CHAPTER 6

THE TEEBAGRIFOOD FRAMEWORK: TOWARDS COMPREHENSIVE EVALUATION OF ECO-AGRI-FOOD SYSTEMS

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SUMMARY

Chapter 6 presents the TEEBAgriFood Evaluation Framework. The Framework establishes "what should be evaluated" and represents the next generation in assessment tools for eco-agri-food systems. It supports the assessment of different eco-agri-food systems, covering their human, social, economic, and environmental dimensions, from production through to consumption. The common, production-only, focus of assessment, using for example metrics of yield per hectare, ignores the significant range of social and environmental impacts that must be included for a complete evaluation. The Framework applies a multiple-capitals based approach, and supports the use of monetary and non-monetary approaches to impact assessment, including value-addition. As a comprehensive and universal framework, it highlights all relevant dimensions, and drives policymakers, researchers, and businesses to broaden their information set for decision-making.

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6.0 KEY MESSAGES

- This chapter presents a framework that supports the evaluation of different eco-agri-food systems, covering their human, social, economic, and environmental dimensions, from production through to consumption.
- Common assessment metrics, such as yield per hectare, ignore a wide and significant range of social, human, and environmental costs and benefits of eco-agri-food systems.
- The primary goal of the TEEB-Agri-Food Evaluation Framework is to support decision-makers in establishing "what should be evaluated" in a given assessment, and consequently, to bring transparency and context to all assessments, by highlighting elements which may have been overlooked.
- The Framework systematically categorizes all elements – including human, social, economic, and environmental stocks, flows, outcomes and impacts - which could potentially be described and analyzed in an assessment of eco-agri-food systems.
- The Framework has been developed with three guiding principles:
    i) universality: providing a common language in all decision-making contexts;
    ii) comprehensiveness: including all relevant social, environmental, human, and economic elements along the entire value chain;
    iii) inclusiveness: supporting multiple approaches to evaluation and assessment including in both qualitative and quantitative terms.
- The Framework is designed to support: i) the description of the structure and trends in eco-agri-food systems and hence underpin the derivation of indicators and metrics to better understand issues such as capacity, sustainability, productivity and efficiency, and ii) the analysis of eco-agri-food systems using various tools such as cost-benefit analyses, integrated profit and loss statements, ecosystem services valuation, and measures of inclusive wealth.
- The Framework adopts a multiple capitals approach recognizing that eco-agri-food systems, from the production to the consumption stages, are sustained by – and impact upon – all four types of capital: human, produced, social, and natural. A holistic assessment should include all pathways by which eco-agri-food systems interact with these capital bases.
- Eco-agri-food systems are dynamic, with their elements changing and influencing each other over varying spatial and temporal scales; any assessment needs to account for these dynamics.
- The extent of exposure to risk and the degree of resilience of an eco-agri-food system are important considerations for any assessment.
- The range of qualitative and quantitative information needed in order to provide a complete description of an eco-agri-food system cannot be simply aggregated; and, in analysis, care must be taken in selecting relevant variables for each decision-making context.
- The Framework is intended for use in an interdisciplinary manner, where the questions to be analysed, the options to be compared, and the scale, scope, and relevant variables included are determined in an open and participatory way, before the appropriate assessment and valuation methods are implemented.

CHAPTER 6

THE TEEBAGRIFOOD FRAMEWORK: TOWARDS COMPREHENSIVE EVALUATION OF ECO-AGRI-FOOD SYSTEMS

6.1 INTRODUCTION

TEEBAgriFood seeks to evaluate all significant externalities related to eco-agri-food systems. As explored in Chapter 1 and Chapter 2, the term externalities refer to the impacts of business on the natural environment – the effects of which tend not to be reflected in the market prices of associated financial transactions, and hence may be "invisible" to decision makers. An 'eco-agri-food' system rests at the nexus of the three systems (economic, ecological and climatic, and social) that are variously involved in growing, processing, distributing and consuming food. Chapter 2 demonstrates that eco-agri-food systems are dynamic and complex with many parts interacting at varying spatial and temporal scales, across economic, environmental and social dimensions. Moreover, crops, production systems and supply chains each have their own set of inputs, environmental and social contexts, policy drivers, and create a wide range of visible and invisible, positive and negative impacts.

