True Cost Accounting

Inventory Report

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Executive Summary

This research is commissioned by the Global Alliance for the Future of Food and is conducted by Soil & More Impacts and TMG Thinktank for Sustainability. This report accompanies an **Inventory** of evaluation framework, resources, databases, and case studies that are useful for researchers, civil society organizations, policymakers, farmers and the private sector when conducting a true cost accounting (TCA) assessment in the field of agriculture and food systems.

The report includes a review and synthesis of existing frameworks and methodologies used to apply TCA across food systems, background information on the inventory of databases, and a review of existing studies that can be considered as leading examples or current good practice in the field of TCA applications in the food and agriculture sector. Finally, the report presents strategic recommendations on how to strengthen the TCA systemic approach across food systems and outlines proposed next steps for the TCA for Food Systems Accelerator. The report is based on an online survey with the TCA Community of Practice, telephone interviews with TCA experts and practitioners, as well as on an extensive literature review.

For the synthesis of TCA methodologies, the TEEBAgriFood Foundation Report, the Natural Capital Protocol, the Human and Social Capital Protocol and other familiar frameworks and publications as the ISO 14008 standard for "Monetary valuation of environmental impacts and related environmental aspects" were reviewed. From the analysis of the similarities and differences of methodological aspects of conducting a TCA assessment, common elements were identified.

The extensive search and selection of databases resulted in an inventory of databases which provide secondary data for TCA assessments. The **TCA Inventory** currently comprises 64 databases of which 21 databases are useful for the measurement of impacts and 23 databases for the valuation step. Additionally, 20 databases were added to show what other kinds of databases can be of use for TCA assessments. The inventory shows that natural capital has the most extensive data coverage, closely followed by human health. Data for the other forms of human capital and social capital are available to a lesser extent.

Similar results can be found for case studies. Many case studies present and analyze natural capital and human health impacts, while other human capital topics and social capital are less often analyzed. The studies were selected so that all capitals, application families of TCA assessments and steps of a TCA assessment were represented in the inventory of good practice examples. However, studies considered for this inventory did not investigate all material impacts of all capitals throughout the agricultural value chain. Therefore, no single blueprint for a TCA application can be derived from this inventory.

All the expressed strategic recommendations have one overarching theme in common: harmonization. We identified the need to harmonize the definition and understanding of TCA, derive a common language, including the relationship between the terms, develop one standardized TCA methodology, unify data relevant for TCA for food systems in one database, inspire the application of TCA through best practice case studies for each application family, use the TCA accelerator to serve as a knowledge hub for TCA. All of these proposed activities require a well-designed harmonization process and should cover common capitals, categories and indicators. This process should be set up by an independent institution exploring options for harmonization and starting a process to develop this joint understanding.

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1. Introduction

Current prices do not provide the true value of food because not all costs and benefits are internalized. Agriculture and food production do not only rely solely on produced capital but also on natural, social and human capital. Unfortunately, today's standard accounting and economic evaluation systems do not consider positive nor negative externalities which are critical for the long-term resilience of eco-agri-food systems and the people depending on them. Ignoring these externalities and some forms of capital leads to distorted markets and false accounting. Governments and businesses treat food often as a solely commercial product, but growing food entails so much more such as passing on knowledge, traditions and cultural goods within families, communities, societies, and generations, and is central to well-being and health.

True cost accounting (TCA) aims at evaluating the externalities of a defined eco-agri-food system that goes beyond the traditional measurement of economic key performance indicators (KPIs). By expressing impacts via their monetary losses or gains they become harder to neglect by decision-makers. TCA does not only inform but also justifies in economic terms decisions made by policymakers and thereby could promote a food system that has more positive impacts on society and the environment. **By making the real costs of production and consumption transparent to society, governments and businesses, TCA becomes an instrument to transform our current eco-agri-food system into a more sustainable one.**

TCA uses a systemic approach to evaluate all visible and invisible, direct and indirect impacts of the eco-agri-food system. SDG goals, such as freshwater (SDG 6), biodiversity and ecosystems (SDGs 14 and 15), human health (SDG 3), social equity (SDGs 5 and 10) and livelihoods (SDG's 1 and 8) can be analyzed together within one eco-agri-food system which enables a more holistic view, often not applied in other reporting schemes. The eco-agri-food system is highly interconnected and linked to other systems like the health sector. Food provides energy and nutrients but at the same time, contaminated food (e.g. through pesticides) poses a threat to consumers' well-being and health.

Even though TCA has gained attention in academia as well as in the private and public sector, its application varies widely depending on the use of existing frameworks, scope, methods and availability of data. To understand, improve, and realize the potential of holistic TCA across eco-agri-food systems, there is a need to inventory and systematically review both the methodologies and data that have been used in applying TCA as well as case studies providing good practice examples.

On these grounds, this project created an **Inventory** of methodological frameworks and resources, databases, and case studies that are useful for researchers, civil society organizations, policymakers, farmers and companies when conducting TCA in the field of eco-agri-food systems.

2. Terms & Definitions

This lexicon serves as an overview of the terms and definitions used in this report and the accompanying inventory. It does not try to cover all the relevant terms in the context of TCA. Instead, it gives guidance to the reader regarding the interpretation of the terms here used, which can vary slightly between the different TCA frameworks and guidelines documents.

Term	Definition	Source
baseline	state of environment or [other stock] against which changes in capital are valued	ISO14008/ Natural Capital Protocol
capital	the economic framing of the various stocks in which each type of capital embodies future streams of benefits that contribute to human well-being	TEEBAgriFood
human capital	the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being	TEEBAgriFood
natural capital	the limited stocks of physical and biological resources found on earth, and of the limited capacity of ecosystems to provide ecosystem services	TEEBAgriFood
produced capital	all manufactured capital, such as buildings, factories, machinery, physical infrastructure (roads, water systems), as well as all financial capital and intellectual capital (technology, software, patents, brands, etc.)	TEEBAgriFood
social capital	encompasses networks, including institutions, together with shared norms, values and understandings that facilitate cooperation within or among groups	TEEBAgriFood
(natural capital) dependency	a business reliance on or use of [..] capital	Natural Capital Protocol
dependency pathway	shows how a particular business activity depends upon specific features of [...] capital. It identifies how observed or potential changes in [...] capital affect the costs and/or benefits of doing business	Natural Capital Protocol
driver	a flow (e.g. input or non-product output) which arises from the activities of agents (i.e.governments, corporations, individuals) in eco-agri-food value chains, resulting in significant outcomes and leading to material impacts	TEEBAgriFood/ Natural Capital Protocol

externality	a positive or negative consequence of an economic activity or transaction that affects other parties without this being reflected in the price of the goods or services transacted	TEEBAgriFood
flow	a cost or benefit derived from the use of various capital stocks (categorized into agricultural and food outputs, purchased inputs, ecosystem services and residuals)	TEEBAgrifFood
impact	a positive or negative contribution to one or more dimensions (environmental, economic, health or social) of human well-being	TEEBAgriFood
impact pathway	series of consecutive, causal relationships, ultimately starting at a stock, describing how an impact driver results in changes in [...] capital and what impact these changes have on different stakeholders	ISO14008/ Natural Capital Protocol
materiality	an impact or dependency on [...] capital is material if consideration of its value, as part of the set of information used for decision making, has the potential to alter that decision (Adapted from OECD 2015 and IIRC 2013)	Natural Capital Protocol
outcome	a change in the extent or condition of the stocks of capital (natural, produced, social and human) due to value-chain activities	TEEBAgriFood
stock	the physical or observable quantities and qualities that underpin various flows within the system, classified as being produced, natural, human or social	TEEBAgriFood
true cost accounting	evolving methodology to measure and value the positive and negative environmental, social, and health externalities in order to allow analyzing the costs and benefits of business and/or policy decisions	Own definition
value	the importance, worth, or usefulness of a good or service- including all relevant market and non-market values -determined by people's preferences and the trade-offs they choose to make given their scarce resources, or the value the market places on an item	TEEBAgriFood/ Natural Capital Protocol

3. TCA Inventory

The **TCA Inventory** is a collection of **evaluation frameworks, resources**, **databases**, and **case studies** useful for researchers, civil society organizations, policymakers, farmers and the private sector when conducting a TCA assessment in the field of agriculture and food systems. It was compiled through literature reviews and expert surveys and interviews and concluded as of January 2020.

