of the Colombian coffee value chain assessed were cultivation and on-farm processing of coffee cherries to parchment coffee. Transportation was assessed if it directly affected farmer income. Activities further up the value chain were excluded, however, for example, transportation and roasting.	different in the various systems compared were excluded.
7	True price of cocoa[vii]	For companies, reducing the external costs of own chocolate; for the sector, contributing to the mission of making the cocoa sector child-labour and forced-labour free (and that all cocoa farmers make a living income)	True Price	Baseline assessment with a comparison between Tony's and benchmark cacao with a time comparison (2013 and 2017)	Product (1 kg of cocoa at farm-gate level)	The main analysis focuses on cocoa farms (suppliers of suppliers), where most external costs are generated. An estimate was made of external costs for a (milk and dark) chocolate bar using per kg rather than total costs of all cocoa purchased to make it comparable over time. Specific boundaries: The Ivorian and Ghanian Cocoa on-farm production phase was the main focus, as it was estimated to be the main driver of external costs, excluding transport and manufacturing processes further upstream in the value chain.	Includes all 14 externalities included as standard in the True Price methodology. The focus is on child and forced labour and underpayment, as these are most material, both in terms of severity and how Tony's Chocolonely distinguishes itself from conventional cocoa producers.
8	Genetically modified vs organic corn production in Minnesota[viii]	Showcasing the external costs associated with genetically modified and organic corn production using the TEEBAgriFood Evaluation Framework	TEEBAgriFood Evaluation Framework	Baseline assessment and a scenario analysis (intervention)	Product (bushel of corn)	The study aimed to show the external costs of corn production and options to reduce these by shifting agricultural practices, with a focus on regional farmers, industry and policymakers. The choice of a bushel of corn as the functional unit allows comparison with the market pricing unit and removes the need for adjustments to changes in total production. Specific boundaries: System of corn production, processing and human consumption of corn-based meat and other	Includes eight impacts in the environmental, health, social and economic domains. Effects that are more complex to model (such as pesticide impacts on human health and biodiversity and flooding) were explicitly placed out of scope.

Study		Policy goal	Framework/ approaches used	Assessment design	Chosen functional unit	Rationale behind chosen functional units and boundaries	Indicators in scope
						food products in the Minnesota river basin. Natural, social and human external costs were assessed at farm and landscape scale. Health impacts were assessed in the State of Minnesota.	
9	The true price of cheap beef and pork[ix]	Identifying the gap between the market prices and true costs of meat to show the failure of current market conditions; stimulating a shift in fiscal and regulatory policy to incentivize a reduction in and internalization of external costs	TEEBAgriFood (for definitions), Natural Capital Protocol (for analysis)	Baseline assessment: comparison between different kinds of meat, differently produced – used to identify levers where external costs can be reduced in the future	Product(s): 1 kg of beef (German business as usual, German organic, Argentinian business as usual) and 1 kg of pork (German business as usual, German organic)	To shift incentives for meat production and consumption, it is crucial to know what the current costs of common meat products are. With this functional unit, different kinds of meat are comparable and serve as a reference point for which costs of meat need to be reduced and internalized. Specific boundaries: Livestock within country-specific boundaries. Excludes meat from cows that were producing milk for consumption during their life (to avoid a complete attribution discussion).	Six impacts were included, but only environmental impacts due to data constraints and the need for further development of social/human costs.

Sources: Authors' own elaboration based on [i] Hendriks *et al*. (2021); [ii] Kurth *et al.* (2019); [iii] TEEB (2018a); [iv] Rockefeller Foundation (2021a); [v] Rockefeller Foundation (2021b); [vi] Brounen *et al.* (2019); [vii] True Price (2018); [viii] Sandhu (2019); [ix] Bandel *et al.* (2020a).

6 Guidance on conducting a true cost accounting study: measuring and valuing stage

After selecting the relevant indicators based on materiality, as well as the valuation approach, the indicators can be measured and valued in the subsequent stages. Table 10 illustrates the described measurement, valuation and application stages with case studies.

6.1 Measurement

The chosen indicators determine which metrics, methods and data are required. Annex 5 provides both a suggested list of indicators to include in a TCA study and guidance on how to measure them. The complexity of indicator measurement varies significantly, for example, based on the availability of data and/or the methodology. If the feasibility of the TCA study appears to be low due to limited data, for instance, the framing and scoping of the TCA study should be revised. This is an iterative process. Chapter 8 provides more detail on data collection.

6.2 Valuation

Valuation of indicators involves estimating their relative importance, worth or usefulness to people or society (TCA Accelerator and Impact Institute, 2023). Valuation is the step in which measured indicators are translated into information understandable to the users of TCA frameworks, informing decision-making (Section 2.3). Valuation approaches can be qualitative, quantitative or use monetization, as well as combine different approaches (Eigenraam *et al.*, 2020; TCA Accelerator and Impact Institute, 2023). For example, monetization can be applied to all or some indicators.

6.2.1 Valuation techniques

The TEEB AgriFood Evaluation Framework and other TCA frameworks support multiple valuation approaches (Eigenraam *et al.*, 2020). Within these valuation approaches, there are different robust techniques. Valuation techniques for environmental and health indicators are often the most evolved and those for social indicators the least evolved (Lord, 2020). Table 9 describes existing valuation techniques for natural capital (Natural Capital Coalition, 2016).

Table 9. Valuation techniques for natural capital

Technique	Description
Qualitative	
Opinion surveys	Undertaking surveys to gather views
Deliberative approaches	Consulting focus groups (for example, through in-depth discussion)
Relative valuation	Using a scale (for example, low/medium/high) to determine the relative value of costs and benefits, based on available data and expert judgement)
Quantitative	
Structured surveys	Undertaking surveys to obtain quantitative values involving a structured set of closed questions to which statistics can be applied

Technique		Description
Indicators		Using indicators to quantify information, for example, yield/ha, GHG emissions or disability-adjusted life years
Multi-criteria analysis using scoring and weighting		Ranking the value of a set of criteria through scoring and weighting, based on available data, workshops and/or expert judgement
Monetary valuation*		
Market and financial prices		Using available data on market prices to estimate values such as prices paid for tradable goods and services (timber, pollution permit)
Production function		Applying an empirical modelling approach to estimate change in the output of a good or service because of a change in capital inputs
Cost-based approaches	Replacement costs	Using the required costs to substitute a service provided by natural capital with an artificial equivalent based on the market price
	Damage costs avoided	Estimating the costs of property, infrastructure and production losses due to damage to natural capital, treated as saved costs from conserving capital
	Compensation costs	Estimating the costs of compensating for negative indicators
	Defensive expenditure	Estimating the value paid to mitigate a risk or disadvantage (for example, for safety equipment)
Revealed preference	Hedonic pricing	Using market prices of goods and services to derive the assumed contributed value of capital indicators, by controlling for other variables
	Travel costs	Using travel and other expenses spent for a recreational visit to a natural asset to estimate its value
	Subjective well-being valuation	Using the relationship between life circumstances (such as level of employment and safety) and levels, or self-reporting well-being
Stated preference	Contingent valuation	Consulting individuals for their maximum willingness to pay or accept compensation for a change in the good or service provided by capital
	Choice experiments	Consulting individuals on their preferred option when presented with various alternative goods/services with different features and prices
	Valuation game	Consulting individuals on how they value outcomes by comparing preferences for goods/services with known market values
	Hybrid stated preference/well-being valuation	Consulting individuals on their willingness to accept compensation for a loss that keeps their well-being level stable

Note: * Market price proxies are preferred overstated or revealed preference methods (Bandel *et al*., 2020b) and prevention cost over damage cost (True Cost Initiative, 2022; True Price, 2018).

Sources: Adapted from Natural Capital Coalition. 2016. *Natural Capital Protocol.* The Hague. https://capitalscoalition.org/capitals-approach/natural-capital-protocol/?fwp_filter_tabs=guide_supplement; Social & Human Capital Coalition. 2019. *Social & Human Capital Protocol.* The Hague. https://capitalscoalition.org/capitals-approach/social-human-capital-protocol

Monetization is usually done by multiplying a monetization factor by an indicator in its natural unit (IEF, 2022a). Monetization factors are available, but can be estimated in different ways, such as damage or replacement cost (True Cost Initiative, 2022; True Price, 2021). Developing these monetization factors requires normative assumptions, on which broad consensus might be lacking (TCA Accelerator and Impact Institute, 2023). Databases for (monetary) valuation, which can be used in TCA studies, can be found in Table A2 (Annex 3).

Recommendation:

Communicate clearly on the method and underlying assumptions used.

Suggested further reading on the resources required, (dis)advantages and application examples:

- Natural Capital Protocol (Natural Capital Coalition, 2016)
- TEEB for Agriculture & Food: Scientific and Economic Foundations, Chapter 7 (TEEB, 2018b)

6.2.2 Discount rate

Many policy (and business) interventions deliver their costs and benefits in the future, and with a degree of uncertainty. Applying TCA in such contexts is then very similar to investment analysis or making business cases in traditional finance. There, a discount rate is used to make projected costs and revenues in different years comparable and to create a single indicator for guidance, often the net present value (NPV).

$$NPV = \sum_{t} \frac{revenue\ (t) - costs\ (t)}{(1 + discount\ rate)^t} \quad (1)$$

In finance, the discount rate is typically related to the cost of capital of the company or the investor. In TCA, where effects on different stakeholders in society are included, it is more apt to use a social discount rate (Lord, 2020).

Choosing a value for the (social) discount rate can have substantial effects on the outcomes of the TCA study (and, hence, on the decisions taken based on them). Investment and business decisions frequently use discount rates of 10 percent or even more. Note that a high discount rate makes the denominator in formula (1) large for years ahead, so reduces the contribution of these years to the NPV. In a business context, this suggests that investors would rather have their money today than tomorrow.

In a TCA context, however, a high discount rate implies the prioritization of people's well-being today rather than in the future. Relatively low discount rates are advised, therefore. The chosen discount rate is particularly relevant for natural capital indicators. It is, for example, an important parameter for the development of regulatory policies for the protection of natural resources; a low discount rate helps to avoid ecosystem degradation (TEEB, 2018b). The following recommendations can be made.

Recommendations:

If a TCA study requires the valuation of future indicators, use a discount rate to aggregate costs and benefits in different years.

When conducting multiple, related TCA studies, use a single discount rate to keep results comparable.

Use a relatively low discount rate of 3–5 percent, in line with that of TEEB (2018b).

7 Guidance on conducting a true cost accounting study: applying

In this stage, the results of a TCA study are presented and interpreted, ensuring a structured way of accounting for different external effects and, ultimately, informing decision-making.

7.1 Interpretation and testing

Before interpreting the results of a TCA study, the results should be tested for their sensitivity to changes in the assumptions made – for example, how the results (and conclusions) are affected when a considered investment in more efficient irrigation techniques only realizes half the forecast water savings. However, the sensitivity of the results to less specific assumptions should also be considered, such as a change in the number of people affected or a change in the assumed discount rate. A sensitivity analysis specifies the level of confidence one can have in the results of a TCA study by providing the necessary margins of error. A sensitivity analysis is arguably most important when working in data-scarce contexts, as many of the results will rely on estimations and assumptions.

If a "back-of-the-envelope" calculation, as described in Section 5.2.2, has been done, one can compare the expected results based on the first rough estimate with the actual results found after the measuring and valuation stages. If they are close, this is an indication that both the materiality assessment and the measurements are robust. If they deviate more substantially, one should dig deeper into why this is the case. This can also lead to a reassessment of the indicator selection. If some indicators were expected to be highly material, but in reality were not, the opposite might be true. Some indicators that were deemed not very material might actually be material. It might now be worth repeating the measurement and value step for these indicators.

Recommendation:

Ensure the robustness of a TCA study by undertaking a sensitivity analysis on the chosen indicators, as well as measurement and valuation approaches, and provide quantitative results with error bars in a range or as a rounded number (Eigenraam *et al*., 2020).

7.1.1 Aggregation

Once the sensitivity of the results has been assessed, the results need to be presented in an aggregated way that can inform decision-making. Aggregation is the active choice of combining multiple individual indicators (as a result of the measurement and valuation process) into a single value. Through aggregation, the number of outcomes of a TCA study can be reduced to enable interpretation.

Aggregation can, in theory, be straightforward if all indicators are valued in the same (monetary) unit. However, caution still applies, as benefits to some do not automatically justify costs to others. Even if the benefits to one stakeholder group are larger than the cost to another group, policymakers must choose what costs are acceptable to whom in exchange for benefits to others.

Recommendation:

Take care in interpreting the effects of outcomes. Ensure that all stakeholders are included (Eigenraam *et al*., 2020). This is especially relevant to policymaking and deciding the "winners" and "losers" in policy scenarios (Sandhu *et al*., 2021).

The split between costs and benefits is the most obvious separation when aggregating TCA results. It makes explicit whether certain stakeholders or capitals are "losing out" under certain scenarios compared with others. In other words, netting costs and benefits should be avoided. Other, non-exhaustive options are to aggregate results by stakeholder group or capital. Aggregating the results in different ways can provide decision-makers with different insights into the intended policy goal.

Recommendation:

Do not aggregate costs and benefits to different stakeholders.

If the results of a TCA study consist of indicators that are valued in different units, such as a qualitative scale and monetized values, the interpretation phase asks policymakers to form an opinion on their relative importance to the decision at hand (see the TEEBAgriFood organic rice production study in Table 10 [Faculty of Economics, Khon Kaen University, 2022]).

A suitable, comprehensive way of presenting TCA analyses to stakeholders is key to scaling up TCA for policymaking and taking action. In presenting TCA analyses, ensure that all stakeholders in the agrifood systems understand the TCA study and the meaning of the results (True Cost Initiative, 2022), including its assumptions, uncertainties and limitations (Eigenraam *et al.*, 2020).

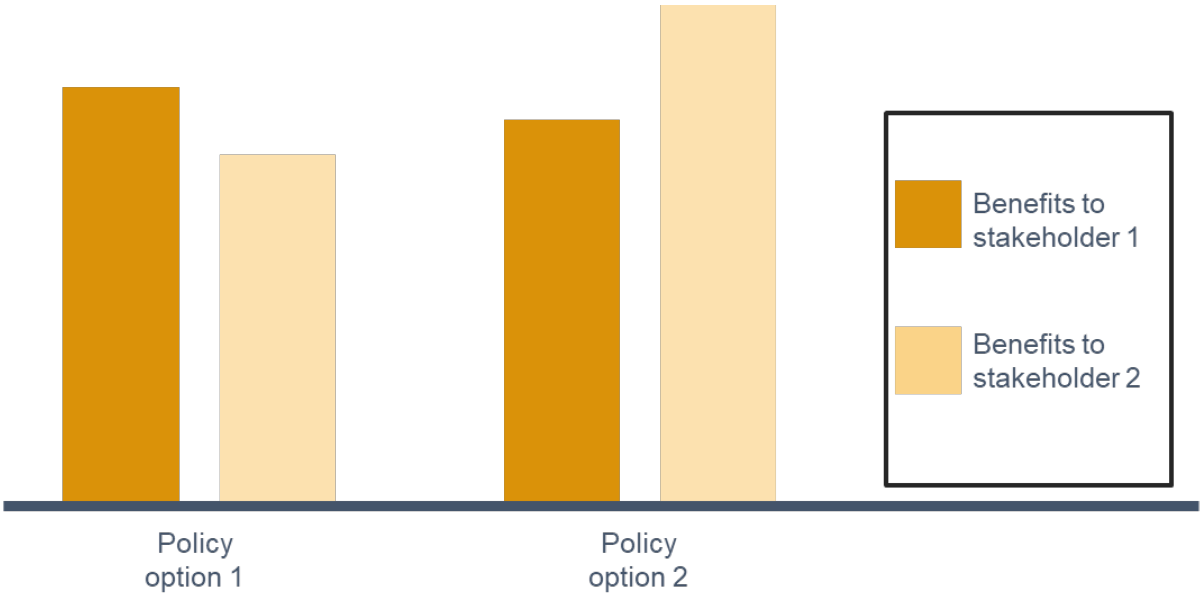
Recommendation:

Present TCA analyses in a comprehensive way and ensure all stakeholders understand the TCA study, including results, but also its main assumptions, uncertainties and limitations.