Given the heterogeneity and complexity of eco-agri-food systems, simple economic performance measures such as yields per hectare, value-added or profit offer a convenient but incomplete means to compare and rank production systems. Such measures do not take account of complex value chains or environmental and social relationships, even though these relationships are often significant and consequential to human well-being. Excluding them from the information base used to support decision-making can lead to disastrous effects on ecosystems, human health and well-being, as described in previous chapters; and overlooking such factors can also ultimately undermine the sustainability of agricultural incomes and productivity.

This chapter presents a novel Framework to support comprehensive evaluations of eco-agri-food systems, covering environmental, economic and social dimensions, and both positive and negative impacts. We begin by defining the stocks, flows, outcomes and impacts of eco-agri-food systems. The stocks of eco-agri-food systems comprise four different "capitals" – produced capital, natural capital, human capital and social capital. These stocks underpin a variety of flows encompassing production and consumption activity, ecosystem services, purchased inputs and residual flows. The dynamics of an eco-agri-food system lead to outcomes that are reflected in the Framework as changes in the quantity and quality of the stocks. In turn, these outcomes will have impacts on human well-being.

We outline the connections between these elements, as reflected in accounting-based measurement Frameworks, and consistent with the systems theory described in Chapter 2. Collectively, these four elements can be used to describe eco-agri-food systems and to analyse associated impacts on the environment and human well-being.

By providing key definitions and associated measurement concepts and boundaries, the TEEBAgriFood Evaluation Framework establishes what aspects of eco-agri-food systems may be included within a holistic evaluation. This chapter does not focus on how assessments should be undertaken, nor does it prescribe methods for assessments. The choice of methods will depend on the focus and purpose of any given assessment, availability of data, and scope of analysis. Practical guidance and examples of how these and other factors affect the selection of methods are provided in Chapter 7 and Chapter 8, respectively.

We hope the Framework presented in this chapter will also orient future interdisciplinary research, providing a starting point for testing and conceptual development. Indeed, given the very broad coverage of the Framework, this chapter cannot describe all aspects of measurement that may be required in every situation. At the same time, this chapter demonstrates the potential to integrate and build on existing Frameworks to provide a basis for the next generation of measurement and analysis. Thus, the chapter provides a step towards the presentation of a holistic picture of eco-agri-food systems, so that future assessments can better inform and improve decision-making.

The chapter is organized as follows: Section 6.2 highlights the role of a common evaluation framework, presents the key principles and broad structure of the TEEBAgriFood Evaluation Framework, and summarizes previous related initiatives. Section 6.3 describes the elements of the Framework and discusses measurement boundaries and linkages. Section 6.4 discusses how the Framework may be applied, including possible entry points for evaluations, how temporal and spatial aspects can be taken into account, and links to assessing the risk and resilience of eco-agri-food systems. Section 6.5 concludes the chapter and sets the scene for a discussion of methods and applications in the following chapters.