The presented reviews, synthesis, and inventories are grounded on the analysis of different resources. For the analysis of TCA methodologies, the most prominent TCA frameworks were being compared. To inventory relevant databases, a comprehensive online search for databases was conducted. Finally, a large number of case studies were reviewed in order to provide good practice examples.

Additionally to the literature reviews, we conducted an online survey that was sent out to the Community of Practice (CoP) and its broader network. 15 experts and stakeholders from academia, civil society, business, and the public sector participated in the survey. The survey served multiple purposes. It was used to find out how potential users would apply the database to ensure the appropriate user-applicability of the inventory. Furthermore, participants were asked to share their existing knowledge and expertise on TCA.

Lastly, during November and December 2019 we conducted 6 phone interviews with experts and stakeholders with different backgrounds. We discussed with them their interests and needs concerning TCA methodologies, case studies, and databases in detail. The interviews allowed especially for a more in-depth analysis of the current challenges of conducting TCA assessments. TMG and SMI engaged closely with the CoP for this inventory by consulting the community for the online survey and expert interviews. Updating of the inventory concluded in January 2020.

4. Evaluation Frameworks

The overall idea of TCA is increasingly well recognized but a common understanding of the underlying, defining methodological features of a TCA assessment is lacking.

The review of TCA framework methodologies showed that the overarching concept of TCA is very similar across the analyzed frameworks. However, the use of different terminology, as well as the variation in categorizing methodological steps and substeps, leads to inconsistency and confusion when comparing frameworks. Frameworks with e.g. a focus on businesses or even business value tend to describe a smaller and more business-centred scope in their examples than more overarching systems including several application families. Even though it is mostly stated that tools and measurement methods listed in frameworks only serve as an example, it automatically influences the reader and therefore also the assessment.

A total of 11 frameworks met the selection criteria of stating consecutive methodological steps on how to carry out a true cost accounting for at least one capital. These frameworks can be found in the TCA Inventory, along with other relevant resources including software, search engines, and other standards.

To comply with the TEEBAgriFood principles a TCA assessment should be:

- universal, being relevant to and understood by all stakeholders,
- comprehensive, including all relevant impacts of all four capitals, and
- inclusive, using equitable methods and tools, quantitative and qualitative to assess impacts and dependency pathways and evaluate impacts.

Every methodological step in the assessment should be transparent to the reader and taken choices e.g. for tools or methods during the TCA assessment must be justified and documented. Other frameworks state different principles but no contradicting principles could be identified.

Frameworks included in the TCA inventory all describe similar procedures for conducting a TCA assessment. Analysis of the TEEBAgriFood evaluation framework, the Natural Capital Protocol, the Social & Human Capital Protocol, the ISO14008 Standard and other publications from business consultancies and private and public organizations identified common elements of conducting a TCA assessment which are described below.

Common Elements

Framing

Every TCA assessment should state clearly its objective by framing the study. Many frameworks use slightly different terminologies for the first step and recommend displaying different details of information. In the TEEBAgriFood this step is covered under *Purpose and Entry Point,* whereas the NCP covers these steps with the stages *Why?* divided into more detailed sub-steps, the ISO Standard 14008 requires to define only the *goal.*

Describing and Scoping

Describe the impact pathways, dependencies and relationships

After having identified the objective of the TCA assessment, the impact drivers in the system need to be identified. Therefore, the connection between impact drivers and capital stocks, other flows, and their outcomes have to be described and analyzed. Qualitative methods such as systems thinking as well as quantitative methods such as system dynamics can help to map and connect impacts and impact drivers, by defining and if possible quantifying causal relations. Impact pathways do only illustrate visible and direct flows but also need to capture invisible and/or indirect flows.

Categories for flows in eco-agri-food systems suggested in TEEBAgriFood are agricultural and food outputs purchased inputs, ecosystem services, and residuals flow. In order to connect impact drivers and impacts through flows and outcomes, cause-effect relationships need to be stated. This also includes stating the uncertainty of cause-effect relationships.

Scope using materiality analysis

Scoping after the impact pathways, dependencies and relationships have been described ensures that all connections and effects relevant to the assessment are identified before determining their relative importance. The analysis of case studies showed that a TCA assessment can vary highly in its scope, e.g. business analyses tend to assess their supply chain and involved stakeholders, whereas policy-focused assessments often evaluate entire regional or national crop sectors.

A materiality analysis helps to determine the relevant impacts of a TCA assessment for the set objective. Because eco-agri-food systems are very complex and highly interconnected, identifying and evaluating all impacts within set systems boundaries is challenging. When defining impact pathways one flow can have more than one outcome and consequently more than one impact. To ensure all material impacts are identified, scoping and describing should be an iterative process.

Even though TEEBAgriFood does not explicitly state the need to conduct a materiality analysis, it is a necessary step to comply with the principle of comprehensiveness. To comply with the principle of universality all stakeholders across the value chain need to be included in the materiality analysis.

When reviewing different frameworks and guidelines it is apparent that many examples are given for possible indicators to be measured. Still, no comprehensive list with material impacts for eco-agri-food systems has been published by any of the discussed frameworks. Many resources e.g. the SASB Materiality Map or the Land Materiality Screening Tool exist to give guidance and suggestions.

Measuring and Valuing

Impact Assessment & Measurement

Once material impacts, outcomes, flows and impact drivers are defined, they need to be measured. A vast body of literature exists which analyze different value chain elements and evaluate various outcomes and linked impacts of eco-agri-food systems. However, when analyzing a specific eco-agri-food system it can be very research-intensive to find relevant data on material impacts (see

Chapter 5). Besides the trouble of finding the right resources, it also requires the skills to properly transfer the information to a new assessment. The Food and Beverage Sector Guide as an addition to the Natural Capital Protocol gives valuable examples for tools and publications regarding the measurement of outcomes and impacts. However, this is again only a collection of a few good examples but not a comprehensive list of impact measurement tools. The lack of measurement tools for all common material impacts in an eco-agri-food system seems to be a big obstacle for the application of TCA assessments. Life Cycle Assessments (LCAs) are the most common method used to measure mostly natural capital changes and related impacts but partly covers also health aspects. Social life cycle assessment, assessing social impacts, is a rather new method. However, LCA applications have often pre-defined midpoints and endpoints, representing outcomes and impacts, which limits the selection of impact indicators. In general, most data, tools and methods available focus on natural capital or produced capital. Finding data, tools and methods for human and social capital poses a greater challenge when conducting a TCA assessment.

No tool will ever be able to assess all elements of a system. However, tools already exist which provide relevant indicators and metrics of mostly flows and outcomes. Examples of these are *The Cool Farm Tool*, *CropWat*, *SWAT*, *Invest*, *ARIES*, as listed in the TEEBAgriFood and Food and Beverage Sector Guide. It is striking that most tools only assess the negative outcomes and impacts and only a few can measure positive outcomes e.g. carbon sequestration.

Most TCA assessments use a portfolio of different tools for assessing and measuring different outcomes and impacts. Others do not use any tools and base their assessment on a literature review (see **Case Studies**). Databases that are also relevant for this methodological step are covered in the **Inventory** section.

Valuation and Monetization

After assessing and measuring impacts they can be monetized or otherwise valued. Yet it is important to stress that not all impacts need or should be monetized. Some information can be very challenging to monetize e.g. biodiversity, or it can be simply chosen not to monetize because no value should be presumed e.g. life years. However, this should not lead to impacts being left out of the assessment but rather stated clearly in the assessment or other valuation methods should be chosen.