7.1.2 Making policy decisions based on true cost accounting results

The step in which the obtained information is integrated into decision-making requires political choices, as illustrated by the example in Figure 10. In this hypothetical TCA study, the benefits of two stakeholders were compared under two policy options. The TCA study makes explicit that option 1 creates more benefits for stakeholder 1, while option 2 is more beneficial to stakeholder 2. However, the TCA results do not profess a preference for either option; they merely enable a policymaker with common sense and a moral compass to make an informed decision.

Figure 10. Hypothetical results of a true cost accounting study comparing the benefits for two stakeholders under two policy options



Source: Authors' own elaboration.

Properly scoped TCA studies expand informed decision-making to include trade-offs and synergies between environmental and social capital indicators and dependencies across stakeholder groups, as illustrated by the case studies and their applications in Table 10. For example, the study on CSA in coffee shows clear benefits (Brounen *et al.*, 2019), but relatively high upfront investments are required. These should be provided in part through the investment of public money, but also require lobbying to secure finance from private investment. In addition, the "true" return of investment used in the case study is subject to uncertainty, making decision-making more complex.

When comparing different policy options, it is also important to consider their transboundary and intergenerational effects. An example of a transboundary effect is stimulating agricultural production in region A rather than region B, which decreases overall pollution, but increases it in region A. There are no objective criteria to say whether this is just or not. When there is an effect on the climate, the issue is even more complex, as intergenerational equity is also involved.

Table 10. Selection of true cost accounting studies with their policy goals, framework used, assessment design, chosen functional unit including rationale and boundaries, and indicators in scope

Study		Measure	Value	Apply
1	True cost and true price of food (global)[i]	Secondary data from multiple data sources were used. Estimates of the externalities of food production were based on national data and food groups and were combined to obtain a global estimate. Expenditure data were used to estimate the externalities related to consumption.	To obtain monetary values for the environmental externalities, remediation costs at country level were used in line with the True Price methodology. To obtain the health costs, the median global value of statistical life was used.	The study showed the high-level usefulness of TCA in policymaking. It is recommended that policymakers increase access to the application of TCA and stimulate harmonization in the TCA field. Furthermore, policymakers should integrate true pricing into market prices in the short term using pragmatic, second-best policy interventions.
2	External costs and biodiversity effects of agriculture in Germany[ii]	Secondary data (based on other studies), mostly country-specific data; gaps were filled using European Union or global mean values applied to the German context.	The monetary values were calculated based on damage and abatement costs.	The study outlined different options for sustainable agriculture, showing some scenarios that were not advisable and other measures that were ready to be adopted. It thus contributed to the overall discussion (Germany- and European Union-wide) of what sustainable agriculture could or should be.
3	Organic rice production in Thailand (2018)[iii]	Field studies were conducted to obtain primary data on biodiversity. The Denitrification–Decomposition (DNDC) GHG model and a literature review were used to estimate GHG emissions. Health impacts were estimated using an exposure risk function and household surveys that obtained socioeconomic data from farmer households. Future projections were based on land-use modelling. The modelled land-use estimates were used to compare the biodiversity index, GHG emissions, yield, the effect of air pollution on people's health and the effect of pesticides on farmers' health between conventional and organic rice practices.	Health impacts were valued using choice experiments (using value of statistical life) and the amended human capital approach. A carbon price was used to monetize GHG emissions.	The study results were used to provide policy recommendations, namely: • The study emphasized the need to stimulate organic rice production by extending, adding or changing policy. • The government should ensure that farmers can ask a higher price for their organic rice to offset potentially lower yields. • Farmers can be encouraged to adopt organic production with subsidies.

Study		Measure	Value	Apply
4	True costs of the United States of America (US) food system[iv]	Secondary data comprised a mix of governmental statistics, scientific literature and renowned publications, such as reports by international organizations and non-governmental organizations (NGOs).	Monetization was based on factors using the True Price methodology (remediation costs that included damage and remediation costs).	This TCA study served as a starting point for estimating the costs of the US agrifood systems and laying the foundations for future interventions with a view to a more sustainable agrifood systems. It laid the groundwork for a targeted TCA for the improvement of the public school meal programme.
5	True cost of food: school meals case study[v]	Secondary data comprised a mix of governmental statistics, scientific literature and renowned publications, such as reports by international organizations and NGOs.	Monetization factors were based on factors using the True Price methodology (see above).	In addition to showing the current meaningfulness of the school meal programmes in terms of their impact, the study promoted additional, targeted investment in the programmes to further increase its true value, especially in terms of health benefits, environmental and biodiversity effects and livelihoods.
6	Climate-smart agriculture (CSA) in coffee[vi]	The study was mostly based on primary data collected by a survey of 60 smallholder farmers. Publicly available secondary data were used to supplement and compare. For some impacts, calculations were based on datasets collected by federal/national statistical offices, while other impact assessments were based on country-specific mean values, references from the Water Footprint Network and the Cool Farm Tool.	Based on the True Price methodology (see above).	The study substantiated the use of a true return on investment (ROI) in TCA studies and in steering investments. Based on the results, the study recommended financial support for farmers by investing in a shift to CSA practices. Policymakers and the financial sector can help incentivize the adoption of CSA practices, for example, through better loan conditions or payments for environmental services. The Solidaridad Network published the study and uses it as part of its campaign to promote CSA.
7	True price of cocoa[vii]	Primary data were collected as much as feasible by Tony's Chocolonely as part of a supplier survey. Data for the benchmark cacao were retrieved from the literature, in particular, the cocoa barometer and a Tulane University study on child labour in the cocoa sector. If primary data were lacking, secondary data were used that most closely resembled the system (unless there were arguments as to why	Based on the True Price methodology (see above).	Tony's main conclusion is that it is on the right track to produce chocolate with minimal external costs, but that further improvements are required. A number of impacts are identified as blind spots: Tony's was less aware of these, so these were measured and managed less. An assessment of the living wage is of direct importance and coupled to pricing strategy.

Study		Measure	Value	Apply
		Tony's would under- or overperform the sector). See Box 2, Chapter 8 for details. For example, when data for 2013 and 2017 were not available, the study extrapolated datapoints for existing years. Data collection accounted for a substantial part of project time, notably to resolve differences between the two systems and time periods.		Unfortunately, changing the sector is slow. While the assessment of the living wage was conducted prior to the study in question, it remains a point of tension.
8	Genetically modified vs organic corn production in Minnesota[viii]	Primary and secondary data were used to roughly estimate the health impacts. In addition, the study reviewed existing scientific literature to assess all capitals. Mainly, data on average corn production in Minnesota were used.	Health impacts were valued using the Well-being Valuation method.	Stakeholders have different roles and options to reduce external costs. Farming communities can adopt sustainable agricultural practices to reduce external costs. However, the way in which farmers receive the insights obtained during this study and the potential practices they can adopt need to be developed further. Policymakers can incentivize these alternative farming systems, but changing current agricultural and energy policies will take substantial effort.
9	The true price of cheap beef and pork[ix]	Publicly available secondary data were used. For some impacts, the calculations were based on datasets collected by federal/national statistical offices, while other impact assessments were based on country-specific mean values, references from the Water Footprint Network and the Cool Farm Tool.	Monetization based on suggested monetization factors by FAO for agricultural farms (2014).	The study showed that the consumption of all examined products comes with significant extra costs that are not included in the market price. There are different ways to go about reducing these externalities depending on the kind of meat. While the environmental costs of pork can be reduced by extending the share of organic livestock, there is a conflict of interest when it comes to how to reduce the cost of beef (methane vs other externalities), which requires further research.

Sources: Authors' own elaboration based on [i] Hendriks *et al*. (2021); [ii] Kurth *et al.* (2019); [iii] TEEB (2018a); [iv] Rockefeller Foundation (2021a); [v] Rockefeller Foundation (2021b); [vi] Brounen *et al.* (2019); [vii] True Price (2018); [viii] Sandhu (2019); [ix] Bandel *et al.* (2020a).

8 Gathering data for a true cost accounting study

A TCA study requires a substantial amount of data to be collected to assess the costs (and benefits) in scope. When taking a ⅓-⅓-⅓ approach (Section 3.3), most of the final third is spent on data collection. And in TCA studies where the objective and scope phase receive less attention, data collection can easily eat up the majority of time and resources.

The obvious goal is to ensure that data are fit for purpose. The data used should have the quality and granularity necessary to make the policy decision, but need not be more detailed than that. A lack of (robust) data at low cost is potentially the main barrier to scaling up TCA (Bandel *et al*., 2020b). This is particularly pressing for TCA studies set in middle- and low-income countries, where secondary data are scarce and primary data collection is costly. The *TCA Agrifood Handbook* provides an in-depth overview of data limitations per TCA indicators in Annex II (True Cost Initiative, 2022).

The following questions now guide the scaling up of TCA in view of the data-scarcity bottleneck:

- How can the required resource intensity of data collection be reduced?
- How can estimations of missing data be used in TCA?
- Can data of "insufficient" quality be included in TCA and ultimately inform policy decision-making?

8.1 Data strategy

Data can be obtained from three sources (Eigenraam *et al*., 2020; Lord, 2020):

- Primary data: Data directly obtained during the data collection specifically conducted for the TCA study. This includes surveys, physical measurements and (field) experiments.
- Secondary data: Data originally collected and published for another purpose or a different study, but which approximately describes the information required (Eigenraam *et al*., 2020; True Cost Initiative, 2022). Secondary data can, for example, be obtained from earlier TCA studies, (peer-reviewed) literature and existing databases. In addition, governments often have data on the agrifood systems, such as water pollution and farmer income.
- Modelled data: In the absence of suitable primary and secondary data, data can be modelled based on primary and secondary data from different contexts. Readily available models are the Cool Farm Tool, environmentally extended input-output models, and general or partial equilibrium economic models (Cool Farm Alliance, 2019; Lord, 2020; TEEB, 2018b).

More guidance on the collection of these three types of data can be found in Section 8.4.

8.1.1 Data hierarchy

At the start of the data collection phase, it is important to make clear which data sources are preferred. Such a data hierarchy can lead the data collection and guide choices when data are scarce (see Section 8.2).

Overall, the TCA literature states a preference for primary data where possible and the following recommendation follows on from that:

Recommendation (if resources are abundant)**:**

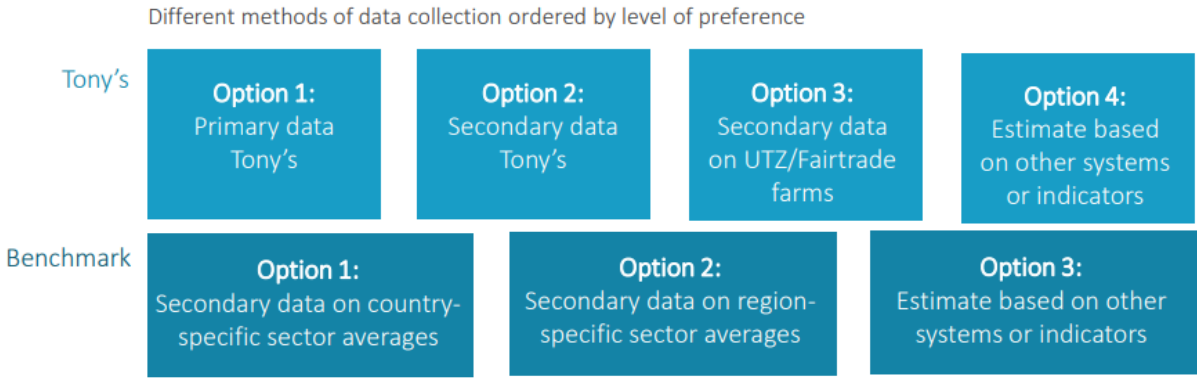
Use primary data where available, adding and substituting with secondary data as necessary (True Cost Initiative, 2022).

Data quality depends on completeness, methodological appropriateness and representativeness in terms of time, geography and precision (Zampori and Pant, 2019). The preference for using primary data is down to the fact that such data can be made fit for purpose by the project team itself, so typically scores best on data quality criteria.

Figure 11 gives an example of a data hierarchy in a TCA study, where the true prices of two systems were compared (cocoa in Tony's Chocolonely chocolate bars and benchmark cocoa from Ghana and Côte d'Ivoire).[14] For all indicators of Tony's and benchmark cacao, primary data were sought, but were only available for some of the former.

Care should be taken when using both types of data, as the results might be biased when comparing two types of data of differing quality. In the Tony's Chocolonely example, primary data were used for some indicators of Tony's chocolate, while secondary data were exclusively used for the benchmark.

Figure 11. Example of a data hierarchy



Source: True Price. 2018. *The True Cost of Cocoa: Tony's Chocolonely.* Amsterdam. https://trueprice.org/wp-content/uploads/2022/07/The-True-Price-of-Cocoa.-Progress-Tonys-Chocolonely-2018.pdf

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Recommendation:

Use a data hierarchy to make clear which type of data to select over others if multiple approaches are available.

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[14] For more detail, see IEF (2023).

8.1.2 Reversing the data strategy

Unfortunately, situations in which resources are abundant are rare. Of the three data options, primary data collection is typically the most expensive in terms of time and resources. One has to be in the field to collect the data through surveys, measurements and experiments, rather than use literature and databases that capitalize on the hard work of others.

In practice, the preference for primary data is often reversed. At the start of the analysis phase, all data points are roughly estimated based on easily available secondary or modelled data sources.

They are subsequently tested to see what the conclusions of the TCA study would be if this were the final model. The team then tests to see which data-point variations would lead to substantially different conclusions and which would not. This is very similar to the "back-of-the-envelope" calculation mentioned in Section 5.2.2. This first, rough estimate can be compiled using hotspot analysis, for example (Section 8.2), or extended input-output models (Section 8.4.3).

Recommendation (if resources are limited):

Start with the data that are available. Use this to determine which data points are crucial to answering the policy question, then focus on refining the available data points and filling in missing data points only.

Only for the first set of data points do data need to be refined. This can involve the targeted collection of primary data or spending more time and budget on better-fitting secondary or modelled data. Within each category, higher data quality can be obtained from a higher level of spatial or temporal detail, for example, but this again involves greater complexity (United Nations, 2021).

Recommendation:

Match core data requirements with the TCA study objective. A balance between pragmatism and precision should be sought (Lord, 2020).

Estimating, then refining crucial data points helps make effective choices between increasing the level of detail and practical use for policy.

Stylized example – comparing milk production systems

A TCA study often compares two systems with a view to addressing their costs and benefits with respect to the other. A policymaker can then use the outcomes to press for the better-performing system over the worse-performing one. The absolute value of indicators is not necessarily key; the policy will be guided by where the systems differ. This logic is illustrated using a fictional TCA study comparing the effects of conventional and organic milk production systems (Figure 12).

Fictional case study

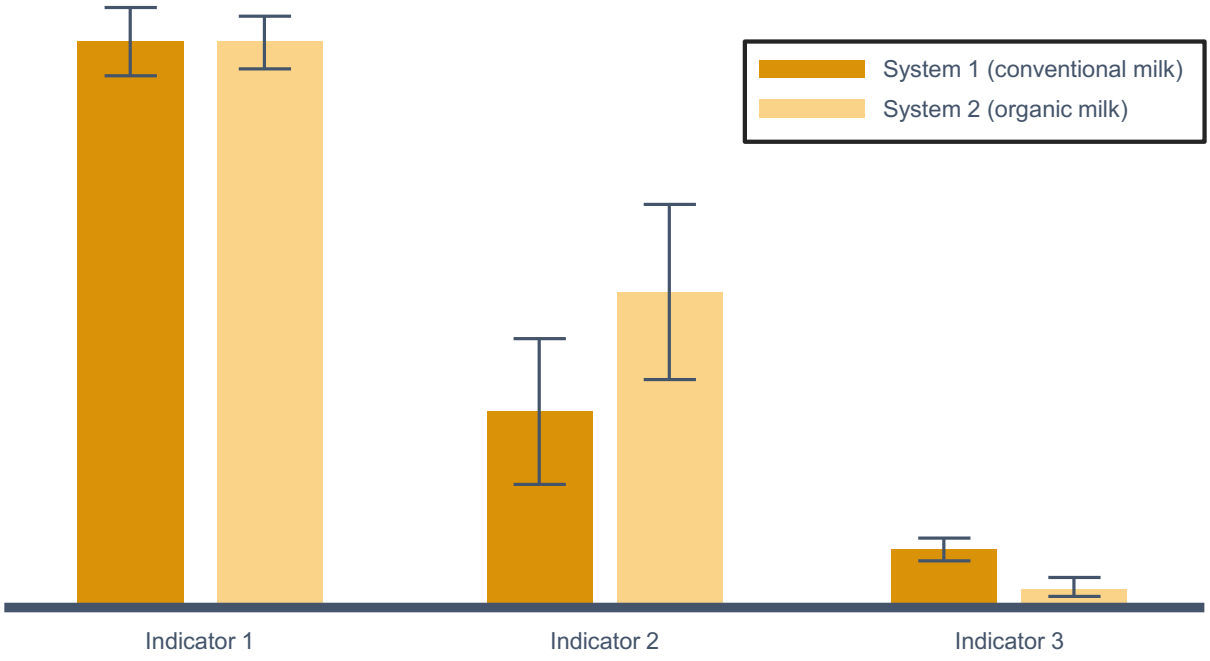
The research team initially makes a first estimate of the costs and benefits of each system. This can be based on readily available data, such as life-cycle assessment (LCA) studies or national statistics. The context of the data does not have to tally exactly with that of the study. For instance, the LCA study can be in another country or several years old.