6.2 RATIONALE AND GUIDING PRINCIPLES OF THE TEEBAGRIFOOD EVALUATION FRAMEWORK

6.2.1 Rationale for the Evaluation Framework

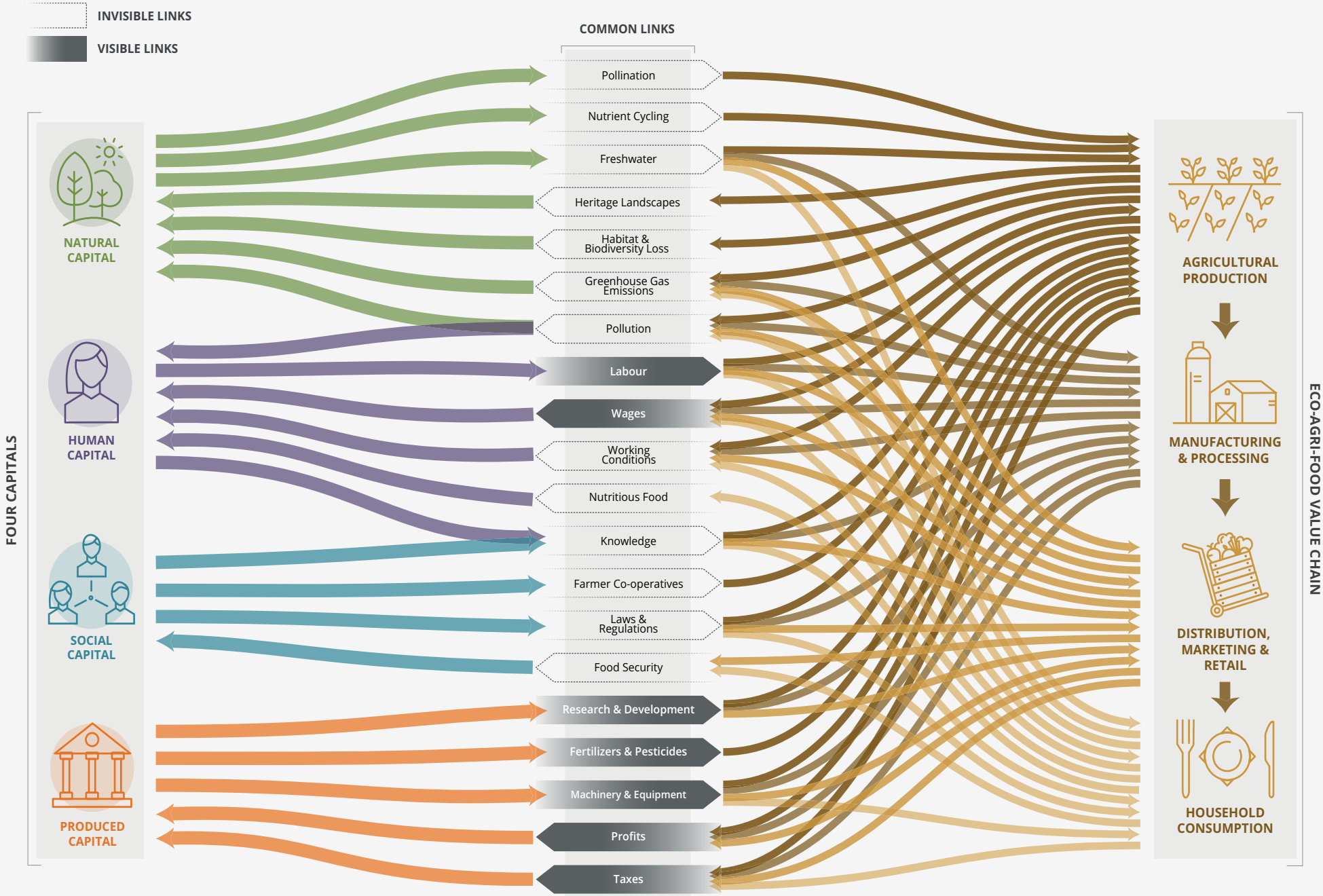
The earlier chapters have amply illustrated the "hidden" or "invisible" costs and benefits in the way we produce, process, distribute, and consume food. These invisible costs and benefits are rarely captured in conventional economic analyses, which usually focus on the production and consumption of goods and services that are traded in markets. For eco-agri-food systems, this approach does not account for a wide array of vital inputs and outputs (see **Figure 6.1** below). From an environmental perspective, recognition of ecological inputs to agriculture (i.e. dependencies), such as freshwater provisioning, nutrient cycling, climate regulation, and pollination (MA 2005) are often lacking. Similarly, key outputs of eco-agri-food systems central to human health and well-being, such as impacts on food security, water quality, food safety and local communities, are often unaccounted for (TEEB 2015b). Perhaps most significantly, conventional assessment systems do not effectively capture the changing capacity of ecosystems and supporting social systems to continue to deliver these critical goods and services over the long run.

Figure 6.1 presents the four capitals on the left hand side as the building blocks of the eco-agri-food value chain from production to consumption on the right hand side. The capitals and the value chain are connected through a wide variety of flows to and from both sides. Those flows that are most commonly included in assessments – the visible flows – are shown distinctly from those that are most commonly excluded – the invisible flows – as just described. There is no doubt that the figure, particularly at first glance, is complex, but this is the reality of eco-agri-food systems. A key motivation for the Framework is to provide a means to recognise and engage with this complexity and hence support assessments that are more context specific and meaningful.

TEEB, in its early work, highlighted the implications of the economic invisibility of nature in decision-making, and shed light on the sizeable contributions of biodiversity and ecosystem services to social and economic well-being (TEEB 2010a; 2010b). Extending this environmental-economic perspective, the TEEBAgriFood Evaluation Framework seeks to consider other hidden stocks and flows, including impacts on human health and social equity.