Different monetization methods have different advantages and disadvantages and will result in different values. Therefore, the choice of method should be carefully made. The different advantages and disadvantages will not be discussed in the inventory, but monetization methods only described. In practice, the selection criteria for the monetization method is heavily influenced by the availability of data on monetary values for different impacts. Common monetary valuation methods are the following:

Market price proxies use data from existing markets to determine, approximate or derive values for goods for which a market exists.

Stated preference methods create hypothetical markets in which respondents state their willingness to pay or accept directly or indirectly. These methods include contingent valuation, choice experiments, conjoint choice or group valuation.

Revealed preference methods use data from existing markets to assign values to goods for which no market exists. These methods include averting costs/defensive expenditures, hedonic pricing or travel costs.

When data is available market price proxies are preferred if not stated or revealed preference methods can be used as a fallback option. However special attention should be given to if the market proxy can capture the actual externality and does not undervalue the impact because the market price is too low (e.g. health cost).

In many TCA assessments *value transfer* is used to evaluate and monetize impacts and no primary data on monetary values themselves is collected. However, knowing the monetization methods is critical to make informed decisions on which monetization factor to choose for impacts. The same impact indicator can be monetized with different monetization methods.

Depending on the chosen methods, equity weighting and discounting need to be applied (ISO 14008:2019). Further details on these techniques can be found in analyzed frameworks and standards.

Taking Action

A TCA assessment can be used for different purposes. The results of the TCA assessment should serve the objective defined in the first step of the TCA. Depending on the scope and complexity of impact pathways the results of an assessment can be challenging to interpret. Hence the results of an assessment should be tested, e.g. with sensitivity analysis and should be verifiable. All steps taken in the assessment should be made transparent. It should be clearly stated what limitations the assessment has, and which assumptions have been made due to e.g. a lack of data availability. After evaluating the results of the TCA assessment their implications regarding the objective should be stated. The use of TCA results go far beyond their communication but can serve as a profound tool for informed decision-making. A TCA assessment can e.g. inform a comparison of two policies, be used to inform climate-related risks of businesses in credit ratings, enrich annual reports of organizations reporting beyond financial capital in an integrated profit & loss statement.

Methodology

The review of frameworks focused on the common methodological aspects of conducting a TCA assessment. It does not give a comprehensive review or summary of underlying frameworks, guidelines or related publications but rather highlights the different steps needed for applying these.

During the interviews, mentioned frameworks were the TEEBAgriFood evaluation framework (TEEBAgriFood), the Natural Capital Protocol, the Human and Social Capital Protocol and the Natural Capital Protocol- Food and Beverage Sector Guide. Additional 17 frameworks, standards, and publications were screened, from which 7 met the selection criteria of stating consecutive methodological steps on how to carry out a true cost accounting for at least one capital. Often considered frameworks do not use the term true cost accounting but use the term *valuation*. In total 11 frameworks, methodologies, standards or other related publications were analyzed and can be found in the inventory.

Most of the terminology used in this chapter refers to the TEEBAgriFood evaluation framework. However, all 11 frameworks and standards were analyzed and their terminology adapted to provide

consistency. The TEEBAgriFood, the Natural Capital Protocol and the Human and Social Capital Protocol and other assessed frameworks e.g. the Essential Guide to Natural and Social Capital Accounting (A4S CFO Leadership Network) or the Total Value - Impact valuation to support decision making (EY) do not focus on how assessments should be undertaken nor recommend specific methods but rather provide a system thinking approach and structure to evaluate impacts and their drivers. Therefore, this chapter was enriched with information from the ISO 14008 standard for "Monetary valuation of environmental impacts and related environmental aspects". Even though the ISO standard refers to environmental valuation its methodological steps are very applicable and meaningful to the valuation of other capitals besides natural capital. Special attention was given to the procedural steps of a TCA assessment that require a choice of different methods and tools. Descriptive methodological aspects and the alignment to principles are not representatively embodied in this document. This by no means attributes less importance to them.

5. Databases

Conducting TCA assessments of a specific eco-agri-food system demands great amounts of data for different value chain elements and various impacts across different capitals. However necessary data can be very costly and timely to generate or collect. Therefore, data constraints are often named as one of the main hindrances to performing TCA. Consequently, identifying and classifying databases containing data useful for TCA is essential to upscale its use and thereby promoting sustainable eco-agri-food systems as well as making results more widely comparable.

On these grounds, this project created an inventory of databases that are useful for researchers, civil society organizations, policymakers, farmers and companies when conducting TCA in the field of eco-agri-food systems. The inventory of databases lowers the challenge of finding appropriate data by providing an overview and link to existing secondary databases, including:

- published, peer-reviewed, and grey literature (for example, life-cycle assessment databases; industry, government, or internal reports)
- estimates derived using modeling techniques (for example, input-output analysis, productivity models, mass balance)

To complete a TCA assessment, secondary data may need to be supplemented with primary data such as internal business data or data collected from suppliers and customers. This is particularly important if a high degree of accuracy is to be achieved because databases usually provide averages. The type of primary data that needs to be collected depends on the TCA framework that is being applied as well as the type of TCA assessment that is being undertaken.

The databases are organized in the TCA Inventory into three categories: measuring, valuing, and other. **Measuring** is an inventory of databases that provide quantitative and qualitative data on natural, social, human and produced capital impacts. It mainly includes databases for life-cycle assessment (LCA), as this is one of the most common and advanced methods to assess outcomes and impacts. **Valuing** is an inventory of environmental and social valuation databases which mainly include monetary values.

Other is an inventory of databases that provide agricultural data and related data relevant for TCA but are not specifically modified or targeted to TCA. They have been added to the inventory to give examples of databases that cover additional data that may be necessary depending on the availability of primary data and the type of TCA assessment. This sheet includes for example satellite and remote sensing data such as in the *Harmonized World Soil Database* or time-series records on land cover and land use that can be found in *FAOSTAT*.

Table 1 provides an overview of the different data requirements of the different steps of TCA. By way of example, the table depicts the type of data sources under each TCA step and where to find them in the inventory.

Table 1: Examples of data requirements for the different steps of TCA and their coverage in the inventory

TCA step	Impact Pathways	Impact Measurement	Valuation
Inventory sheet	Other Databases	Measurement Databases	Valuation Databases
Examples of data sources	Input-output tables, national statistics, trade data, production accounts of livestock and crop operations¸ farm and field record sheets, results from studies and models (e.g. from dose-response model)	Sensors on-farm, pollution sampling of wastewater from factories, accident logs, satellite and remote sensing, national environmental surveys, local water quality surveys	Human well-being surveys, national economic statistics, contingent and preference studies

*When using LCA databases, impact pathways often do not need to be defined in detail, because the data provided is generated through underlying calculations that are based on pe-defined causal relationships.

The databases were inventoried according to predefined categories and subcategories guiding the user to the relevant database. The categories were chosen based on the different characteristics of TCA assessments as well as the recommendations and wishes expressed by the interviewees and survey participants. The categories include the following:

- name of the database
- type of capital (natural, human, social and produced) that the databases covers
- time period covered by the data
- status of whether a database is being maintained or is ceased
- access authorization, such as open asses or requirement of payment
- authors of the database
- geographic scope and level of data
- data type (quantitative, qualitative, monetary)
- short description of the databases, and
- a link to the database.

Subcategories appear for the four capitals to further distinguish the data coverage regarding the different topics within each capital. The sub-categories represent the area of impact.

This category "**natural capital**" indicates whether the inventoried database contains data relevant to natural capital. Natural capital is composed of the sum of environmental assets and services. Examples of natural capital include the earth's atmosphere, pollination services from bees, soil fertility, aquifers, iron ore, and a forest.

There are eight subcategories for natural capital. The first four subcategories are related to assessments and valuations of ecosystem services:

"**Provisioning services**" refers to data of ecosystems services such as food, clean water, timber, etc.

"**Regulating services**" refers to data of regulating ecosystem services such as water-waste management services, carbon sequestration, and pollination.

"**Habitat or supporting services**" refers to data of supportive services for life, such as habitats where animals and plants survive and genetic diversity that enables ecosystems to function.