The team also makes a rough assessment of how robust each result is when data quality is refined. This is shown by the error bars in Figure 12. Note that the error bars are often decided based on qualitative rather than quantitative assessment and cannot always be determined precisely, but it is the order of magnitude that matters.

When indicators between the systems are compared, one indicator can be large in absolute terms, but the difference between the two systems can be small (indicator 1 in Figure 12). This indicates a lower priority for refinement. Another indicator can be medium sized in absolute terms, but the difference between the indicators can be substantial. In addition, the team can be uncertain as to whether the results of the initial analysis are robust (as shown by the indicative error bars). Therefore, this type of indicator should be refined as a higher priority.

Lastly, an indicator can be small in absolute terms, but three times larger in one system than the other (indicator 3 in Figure 12). The total "weight" of the difference is small, even though there is large relative difference. Refinement is lower priority, therefore.

Figure 12. Stylized view of data strategy choices based on an initial analysis with three impacts valued in a consistent unit



Source: Authors' own elaboration.

8.2 Hotspot analysis

Hotspot analysis is an alternative to full quantification and is helpful in the first step of the reversed data strategy. In a hotspot analysis, the relative importance of the different indicators is made explicit without fully quantifying them. It can be used when data are scarce, but also

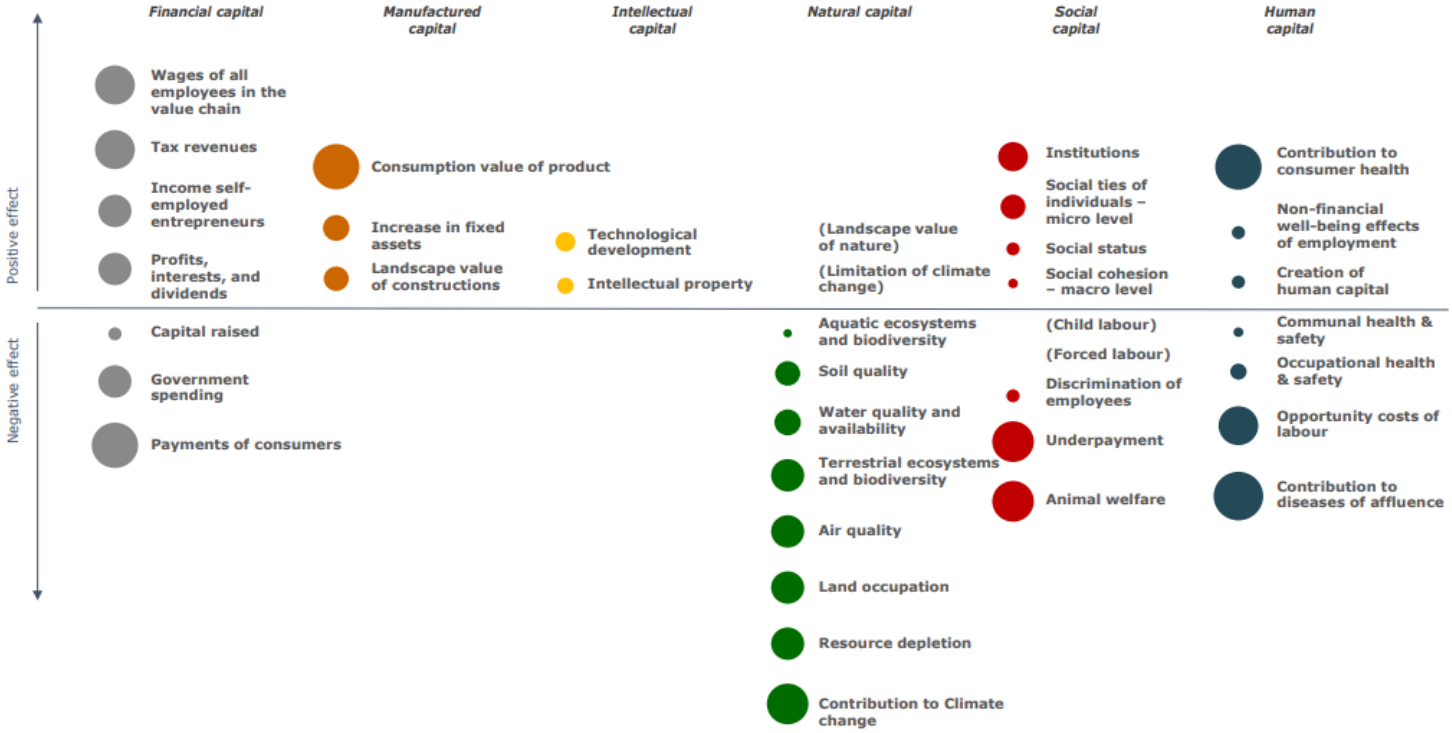
in other contexts where quantification is not possible, for example, if there are no methods to assess certain indicators.

Figure 13 gives an example of the results of a hotspot analysis on milk consumption and production (Baltussen *et al*., 2017). It shows the relative importance of a few TCA indicators on a 0–7 rating scale. In the underlying study, only a couple of the indicators could (easily) be quantified based on the available techniques, data and time. Instead of attempting to quantify the others, they have been assessed qualitatively. The indicators for which quantitative values were available then functioned as points of reference.

Some examples illustrate the logic. A full analysis is available in Baltussen *et al*. (2017) (in Dutch):

- The price of milk is known. This produces the indicator “payments of consumers”, which now functions as one of the main points of reference.
- It is assumed that consumers only buy milk if the value of it is as least as much as what they paid for it. Therefore, the impact “consumption value of product” is at least as large as the impact “payments of consumers”.
- The value distribution over the value chain is roughly known. Together, these add to the milk price (with a correction for subsidies). This means that “wages”, “tax income”, “income of entrepreneurs” and “profits of corporations” are one or two Likert scales smaller (a rating scale in which a scale smaller means less value) than the “payments of consumers”. The first two are estimated higher than the last two in this low-margin sector.
- Based on LCA studies, some of the natural capital impacts are calculated, in particular, “contribution to climate change”. Monetary valuation with a carbon price enables comparison with the milk price. This naturally puts the impact 1 Likert scale below the “payments of consumers”.
- This is repeated for other natural capital impacts. For those where no LCA value and/or no monetary valuation is available, the literature is searched for sources that explicitly describe these as more or less important than the other natural capital impacts that now act as points of reference.
- Milk is rich in both valuable nutrients (in particular, calcium and protein) and fat and calories (especially in some dairy derivatives). Because of this, it is deemed to contribute highly to both consumer health and diseases of affluence.
- The dairy sector is relatively labour extensive compared with other economic sectors. This means that all employment-related indicators (such as the well-being effects of employment, occupational health and safety) are assessed as either medium or small.
- The results can be used to better inform policymakers on how agrifood policy can optimally contribute to well-being.

Figure 13. Hotspot analysis showing the societal effects of production and consumption of milk



Sources: Baltussen, W., de Adelhart Toorop, R., De Blaeij, A., De Groot Ruiz, A., Janssens, B., Logatcheva, K., Van Maanen, E. & Ponsioen, T. 2017. *Maatschappelijke effecten van voedsel: Een verkenning van een nieuwe methodiek*. Wageningen, Kingdom of the Netherlands, Wageningen Economic Research. https://doi.org/10.18174/408313

8.3 Data scarcity

The "reversed" data strategy set out in Section 8.1.2 indicates that roughly estimated data points can already give a sense of urgency on which data to refine. In the example of Figure 12, if no actual datapoints are available for indicator 3 (or even indicator 1), that is not much of a problem. Only for indicator 2 does one really need to dig deeper.

Solutions to data scarcity

When pursuing a "reversed" data strategy, it is relatively rare to encounter a total lack of crucial data, but it can happen. What is more, a solution is required in instances where there is a scarcity of data of sufficient quality. Some pathways can be found in the following sections. In addition, publicly funded research and analysis are required to obtain more data, at the consumer/consumption level, up the food value chain and within agricultural production itself (see also TMG Think Tank and WWF, 2021).

8.3.1 Gap-filling

A frequently observed problem is that no good estimates for a required data point seem to exist in the literature. In such cases, instead of giving up and using the value 0 for the data point, a better approach is to roughly estimate the data point based on the data one has found already. A simplified example is given in Table 11. Water pollution in country 1 is estimated

based on values for water pollution in country 2 and air pollution in countries 1 and 2. A more realistic illustration of gap-filling in practice can be found in Box 2.

Table 11. A simple example of gap-filling

	Country 1	Country 2
Water pollution	??	100 units
Air pollution	20 units	200 units

Note: The underlying assumption is that the ratio between water pollution and air pollution is similar in countries 1 and 2. Water pollution in country 1 can be estimated at $20 \times \frac{100}{200} = 10$ units

Source: Authors' own elaboration.

Almost always, gap-filling leads to a reduction in the representation of the data and, hence, the quality of the analysis.

Box 2. Gap-filling in practice – case study on the true price of cocoa

This TCA study assessed the true price gap of the cocoa used to make Tony's Chocolonely compared with a benchmark for both 2013 and 2017. The cacao is sourced from Ghana and Côte d'Ivoire. See IEF (2023) for a full description of the case study.

Data gaps for material indicators were encountered frequently in the study. The below provides an indication of how gaps were filled:

Occurrence of child labour

Data on the total number of child workers (per age category and type of work [hazardous/non-hazardous]) were collected in 2015, right in the middle of the two-year scope. There was qualitative evidence that this number was not increasing or decreasing rapidly.

Côte d'Ivoire, 2015	
Number of child workers (5–14, hazardous)	840 000

Source: Authors' own elaboration based on True Price. 2018. *The True Cost of Cocoa: Tony's Chocolonely*. Amsterdam, Impact Institute. https://impactinstitute.com/wp-content/uploads/2018/11/Impact-Institute-The-True-Cost-of-Cocoa.-Progress-Tonys-Chocolonely-2018.pdf

However, total production and labour productivity improved over time, suggesting a decreasing amount of child labour per kilogram of cocoa. In addition, labour productivity at Tony's farms was higher than the national average (in both years).

Variable	Côte d'Ivoire		Tony's farms	
	2013	2017	2013	2017
Total cocoa production	1.5 billion kg	2.0 billion kg	5.1 million kg	7.1 million kg
Average labour productivity	532 kg/FTE	769 kg/FTE	1 015 kg/FTE	1 302 kg/FTE

Source: Authors' own elaboration based on True Price. 2018. *The True Cost of Cocoa: Tony's Chocolonely*. Amsterdam, Impact Institute. https://impactinstitute.com/wp-content/uploads/2018/11/Impact-Institute-The-True-Cost-of-Cocoa.-Progress-Tonys-Chocolonely-2018.pdf

Tony's could not prove a lower occurrence of child labour at its farms compared with the national average in 2013. In 2017, it performed an audit that did prove this.

	Côte d'Ivoire, 2017	
	Country	Tony's
Percentage of farms with child labour	32%	11%

Source: Authors' own elaboration based on True Price. 2018. *The True Cost of Cocoa: Tony's Chocolonely*. Amsterdam, Impact Institute. https://impactinstitute.com/wp-content/uploads/2018/11/Impact-Institute-The-True-Cost-of-Cocoa.-Progress-Tonys-Chocolonely-2018.pdf

The above provides sufficient information to estimate child labour per kilogram of cocoa in every system in a comparable way.

Variable	Côte d'Ivoire		Tony's farms	
	2013	2017	2013	2017
Est. child workers per kg cocoa (1/1 000)	0.58	0.40	0.30	0.08
Calculation	840 000 children / 1.5 billion kg	0.58 × 769 / 532	0.58 × 1 015 / 532	0.58 × 1 015 / 532 × 11% / 32%

Source: Authors' own elaboration based on True Price. 2018. *The True Cost of Cocoa: Tony's Chocolonely*. Amsterdam, Impact Institute. https://impactinstitute.com/wp-content/uploads/2018/11/Impact-Institute-The-True-Cost-of-Cocoa.-Progress-Tonys-Chocolonely-2018.pdf

Occupational health and safety risks

- For occupational health and safety risks, the best available data were on the occurrence of incidents on farms both UTZ certified* and not UTZ certified. Explicit data for the farms producing Tony's cacao were not available. However, all Tony's farmers are UTZ certified.
- Tony's farms were set to the average of UTZ-certified farms. For the national average, the proper weighted average of UTZ-certified and non-UTZ-certified farms was used.

Variable	Benchmark 2013		Tony's 2013		Benchmark 2017		Tony's 2017	
	Ghana	Côte d'Ivoire	Ghana	Côte d'Ivoire	Ghana	Côte d'Ivoire	Ghana	Côte d'Ivoire
Share of farms UTZ certified (%)	12	28	100	100	19	33	100	100
Occurrence of incidents (incidents/ person/year)	0.36	0.35	0.32	0.32	0.36	0.35	0.32	0.32

Source: Authors' own elaboration based on True Price. 2018. *The True Cost of Cocoa: Tony's Chocolonely*. Amsterdam, Impact Institute. https://impactinstitute.com/wp-content/uploads/2018/11/Impact-Institute-The-True-Cost-of-Cocoa.-Progress-Tonys-Chocolonely-2018.pdf

Fertilizer use

- For fertilizer use, basically only one data point was available: for Tony's farms in Ghana in 2017.

- There is no clear indication that fertilizer use changed over time, was different on Tony's to other farms, or on Ghanaian and Ivorian farms. Therefore, fertilizer use per hectare in all systems was assumed to be the same.
- Amounts per unit output (kg cocoa) did differ, however, due to variations in land productivity.

Variable	Benchmark 2013		Tony's 2013		Benchmark 2017		Tony's 2017	
	Ghana	Côte d'Ivoire	Ghana	Côte d'Ivoire	Ghana	Côte d'Ivoire	Ghana	Côte d'Ivoire
Crop yield	377	518	230	633	420	486	573	680
Phosphorus fertilizer (kg/ha)	44	44	44	44	44	44	44	44
Phosphorus fertilizer (kg/unit output)	0.12	0.08	0.19	0.07	0.10	0.09	0.12	0.08

Source: Authors' own elaboration based on True Price. 2018. *The True Cost of Cocoa: Tony's Chocolonely*. Amsterdam, Impact Institute. https://impactinstitute.com/wp-content/uploads/2018/11/Impact-Institute-The-True-Cost-of-Cocoa.-Progress-Tonys-Chocolonely-2018.pdf

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Note: * UTZ certification provides a label for sustainable farming practices for tropical products such as cocoa and coffee.

Source: True Price. 2018. *The True Cost of Cocoa: Tony's Chocolonely*. Amsterdam, Impact Institute. https://impactinstitute.com/wp-content/uploads/2018/11/Impact-Institute-The-True-Cost-of-Cocoa.-Progress-Tonys-Chocolonely-2018.pdf

8.3.2 Innovative approaches

Innovative approaches gaining traction include agent-based models, which estimate the behaviour of economic agents when applying different scenarios (TEEB, 2018b).

Transformational Investing in Food Systems (TIFS) developed a TCA-based "system investing assessment" tool for quickly assessing a fund's intended impact, potential externalities and ability to execute on its stated investment thesis. TIFS has also developed an aggregation tool, which allows the comparison of multiple funds, both against each other and against systemic goals. Numerous indicators are aggregated along systemic themes, including environment, life and biodiversity, livelihoods, human health and system sustainability. Data points can be entered as simple yes/no results or using a 1–5 scoring method.