In order to improve and secure our eco-agri-food systems and, in particular, to mitigate their negative impacts, all stakeholders including governments, businesses, farmers and citizens, need to be made more aware of the wider benefits and costs associated with different eco-agri-food systems. Providing analysis and raising awareness are of course only part of the process of improving production and consumptions patterns, which also requires technical innovation, policy reform and behaviour change in order to overcome political and other barriers to change, as discussed in Chapter 9 and Chapter 10.

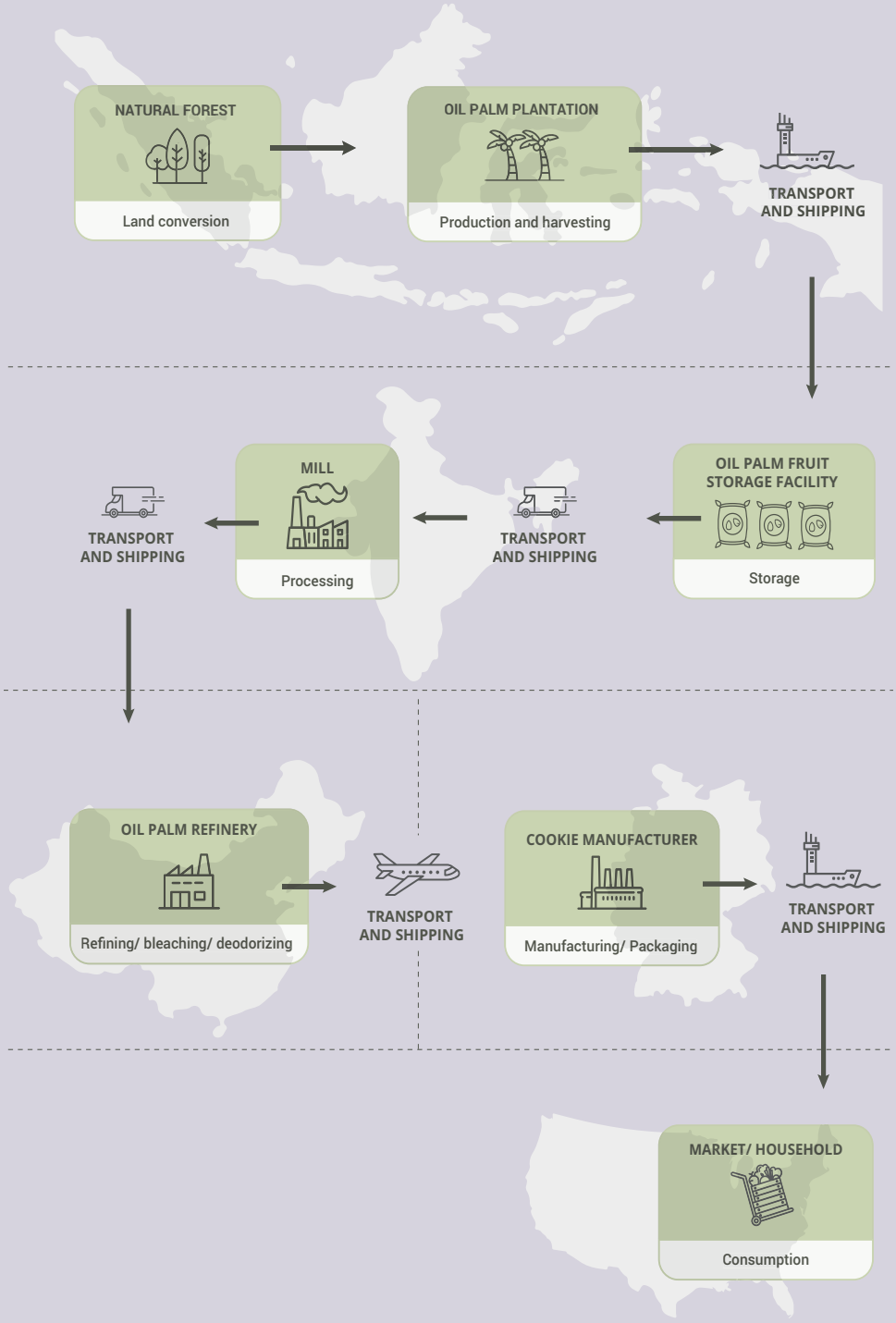
Figure 6.1 Links between four capitals and the eco-agri-food value chain (Source: authors)



Box 6.1 Demonstrating the scope of a comprehensive assessment

To demonstrate some of the considerations that may be included in a comprehensive assessment of eco-agri-food systems, consider a simple palm oil value chain as an example. The following diagram shows the planting and production of palm oil in Indonesia, export and processing of crude palm oil to India[1], subsequent refining, bleaching and deodorizing in China, manufacturing and packaging in Germany, and final consumption in the US, not to mention transport and shipping along the entire way.