"**Cultural services**" refers to data of non-material benefits obtained from nature. For example, indigenous knowledge based on a natural environment and the aesthetic appreciation of green space.

Additionally, a distinction is made according to the type of natural resources the data refers to:

"**Air**" includes data on services and resources related to air such as the cost of air pollution from sulfur dioxide and yield losses caused by ozone concentrations in the lower layers of the atmosphere.

"**Land**" includes data for services and resources related to land such as an estimation of the net social benefit from outdoor recreation, and the willingness to pay for preventing land-use change in a forest reserve for agriculture development.

"**Water**" includes data for services and resources related to water, such as the economic benefits of water streams and the value of improved water quality.

"**Living resources**" includes data for biological services and resources such as the value of native biodiversity enhancement and fisheries stocks.

This category "**human capital**" indicates whether the inventoried database contains data related to human capital. Human capital is composed of the knowledge, skills, and qualities owned by individuals that facilitate the generation of personal and collective well-being, for example, a person's health, literacy and numeracy skills. The three subcategories are:

"**Health, safety, nutrition, and working conditions**" covers different aspects of a person's general well-being, such as valuations of risk of fatality from working conditions and cost estimation of pesticide use.

"**Labour, skills, training**" refers to data of people's knowledge and competencies to perform social and economic activities, such as the economic value of educational and ecological knowledge and an assessment of the average highest educational level attained by a population.

"**Employment and remuneration**" includes data related to income and labor markets, such as an assessment on income inequality or a farmer's average income.

This category "**social capital**" indicates whether the inventoried database contains data relevant to social capital. Social capital is composed of jointly owned networks, shared norms, values and understandings that facilitate the generation of individual and collective well-being. Examples of

social capital include reciprocity among farmer's borrowing groups, shared norms to protect the environment, and trust amongst others. The three subcategories are:

> "**Social networks and cooperation**" refers to data of collective networks, trust and reciprocity, such as the cost of crime or an assessment of the level of trust within groups.
>
> "**Laws and regulations**" refers to data of regulatory frameworks, shared norms, *de jure* and *de facto,* such as an assessment of resource governance systems or the cost of breaking the law.
>
> "**Collective knowledge and values**" includes data of shared information and beliefs such as assessing how desirable equality of income within a population is or how important it is to look after the environment.

This category "**produced capital**" includes produced capital, which refers to all human-made assets, services and economic inputs such as physical infrastructure, intellectual property, machinery and financial assets. Unlike the other capitals, we are not providing subcategories for produced capital. This is the result of very few databases in this inventory containing data relevant to the category. A reason for this is that data for produced capital can be found in national and international statistical databases (e.g. Eurostat, OECD Statistics), in data portals of international organizations (e.g. World Bank), or in the financial statements of businesses and organizations. However, these databases are not included in this inventory since they are not databases specialized for TCA or LCA and are therefore beyond the scope of this project.

Methodology

The goal of the inventory of databases for TCA is to allow users to find relevant data in a fast and convenient way. The inventory is supposed to serve a wide range of users wanting to perform TCA assessments in the food and agriculture sector. These users can include researchers, civil society organizations, policymakers, farmers and companies. Consequently, the database needs to provide for different types of TCA assessments ranging from policy evaluation, over production system comparison to product assessment and other. This requires that the scope of data in the inventory stretches from product level to global averages. Furthermore, different data is needed for the different steps of TCA. This implies that the inventory needs to contain databases for all relevant steps including determination of impact and dependency pathways (e.g. pollution sources and contribution to bad health), measuring outcomes and impacts (e.g. pollution concentration in human habitats to determine contribution to bad health), and valuing impacts (e.g. data on healthcare costs of respiratory diseases and estimates of reduced productivity). Ideally, the inventory would also include data covering all four capitals – human, social, natural and produced – and several topics within each capital, such as health and safety, skills and knowledge as well as socio-economic information in the case of human capital.

Due to the vast array of requirements, a policy of including all relevant databases to the inventory was applied. Nevertheless, a database had to fulfill two selection criteria in order to enter the inventory:

- The database needed to refer to either life cycle assessment or valuation.
- The database needed to contain data relevant to the food and agriculture sector.

The search engines Google and Google-Scholar were used to find databases useful for TCA. Keywords were used to reduce the scope of the search, which included “true cost accounting”, “full cost accounting”, “natural capital accounting”, and “accounting social capital" among others. Our search strategy resulted in finding databases directly, but also indirectly through websites, studies, and reports, which contained references that led us to databases that were then included in the inventory. Online searching was supplemented by grey literature searching, reference list checking and citation searching. Additionally, the results of the online survey and expert interviews were consulted. Especially important for the inventory of databases were questions on databases participants use or know of. The interviewers did not name any new databases not already included in the inventory. However, their perspectives on what is needed for a broader applicability of TCA and the weakness of some of these databases was important for our analysis of the limitations of the status quo of data availability.

Categorization according to the subcategories was very time consuming; the inventory process followed the strategy of searching for at least three keywords per subcategory. For example, for the subcategory *employment and remuneration* under *human capital*, the following keywords were used to find available data: “wages”, “labour”, “labor”, “job”, “income”. In some instances, access to databases was restricted. This implied that we either had to rely on the reports and user manuals or revise a limited number of variables to identify data availability. In this case it was indicated by “NS” that it has not been specified. We were committed to achieving a high degree of certainty; however, a small uncertainty remains of falsely labeling a database of having a lack of data. These capital categories and their subcategories are described in the following section.

A categorization according to the type of natural resource was chosen to allow the user a refined search of relevant data. For example, data on water pollution through the application of pesticides can be found under the subcategory “water”. In some cases, we encountered overlapping data in terms of the relevant natural capital. For example, the net present value per hectare of revenue from timber plantation in Brazilian Amazonia contains values relevant to two sub-categories: *land* and *living resources*. In such cases, we indicated that the database includes data relevant for both categories. Additionally, the categorization according to ecosystems was chosen, because some databases only provide data for some ecosystem services of a natural resource rather than the value of all ecosystem services. For example, some databases may only provide a value for the impact of water pollution through pesticides on the cultural service of a river but do not consider the loss of the regulating service for the valuation.

Findings

The inventory comprises 64 databases useful for TCA in the field of food and agriculture. It includes 21 databases useful for the measurement of impacts and 23 databases helpful for the valuation step. Additionally, 20 databases were added to show exemplarily what other kinds of databases can be of use for TCA assessments.

Many of the databases inventoried under the measurement step of TCA were designed for the purpose of LCA. LCA was developed to measure changes in natural capital, which explains why natural capital has the most data coverage in the inventory. Some of these databases also cover to some extent impacts on human health, such as data on substances causing cancer. Besides environmental LCA databases, databases for social LCA – a method to assess social capital impacts – exist but to a lesser extent. Most of the databases we inventoried for social capital contain broad

metrics, such as respect for human rights. There is little evidence on issues more directly related to eco-agri-food systems, such as trust among members of a farming community or indigenous practices for ecosystem preservation. The most prominent database for social capital assessments in this inventory is the Social Hotspots Database.

Similar data challenges, although to a lesser extent, are evident concerning human capital for both the measurement as well as the valuation step. Data on general human capital issues such as educational attainment are much easier to identify than data specifically relevant for eco-agri-food systems. Out of the aspects comprising human capital, health is the most prominent one with various entries for example of the impact of pesticide use on human health. However, there is almost no secondary data for working conditions and skills and training in eco-agri-food systems. ILOSTAT is the most extensive source for human capital data in this inventory and is the world's largest repository of labor market statistics.

Data for produced capital is rarely covered in LCA and valuation databases. This is because LCA and environmental and social valuation mainly focus on invisible or intangible impacts and capitals.

The databases in the inventory have a wide geographical coverage, with data for national, regional, and global contexts. For example the National Environmental Accounting Database V2.0 provides data at national level for over 200 countries, while the Environmental Price Handbook EU28 Version which provides environmental prices for EU 28. In terms of timeframe, we identified data from 1945 and estimations until 2050.