Artificial intelligence is transforming TCA, just as it is transforming other fields. ARtificial Intelligence for Environment & Sustainability (ARIES) was founded back in 2007. It describes itself as the first "Wikipedia-like" open-source platform for interoperable data and models (ARIES, 2021). Input from multiple users/contributors is integrated into a "semantic web", which enables the system to grow by itself and ensures that every user automatically uses the best data and models available.

8.4 Data-collection guidance

For primary, secondary and modelled data, collecting the data is a substantial part of the TCA study. The following three sections provide guidance.

8.4.1 Primary data: data-collection protocols

Existing data-collection protocols include New Philanthropy Capital for primary data (Noble *et al.*, 2020), the *Guide to Social Return on Investment* (SROI Network, 2012) and the *TCA Agrifood Handbook,* based on Product Environmental Footprint guidance by the European Commission (TCA Accelerator and Impact Institute, 2023; True Cost Initiative, 2022). New Philanthropy Capital and the *Guide to Social Return on Investment* focus on human and social capital, whereas the *TCA Agrifood Handbook* focuses on supply-chain sampling procedures on an organizational and product level.

Recommendation:

Use existing data-collection protocols as basic guidance and tailor them to the functional unit in scope.

8.4.2 Secondary data: available databases

The TCA Inventory provides an extensive overview of the databases, tools and other resources available to support policymakers and other practitioners in conducing TCA studies for agrifood systems (Eigenraam *et al*., 2020). Table A3 in Annex 3 provides examples of global databases, mostly used for monitoring natural capital indicators (Lord, 2020).

For a TCA study at product level, previously conducted LCAs provide a valuable source of data (Figeczky *et al*., 2021; TEEB, 2018b). LCA databases and published studies often provide all or most of the environmental indicators required for a TCA analysis.

If the context of the LCA study and the TCA analysis match perfectly, one can move directly to the valuation phase for these indicators. If the context of the LCA study is slightly different, LCA datapoints can be used as proxy data in a first approximation, as outlined in Section 8.1, for example, a different country or a different but comparable product (for example, using LCA data on grapes for raisins using a conversion factor to account for weight difference).

For social (and human) capital indicators, social LCAs exist, although this is a less developed field. Table A4 in Annex 3 shows a selection of often-used LCA databases. Note that not all databases are available free of charge.

Recommendation:

Use LCA databases and reports abundantly in TCA studies, even if there is no complete match between the scopes of the two.

8.4.3 Modelled data: available resources

Cool Farm Tool

The Cool Farm Tool can be used to roughly model GHGs, biodiversity and water use at farm level over a short period of time (Cool Farm Alliance, 2019). The tool enables the user to model these indicators in response to changes in agricultural management. Management practices

include fertilizer and pesticide applications, energy use, livestock feed, habitat characteristics, crop irrigation and manure processing. Further guidance, including a free e-learning course, is available on the Cool Farm Tool website.

Extended input-output modelling

Economic input-output (IO) models provide statistics by economic sector, showing the added value and final demand for each. They are, by design, mutually exclusive and collectively exhaustive (capturing all of the unique sectors) and can be extended environmentally (and sometimes socially). For each sector, they show environmental aggregate data, for example, for GHG emissions, water use and land use. They also show how sectors trade with each other, allowing insights into value chains.

Environmentally extended IO models (EEIO) can be used as proxy providers in TCA, under the assumption that the activity in scope is well represented by the average activity in its economic sector. The sectoral granularity of EEIO models differs by source. While some (such as Eora) have "agriculture" as a single sector, others (such as the Global Impact Database) split this sector into more granular subsectors (such as rice farming, wheat farming, farming of other grains, or vegetables and fruits).

EEIOs are particularly well suited to the first step in the reversed data strategy of Section 8.1, namely, the top-down estimation of the materiality of an indicator.

Table A5 in Annex 3 shows a selection of frequently used EEIO databases. Note that not all databases are available free of charge.

Recommendation:

Use (environmentally and/or socially extended) IO analysis in TCA studies, in particular, to get a feel for the relative order of indicators at the start of the analysis phase.

General and partial equilibrium models

Equilibrium models can be used as a tool to analyse a whole system or industry, similarly to EEIOs. By recalculating equilibria of supply and demand within a system, industry or economy, the effects of, say, policy intervention scenarios can be simulated. Relevant assessment aspects include labour inputs, wages, ecosystem services and GHG emissions (TEEB, 2018b). Table A6 in Annex 3 shows an example of an equilibrium model. See Section 8.4.3 for further reading on the advantages and limitations of equilibrium models.

9 Outlook

TCA has grown significantly over the past 10 years. A growing body of knowledge is now available to the practitioner. Still, open questions pop up in every analysis of hidden costs and benefits. To some degree, in every TCA study, researchers are reinventing the wheel.

This requires the community as a whole to harmonize approaches, so as to enable the next "wave" of TCA: rapid uptake in all sorts of context. The biggest limitations are in the two main topics of this paper: the approaches available for setting up a TCA study (Chapters 3 to 7) and data (Chapter 8).

9.1 TCA approaches

As discussed in Chapter 3, TCA was developed autonomously and heterogeneously by multiple commercial and non-commercial organizations. Many similarities can be observed among their approaches, but the differences are just as pronounced. Even within each approach, researchers face micro choices, meaning that if two researchers were to carry out a study on the same topic, they would probably come up with different values, possibly different conclusions.

Harmonization is happening, although, as this paper concludes, it has not yet led to a de facto standard.[15] In a sense, TCA is now comparable to financial accounting in the 1930s, when there was high-level agreement on topics such as how to account for depreciation or work in progress, but no formal set of rules to follow. Two accountants would probably have assessed the same company differently. We now have accounting standards. Two dominant ones exist: the United States of America Generally Accepted Accounting Principles and the International Financial Reporting Standards (Corporate Finance Institute, 2022).

Accounting standards provide guidance on micro choices. While there may still be differences in the outcomes of two (teams of) accountants, those differences are bound to be smaller than they would have been without the accounting standards. El-Hage Scialabba *et a*l. suggest ''establishing the legal framework for a TCA standard, such as is done for corporate accounting standards, in order to secure a fair playing field for all, prevent fraudulent practices, and reduce the cost of supporting multiple approaches'' (El-Hage Scialabba *et al.*, 2021, p. 270).

Honing in on the topics discussed in this background paper, there are two that might be most pressing with a view to scaling up the field of TCA. First, Section 5.2 mentioned that there is no consensus on how to determine materiality. Second, a scan of published TCA approaches reveals a total of 366 independent indicators (TCA Accelerator and Impact Institute, 2023). Several sources independently recommend prioritizing this in the harmonization of the field.

Recommendation (to the TCA community as a whole):

Develop a set definition for materiality and agree on a minimum list of indicators.

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[15] See TCA Accelerator and Impact Institute (2023) for an assessment of harmonization efforts and pathways forward.

The list of indicators should then be used in the scoping phase of a TCA study to identify material indicators to investigate further (TMG Think Tank and WWF, 2021). Viewing the implementation of TCA as a process, it is best to start with the indicators that are readily available, then add others over time as they become sufficiently developed (True Cost Initiative, 2022).

9.2 Data

The topic of data availability arguably poses the most pressing problem, particularly for TCA studies in low- and middle-income countries. Here, there may be limited resources for collecting appropriate data, while the same lack of data is likely to cause high uncertainty in the assumptions required to perform a TCA study.

This background paper promotes a "reversed" data strategy. At the start of the analysis phase, all data points are estimated roughly based on easily available secondary or modelled data sources. These are then tested to see what the conclusions of the TCA study would be if it were the final model. The team then tests to see which data-point variations would lead to substantially different conclusions and which ones would cause far less difference. The former become the focus for refinement.

Shared data directories for secondary data and standardized collection tools for primary data can greatly reduce resources for a TCA study (True Cost Initiative, 2022). These initiatives should be a collective effort of the TCA community, working towards universally accepted TCA data standards. A shared data directory and data collection framework enables a scalable approach to TCA. The main aim should be to make TCA feasible for all.

Recommendations (to the TCA community as a whole):

Develop one framework for data collection in the context of harmonization (TCA Accelerator and Impact Institute, 2023). With one data collection approach and using similar data, policy instruments using TCA studies can be developed (Holden and Jones, 2021).

Create a publicly available database of high-quality data. Such a database should build on a TCA data standard.

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Annexes

Annex 1. Glossary

Aggregation. The practice of combining multiple indicators into a single value, for example, summing by capital or stakeholder. Aggregation can entail netting positive and negative indicators.

Agrifood systems. Encompass the entire range of actors and their interlinked value-adding activities, engaged in the primary production of food and non-food agricultural products, as well as in storage, aggregation, post-harvest handling, transportation, processing, distribution, marketing, disposal and consumption of all food products, including those of non-agricultural origin (FAO, 2021).

(Hidden) benefit. A positive impact, that is, one that increases the welfare of a stakeholder. In the case of monetary valuation, this has a positive monetary value. Benefits that are externalities (not reflected in the prices of goods and services) are said to be hidden.

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 (see also "human capital", "natural capital", "produced capital" and "social capital") (TEEB, 2018b).

(Hidden) cost. A negative impact, that is, one that decreases the welfare of a stakeholder. In the case of monetary valuation, this has a negative monetary value. Costs that are externalities (not reflected in the prices of goods and services) are said to be hidden.

Dependency. Reliance on or use of a capital required to produce goods and services (TCA Accelerator and Impact Institute, 2023).

Ecosystem services. The benefits people obtain from ecosystems (Millennium Ecosystem Assessment, 2005).

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 (TEEB, 2018b).

Functional unit. A quantified description of the performance of the systems, for use as a reference unit (Weidema *et al*., 2004). An important step in life-cycle analysis is to define the functional unit for products in scope. The concept can be extended to allow functional units such as organizations or even the entire agrifood systems.

Gap-filling. The practice of filling data gaps (for example, through extrapolation/interpolation, bottom-up aggregation or top-down spatial redistribution).

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

Impact. A positive or negative contribution to one or more dimensions (environmental, economic, health or social) of human well-being (TEEB, 2018b).

Indicator. Indicators are the most granular level of an impact and/or dependency and are used to assess impacts and/or dependencies. Indicators describe what is being measured and, typically, the units that it will be measured in and the data points that will be required to measure

it. Indicators can be aggregated, such as by capital or stakeholder (see also “aggregation”) (TCA Accelerator and Impact Institute, 2023).

Materiality. A measure of how important a piece of information is when making a decision (Cambridge Dictionary, 2023). In the context of TCA, double materiality is followed. Indicators are material if consideration of its value has the potential to alter a decision, either by having a substantial effect on the (future) earnings of a commercial organization or substantially affecting the welfare of a stakeholder group (TCA Accelerator and Impact Institute, 2023). A materiality assessment refers to the process that involves identifying what is (or is potentially) material to the capital’s assessment objective and application (Natural Capital Coalition, 2016).

Monetary valuation. Valuation that uses money as the common unit to assess the values of natural capital impacts or dependencies (see also “valuation”) (Natural Capital Coalition, 2016).

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

Produced capital. All manufactured capital, such as buildings, factories, machinery and physical infrastructure (roads, water systems), as well as all financial capital and intellectual capital (technology, software, patents, brands and so on) (TEEB, 2018b).

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

Stakeholder. Any individual, organization, sector or community with an interest or “stake” in the outcome of a decision or process (Natural Capital Coalition, 2016). Sometimes also referred to as “rightsholders” to emphasize the rights that may be affected by the outcomes.

True cost accounting (TCA). An evolving holistic and systemic approach to measuring and valuing the positive and negative environmental, social, health and economic costs and benefits generated by agrifood systems in order to facilitate improved decisions by policymakers, businesses, farmers, investors and consumers (adapted from UNEP *et al*. [2021]).

Valuation. The process of estimating the relative importance, worth or usefulness of natural capital to people (or to a business) in a particular context. Valuation may involve qualitative, quantitative or monetary approaches (see also “monetary valuation”) or a combination of these (Natural Capital Coalition, 2016).

Value chain (of a product). The full range of processes and activities that characterize the life cycle of a product, from production to manufacturing and processing, to distribution, marketing and retail and, lastly, to consumption (including waste and disposal across all stages) (TEEB, 2018b).

Annex 2. True cost accounting approaches in the literature

Table A1 shows a comparison of eight initiatives for TCA. While the TEEB AgriFood Evaluation Framework is the overarching framework, the other seven initiatives provide approaches and methodologies with which this framework can be substantiated. All relevant documents by the initiatives are publicly available. The assessment of advantages and drawbacks is partially based on reviews in the literature, such as Lord (2020) and TMG Think Tank and WWF (2021).

Table A1. Overview of selected true cost accounting approaches and their characteristics

Characteristics	Overview
TEEBAgriFood Evaluation Framework	
Description	The overarching framework that provides guidance on multicapital TCA for eco-agrifood value chains and was developed by TEEB.
Focus	Food and agriculture.
Functional unit	Organization, system, product.
Scoping, including materiality assessment	After having identified the elements in the eco-agrifood value chain, scoping of impacts is done by determining the functional unit, the relevant stakeholders and the time period. This provides insight into the impact and dependency pathways. Scoping also includes identification of opportunities for change. Impacts are considered material when measurement and communication of the impact has the potential to alter decision-making processes. Steps in the materiality assessment include, but are not limited to i) recalling your issue of interest and your purpose or objective; ii) consulting with the advisory committee and other relevant stakeholders; iii) reviewing the literature; iv) collecting new information and iv) identifying the low-effort opportunities for change.
Capitals included	Natural, social, human and produced.
List of impacts	Lists 20 potentially material impact driver categories in the agrifood systems (in the Operational Guidelines for Business).
Measurement	The focus is on natural capital and biodiversity. Material impacts are measured using indicators, preferably directly. These indicators can be qualitative or quantitative (numerical). Qualitative indicators can be informed by experts and stakeholders. Both models (biophysical, LCA) and primary/secondary data can be used to measure impacts.
Valuation	Uses qualitative, quantitative and monetary valuation and recommends using a combination thereof. It also provides an elaborate overview of valuation techniques and their limitations, but does not provide specific guidance on using these.
Aggregation	Does not give specific guidance for aggregation. It does mention that the range of qualitative and quantitative information cannot be simply aggregated and that obscuring information relevant to decision-making should be avoided (for example, identifying which stakeholders win and lose rather than summing up gains and losses).
Application	Results can be used for reporting (transparency) and decision-making by understanding the interdependencies of food governance for both businesses and governmental policymakers.
Other method information	Provides the overarching framework for TCA for agrifood systems, which can be substantiated by the approaches by the other initiatives presented in this overview.

Characteristics	Overview
Depth of guidance	Guidance is detailed enough to carry out the framing and scoping (materiality) phases of an analysis, but the method suggests using expert input as much as possible. This is particularly relevant to the measurement and valuation phases, although a list of indicators and valuation techniques is provided. As a result, a substantial number of (micro)decisions need to be taken by the user.
Advantages	• Holistic framework to conduct a TCA assessment in the area of agrifood • Focuses on all actors • Existence of various case studies • Lists potentially material impact driver categories in the agrifood systems, covering almost all impacts found relevant for policymakers (Section 5.2) • Provides some guidance on presentation of results
Drawbacks	• Does not prescribe impact pathways • Substantial number of (micro-) decisions needed • Does not provide monetization factors
Source(s)	Eigenraam *et al*., 2020; TEEB, 2018b.
System of Environmental Economic Accounting (SEEA): Ecosystem Accounting	
Description	Approach that provides widely accepted guidance on capturing flows of environmental resources within systems, thereby reflecting how ecosystems are currently used.
Focus	Sectorally independent, with specific guidance on agriculture for the conceptual framework of SEEA.
Functional unit	Geography, system.
Scoping, including materiality assessment	Scoping is based on ecosystem assets within a geographical territory. It considers flow of natural capital via ecosystem services across the ecosystem assets into the economy. Materiality is based on the question of whether a stock of environmental resources turns into a flow between the environmental and the economic sphere. This is the case if a stock is used in producing a product or service.
Capitals included	Natural.
List of impacts	Does not provide a list of potentially material impacts, but lists examples of selected ecosystem services and their descriptions.
Measurement	Measurement of flow accounts to capture the ecosystem asset account (impact): it looks at product flows and residual flows (flows of natural material from the environment to the economy and vice versa) in their physical unit and at money flows from the economy that are related to the environment.
Valuation	Values through monetization. Monetization of ecosystem assets is based on the NPV approach. To monetize ecosystem services, the approach discusses five different techniques, ranked by priority. The preferred methods are those where the price for the ecosystem service is directly observable, while methods where the price for the ecosystem service is based on the expected expenditures or markets are least preferred. The choice of values is left to the user.
Aggregation	Aggregates assets and services by theme (impact area) and by spatial term. Aggregation is possible across ecosystem services and ecosystem types, even with different valuation methods, if the same target valuation concept is used.
Application	The results describe how ecosystem services can be used for several purposes: providing a baseline for further policy interventions, monitoring and reporting on progress, or informing policies by providing data on which to base decisions. Depending on the purpose, a distinction can be made between three different uses of compiled data: aggregates for the broader picture, composite indices to identify an overall movement or trend, and ratio indicators that combine data from different accounts, that is, to compare different ecosystem services per hectare.