Figure 6.2 Palm oil value chain (source: authors)



1 Note that this diagram illustrates just one hypothetical value chain involving Indonesia and India. For instance, there is also considerable processing and export of RDB palm oil (from CPO) in Indonesia; such production choices are strongly influenced by differential tariff rates between Indonesia and India for these varieties of processed palm oil (see GIST Advisory and Global Canopy Program (2014).

Several points are worthy of note:

i) The system has many parts – a value chain, which includes, for the sake of simplicity, land preparation for growing the fruit, planting, growth, harvest, transport, processing, distribution, and consumption. Other upstream activities, which are also part of the value chain, such as manufacturing of fertilizers, research and development for palm oil, marketing and branding, etc., are excluded here.

ii) There are several flows that act as inputs to the value chain – labour, fertilizers, knowledge, and ecosystem services such as freshwater and pollination. There are also several outflows along the value chain – for instance, food and agricultural products and associated incomes, atmospheric emissions, and excess fertilizer in runoff.

iii) These flows can lead to several outcomes – for example, farming incomes support rural households financially, emissions such as suspended particulates in smoke from land clearing can lead to negative health outcomes, while fertilizer in runoff can lead to adverse environmental outcomes such as eutrophication.

iv) These outcomes also have associated negative or positive impacts, defined as changes in human well-being. For example, eutrophication can negatively impact fish stocks and hence the livelihoods of artisanal fisherfolk; farm incomes can positively impact human well-being for farmers and farm labourers; and health outcomes of emissions can negatively impact labour productivity and quality of life for people both near and far.

v) These outcomes vary in nature. For example, they can be economic (income for labourers; profits for farmers), social (working conditions (ILO 2013), access of women to land and other resources), health related (respiratory diseases from emissions), or environmental (deforestation, eutrophication, etc.).

vi) The diagram incorporates elements that are categorically different – i.e. stocks and flows. For example, while on-farm employees are considered a stock of human capital, the ongoing inputs into the production processes (i.e. labour services) are flows.

vii) There is a relationship between the quality and quantity stocks and their respective flows – ecosystem services such as freshwater depend on the quantity and quality of upstream forests ("natural capital"), the labour and knowledge that go into the production process depend on the skills and health ("human capital") of people who work on the plantation, and the condition of processing plants and machinery ("produced capital") is vital to processing the fruit. Understanding the changing composition and condition of these various stocks and the implications for future flows is a key aspect of the Framework.

viii) There is both a spatial and temporal dimension to these flows – for example, flows of ecosystem services such as water and pollination are generated beyond the farm, at a watershed level, over different seasonal or multi-year cycles. Similarly, palm oil produced in Indonesia travels a significant distance before it reaches the final consumers in the US.

ix) Lastly, while several of these considerations are made visible in market transactions, many are invisible and are not incorporated in observed prices and values. For example, while incomes and consumption outcomes of a particular production system are made visible by being captured by GDP, the spread of these outcomes across gender and social classes are not. Similarly, while inputs of ecosystem services can be indirectly captured by yields and reflected as income, current yield measures do not reflect the capacity of ecosystems to deliver these services into the future, which is arguably an important measure of sustainability.

To undertake a comprehensive assessment of a palm oil system, all of the factors mentioned above should be considered.

We identify three fundamental requirements of a TEEBAgriFood Evaluation Framework. First, the Framework must identify and characterize all relevant elements of a system. Second, the Framework should provide a common language relevant to all stakeholders. Lastly, the Framework should enable stakeholders to bring together these disparate elements in an integrated analysis for informed decision-making.

With these requirements in mind, the design of the Framework is aspirational, and its operationalization will require testing and ongoing development. The aspirational intent is nonetheless grounded in the application and integration of existing theory and concepts, many of which have been put into practice. In this context, the Framework should be considered as the "next generation" of framework for the evaluation of eco-agri-food systems.

6.2.2 Guiding principles

The three requirements for the design of the Framework underpin the guiding principles of the TEEBAgriFood Evaluation Framework, namely universality, comprehensiveness and inclusivity. These principles are summarized here building on the descriptions in TEEB (2015a).