Limitations

This inventory of databases useful for TCA assessments in the field of food and agriculture systems faces three main limitations. These are grounded on a lack of homogenous denotations and definitions as well as globally accepted frameworks, guidelines, methodologies, and metrics that standardize the generation and use of data in the context of TCA. This problem was explicitly discussed with experts from different disciplines.

One of the resulting barriers is the lack of a unified means of measuring eco-agri-food systems' sustainability. The interviews with the private sector – but also with other stakeholders such as from policy research – revealed that there is no commonly agreed set of indicators and metrics that guide stakeholders what data to generate or collect in order to perform a TCA assessment. The implications of a lack of agreement on TCA frameworks, indicators and metrics are that it restricts to give guidance and make recommendations regarding the use of data in this inventory. Therefore, the inventory includes data useful for a range of different frameworks, methodologies and metrics, but cannot give guidance regarding the quality and best fit of the databases for the different users and assessment types. At this stage, it is the user who needs to decide how to best make use of the resources here provided.

Secondly, the TCA community faces challenges because there is no globally and interdisciplinary agreed terminology for TCA data. Alone the abbreviation TCA is used to shorten three different names: true cost assessment, true cost accounting, and true cost analysis. This poses hindrances to finding data since it is not clear what denotation and keywords should be used when searching for TCA data. Lacking agreement on a terminology leads to data being fractured, making it more difficult to find existing data. This is reflected by the need to look for databases for a particular capital such as natural and human instead of comprehensive databases for all four capitals. As a result, the

databases identified in the inventory often fail to provide a comprehensive overview of the impacts from eco-agri-food systems. Instead, databases focus on very specific topics (e.g. carbon pricing) or at best concentrate on one capital, such as Envalue which focuses on environmental valuation data. In contrast, searching for LCA data is a lot easier, since LCA is a well-established term. The direct implication for this inventory is that users are likely not to find all currently existing databases containing data useful for TCA for the food and farming sector in this inventory.

Finally, existing TCA data is not easily accessible. In contrast to LCA, where extensive and well-accepted databases such as ecoinvent are available, TCA lacks databases specifically designed for TCA assessments. The TEEB Valuation Databases is a good start; however, it lacks information on human, social and produced capital and is not comparable with the huge data volume offered by LCA providers. Consequently, data is usually not well categorized for TCA assessments. Instead, information often needs to be extracted from case studies and non-TCA databases for benefit transfer, which requires comprehensive knowledge or detailed guidelines.

Less specific to TCA but still a relevant and common challenge of benefit transfer is that socio-economic and cultural contexts of data are often not fully described, leaving numbers and values to stand alone and hence risking having oversimplifications that lead to unrealistic valuations. In this regard, some of the interviews remarked that it is important to support economic values with additional information. While the economic valuation of cost and benefits is essential to conduct TCA, other information in qualitative terms are needed to better understand the context and the assumptions made. Especially socio-cultural issues are very difficult to monetize as they often satisfy non-material needs. Many TCA databases do not include such considerations and additional information, decreasing the usability of the estimations contained especially if benefit transfer is wanted.

6. Case Studies

Existing studies that can be considered as leading examples or current good practice in the field of TCA applications in the food and agriculture sector are presented in the TCA Inventory.

While going through these examples, it is important to emphasize that every study may not be good practice in all parts of the TCA process but may be a leading example in certain aspects. These examples may have been published under different frameworks (e.g. TEEB, NCP) and may include grey literature.

The studies were selected based on four criteria. The first two are concerned with providing a representative example of different studies, while the latter two ensure that the studies meet a certain quality.

1. Studies were selected so that a variety of impacts on produced, natural, social and human capital were showcased.
2. Studies were also selected to represent the various application families of TCA. This includes, in addition to the families mentioned in the TEEBAgriFood report (Agricultural management system, Agricultural products, Dietary comparisons, Policy evaluations and National accounting for the agriculture and food sector), company level and project level TCAs.
3. In order to be selected a study had to include documentation of the aim, scope, and methods of the study.
4. The last criterion was concerned with the rigor that was applied in using a specific framework. This includes also that this inventory of case studies prioritizes examples that include monetization to illustrate the entire process of TCA.

Therefore, this is not an exhaustive list and can be complemented by many others. For further case studies and reports, numerous websites exist with different focal points. A few examples are listed below:

Organization (incl. weblink)	Focus
TEEB	Very diverse range of studies often, but not exclusively linked to policy
TEEB	Country studies
Natural Capital Protocol	Companies and products focusing on natural capital
WBCSD	Companies covering natural, human and social capitals

In addition, TEEBAgriFood Framework (chapter 8) lists 10 case studies covering the 5 different application families.

Methodology

Case studies were directly derived from the engagement with the CoP throughout the preparation of this inventory. The studies listed in the inventory are an excerpt of studies suggested by the CoP directly or indirectly (e.g. part of a suggested summary of other good practice case studies) via the interviews and the submitted questionnaires. For this inventory, we looked at 40 different case

studies and screened different existing inventories of case studies, mentioned below. Out of this list, 10 case studies are included in the TCA Inventory.

Findings

Case studies included in the TCA inventory take various approaches to impact assessment and measurement, valuation and monetization, and communication and taking action. These are discussed below.

Impact Assessment and Measurement

Natural Capital

Studies analyzed reported best on natural capital dependencies and externalities. The main focus was the climate, water, soil and air. Some studies have also reported and partly monetized biodiversity-related issues such as implementing agroforestry or implementing flowering strips as beneficial externalities. It is important to emphasize that these domains have been quite different between the different studies. A few examples are listed below:

Air	air pollution mostly feeding into health, emissions from N application, emissions from the production of agricultural inputs, emissions from soil carbon loss, more comprehensive GHG assessment of inputs, GHG emissions via means of production
Water	water pollution, water use
Land	soil and land-use change
Soil	soil erosion, soil degradation via loss of soil organic carbon, soil pollution, soil and land-use change
Provisioning Services	soil loss, pollination
Regulating Services	soil loss, climate regulation
Habitat or Supporting Services	soil loss, biodiversity, training in conservation, support adaptation measures (shade trees)
Cultural Services	recreation

The methods applied to quantify the outcomes and impacts varied between the different studies. While many studies refer to peer-reviewed literature to quantify outcomes and impacts, others used models or direct measurements. For example, GHG emissions have been based on equations derived from the scientific literature and covered only isolated aspects of the GHG balance (White n.d., Sandhu et al. 2019, De Vivo n.d.), others used more comprehensive modeling approaches (Eosta et al. 2016).

Human Capital

Unlike natural capital, not all studies reported on human capital. The main concern of studies analyzing the human capital were health-related issues, either during the production of agricultural

commodities or consumption. The methods used varied from Disability-adjusted life years (DALY's)(Eosta et al. 2016, Bergman et al. 2016), well-being valuation method (Sandhu et al. 2019) to Lost time injury frequency rate (LTIFR) (Olam 2018). The Sustainable Food Trust is estimating total UK food costs based on reported federal values on food-related diseases and thus is able to include all costs currently covered by the National Health Service (NHS).

Few studies also reported on training and skills, however most often not under human capital, but under social capital revealing unclarity in the use of TCA terminology. The True Price study on palm oil production also investigated impacts on human capital linked to poor payment of farmworkers.

Again, the emphasis has been very different between different studies:

Health, Safety, Nutrition, and Working Conditions	health production (pesticide exposure, workers accidents/injuries), health consumption (obesity, heart diseases, pesticide exposure, air pollution), labor/working conditions, food prices, disposition
Labor, Skills, Training	money invested in training, number of people trained, number of children educated at school.
Employment and Remuneration	salary, occupation, the economic dependency of a region

Social Capital

While social capital was mentioned in most studies listed in this inventory it was investigated to a much smaller extent compared to the other capitals. The considered case studies also revealed that there is a lower clarity about what belongs to social capital. In this inventory, the definitions of the TEEBAgriFood framework were used and thus social capital consists of networks and shared values. However, studies also considered recreational space, improved air quality leading to better health, and training under social capital.