Characteristics	Overview
Other method information	Follows a similar accounting approach to the system of national accounts (SNA), facilitating comparison and integration with the economic data prepared in accordance with the SNA.
Depth of guidance	Thorough guidance on how to approach the analysis and carry out the steps of the analysis. For the monetization stage, either experience/high expertise or additional, practical guidance may be needed.
Advantages	• Valuation is in line with standard economic accounting principles: supports comparison with standard economic and financial data • Provides guidance on which valuation techniques to deploy (priority ranking)
Drawbacks	• Does not cover social and human capital • Resolution at national level too coarse for systems level • Does not provide monetization factors
Source(s)	United Nations, 2021.
True Price	
Description	Approach that focuses on the true price of a product, which is the sum of the market price and social and environmental costs (the true price gap). Reducing the true price gap is seen as a way to make products more sustainable.
Focus	Sectorally independent, specific impact modules on the method for agrifood products.
Functional unit	Product.
Scoping, including materiality assessment	The scope is defined by a standard list of impacts developed by True Price. These standard impacts are material if the product is causing, contributing to or in a direct link with an impact in any of the life-cycle phases. To determine whether this is the case, the consideration of secondary data, stakeholder engagement and expert consultation is prescribed.
Capitals included	Natural, social.
List of impacts	Provides a standard list of 20 impacts (10 social, 10 environmental) with their footprint indicators, units and monetization factors.
Measurement	True Price measures impacts through the various footprint indicators laid down in the methodology for each impact. These indicators are measured by combining primary and secondary data. If the latter are deployed, it follows a clear data hierarchy.
Valuation	Uses monetary terms to value impacts. The monetization is based on the concept of remediation costs (restoration, compensation, retribution and prevention costs) and respective monetization factors that were developed by True Price. These are publicly available and updated regularly.
Aggregation	Impacts can be aggregated within their capital as social or environmental impacts, but not beyond. Impacts can also stand alone and do not necessarily need aggregation to be reported.
Application	Results can be used to inform decision-making and to facilitate transparency. Primary application is by companies making the products for which the true price is assessed. Secondary application can be by policymakers aiming to reduce true prices.
Other method information	Only focuses on externalities and does not include positive impacts.
Depth of guidance	This approach provides detailed guidance on the general principles, methodology, monetization factors and detailed methods for 8 of the 20 impacts. Conducting a complete analysis is currently not possible without an expert.
Advantages	• Rights-based approach gives theoretical foundation for what constitutes an externality

Characteristics	Overview
	• Standardized impact with monetization factors • Provides thorough guidance on 6 out of the 15 relevant indicators identified in this background paper
Drawbacks	• Methodology does not include positive impacts • Detailed methods for some impacts are still under development (so not yet publicly available) • Application by policymakers less straightforward
Source(s)	True Price Foundation, 2019; Galgani *et al*., 2021a.
TCA Agrifood Handbook	
Description	Developed by the True Cost Accounting Initiative, which offers a methodological handbook for calculating external costs in the agrifood and farming sector. Specifically, it focuses on external environmental, social and health costs in the supply chain of (plant-based) food products.
Focus	Food and agriculture (specifically plant-based systems).
Functional unit	Organization, system, product.
Scoping, including materiality assessment	The method is based on the TEEBAgriFood Evaluation Framework (see description of scoping and materiality assessment).
Capitals included	Natural, social, human and produced.
List of impacts	Provides a list of 16 standardized indicators for assessment, which were selected based on the concept of materiality, as defined by the GRI, and on the availability of output models and monetization factors.
Measurement	Focus on natural, social and human capital. The handbook prescribes a detailed practical measurement approach for 16 indicators. It includes a data-collection procedure and recommends tools, as well as describing shortcomings of commonly used indicators.
Valuation	Uses monetary valuation and provides monetization factors with the valuation method used for each indicator.
Aggregation	Gives guidance in aggregation: calculating true price (for products) using all indicators at any point in the value chain. Aggregation can also be done across impact categories, products, regions and so on, and the handbook provides examples to illustrate aggregation calculations.
Application	Results can be used for reporting (transparency) on companies' value chains, as well as identifying risks and opportunities. Governmental policymakers can use the handbook as a practical way to map externalities within value chains in the agrifood systems and as a basis for designing policies that incentivize and support sustainable businesses and farming practices.
Other method information	
Depth of guidance	Guidance on the framing and scoping phases follows the level of detail that TEEBAgriFood provides. The measurement phase is described in detail and also supports the user by providing a list of material indicators and monetization factors. As a result, relatively few microdecisions are needed.
Advantages	• Lists material issues in the agrifood systems including the rationale • Relatively few microdecisions are needed • Provides monetization factors for a list of impacts • Provides guidance on reporting and presentation of results

Characteristics	Overview
	• List of impacts categories and indicators with guidance provided, covering almost all impacts relevant to policymakers (Section 5.2)
Drawbacks	• Method does not include positive impacts • Limited focus (plant-based systems)
Source(s)	True Cost Initiative, 2022.
Food System Impact Valuation Initiative (FoodSIVI)	
Description	TCA approach that provides guidance on detailed multicapital impact measurement and valuation. It further lists the requirements for a non-financial capital accounting framework for the food sector.
Focus	Food and agriculture.
Functional unit	Product, system.
Scoping, including materiality assessment	It refers to the scoping guidance described in the Natural Capital Protocol, Social & Human Capital Protocol and TEEBAgriFood Evaluation Framework. It also presents good practices on scoping. Materiality of impacts is determined by the extent to which they reflect social or environmental issues specific to the agrifood systems or to society at large.
Capitals included	Natural, social, human and produced.
List of impacts	Provides a list of nine potential “sustainability issues” material to society.
Measurement	Describes how to use footprint to inform capital changes and impact pathways (the rationale), but does not provide practical guidance. Recommends models, primary and secondary data.
Valuation	Discusses multiple valuation approaches and their rationale. The focus is on providing a background on monetization through the calculation of shadow prices (using, for example, the cost of carbon based on marginal social costs and abatement costs). Specifically, it provides an outlook on how calculating the cost of carbon can be extended to estimating food-related externalities in the longer term.
Aggregation	Mentions application of aggregation, but does not provide specific guidance. However, the handbook recommends not compensating for (social) costs with benefits for ethical reasons and because of ambivalence in valuation.
Application	Results can be used for reporting (transparency) and decision-making by businesses. Governmental policymakers can use the approach to obtain insights into internalization mechanisms and where corrective policy interventions are required.
Other method information	
Depth of guidance	Guidance of framing and scoping phases follows the level of detail that TEEBAgriFood and the protocols provide. There are references to models and databases that can be used to measure impacts and the valuation approaches are described in great detail. However, expert help is required. As a result, the user needs to take a substantial number of (micro) decisions.
Advantages	• Contains detailed valuation rationale • Provides multiple case studies on the valuation step • Provides potential material sustainability issues, covering almost all impacts deemed relevant to policymakers (Section 5.2)
Drawbacks	• Detailed approach, but not very practical • Substantial amount of (micro) decisions needed • Does not give guidance on presentation of results

Characteristics	Overview
	• Does not provide monetization factors
Source(s)	Lord, 2020.
Natural Capital Protocol	
Description	Approach developed by a predecessor of the Capitals Coalition (the Natural Capital Coalition), which provides guidance on how to measure and value natural capital, providing widely accepted standardization.
Focus	Sector independent, frequent application in the context of agrifood; co-developer of a sector-specific guide together with TEEBAgriFood that follows the same steps.
Functional unit	Organization, investment (project), product.
Scoping, including materiality assessment	Scoping relies on the objective of the analysis and respective flows of natural capital. Defined by boundaries of the value chain (scopes 1, 2 and 3), which can (but must not) entail three components: i) impact on business, ii) impact on society (both described by impact pathways) and iii) dependency of the business on natural capital (dependency pathways). It provides some guidance on when to use a certain component or all components, depending on the application. It also considers technical and planning issues. Provides high-level guidance and tools to define own material assessment criteria.
Capitals included	Natural.
List of impacts	Provides examples of 11 possible impact drivers and 10 possible dependencies.
Measurement	Looks at the changes in natural capital. Measures impact drivers (of the impact pathways) and/or dependencies, suggesting using a specific, quantitative indicator per driver/dependency. Suggests the collection of both primary and secondary data, depending on the objective and context of the assessment.
Valuation	Does not prescribe a certain valuation technique, but describes several methods for qualitative, quantitative, monetary approaches with guidance for their selection, such as duration, budget, skills, advantages and disadvantages.
Aggregation	Mentions several techniques without suggesting a specific aggregation approach as long as there is no attribution of additional responsibility or double counting.
Application	Using the results as a basis for a decision, that is, carrying out another assessment or internalizing externalities and for communication with stakeholders. Also mentions impact assessment as application which can be useful for policymakers in evaluating interventions.
Other method information	Can be used together with the Social and Human Capital Protocol.
Depth of guidance	Guidance is detailed enough to carry out an analysis (with many micro choices left to the practitioner). For the valuation step, additional expertise or knowledge may be required to make an apt choice.
Advantages	• Clear and extensive strategy for understanding both positive and negative impacts • Clarifies each strategy step with case studies • Food and beverage sector guide, with specific case studies on food companies
Drawbacks	• Strategy comes with limitations for functional units other than organization and product • Not clear on how to identify and attribute capital change to other drivers than the actor itself • Does not provide monetization factors
Source(s)	Natural Capital Coalition, 2016.

Characteristics	Overview
Social and Human Capital Protocol	
Description	Approach that provides widely accepted guidance on how to measure and value human and social capital, thereby complementing the strategy developed in the Natural Capital Protocol.
Focus	Sector independent.
Functional unit	Organization, investment (project), product.
Scoping, including materiality assessment	Scoping relies on the objective of the analysis and respective flows of natural capital. Defined by boundaries of the value chain (scope 1, 2 and 3), which can (but must not) entail three components: i) impact on business, ii) impact on society (both described by impact pathways) and iii) dependency of the business on natural capital (dependency pathways). It provides some guidance on when to use a certain component or all components depending on the application. It also considers technical and planning issues. Provides high-level guidance and some tools to define own material assessment criteria.
Capitals included	Focus on social and human; also refers to natural and produced
List of impacts	Provides non-exhaustive examples of business impacts and dependencies, covering 12 topical areas.
Measurement	Measures impact drivers. Does not prescribe a specific measurement method and leaves it to the user to identify and define apt indicators and metrics. Provides guidance that requirements indicators need to meet, namely, SMART (specific, measurable, achievable, realistic and time-bound) criteria and to be balanced and transparent. Provides high-level guidance on determining changes in social and human capital, such as baselines and counterfactual scenarios.
Valuation	Discusses qualitative, quantitative and monetary valuation in light of the fit-for-purpose approach. Monetization is seen as the preferred option, if feasible. Does not suggest one specific monetary valuation technique or actual valuation factors, but provides information on market-based approaches, revealed preference techniques, stated preference technique, cost approaches and value transfer to guide decisions on the best choice in individual cases.
Aggregation	Emphasizes importance of comparability of values in order to aggregate and provides a few examples. Flags the importance of gender-disaggregated values to detect, for example, gender inequalities.
Application	Using the results as a basis for a decision, pointing to new/adjusted (business) activities that include strategic planning and goal setting, CBA, impact assessment, external reporting, risk assessment and product portfolio management. Can also suggest further assessments based on outcomes and priorities. Though it does not address policymakers, the application of impact assessments can be useful in evaluating policies.
Other method information	Can be used together with the Natural Capital Protocol.
Depth of guidance	Guidance is detailed enough to carry out the scoping and materiality assessment. For the measurement and valuation steps, additional expertise or knowledge may be required for correct execution, as the definition of impact drivers/ dependencies and their respective metrics depends on the user's choice.
Advantages	• Clear and extensive strategy for understanding both positive and negative impacts • Clarifies each strategy step with case studies • Food and beverage sector guide with specific case studies on food companies

Characteristics	Overview
Drawbacks	• Strategy comes with limitations for functional units other than organization and product • Not clear on how to identify and attribute capital change to other drivers than the actor itself • Does not provide monetization factors
Source(s)	Social & Human Capital Coalition (2019)
Social Return on Investment (SROI)	
Description	Approach that provides guidance for calculating the social return of investment developed by Social Value UK.
Focus	Sector independent.
Functional unit	Organization, investment.
Scoping, including materiality assessment	Scoping is based on determining the target audience and objective as a first step before defining the boundary conditions in terms of organization, geography, time and value chain. The protocol provides guiding questions that help with setting suitable boundaries. Ultimately, the value perspective is defined, choosing one or more of the following components: i) business dependencies, ii) impacts on society and iii) impacts on the business. For the materiality assessment, it refers to three highly recognized frameworks (United Nations Declaration of Human Rights, the Multinational Enterprises and Social Policy Declaration and the SDGs) and introduces several methods that can facilitate to assess the materiality.
Capitals included	Natural, social and produced.
List of impacts	Does not provide a list of potentially material impacts.
Measurement	Measurement of impacts is done by using the subjective and objective outcome indicators developed in the scoping step. There is guidance on developing outcome indicators. Further guidance on selecting proxies for potential indicators is provided for a case study, but a general list is not given. It is recommended to gather both primary and secondary data on the indicators.
Valuation	Valuates through monetization. Monetization of ecosystem assets is based on the NPV approach. To monetize ecosystem services, the approach discusses five different techniques, ranked by prioritization. The most preferred methods are those where the price for the ecosystem service is directly observable, while methods where the price for the ecosystem service is based on expected expenditures or markets are least preferred. The choice of values is eventually left to the user.
Aggregation	The resulting SROI ratio is an aggregated metric for the monetized social return of an investment or organization.
Application	Results can be used for reporting (transparency) and decision-making. Governmental policymakers can use SROI to commission and invest in activities to create social value.
Other method information	–
Depth of guidance	Guidance is detailed enough to carry out an analysis, including calculation examples and “workbook”-type, step-by-step exercises. Additional help may be required for the measurement and valuation steps. It mentions that users would benefit from prior experience of engaging stakeholders, outcome measurement or evaluation, and might consider undertaking training or getting external help. As a result, the user needs to take a substantial number of (micro) decisions.
Advantages	• The guidance reads as a workbook with calculation guidance • Provides a case study and calculation examples

Characteristics	Overview
	• Provides some guidance on the presentation of results • Provides a checklist for the different stages of the analysis
Drawbacks	• The guidance reads as a workbook with calculation guidance • Provides a case study and calculation examples • Provides some guidance on the presentation of results • Provides a checklist for the different stages of the analysis
Source(s)	SROI Network, 2012.

Source: Authors' own elaboration.

Annex 3. Examples of databases and equilibrium models available online

Table A2. Available monetization factors databases

Database	Description
TCA Inventory[i]	Presents an overview of databases, and measurement and valuation approaches; it was developed by the Global Alliance for the Future of Food, Soil & More Impacts and the TMG Think Tank for Sustainability and is updated continuously.
TEEB Valuation Database for valuation methods[ii]	Contains (monetary) valuation for 30 categories of ecosystem service, covering different biomes and world regions.
Monetization Factors for True Pricing[iii]	Contains monetization factors for 20 true price impacts (10 environmental and 10 social), along with the relevant footprint (sub-)indicators.
Ecosystem Services Valuation Database[iv]	Contains monetary values of ecosystem services, covering data from over 950 studies across different biomes and geographical regions.
EU-28 Handbook: Environment prices for monetization factors[v]	Contains international estimates of environmental prices at the level of the EU-28.
TCA Agrifood Handbook[vi]	Contains monetization factors, including footprint indicators and calculation methods, for 16 impact indicators.