The first guiding principle is **universality**: no matter the entry point or application, the same Framework can be used for assessing any eco-agri-food system, and can be used equally by policymakers, businesses, producers and citizens. While each assessment may be different in scope and methods, to assure completeness within - and comparability across - assessments, it is important that the *elements* considered and evaluated in each assessment are defined and described in a consistent manner. Failing that, it will not be possible to draw conclusions from comparisons across different scenarios or strategies, since each assessment would be using its own lexicon and definitions. This is precisely why we need a *universal* framework, which consistently and clearly answers the question: *"What should be evaluated?"*

The principle of universality stands in contrast to the current model of siloed assessments, wherein each assessment of a particular eco-agri-food system includes an independently determined set of economic, environmental and social variables, evaluated using different methods which then provide, unsurprisingly, non-comparable results. For example, silo assessments may include assessing agricultural systems solely on the basis of yield per hectare, or efficiency in the use of water or energy, leaving out broader issues of sustainability or equity, which are related to yield and efficiency concerns, but encompass other considerations.

These silo effects become even more distinct across different eco-agri-food systems, for example, when comparing the production and consumption of substitutable outputs, such as types of edible oils. In this example, the Framework should allow for comparison between a small-scale peanut oil production system with a broad-scale palm oil production system. To ensure universality, our Framework is designed to be adaptable to various applications, entry points and pathways of analyses; and the principle of universality requires that different systems can be compared using a single frame of analysis. These elements are further discussed in Section 6.4.

The second guiding principle of our Framework is **comprehensiveness**: both in terms of encompassing the entire value chain, and in terms of including all stocks, flows, outcomes and impacts within an eco-agri-food system. A comprehensive framework ensures that all hidden costs and benefits, including dependencies and impacts upstream and downstream, are part of each assessment over the entire eco-agri-food value chain, covering all aspects of production and consumption.

By way of example, various natural capital inputs to farming such as freshwater, climate regulation and pollination come from beyond the "farm gate", likely at the watershed or landscape scale. Similarly, some hidden costs of farming may occur downstream of the farm gate, for instance, the effects of runoff from excess use of fertilizers. Analyses limited to the agricultural area of a farm may be appealingly simple, but they are also partial and potentially misleading.

Furthermore, value chains for agricultural commodities can differ substantially for the same commodity and such differences will imply different economic, environmental, health and social outcomes and impacts for different types of eco-agri-food systems. For example, corn produced for human consumption has different outcomes for human health compared to corn produced for ethanol or animal feed.

A comprehensive assessment also implies that systems are assessed in terms of observed economic, environmental and social flows, such as production, consumption, ecosystem services, pollution and social benefits, and in terms of the underlying capital base that both sustains the system and can be impacted by the activities within the system. The capital base considered in the TEEB Evaluation Framework is comprehensive, covering produced capital, natural capital, human capital and social capital.

The third guiding principle that flows from universality and comprehensiveness, particularly with respect to the inclusion of social capital, is that the Framework must be **inclusive** in supporting multiple approaches to assessment, including in quantitative and qualitative terms. The evaluation of impacts in the TEEB Evaluation Framework stems primarily from an economic perspective and the accounting-based nature of the Framework directly supports analysis in line with economic theory and the valuation of impacts on human well-being in monetary terms. However, while many flows and stocks can be measured in monetary terms, this is not possible for all aspects of human well-being. Indeed, in different contexts, monetary valuation may not be possible or ethically appropriate, and measurement in qualitative, physical, or non-monetary terms may provide important insights (Pascual *et al.* 2017). Thus, the Framework should allow for a plurality of value perspectives and assessment techniques, such as multi-criteria analysis (See Chapter 7).

Furthermore, while the Framework is designed to support economic analysis, it can also provide relevant data and indicators to support more informed decision making. For example, the Framework design supports the estimation of carbon and water footprints, life cycle analysis, measurement of social equity, and the development of sustainability metrics and indicator sets. The principle of inclusiveness thus extends to developing a common information base that underpins not only economic analysis but also other associated lines of measurement and inquiry.

6.2.3 Relationship to other frameworks

The TEEBAgriFood Evaluation Framework presented in this chapter flows from these guiding principles. Viewed from the perspective of human wellbeing, the Evaluation Framework encompasses a broad range of economic, environmental, health and social outcomes and impacts. Securing these outcomes is related directly to the stock of all forms of capital – produced, natural, human and social. The Evaluation Framework thus posits that the delivery of current human well-being and the capacity to sustain and improve well-being for future generations is predicated on our ability to maintain and enhance the stock of all capitals.