Social impacts described in different studies were:

Social Networks and Cooperation	the economic dependency of a region, networks
Laws and Regulations	land ownership, disposition, taxes paid
Collective Knowledge and Values	network and common knowledge of local food production, common heritage, cultural heritage

This inventory indicates that results for the social capital are largely descriptive, while for natural capital and partly also human capital models or tools have been used to assess the impact using quantitative and partly qualitative methods. However, the impacts and impact pathways are often thoroughly described.

Valuation and Monetization

Even though this inventory focused on selecting case studies that included valuation and monetization, many reports were not including this final step of the TCA or only for part of the considered impacts. Studies showed a great difference in how much information about the monetization method has been disclosed. Some case studies revealed the monetization approach

including the monetization factors, others just named the source or did not provide any information. The study on Palm Oil by Trucost provides the greatest detail on monetization factors (Raynaud et al. 2016). As the method significantly changes the value, a direct comparison of some of these case studies may be cumbersome. For example, for GHG emissions monetization factors of 20 (Ce Vivo n.d.), 42 (Sandhu et al. 2019), 114 (White n.d.), 123 (Raynaud et al. 2016) and 220 (Fitzpatrick et al. 2019) USD per ton CO_2e were applied. Given this great range, the importance of revealing the source and monetary evaluation method is greatly underestimated. Following the inconsistency in considered impacts, this may be the greatest obstacle in making TCA studies more comparable.

Communication and Taking Action

The great majority of the case studies analyzed for this inventory focused on communicating their findings to the general public, by addressing a wide group of audience and providing different levels of detail. This was, in particular, true for the business-related TCA studies (Eosta et al. 2016, Olam 2018, ABN AMRO 2018), but also the TCA assessment of the UK food system (Fitzpatrick et al. 2019). Communication-related to the TCA studies outside of the report, such as usage of social media and other media coverage was not analyzed for this inventory.

High-level recommendations that can trigger action have been provided by a few studies such as Raynaud et al. 2016, White n.d., Westerberg et al. 2019 and Bergman et al. 2016. Raynaud et al. 2016 distinguishes between recommendations at the business and policy level, while Westerberg et al. 2019 considered different stakeholder groups. As these studies often support decision making, but the authors or authoring institutions are not in the position to demand action, the outcome of these TCA assessments are often limited to recommendations.

Limitations and Summary

The case studies covered in this inventory showed a great variety of applications being mostly aligned with the TEEBAgriFood. These studies were identified as good examples of TCA assessments because they have covered a wide range of impacts within the natural, human and social capital. While not all capitals have been valued and monetized, these studies put a substantial effort into describing the cost and benefits of the system.

However, studies considered for this inventory did not investigate all material impacts of all capitals throughout the agricultural value chain. Therefore, no single blueprint for a TCA can be derived from this inventory and the case studies in their entirety should be considered. Especially because different TCA application families are covered. While the study of Sandhu et al. (2019) is a great example of covering all capitals in great length, it has a more limited scope when looking along the value chain and including processing, etc. This aspect is much better covered in the study on UK food, where farming, part of processing and human consumption has been covered (Fitzpatrick et al. 2019). However, given the complexity of the eco-agri-food system when considering all capitals along the value chain, it is apparent that selected studies had different focal points. A materiality analysis, which was done only by a few studies, can help to define the relevant focal points and related impacts (Bergman et al. 2016, Olam 2018, ABN AMRO 2018, Eosta et al. 2016, Raynaud et al. 2016).

The variety of application families considered in this inventory makes a direct comparison of used methods difficult, but it is important to highlight that considered impacts and impact pathways varied substantially and require further alignment in the future. In addition, addressing

environmental impacts at the product level (e.g. CO_2e/ton of product) or at the spatial level (e.g. CO_2e/ha used for production) in different studies may further hinder comparability and are scope specific. While there was often a high consistency within studies, a comparison across studies is often not possible. The main reasons are inconsistency in analyzed impacts, different methods to qualitatively or quantitatively assess impacts as well as different valuing and monetization approaches. This should not be seen as a call for full alignment across studies as main impacts, data and method availability and monetization approaches can differ substantially between different geographical regions and different parts of the eco-agri-food system. However, it should be seen as a call for harvesting from existing approaches that have been successfully applied and more clearly describe and disclose information on the applied TCA process to facilitate cross-learning.

Example 1: The Hidden Cost of UK Food Revised Edition 2019

This study is further described in this inventory, as it provides a good example on how to include health costs of production and consumption into a TCA. Even though this is a study at the national level and requires governmental statistics, it may inform other application families of TCA's as well (e.g. product level). Furthermore, it also provides a good example on how to include positive externalities into national level TCA.

Objective & Scope

The objective of this study was to investigate externalities of the entire UK food system looking at natural and human capital. The report considers degradation of the natural capital (GHG, air pollution, food waste, soil degradation, water used, biodiversity), health (malnutrition, obesity, hypertension, antibiotic resistance, food poisoning, colon cancer, organophosphate pesticides, cardiovascular disease, diabetes, cancer, dental caries), farm support payments as well as food imports to the UK.

Impact Pathways, Dependencies & Relationships

The authors describe the impact pathways for most considered externalities listed under *Objective & Scope* in the various Background and Cost sections of the report. Not all of these impact pathways clearly mention flows and outcome but focus on monetized impacts. The main reason lies in the nature of this report being based on a literature review. The study also investigates the positive externalities of the UK eco-agri-food system food system. UK agricultural landscapes show a broad range of habitat types and thus biodiversity, sequester carbon and fix nitrogen.

Materiality Analysis

The authors list impacts that were not considered for this report, mostly due to lack of data and academic research. The method of the materiality analysis was not described.

Impact Assessment & Measurement

The impacts described in this study are derived from an extensive literature study. For some impacts the authors directly named the monetized value without explicitly mentioning the impact, for others the impact is mentioned as well. Some impacts are valued by describing overall costs for the UK, before allocating a certain fraction to the eco-agri-food system food system.

Valuation & Monetization

As the study is largely based on a literature review the valuation and monetization methods vary greatly. The study does not list the approaches used for the different impacts in the referenced literature.

Example 2: The True Price of Tea from Kenya

This study was conducted by True Price and the sustainable trade initiative. It was selected as it puts a great emphasis on human and social externalities and belongs to a group of studies also covering cocoa, coffee and tea.

Objective & Scope

The study investigates the difference of external costs comparing conventional green leaf tea and tea grown by smallholder farmers participating in Farmer Field Schools. The focus of this TCA was agricultural production and to a smaller extent also manufacturing and transport. The tea considered in this report is secondary processed in Europe and consumed in the UK.

Impact Pathways, Dependencies & Relationships

Figure 3 of the report shows the list of externalities considered for this study and also partly mentions the impacts pathways. The impacts considered included the following areas: resources used (e.g. land, energy), pollution (e.g. water pollution, air pollution), workers (e.g. health & safety, income) and society. Only the 4 greatest externalities have been described more closely. Three of them belonged to the human capital (here named under social) namely income, child labor and social security and natural capital namely water pollution. The reason for listing this study here is the TCA on human capital.

Materiality Analysis

The authors have conducted a materiality analysis at the beginning of the study, but also mention that there is a lack of data describing the materiality of the different environmental and social externalities for tea in Kenya. The materiality analysis led to the exclusion of the retail phase and put a focus on the cultivation phase.

Impact Assessment & Measurement

While the study does only describe the impact assessment & measurement for the 4 biggest externalities, it refers to the Principles on Impact Measurement and Valuation published by True Price. The described impacts considered national statistics, publications and own estimates.

Valuation & Monetization

The True Price study provides a good description on how monetization can be done in the introductory section of the report. A comprehensive list for each impact or a description of the valuation method is missing. More detail is provided in the Principles on Impact Measurement and Valuation document published by True Price.