Source: Authors' own elaboration based on [i] Eigenraam *et al.* (2020); [ii] McVittie and Hussain (2013); [iii] True Price, 2021); [iv] ESVD (n.d.); [v] De Bruyn *et al.* (2018); [vi] True Cost Initiative (2022).

Table A3. Available databases

Database	Description	More information
World Resources Institute	Datasets on crop diversity and water consumption of livestock.	WRI, 2023
UN Environment Programme - World Conservation Monitoring Centre (UNEP-WCMC)	Biodiversity indicators and national ecosystem assessments.	UNEP-WCMC, 2023
FAO Corporate Statistical Database (FAOSTAT)	Food and agriculture data at national, international and regional level. Statistics include the value of agricultural production, food security and nutrition, prices, employment, government expenditure on agriculture, sustainable indicators, such as land use and application of pesticides and fertilizers.	FAO, 2023
World Bank	Global development data, such as demographics.	World Bank, 2023b
Institute for Health Metrics and Evaluation Global Burden of Disease database	Human preventable disease and death on a national level.	IHME, 2023

Source: Authors' own elaboration.

Table A4. Selection of life-cycle assessment databases

Database	Description	More information
EcoInvent	Contains more than 18 000 life-cycle inventories (LCIs), for example, for the agricultural, animal husbandry and energy sectors on natural resources withdrawal, emissions to water, soil and air, material supply, energy use and waste production.	Ecoinvent, 2020
AGRIBALYSE	Contains more than 2 600 LCIs with environmental impacts for agricultural and food products produced or consumed in France.	AGRIBALYSE, 2022
Agri-footprint	Contains LCIs with environmental impacts for more than 5 000 country-specific products and processes; available data on feed, food and agricultural intermediate products.	Blonk, 2023
ESU World Food	Contains more than 2 100 LCIs with environmental impacts on agriculture, food processing and consumption activities, with a focus on water use and food waste.	ESU Services, 2023
World Food LCA Database (WFLDB)	Contains more than 2 300 LCIs with environmental impacts for 120 products in 56 countries.	Quantis, 2023
RIVM Database: Environmental Impact of Food Products*	Contains LCIs with environmental impacts for 250 foods, divided into various product groups; these foods were mostly selected as they cover a large part of the environmental impact of Dutch food consumption.	RIVM, 2023
Life Cycle Assessment of Food & Drink Products: Meta-Analysis Model	Contains LCIs with environmental impacts for more than 57 000 food and drink products in Ireland and the United Kingdom of Great Britain and Northern Ireland.	Poore, 2018

Note: Note that this database has not been reviewed sufficiently to be used in public communication without an external review.

Source: Authors' own elaboration.

Table A5. Database resources for input-output analysis

Database	Description	More information
Eora	Global supply-chain database consisting of a multi-region input-output table model; contains time series (1990–2021) of environmentally and socially extended IO tables, covering 15 909 sectors in over 190 countries.	EORA, 2023
EXIOBASE	Consists of a global, detailed multi-regional environmentally extended supply-use table and IO table; covers more than 43 countries, 200 products and 163 industries.	Exiobase, 2015
Global Impact Database	Contains integrated impact data for 24 impact indicators (environmental, social and economic), covering 9 100 global sectors and 140 countries worldwide and 3 500 companies; includes direct, upstream and downstream value-chain impacts; partly based on the above databases.	Impact Institute, 2022
US EEIO	Consists of a family of models to estimate environmental and economic impact, covering 411 sectors in the United States of America.	US EPA, 2017

Source: Authors' own elaboration.

Table A6. Example of equilibrium model

Model	Description	More information
IMPACT	Consists of a partial equilibrium multi-market economic model, based on linked economic, water and crop models; covers both national and international agricultural markets.	IFPRI, 2023

Source: Authors' own elaboration.

Annex 4. Further guidance on true cost accounting studies with the most used functional units

While Chapter 5 gives a general overview on how to choose appropriate functional units, this annex gives additional detail on each unit of analysis to further guide appropriate choices.

A. Agrifood systems

The (relative) completeness of agrifood systems as a functional unit also means that it is the most challenging one. During the scoping phase of a TCA study, it will show whether it is:

a) feasible to conduct such a complete analysis
b) fits the policy goal of the TCA study.

If the answer is "no" to either question, the scope will need to be reduced by either setting geographical boundaries or honing in on a more granular functional unit. Such boundary-setting or potential downsizing of the functional unit must not be confused with neglecting the system's overall perspective, however. Taking the system into account is crucial to understanding the ripple effects of policy decisions, for instance, when introducing or cutting subsidies, taxes and regulations for a particular food product. The TEEB case study on a pesticide tax in Thailand (TEEB, 2018b) is a meaningful example of this.

Recommendation:

Always consider the full system in the scoping phase of your TCA study. When a systems-level analysis is not feasible or suitable, downsize the scope of the study.

Major challenges of this functional unit

Due to its broad scope, the major challenge of deciding on "the system" as the functional unit is to capture what is understood as "the system", as there is a gap between common descriptions of a system and their practical application in a study. Consequently, how the system is captured in one TCA study is not necessarily comparable to how the system is captured in another. Comparing four TCA analyses on maize in Mexico, Minnesota, Malawi and Zambia, Gasman *et al.* (2021) outline the limited comparability of the systemic framing of TCA studies due to their scopes.

This point to another guiding principle on the use of TCA for policymakers:

Recommendation:

The systems perspective is always relevant for policymakers, but cannot be used to capture everything. The key task is to strike a balance between completeness and being able to scale.

System with geographical boundaries as a common application

To allow a TCA study within a scope that can be influenced by policymakers while simultaneously acknowledging embeddedness within a global agrifood systems, it is common to analyse the system within geographical boundaries.

EXAMPLES OF USING "THE SYSTEM" AS THE FUNCTIONAL UNIT

Agrifood systems with global boundaries

Contributing to the Food Systems Summit Report, Hendriks *et al*. (2021) conducted a study on the true costs of the global agrifood systems. Calculating environmental and health-related costs of the global production and consumption of food, the team was able to provide an estimate of the current negative impacts of the agrifood systems. Using this a baseline, the researchers compared how the identified costs would change for different diets (if applied globally).

There are two major insights from this case study that are worth emphasizing. First, it depicts how the functional unit of the "agrifood systems" can be used alongside the functional unit of "diet" (see Section B). Second, it shows – while providing an insightful indication of the current situation – that such a study on a systemic level does not allow the assessment of tangible policy interventions.

Agrifood systems with geographical boundaries

With the intention of providing a starting point for integrating TCA into decision-making for agrifood policies in the United States of America, the Rockefeller Foundation identified hidden costs of the food produced, processed, retailed, consumed and wasted across the country (Rockefeller Foundation, 2021a). In its design, it set specific geographical boundaries, which allowed the inclusion of exports during the production stage and imports in the consumption phase, thus accounting for the global nature of the agrifood systems. By showing the need and potential for improvement in current impacts, the results could inspire further targeted research into precise interventions, as discussed in the next sections.

Table 8 provides two other examples (Kurth *et al.*, 2019; TEEB, 2018a) of how the system is used with geographical boundaries.[16]

How to capture the system effects

Equilibrium models serve as a tool for conducting a system- or sector-wide analysis. Both partial equilibrium (PE) models and (computable) general equilibrium (CGE) models help to estimate the impact of a policy intervention by calculating the new equilibrium of supply and demand within a sector or system.

A comparison of the different model types helps to make the right choice when it comes to the policy in question (Table A7).

[16] For further elaboration, see IEF (2023).

Table A7. Computable general equilibrium (CGE) vs partial equilibrium (PE) models advantages and disadvantages

	CGE models	PE models
Advantages	• Cover the whole system: suitable for addressing distributional questions • Can estimate direct and indirect impacts of a policy or an investment	• Higher level of detail • Easier to execute • Higher customization and transparency
Disadvantages	• Low level of detail • High level of uncertainty, as it requires assumptions and relies on potentially outdated data • Does not consider that some inputs might be scarce	• Cannot capture feedback from other sectors or stages of the value chain • Not suitable for addressing distributional issues

Source: TEEB. 2018. *TEEB for Agriculture & Food: Scientific and Economic Foundations*. Geneva, Switzerland.

Notwithstanding its higher feasibility, the inability of the PE model to capture feedback from other sectors or stages of the value chain is a strong limitation that always needs to be considered when opting for it as a model (TEEB, 2018b).

Moreover, these economic models cannot provide a valuation of impacts that also covers broader aspects of social and human well-being (Lord, 2020). Showing the limitations of the current models, Lord (2020) suggests a formula for calculating a new equilibrium to address these shortages. While the new approach might not yet be implemented on a practical level, it does help further the understanding of the weakness of CGE models.

Recommendation:

Equilibrium models are only used when the analysis stays at a systems level. If feasible, a CGE model is preferable, as it is the most complete. Otherwise, it is better to use a PE model and describe its limitations in the analysis. In any case, it is always important to consider the secondary effects of policies while taking the constraints of the chosen model into account.

Suggested reading on the application, strengths and weakness of equilibrium models:

- TEEB for Agriculture & Food: Scientific and Economic Foundations (TEEB, 2018b, Chapter 7.5).
- Valuing the impact of food: Towards practical and comparable monetary valuation of agrifood systems impacts (Lord, 2020).

B. Diet

"Diet" stands out as a functional unit that has not been covered in the methodology review (de Adelhart Toorop *et al*., 2021), but has been proposed as a useful unit by TEEB (2018b) and TMG Think Tank for Sustainability and WWF (2021). Depending on the intended goal of the TCA study, a distinction can be made between two main applications:

1. Dietary comparison, which analyses the impacts of different diets, for example, pescetarian, carnivore, vegetarian or the EAT-Lancet Planetary Health Diet, to identify the most preferable or most harmful one(s).

Recommendation:

Using dietary comparisons can support policymakers in deciding which diet should be incentivized or disincentivized with policies.

2. When the overarching goal of the TCA study is to achieve a healthy, sustainable diet for all, the focus tends to be on understanding current dietary patterns. It can thereby serve as a starting point for examining policy interventions with a view to a more sustainable and healthy diet within a certain population. What is deemed a desired diet is based on assumptions and pre-defined targets for the food and agriculture system and can vary according to the national and regional policy context (TMG Think Tank and WWF, 2021).

From this perspective, using dietary patterns as a unit of analysis can help to answer questions such as:

- Are there differences between social groups as to whether dietary recommendations are met? What are the effects or costs thereof?
- Does the prevalence of diets with high meat consumption or high sugar intake differ within the population? What are the externalities arising from that?

Suggested reading: *True Cost Accounting and Dietary Patterns: An Opportunity for Coherent Food System Policy* (TMG Think Tank and WWF, 2021).

Recommendation:

Choosing dietary patterns as a unit of analysis can help show where policymakers can intervene to plug the gaps between the current state of a diet and the desired state.

EXAMPLES

Dietary comparison

The use of a dietary comparison with TCA is shown by a study on the true costs of the global agrifood systems, which was conducted as a contribution to the UNFSS (Hendriks *et al.*, 2021). Apart from calculating an estimate of the external costs of the global agrifood systems, the researchers also compared how these costs would change from diet to diet. The comparison included four options:

- healthy reference diet
- pescatarian
- vegetarian
- vegan

While presenting how all four diets would reduce the externalities within the global agrifood systems compared with its current state, the study also demonstrated a systems-level approach, as outlined in Section A, underscoring that a case study can have more than one functional unit.[17]

[17] For more details on the case study, see IEF (2023).

Dietary patterns

An applied example for using diet as a functional unit in terms of dietary patterns is the Rockefeller Foundation's 2021 true cost evaluation of United States of America school food programmes (Rockefeller Foundation, 2021a). Based on this TCA study on the true costs of the US agrifood systems, the public school meal programme was analysed with a view to finding out how it could contribute to an overall reduction in the external costs of the US agrifood systems. One of the three drivers was to improve dietary composition by comparing the current average American diet with the diet of school meals and assumptions of what was considered healthy.

In addition to showing how diet can be used as a functional unit, this case study is an example of how different TCA studies can build on each other to support the achievement of an overarching political goal. Furthermore, it not only reflects the use of diet as functional unit, but also its application within the functional unit of "investment", on which the following section elaborates.

C. Investment

While investment by commercial institutions and the financial sector is well covered in the TCA literature – which typically describes investments made by organizations, investors or investment organizations (de Adelhart Toorop *et al*., 2021) – the concept of investment and its application is different for policymakers. Unlike investments by private actors, public investments have the dual characteristic of being both a functional unit and a policy tool at the same time. Consequently, their steering potential needs to be considered holistically, which once again calls for an acknowledgement of system effects. More precisely, this means that it is not enough to assess whether a public investment should be dedicated to the best of several options (marginal impact); policymakers must decide whether an investment fits into the overall theory of change for the agrifood systems at all (absolute impact).

Recommendation:

Using "investment" as a functional unit should always consider system effects to take into account the underlying steering potential as a policy tool. In particular, the absolute impact of an investment must be considered to assess its overall contribution to the agrifood systems.

EXAMPLE

Analysing the true value of two large United States of America school meal programmes, the primary functional unit of the case study was "investment" (Rockefeller Foundation, 2021b). By looking at the ROI of expenditure on public school meal programmes, the study took into account the fact that spending public money on these programmes was simultaneously a policy tool. More precisely, it analysed the costs and benefits of school meal programmes against an alternative scenario in which these programmes did not exist, providing an estimate of the current true value (as absolute impact). Against this background, three drivers of increased benefits could be assessed by comparing different changes in the programme elements. With one of the drivers being an improvement in dietary composition, it linked back to the simultaneous application of diet as functional unit, as previously described. Moreover, it exemplified how the results of a TCA study with a large scope (Rockefeller Foundation, 2021a),

as discussed in C.2, could be acted upon with a more granular, targeted TCA study on a policy tool.

D. Organization

While the majority of existing TCA approaches target the commercial organization (de Adelhart Toorop *et al.*, 2021), the relevance of this functional unit for policymakers is limited. As the initiative to conduct TCA tends to be organizational, thorough guidance on its application is of little relevance to this paper. Nevertheless, two considerations are worth highlighting:

1. TCA analyses by organizations can provide rich insights that policymakers can tap into to inform their decision-making.
2. If the policy goal of a TCA study is public-private collaboration, for instance, to support companies in conducting TCA studies for their entities or to steer intrinsic motivation to start implementing TCA, using the "organization" as a functional unit can be useful.

Recommendation:

If working with organizations is a part of the underlying strategy, this functional unit is suitable, otherwise its use is not recommended.

EXAMPLE

When new policies aim to support organizations in their main challenges with regard to social and environmental sustainability, this functional unit can help to find out what these major challenges are. Eosta, for example, conducted a TCA-based study on its impacts, which showed what areas the organization should focus on in future. It thereby served as pilot for developing practical guidance for TCA in the financial, farming and food sectors (Eosta *et al.*, 2017). While supporting pilots to enable organizations to conduct TCA can be a policy goal in itself, policymakers can also use these or similar results to understand where governmental support is needed most.

E. Product

Typically, functional units of analysis are most applicable to those who create or consume them (de Adelhart Toorop *et al.*, 2021). Since the responsibility of policymakers – in contrast to companies, for example – goes beyond a single product, the "product" functional unit is not usually the preferred one for applications within policymaking. At the same time, the product level is often crucial to understanding the means by which the system can be improved, making it relevant for political decision-making. As there is detailed guidance in the literature on how to conduct a TCA study at product level, it is not discussed further here.

Recommendation:

Principles and knowledge developed by the True Price Foundation provide guidance on how to conduct a TCA at product level. See, for example, Galgani *et al.* (2021a) and True Price Foundation (2020b).

Major challenges of this functional unit

Before choosing "product" as a functional unit, the following limitations should be noted. First, systems-level indicators, such as availability of healthy diets, are excluded due to the limited scope of the study. In the same vein, only focusing on the product level comes with the same risks as LCAs: by not considering the whole production system, comparisons are likely to be biased towards a preference for products from intensive production systems (Figeczky *et al*., 2021). Both of these limitations result in an ignorance of second-order effects, which can jeopardize the intended policy goal. For instance, if a specific product is disincentivized, but the assessment does not consider the increased use of an alternative product with relatively large negative externalities (such as increased health or environmental costs), the overall policy intervention fails to meet its goal.

Introducing a agrifood systems footprint for products, as Lord (2020) suggests, can help to address these limitations. Building on the principle of footprints, SEEA and the Sustainability Assessment of Food and Agriculture systems guidelines, Lord proposes the development of an approach that includes marginal social costs or marginal abatement costs.

Recommendation:

Another way to deal with the relevance of system and product levels is to use "product" as an effective functional unit that follows a TCA study with a larger scope, such as "system", "diet" or "investment".

This means that a study with a larger scope – such as system, diet or investment – as a first step will most likely lead to a product as the effective unit of analysis in a second step. To conduct a TCA study for the selected product, there is a large body of literature on LCA that can help with the analysis (see also Chapter 8). In any case, it is crucial to link the results of the product level back to the systems level to holistically assess the effects of product-specific (dis)incentives.

EXAMPLE

Disincentivizing beef and pork production and consumption

Aiming to inform decision-making on how Germany could transform its intense use of natural resources in agriculture, Greenpeace commissioned a TCA study comparing the external environmental costs of five specific meat products (Bandel *et al*., 2020a):

1. German pork under business-as-usual conditions
2. German organic pork
3. Argentinian beef under business-as-usual-conditions
4. German beef under business-as-usual-conditions
5. German organic beef

Based on the results, the report concludes with a suggestion to adjust agricultural subsidies to incentivize the production of organic meat while disincentivizing high meat consumption overall. To account for system effects, this could be linked back to the overall systems context as a second step, for example, by considering alternative behaviour and respective social costs if the prices of beef and pork were increased.

Annex 5. Further guidance on assessing the most used true cost accounting indicators

A potential pathway to the harmonization of TCA applications is to agree on standardized indicators (see Section 5.2) to include in a TCA study. Section 5.2 introduced 15 indicator categories (Table 7) that are frequently used in TCA initiatives (TCA Accelerator and Impact Institute, 2023) and/or are particularly relevant to the agrifood sector. This annex briefly discusses the limitations and challenges of standardized indicators before providing more detail on each indicator: a description of its relevance, how it is measured and open issues to address before scaling up TCA.

Limits and challenges of standardized indicators

While agreement on a list of standardized indicator categories would contribute to the scaling up of TCA (in policymaking), such a list would not guarantee that a TCA study covered all material hidden costs. This annex should not be considered a TCA community-agreed list of indicators. It does, however, provide an overview based on frequency of use and topical relevance.

The level of completeness of indicators in scope is an important determinant of the quality of a TCA study. Therefore, any TCA study should consider including indicators in scope beyond a standardized list, based on the materiality of hidden costs to the study's stakeholders. The overview presented here does not, for example, include the availability of public services. Consequently, a list of standardized indicators reduces, but does not do away with completely, the need to (further) develop indicator methodologies when performing a TCA study. In any case, should new indicators be added to the list when underlying methodologies are sufficiently developed and already included, indicators should be regularly updated.

A. Natural capital indicators

Natural capital can be defined as the "limited stocks of physical and biological resources found on earth, and of the limited capacity of ecosystems to provide ecosystem services" (TEEB, 2018b, p. 48). The indicators "effects on climate change", "land use, land transformation and associated biodiversity effects", "air, water and soil quality and pollution" and "water use and water scarcity" are part of most TCA initiatives (TCA Accelerator and Impact Institute, 2023) and, therefore, well developed (Table 7).

Biodiversity loss and loss of ecosystem services

Agricultural activities affect biodiversity and ecosystem services (both directly and through their dependency on biodiverse, healthy ecosystems) through many different pathways. The first four indicators in Table 7 together capture the main effects on biodiversity and ecosystem services. Therefore, "biodiversity" and "ecosystem services" are not included as separate indicators. Nonetheless, this set of indicators does not capture biodiversity loss completely and further development is required if the goal is to be complete.

For a more detailed overview of natural capital, see IEF (2023).

A1. Effect on climate change

Why it is relevant

Measuring the effect on climate change is highly relevant for policymaking in the field of agrifood, as the sector is i) one of the most significant sources of GHG emissions, while also ii) being able to store and release CO_2 from the atmosphere (True Cost Initiative, 2022). Effects on climate change are covered by most of the TCA initiatives (TCA Accelerator and Impact Institute, 2023).

Recommendation:

Use this indicator when the policy intervention in question is expected to affect the release of new or stored greenhouse gas emissions.

What is measured

The effect on climate change (both contribution to and reduction of) is measured through the footprint indicator "GHG emissions" and includes multiple types of GHG emission, expressed as kilograms of CO_2 equivalent (CO_2e).

More details on quantification and valuation can be found in the literature (Galgani *et al*., 2021d; True Cost Initiative, 2022). It also includes a list of drivers of this indicator, indicating when it could be material.

A2. Land occupation and land transformation

Why it is relevant

Land use is the impact of occupying land (for agricultural production), while land-use change is the impact of changing the use of land to another use. Agriculture and food are responsible for the use of nearly 50 percent of habitable land and are directly linked to the loss of biodiversity and ecosystem services. It is a basic requirement for a biodiverse and, hence, existing, functioning and evolving biosphere that enables the well-being of humans (Galgani *et al*., 2021b). Land occupation and land transformation are included in most TCA initiatives (TCA Accelerator and Impact Institute, 2023).

What is measured

The effect of land occupation and land transformation can be measured using two indicators:

1) land use, which represents the decreased availability of land for other purposes, such as providing natural habitat and thereby hosting a healthy ecosystem;
2) land-use change, which represents a change in land cover, leading to the loss of natural habitats, over a certain period of time.

To account for the associated (direct) effects on biodiversity and ecosystem services, the indicators can be adjusted for the loss of biodiversity, comparing the current state to the state of pristine nature based on land-use intensity. The state of pristine nature on the occupied land can be described on a biome level or on a more detailed level.

Further guidance on quantification and valuation is provided in Galgani *et al*. (2021b).

Recommendation:

Include this indicator in policy scenarios with significant (differences in) land use, land-use change or land-use intensity (as an indication of biodiversity loss). This indicator should be included in any agricultural process that requires land or the conversion of an area from natural land to farmland.

Limitations

There are several assumptions that introduce uncertainty into the current indicator, such as the choice of reference scenario (pristine nature), the choice to include both land use and land-use change, and the choice not to distinguish between reversible and irreversible loss of species. More details on limitations and suggestions for development are discussed in Galgani *et al*. (2021b).

A3. Air, water and soil quality and pollution

Why it is relevant

Air, water and soil quality and pollution are relevant to policymaking, as they directly affect the capacity of ecosystems to produce food (True Cost Initiative, 2022). Simultaneously, pollution of air, water or soil can have adverse effects on human health. Their relevance as an indicator category in TCA studies is widely acknowledged and they are covered by most TCA initiatives (TCA Accelerator and Impact Institute, 2023).

What is measured

As the name of this impact category suggests, it covers the quality and pollution of air, soil and water, with a multitude of indicators to capture it.

Pollution is split into the following three main areas:

- **Air pollution**: covering any impact of emissions to air other than climate change;
- **Water pollution**: covering the impact caused by emissions to water, such as ecotoxicity, human toxicity or eutrophication of marine – and freshwater;
- **Soil pollution**: covering the impact caused by emissions to soil or crops, such as pesticides or heavy metals, leading to eco- or human toxicity.

More precise indicators and subindicators are shown in Table A8.

Table A8. The three main areas of pollution with indicators and subindicators

	Footprint indicators and subindicators	
Air pollution	Particulate matter formation	
	Photochemical oxidant formation	
	Ozone layer depleting emissions	
	Acidification	
	Nitrogen deposition	NH_3 from animal husbandry (in stables)
		NH_3 from use of manure
		NH_3 from other sources
		NOx from use of agricultural machines and vehicles
		NOx from other source
	Toxic emissions to air	Human toxicity
		Terrestrial ecotoxicity
		Freshwater ecotoxicity
		Marine ecotoxicity
	Freshwater eutrophication	
	Marine eutrophication	
Water pollution	Toxic emissions to water	Human toxicity
		Terrestrial ecotoxicity
		Freshwater ecotoxicity
		Marine ecotoxicity
Soil pollution	Toxic emission to soil	Human toxicity
		Terrestrial ecotoxicity
		Freshwater ecotoxicity
		Marine ecotoxicity

Source: Galgani, P., Woltjer, P., de Adelhart Toorop, R., De Groot Ruiz, A. & Varoucha, E. 2021. *Contribution to Climate Change: True pricing method for agri-food products*. Amsterdam, True Price. https://trueprice.org/wp-content/uploads/2022/07/Contribution-To-Climate-Change-2.pdf

Besides these indicators of pollution, the **quality of soil** requires consideration, capturing whether soil has the capacity to fulfil its functions, for instance, food production or preserving biodiversity. It can be measured by three indicators: i) soil erosion, ii) soil organic carbon and iii) soil compaction.

Further guidance on quantification and valuation for this indicator (category) can be found in the literature (Galgani *et al*., 2022b; Galgani *et al*., 2023; True Cost Initiative, 2022).

Recommendation:

The assessment of policies linked to (enhanced) food production should lead to the inclusion of this indicator. It should also be included if there is evidence or an assumption that human health is affected by a policy.

A4. Water scarcity

Why it is relevant

In the agrifood sector, water is primarily used for irrigation and fertilizer and pesticide application. It is responsible for approximately 70 percent of freshwater withdrawals worldwide, accounting for water use and scarcity. These circumstances make the consideration of water scarcity and use essential to decision-making in the area of eco-agrifood (True Cost Initiative, 2022). As billions of people lack access to clean water and sanitation, which are a basic need and boundary condition for health and well-being, its high relevance for policymakers is evident. Most TCA initiatives include this indicator (TCA Accelerator and Impact Institute, 2023).

Recommendation:

Include this indicator in any geographical context when water is used in an area where some degree of water scarcity exists.

What is measured

Water scarcity or water stress assesses the use of fresh surface and groundwater (blue water) in areas where it is scarce, making it thereby unavailable in the watershed of origin for both humans and ecosystems (Galgani *et al*., 2021c). The water scarcity (or water stress) indicator is measured in m^3 of scarce water. It relies on the footprint of blue water used and a scarcity factor and represents the withdrawal of blue water compared with local availability. For more details, see Galgani *et al*. (2021c) and True Cost Initiative (2022).

Limitations

The indicator does not take into account the timing of water shortages due to droughts and (seasonal) variations in supply, but this can be decisive in some contexts. The geographical scale of the water scarcity/stress factors will limit the sensitivity of this indicator in regions with large variability in water availability. Water conservation practices are not considered in most models that predict on-farm water use. Other limitations and items for further development are discussed in Galgani *et al.* (2021c) and True Cost Initiative (2022).

A5. Recycling and waste management

Why it is relevant

A systemic approach to agrifood does not stop at the point of consumption, but should consider recycling and waste management as well. As food wastage is linked to concerns about food security, planetary boundaries and landfill (TEEB, 2018a), it is relevant for policymakers to take this indicator into account.

Recommendation:

Consider recycling and waste management for a TCA analysis if the policy in question affects the output of waste or the way waste is managed.

What is measured

This indicator can be measured by the volume of solid waste that is produced. Depending on the policy goal to be assessed, practitioners can distinguish between different classifications of waste, by specific material constituents or by disposal method (Natural Capital Coalition, 2016). Table A9 gives an overview of possible categories.

Table A9. Waste categories

Waste by classification	Specific material constituents	Disposal method
Non-hazardous	Lead	Landfill
Hazardous	Plastic	Incineration
Radioactive		Recycling
		Specialist processing

Source: Natural Capital Coalition. 2016. *Natural Capital Protocol*. The Hague. https://capitalscoalition.org/capitals-approach/natural-capital-protocol/?fwp_filter_tabs=training_material

B. Social capital indicators

Social capital is characterized by the relationships that form groups and communities. Due to the nature of this relationship and the absence of income generated by social capital itself, it has proven difficult to measure. Nonetheless, proxies can be very insightful for policymakers (TEEB, 2018a). For a detailed discussion of social capital, see IEF (2023) (Table 7).

B1. Food security

Why it is relevant

Ensuring that people have physical and economic access to food is one of the key mandates of policymakers, and food insecurity is one of five impact channels of the agrifood systems on health (Rocha *et al*., 2021). Both arguments reinforce the significance of taking this indicator category into account. Food security is frequently encountered in agrifood-specific TCA initiatives, while often absent from more generic applications (TCA Accelerator and Impact Institute, 2023).

What is measured

The FAO defines four dimensions of food security (FAO, 2008), which are used by the TEEB AgriFood Evaluation Framework, as shown in Figure A1. Therefore, when including food security in a TCA study, it should be treated as a category that covers multiple indicators along these four dimensions. The indicators will potentially overlap with indicators outside of this category and care should, therefore, be taken to prevent double counting. For example, economic access to food is strongly linked to poverty (see Section B2), as the affordability of food has two dimensions: the price of food products and the earnings of consumers. Food utilization overlaps with effects of a diet on human health (see Section C1), which can be included when the study takes a more individual than a population perspective.

Figure A1. The four dimensions of food security

Source: FAO. 2008. *An Introduction to the Basic Concepts of Food Security.* Rome. www.fao.org/3/al936e/al936e.pdf

There are different tools and standards that provide indicators to capture food (in)security, but a mutually exclusive and collectively exhaustive set of indicators has yet to be defined. The Healthy Diet Basket captures the affordability of food by calculating the costs of affordability of a healthy diet within a country (Herforth *et al.*, 2022). The Food Insecurity Experience Scale (FIES) allows policymakers to assess how food security is experienced within their population. FIES has been applied in *The State of Food Security and Nutrition 2022* to assess limited access to food (FAO, 2022b). FIES is used alongside the prevalence of undernourishment (PoU) indicator. PoU is an estimate of the percentage of individuals in a population that are in a condition of undernourishment and should, therefore, be viewed as an indicator that captures the combination of food utilization, availability and access. Combining 68 indicators, the Global Food Security Index does not only give an indication of the multiple aspects of food security that can be measured, but also points to the most challenging areas that policymakers might need to address (Economist Impact, 2022).

Recommendation:

If a policy is expected to affect one or more of the four dimensions of food security, this indicator should be considered. The choice of indicators should be informed by potential overlaps with other indicators and existing tools and standards to measure food (in)security.

Limitations

As discussed, a coherent set of indicators of food security needs to be developed and requires further standardization. As food security entails multiple indicators, the extent to which the four dimensions and current standards can guide the TCA study depends on the policies that are analysed and may be reflected in other indicators as well.

B2. Effects on poverty

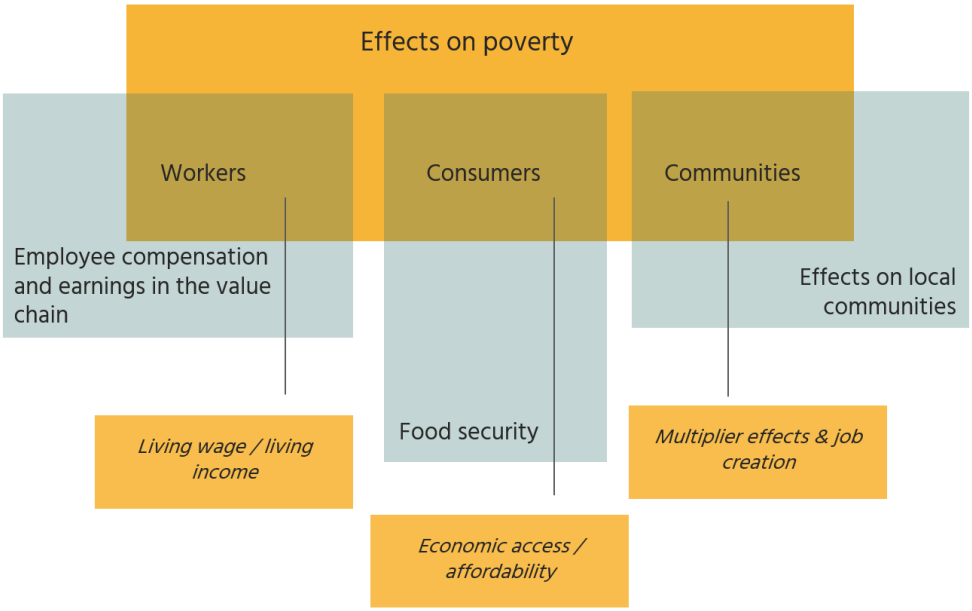
Why it is relevant

Evaluating the effects of policy decisions on poverty is highly relevant due to their relationship with the economic aspects (such as affordability of food, employment in agrifood value chains) of different agrifood systems, ranging from "traditional" to modern agrifood systems. For instance, modern systems tend to reduce the share of household budget spent on food, while mixed agrifood systems employ more people (TEEB, 2018b).