Table 2: Good practice or leading examples sorted by application families of True Cost Accounting.

The color-coding indicates whether impacts for social, human and natural capital have been evaluated and monetized or if they have just partly monetized or only discussed qualitatively or quantitatively and not monetized. The externalities and dependencies are named under the same capital as in the source file. This may differ from the definitions used in this report.

Family	Framework applied	Study	Authoring institution	Description	Natural capital	Human capital	Social capital
Policy evaluation	TEEB	The Malawi Maize Agrifood System (White n.d.)	Michigan State University	Study describing the history and importance of maize production and describing different natural and social impacts.	GHG, LUC, soil loss	Nutrition (health, productivity, education)	Cost of degrading local agricultural knowledge and seed exchange networks, Lock In Effect
Agricultural management system	TEEB	Application of TEEBAgriFood Evaluation Framework to corn systems in the US (Sandhu et al. 2019)	Global Alliance for the Future of Food	Study comparing organic and GM corn in Minnesota, where corn is one of the dominant field crops.	GHG, air quality, water quality, soil quality	Consumption related health cost	Social importance of production
Agricultural products	NA	True Cost Accounting for Food, Farming & Finance (TCA-FFF) (Eosta et al. 2016)	Eosta, Soil & More International, EY, Triodos Bank	Study analysing the true costs of different fruits traded by eosta comparing organic vs. conventional production.	GHG, water use, soil, biodiversity	Consumption related health cost, production related health cost	Employment & salaries, taxes
Agricultural products	TEEB	Improving business decision making: valuing the hidden costs of production in the palm oil sector – case study Indonesia (Raynaud et al. 2016)	Trucost & True Price, Julie Raynaud	Investigating external costs for palm oil production including a national case study for Indonesia	GHG, air quality, soil quality, water quality, water use	Underpayment, production related health cost	Loss of livelihoods, land dispossession
Agricultural products	NA	The True Price of Tea from Kenya	True Price & Sustainable Trade Initiative	Investigating externalities of Conventional and trained	Land use, water use, materials Consumed,	Health & safety, income, child Labor,	Freedom of an association

		(Bergman et al. 2016)		smallholder tea production	usage of non-renewable energy sources, pollution of water soil & air, waste	forced labor discrimination, harassment, social security, overtime	
National accounting for the agriculture and food sector	NA	The Hidden Cost of UK Food Revised Edition 2019 (Fitzpatrick et al. 2019)	Sustainable Food Trust	Investigating the costs associated with UK food system at the national level	GHG, air quality, water, soil, biodiversity	Consumption related health cost, production related health cost	
Company	NA	Re-imagining Olam - Offering tomorrow's products and services - Strategy Report (Olam 2019)	Olam	Annual report of Olam; closely linked to an integrated profit & loss statement	GHG, training in conservation, support adaptation measures (shade trees)	Training production related health cost (safety at the workspace)	Training, loans for development, Olam livelihood charter, supporting early child education
Company	NA	Impact Report 2018 - Including Integrated Profit & Loss and other impact statements (ABN AMRO 2019)	ABN AMRO		Use of scarce water, use of scarce materials, water pollution, contribution to climate change, land use and transformation, air pollution	Creation of human capital, well-being effects of employment, workplace health and safety incidents, value of time	Detected suspicious transactions and tax evasion, change in brand value and customer loyalty, decrease in cash-related crime, child labor in value chain, gender discrimination in access to higher skill jobs, financial distress due to repayment difficulties of loans, underpayment in value chain

Project	NA	The Case for Farmer Managed Natural Regeneration (FMNR) in the Upper West Region of Ghana (Westerberg et al. 2019)	The Economics of Land degradation	Analysis of costs and benefits of Farmer managed natural regeneration.	Soil carbon, above ground carbon Stocks, regulating services such as climate resilience, provisioning services as increased food security	Income, training	
Project		Multifunctional Field Margins. Assessing the benefits for nature, society and business (De Vivo n.d.)	Arcadis & Syngenta	Analysis of social and natural benefits of field margins.	Climate regulation, water quality & storage, soil erosion, pollination, GHG	Recreation	

	All covered externalities have been monetized
	Covered externalities have been mostly monetized
	Covered externalities have been partly or not monetized

7. Strategic Recommendations

The abundance of resources brought to light by the inventory shows, on the one hand, the great interest in TCA. On the other hand, it highlights the confusion of terminology and definitions within the TCA movement and calls for a harmonization of the approach. There is already a good degree of harmonization with regard to the general approach, but the inconsistent and disorderly use of terms such as "parameter", "indicator", ”outcome”, "impact category" undermines the fact that the different approaches have much more in common than it appears. This fragmentation does not only create difficulties in comparing studies, but it also poses a systematic problem for applying TCA. Today it is possible to use these different approaches as a “menu” to select a convenient approach and to influence the results. This entails a high risk of losing the transformative potential of TCA as the application could hide problems and TCA could become another instrument for greenwashing. The good news is a common approach presents a huge potential to really take TCA to scale. However, a consistent inventory and hierarchy of terms must first be established, also with regard to the question of which parts should be standardized and which parts can be approached context-specifically, e.g. on the basis of materiality. To avoid misleading results and communication, full transparency on scope, boundaries, approaches and assumptions should be ensured. With these aspects in mind, we recommend the following activities to advance and scale TCA:

Defining TCA

One important first step should be to develop a clear understanding and definition of TCA. So far, TCA has been used as the overarching concept, connecting frameworks like *TEEB*, guidelines like *Natural Capital Protocol* and tools developed by consultancies. However, neither of them define TCA, leaving it to the user to interpret it as a framework, approach, method, tool etc. Removing this uncertainty by providing a clear definition of TCA will help to better communicate TCA and its potentials.

Developing this definition of TCA needs to be done in a carefully designed process involving experts as well as all relevant stakeholders. It needs to be based on sound technical expertise but will also require to set up a platform where the different stakeholders can agree on the way forward. The following recommendations also need to be picked up during this process.

Developing a Common Language

In order for the CoP to keep having meaningful conversations and discussions, a common language is needed. The issue attempted to remedy here, is the tendency of each subject field to create its own sub-language of specific terms and their definitions. In the case of TCA, terms such as capitals, indicators, flows etc. are shared with other subject fields (e.g environmental impact assessment, LCA), but the definitions might be different. Furthermore, the same terms are used and defined differently by the various TCA initiatives. At the same time, new, distinct terms are developed in the field of TCA used to describe the same concept as other terms found in other subject fields. So, we end up with (a) same words but different definitions and (b) same definitions but different words.

A common language could derive from definitions of relevant terms and their semantic relationship. The aim would be to derive a reference document that defines the relevant terms related to TCA and

describes their relationship and hierarchical order. This should be closely developed together with the methodology mentioned below.

Harmonization of language must be seen as an integral part of the overall effort to develop a joint understanding and to define TCA in a comprehensive way.

Agreeing on TCA Must-Haves and Common Required Indicators

The here conducted analysis of frameworks and interviews with experts has brought to light a lack of commonly agreed sector-specific minimum requirements or mandatory material impacts that should be fulfilled by a TCA assessment. The concern was expressed, that the current flexibility in the materiality analysis allows for greenwashing and opacity on why impacts are being assets or not assets. Hence, we recommend developing a sector-specific, mandatory minimum-set of material impacts.

Additionally, we advise to go even further and to decide on sector-specific indicators for each type of capital, i.e. natural capital, human capital, social capital and at each level of the eco-agri-food system, i.e. farm, processing, distribution, consumption, recycling. The current lack of commonly agreed set of indicators and metrics poses especially challenges for the private sector, which is less interested in developing company individual TCA assessments but wishes for standardized ways of measuring and valuing impacts in order to be able to compare sustainability performance across companies. In other words, the private sector does not only want to know how to perform materiality analysis and the following steps of a TCA assessment – as it is for example described in the Natural Capital Protocol – but they also want to have sector-specific guidance on what to measure. This includes guidance for materiality, indicating what material impacts are part of a standard TCA assessment as well as standardized indicators and metrics for measuring these material impacts. The Sustainability Metrics project by the Sustainable Food Trust which strives towards convergence of existing schemes for measuring on-farm sustainability is an important step in the right direction. However, standardized indicators and metrics also need to be extended beyond the farm gate offering guidance along the entire value chain. New initiatives such as TRUE COST – From Cost to Benefits in Food and Farming by TMG – Think Tank for Sustainability and Soil & More Impacts are starting to address this problem.