What is measured

A specific set of indicators still needs to be developed to measure the effects of food policy on poverty. On a general level, these effects can be categorized based on the group affected. Poverty is partly covered by the affordability of food for consumers (and overlaps with food security, see Section B1). Another driver of poverty (reduction) is the renumeration of employees and the income of farmers and entrepreneurs in the agrifood value chains (see Section C2). Lastly, the spillover effects of agrifood systems (for example, from production or processing activities) affect the poverty of local communities, for example, with the hidden benefit of providing livelihoods. Figure A2 provides an overview of the different drivers and indicators.

Figure A2. Effects on poverty and its relationship with other indicator categories



Source: Authors' own elaboration.

Recommendation:

Include effects on poverty in the TCA study if the financial situation of workers, consumers or communities may be affected by a policy intervention. Use this to evaluate which aspects will be covered by other indicators.

Limitations

The close ties of this indicator category with food security, employee compensation and earnings in the value chain make it difficult to draw clear distinctions and double counting should be avoided.

B3. Effects on local communities

Why it is relevant

As mentioned, the indirect creation of jobs for local communities is an effect of agrifood policies with relevance for policymakers. More generally, it is important to assess how policies affect different groups in the population in order to eliminate inequality and injustice. The importance of doing so is clear in the results of the True Price study of the United States of America system, which show how the adverse effects of current food policies are unequally distributed and particularly borne by communities of colour (Rockefeller Foundation, 2021a).

What is measured

While this aspect has an overlap with capturing effects on poverty, there are further elements to consider, such as equality and the granting of indigenous rights.

Development and further guidance are needed to define and apply this indicator. It is helpful to take the following elements into account:

- if and how institutions of communities are affected (TEEB, 2018a);
- whether there is a shared benefit with indigenous communities (Capitals Coalition, 2022).

Recommendation:

Include this indicator if the living conditions of local communities are a pressing issue within the policy context in question. Always check whether policies may have adverse effects on local communities in order to prevent them.

B4. Diversity, equality and inclusion

Why it is relevant

Diversity, equality and inclusion constitute another important group of indicators included by various TCA initiatives (TCA Accelerator and Impact Institute, 2023). These indicators strongly influence the distributional effects of the agrifood systems, so are highly relevant to policymakers. In other words, “TCA, if it is to be transformative, must address issues of power and existing structural inequities in agrifood systems that impose the greatest costs on the most vulnerable members of society” (Gemmill-Herren *et al.*, 2021, p. 6).

What is measured

While there is no agreement on a specific set of indicators, several different indicators have been used to date (TCA Accelerator and Impact Institute, 2023). These include the (gender) pay gap (True Cost Initiative, 2022) and opportunities for gender- and minority-related empowerment (TEEB, 2018b). For guidance on the quantification and valuation of the gender pay gap, consult the TCA Handbook (True Cost Initiative, 2022).

Recommendation:

Include relevant indicators if the system shows structural imbalances of distributional effects, or if policy interventions may weaken or aim to strengthen them. Note that many policies carry either the risk of affecting or the opportunity to affect diversity, equality and inclusion.

Limitations

Apart from clear guidance on how to calculate a gender pay gap, other dimensions of this indicator still require more development and guidance. Initiatives that look beyond the gender divide are necessary to consider minorities of all kinds and include them when assessing the distributional effects of an intervention or system. In the same vein, the scope of this indicator depends on the vulnerable groups that are considered.

B5. (Other) effects on human rights

Why it is relevant

There is a high incidence of human rights violations in the agrifood sector, requiring their consideration when evaluating policy design. In a TCA study, "effects on human rights" is an umbrella-term for multiple indicators. It is necessary to define which rights violations are relevant. Two subcategories of human rights violation particularly prevalent in agrifood systems are child labour and forced labour (True Cost Initiative, 2022).

What is measured

There are different approaches to measuring the effects of human rights violations. The *TCA Agrifood Handbook* (True Cost Initiative, 2022) recommends using disability-adjusted life years (DALYs), while True Price looks at both the medical and educational implications of child labour (Galgani *et al*., 2021a). Further guidance on quantifying and valuating child labour and forced labour can be found in these sources.

Recommendation:

When the policy in question affects the conditions in which food is produced, violations of human rights should be considered.

Limitations

As well as different approaches to how to capture effects on human rights, this indicator requires transparency on current and likely violations within a country, system or supply chain. Relying on ethics and due diligence, there are two major limitations inherent in this indicator:

i) a human rights violation must be acknowledged as such within a political context and ii) it needs to be reported.

C. Human capital (and health) indicators

Human capital describes "an individual's knowledge, skills, competencies and attributes" (Social & Human Capital Coalition, 2019, p. 9) which "facilitate the creation of personal, social and economic wellbeing" (TEEB, 2018b, p. 219).

While often measured by monetary investments in areas such as education and health across countries (TMG Think Tank and WWF, 2021), the challenge of measuring human health capital and health indictors remains calculating components that have no clear economic return. Particularly when it comes to health, assessments vary from individual to individual and entail ethical questions such as what constitutes good health (TEEB, 2018b).

The state of development of the different indicators reflects such difficulties. For an elaborate discussion of human capital and health, see IEF (2023).

C1. Health effects of food consumption

Why it is relevant

Health is one of the core pillars of a well-functioning society. How policy interventions affect the health of a population is, therefore, relevant to most policymakers. One of many pathways through which agrifood systems policies can affect human health is their effect on a population's diet, even when health is not the primary outcome. A recent TCA study revealed the costs of an overshoot in dietary intake, resulting in obesity, alongside other hidden costs of the agrifood systems in the United States of America (Rockefeller Foundation, 2021a).

What is measured

Generally, two pathways of food consumption that affect health are considered: food safety (pesticide residue on food products) and (un)healthy dietary patterns.

If a policy intervention touches on food production techniques and affects whether contaminants are used and how they are dealt with (food safety), human toxicity is a suitable indicator for measuring health effects. An assessment can thus be made of which health risks – both cancerous and non-cancerous – are caused by the intake of chemical residues on food products. Although under development, recent efforts have aimed to include human toxicity from pesticide residues in LCAs of agricultural products (Nemecek *et al*., 2022).

Depending on the geopolitical context, different drivers of (un)healthy or unbalanced diets may be more prevalent. Over- and underconsumption of certain food categories are associated with a variety of non-communicable diseases in the *Global Burden of Disease* study (Murray *et al*., 2020). These associations between dietary intake and disease burden allowed the calculation of costs associated with global dietary changes, based on relative risk factors (Springmann *et al*., 2016). Please note that assessing the health effects of dietary patterns, as described in this paragraph, overlaps with the indicators of food security (especially food utilization) (Section B1). Using relative risk factors to estimate disease burden allows for a more detailed analysis of how specific food categories impose costs on society.

Recommendation:

Define during the scoping phase whether health effects play a primary or secondary role. Based on that, as well as the context of the study, determine how it will be included.

Limitations

Even though some indicators are well established, further development is required to cover more components of health effects. The fact that health effects are unequally distributed within a population, for example, by area (rural/urban), wealth and education (FAO, 2022b), reinforces this need, while showing the importance of being context-sensitive for the apt use of this indicator.

C2. Employee compensation and earnings in the value chain

Why it is relevant

Included in most existing TCA initiatives (TCA Accelerator and Impact Institute, 2023), the high relevance of considering employee renumeration and earnings in the agrifood sector value chain is strongly linked to meeting basic needs, such as having access to water and nutrition, housing and clothing. As outlined in the sections above, it is closely linked to food security (Section B1) and effects on poverty (Section B2). At the same time, having an adequate standard of living is a basic human right that is connected to access to health and education (True Cost Initiative, 2022). With agriculture being the second-largest source of employment globally (FAO, 2022a), regulation of employee compensation can be a huge policy lever to realize better living conditions.

What is measured

Depending on the employment situation, different indicators measure whether renumeration is sufficient to meet basic needs. For employee compensation, the gap between the actual wage of employees and the living wage is a frequently used indicator (Anker and Anker, 2017; Global Living Wage Coalition, 2018; True Cost Initiative, 2022). For self-employed workers, such as smallholder farmers and small entrepreneurs in the value chain, the gap between actual income and living income is better suited (Van Veen and Galgani, 2022).

Recommendation:

Include this indicator if poverty and meeting basic needs is an issue in the policy context in question.

Employee compensation above the living wage benchmark can be considered an additional benefit to employees. This benefit is the increase in well-being that people experience when they get paid more. Arguably, the same increase in renumeration causes a larger increase in well-being for someone who earns relatively little than for someone who can already afford a luxurious lifestyle. A standardized indicator to account for the benefits from employee compensation above the living wage benchmark has yet to be developed. An approach developed and proposed by Nestlé for the private sector can serve as a first step. Linking

income inequality with health, it developed a methodology that does not assume that employment is a positive impact in and of itself, only if it is above the baseline of living wage or minimum income (Social & Human Capital Coalition, 2019).

Limitations

If income data are not readily available, this indicator may require primary data collection at household level. It should be noted that this indicator is highly context specific (to household situation, geographical location and so on), so primary data collection may require relatively large investments of time and money to obtain accurate results. When using secondary data, caution should be taken to use data that are representative of the context of the households in scope.

C3. Employee health and safety

Why it is relevant

The important counterpart to consumer health effects is ensuring the employee's health and safety in the agrifood sector. Its high relevance is not only reflected in its coverage by the majority of initiatives (TCA Accelerator and Impact Institute, 2023), but also by the fact that agriculture is one of the most hazardous sectors when it comes to work-related accidents and occupational diseases (True Cost Initiative, 2022). Policy interventions that aim to improve working conditions or at least affect them, therefore, call for the consideration of this indicator.

What is measured

On a high level, employee health and safety is often separated into occupational injuries and occupational diseases (even though other aspects of employee health, such as mental health problems, exist but are currently not accounted for). While the latter still needs further development, occupational injuries can be divided into different subindicators (Galgani *et al*., 2022a; True Cost Initiative, 2022), such as non-fatal injuries, measured in DALYs, and fatal injuries, measured in value of statistical life (Galgani *et al*., 2022a). Ideally, the number of accidents, the severity of accidents and the stay in the hospital are considered to determine the health effects. If these data points are unavailable, the type of accidents (non-fatal/fatal) and their measurement in DALYs can be used as an alternative (Galgani *et al*., 2022a).

Besides the consideration of injuries, further indicators could include work performed in violation of health and safety standards (Galgani *et al*., 2022a), for example, excessive working hours (True Cost Initiative, 2022).

Recommendation:

Include this indicator if the policy decision in question affects the working conditions of employees in the agrifood sector.

Limitations

To include occupational diseases in this indicator, the question of how to attribute them to working conditions still needs further study (Galgani *et al.*, 2022a). Similarly, more development is needed to include indicators other than physical injuries, so as to consider all relevant aspects of employee health and safety.

C4. Employee career and skills development

Why it is relevant

Addressed by the majority of initiatives (TCA Accelerator and Impact Institute, 2023), employee skills development is another relevant indicator within human capital for policymakers. While it is more of a side benefit of employment that should not be ignored, its importance for policymakers lies in the value of education in rural areas, to enable farmers to accomplish food production and management sustainably (TEEB, 2018b).

What is measured

Indicators for this indicator are still under development and require more study. As a starting point, policymakers can learn from the application of TEEB for businesses. It is important to understand the required capabilities and the workforce targeted by the intervention in question (Capitals Coalition, 2022).

Limitations

This indicator needs further development to capture employee career and skills development in a quantifiable way. While there are already initial approaches with regard to the private sector, it is important to translate them for use by policymakers.

D. Produced capital indicators

Produced capital describes "all man-made assets, such as buildings, factories, machinery, physical infrastructure (roads, water systems) as well as financial assets" (TEEB, 2018a, p. 48), such as community centres, farm and food processing equipment, storage and warehouses (Sandhu *et al*., 2021; TMG Think Tank & WWF, 2021).

For a detailed discussion of produced capital, see IEF (2023).

D1. Taxes and subsidies

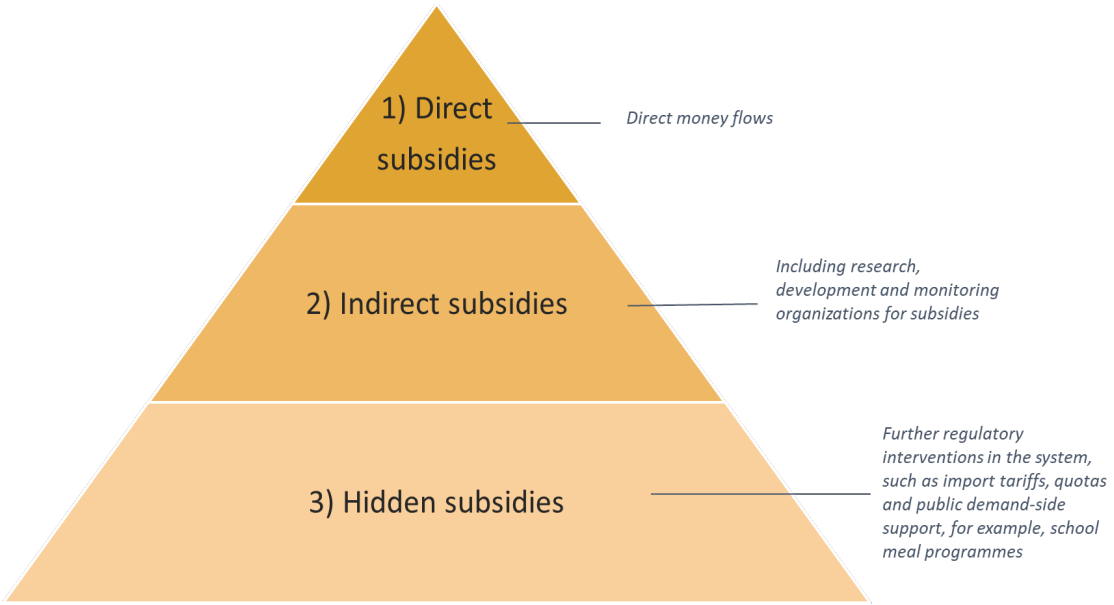
Why it is relevant

While taxes and subsidies are typically not the main focus of a TCA study, it is important to consider them to ensure that they are effective and beneficial. With the high steering potential of targeted taxes (for example, tariffs and excise duties) and subsidies on the one hand (TEEB, 2018b) and the investment of high sums of money on the other, the relevance of this indicator for policymakers, to capture both financial losses and benefits, is evident.

What is measured

Alongside measuring (the change in) taxes, there are three levels of subsidy that serve as subindicators for this indicator (Figure A3).

Figure A3. Three levels of subsidy that can serve as indicators



Source: Based on Rockefeller Foundation. 2021a. *True Cost of Food: Measuring What Matters to Transform the U.S. Food System*. New York, USA. https://www.rockefellerfoundation.org/wp-content/uploads/2021/07/True-Cost-of-Food-Full-Report-Final.pdf

Recommendation:

Include at least the first level of subsidies in the TCA assessment if the policy intervention affects how public money is spent and distributed.

Limitations

While the first level of agricultural subsidies is comparatively easy to identify, level 2 and especially level 3 are challenging to determine. Moreover, it is crucial to see this indicator in its overarching context (with other impact indicators and considering system effects), as it does not capture the consequences of distorted incentives through subsidies and taxes on its own (Rockefeller Foundation, 2021a).

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