Even if we do not agree on all metrics within the eco-agri-food system, having chosen common indicators (e.g. soil fertility, species richness, pesticide exposure) per category (e.g. soil, biodiversity, health)and capital and level of the eco-agri-food system would enhance the comparability of TCA analysis. First, it would help to provide consistent information that would facilitate decision-making. Second, it would reduce the scope for opportunistic behavior from, for example, not measuring certain aspects of the eco-agri-food systems for being “too complex” or “inconvenient truths”. Instead, a defined set of material impacts and indicators would reduce the effort of conducting TCA assessments while upholding the complexity of the system. Finally, developing a set of key metrics would reduce the methodological difficulties and provide enough incentives to make the whole system move in the desired direction – sustainable production and consumption patterns. We noted agreement among the experts we interviewed on the need to ensure consistency or at least jointly agreed equivalent methodologies and indicators for conducting TCA. While moving in this direction TCA has to remain inclusive and selected indicators and methods should not generate insurmountable barriers.

Harmonizing the Methodology

Once the key performance indicators stand, it will be important to harmonize the TCA methodology even further. This step could include deriving an agreement on scientifically proven impact pathways, which are transparent and can be adjusted to the context of the assessment. This would help reduce the individual research efforts as part of the materiality analysis, while allowing the complexity and would improve the comparability between TCA assessments.

When assessing the impacts, it should be clear for each impact what needs to be measured and what lies in the scope. For GHG emissions this is already far developed. In order to ensure the same quality of assessment for other impacts we could envision similar protocols for all key performance indicators.

Another helpful harmonization would be to agree on a functional unit for TCA assessment families, such as costs per hectare or costs per ton of product. However, this does not imply that we propose a simplification of systems thinking. A complete picture can only be given if the entire system is evaluated. Taking the example of potato production, the TCA assessment should not be an isolated assessment of a potato but should consider the whole crop rotation the potato cultivation is part of. These impacts would then be taken into account by e.g. taking the weighted average of all crops. Only then one can see the true impact of growing potatoes. Agreement on a functional unit for each TCA assessment family would strengthen the possibility to compare and benchmark e.g. products, systems or policies.

Furthermore, it would be helpful to develop standardized benefit transfer functions that allow deriving monetary values for the different mandatory impact assessments. This would ensure that values taken from other studies are properly transferred to different contexts. Even though it might be difficult to provide functions that cover all contextual aspects, we would estimate an improvement since often no proper benefit transfer is performed. Additionally, providing standardized benefit transfer functions could enable more TCA assessments to be performed by e.g. facilitating the use of national case studies for other countries.

Unifying TCA Data into a Reference TCA Database

The inventory shows that vast amounts of data on natural capital, and to a wide extent on human health and to a lesser extent on other forms of human and social capital exist. However, most data have not been directly generated for the purpose of TCA. Hence, data often needs to be processed before it can be applied for TCA assessments. Challenges of finding the right data are related to a lack of homogenous denotations and definitions as well as a lack of globally accepted frameworks, guidelines, methodologies, and metrics that standardize the generation and use of data in the context of TCA.

In the short and medium-term, we therefore recommend developing a set of guidelines for the generation of data for TCA as well as guidelines on how to use data for TCA analysis that have not been specifically collected for TCA. Additionally, a search engine for databases useful for TCA of eco-agri-food systems could be developed. This would help to navigate the landscape of databases and to identify relevant databases for each step of the TCA assessment.

In the long term, we advise developing and establishing a reference TCA database. This database should comprise of data useful for all steps of TCA and for all capitals. It should be governed by high-quality assurance and transparency and should provide a toolkit to data providers in order to continuously expand and update the high-quality database. The database can then feed into the below mentioned TCA tools.

Leading by Example

To bring TCA to scale, best practice studies would be helpful. On the one hand, they would showcase the usefulness of TCA and provide inspiration. On the other hand, they would give guidance regarding the methodological procedure based on examples. We recommend to commission and conduct best practice TCA assessments for each application family, i.e. agricultural product, agricultural management system, policy evaluation focusing on all capital. As mentioned before currently only a few studies fully describe their procedure for the materiality analysis, impact measurement and valuation. It would be essential that the best practice case studies are detailed regarding their procedure and methodology making transparent all methodological considerations, i.e. assumptions, calculations, reference data. Leading examples with disclosed approaches may encourage others to disclose their methodology and trigger transparency, discussion and collaboration.

Developing a TCA Tool (Software)

If a harmonized methodology was developed and key performance indicators agreed on, the next step to operationalize TCA could be the development of a practical application tool to carry out a TCA assessment for different application families e.g. TCA Business Tool and TCA Policy Tool. Many impact assessment methods require expert knowledge and are therefore not inclusive to all applicants. Similar to LCA software, a TCA software could perform complex assessments and include predefined impact pathways. However, when designing such a tool it should be taken special care that TCA will not become an inseparable addition to LCA where creators and experts also heavily influence the results and possible applications.

The Role of the TCA Accelerator

In order to advance the application of TCA the TCA Accelerator should serve as a *TCA Knowledge Hub for Food and Farming*. It should try to establish itself as a reference institution for TCA and become the first source of information when it comes to TCA for eco-agri-food systems. Through a website, the TCA accelerator could provide harmonized reference documents – such as the TEEBAgriFood guidance document for application currently underway – guiding the implementation of TCA for business and policy alike. Through the website the TCA Accelerator could provide links to existing initiatives in the field guiding interested parties to the relevant documents, activities and initiatives. In other words, the TCA Accelerator as a *TCA Knowledge Hub for Food and Farming* would be a living global TCA inventory.

The TCA Accelerator could serve as the joint mouthpiece of the CoP. In other words, it could become the communication department for TCA for eco-agri-food systems, convey stakeholder appropriate narratives (e.g. TCA as a policy tool, investment tool, risk management tool) and providing TCA related information for international policy processes (e.g. World Food Systems Summit 2021,

European Green Deal). This would help to raise more attention for TCA and increase funding for further development in the field of TCA. Consideration should also be given to the idea of an ambassador that gives TCA a face. Together with success stories and best practice examples, it might help to gain more media attention.

Harmonization: the Need for a Well-Designed Process

There is little experience in the implementation of the various TCA approaches. Currently, the CoP is gaining experience in applying the various forms of TCA. And it is impressive to see more and more concrete applications demonstrating the potential of TCA. With these publications, the concept receives more support. However, there is a clear consequence: As long as all these valuable applications and the insightful articles presenting results are not embedded in a systematic learning process – but rather as a successful attempt to increase diversity – the risk increases that TCA application will not be able to establish itself as a powerful comprehensive methodology supporting the implementation of the SDGs.

Based on the findings of this inventory and taking into account the relevant activities of the TCA Accelerator a process needs to be initiated to explore with relevant partners, scientists, private sector, policymakers if and how next steps for coordination and harmonization can be started. The process for harmonization should be led by an independent institution that does not have strong own interests and is independent of the various TCA initiatives. Its task would be to design and guide the process of harmonizing TCA with the involvement of all stakeholders. The success of TCA has initiated a lively diversity of approaches and applications, it has generated political and economic interest and – based on experiences with attempts trying to harmonize other methodologies – it is proposed to explore options for harmonization and to start working on a process to develop this joint understanding.

Example of harmonized hierarchy and terms

Capital	Category	Indicator	Metric	Unit	Value
Natural Capital	Soil	Soil Fertility	Soil Organic Matter	mg/m^3	€/kg

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