The inclusion of all types of capital and the use of a standard analytical approach in the Framework builds directly on the ongoing work to measure the overall wealth of countries and their genuine savings when it comes to produced, natural, human and social capital (see, for example, Arrow *et al.* 2013; UNU-IHDP and UNEP 2014; IISD 2016; Lange *et al.* 2018). These wealth accounting-based approaches provide a clear economic rationale for the consideration of all types of capital in providing a holistic assessment.

At the same time, the Framework goes further in encouraging the application of wealth accounting at different spatial scales and for specific and potentially globally connected eco-agri-food systems, distinct from the common focus of wealth accounting on national wealth. The Framework also more explicitly recognizes the differences between stocks, and the associated flows and outcomes since, in practice, these are often measured in separate ways rather than in the fully integrated manner envisaged in wealth accounting theory. Finally, the Framework aims to go beyond the productive, economic focus of wealth accounting to encompass other considerations, such as equity.

Within this broad capital accounting framing, the Framework utilizes the rich body of work on measurement reflected in established international statistical standards. In relation to produced and natural capital and associated flows these standards include[2]:

- The System of National Accounts (SNA) and the Balance of Payments (BoP) (EC *et al.* 2009) for the measurement of produced assets (including financial assets and liabilities) and associated flows of production, income and consumption.
- The System of Environmental-Economic Accounting (SEEA) Central Framework (UN *et al.* 2014a) for the measurement of environmental flows (e.g. water, energy, emissions, etc.) and environmental assets (e.g. land, soil, timber, fish)
- The SEEA Experimental Ecosystem Accounting (UN *et al.* 2014b) for the measurement of ecosystem assets, ecosystem services and biodiversity.
- The SEEA Agriculture, Forestry and Fisheries (FAO and UN 2018) for the measurement of environmental assets and flows in the context of agricultural activity (e.g. energy, water, nutrients, emissions, land and soil).

Incorporating a comprehensive natural capital base that includes biodiversity and ecosystem services puts the TEEBAgriFood Evaluation Framework in line with other initiatives such as the Millennium Ecosystem Assessment (MA 2005) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES 2018). Consistent with these initiatives, the Framework recognises the importance of the spatial dimension so that the Framework has relevance from the farm level to the global level and, at the same time, reflects the reality that system-elements will vary from location to location and from system to system.

2 Note that in these statistical standards the term "asset" is applied in relation to the measurement of produced and natural capital. In a national accounting context, the term "asset" embodies the concepts of both "stock" and "capital" that are commonly distinguished in the wealth accounting literature.

Other factors such as human capital, social capital and wellbeing are also being better assessed by a number of initiatives, most notably by the OECD (Healy and Côté 2001; Keeley 2007). As for wealth accounting, the focus of work in this area is commonly on national level assessment or for particular population groups. The consideration of finer spatial dimensions or for specific activities and sectors is not apparent at this stage.

In the very broad area of sustainability measurement, both at national and local scales, and for the agricultural sector specifically, there is a broad array of tools, composite indicators and sets of indicators (Reytar *et al.* 2014; FAO 2014; The Keystone Policy Center 2018; People 4 Earth 2018). Although they are commonly motivated to provide a richer picture of progress and sustainability, and in many cases, there is considerable overlap in the themes that are included in any assessment, there is no agreed, underlying framework for integration and there is no standardisation that supports comparison. At a sector level, such as agriculture, sustainability metrics (while usually covering the three primary dimensions of economy, environment and society) are selected from a production perspective and do not encompass the corresponding sustainability of food consumption. This extension is perhaps the most fundamental difference between the TEEBAgriFood approach and other related approaches.

The UN Sustainable Development Goals (SDGs) (UN 2015), which provide an overarching, internationally agreed and universal set of themes and alignment of indicators within this framing, represent a potential step forward. However, there is no underlying conceptual framework that links the 17 goals and 169 targets together. While food production (SDG 2) and health outcomes (SDG 3) are front and centre in the SDGs, the linkages between them have not been broadly articulated, in concept or in practice.

In economic analysis, the application of the general principles of measuring social costs and benefits in relation to agricultural activity are well established. Indeed, Chapter 7 demonstrates that the methods to apply the TEEBAgriFood Framework can in large part be drawn from the literature and experience of valuing externalities. There is a limitation in valuation of some social aspects, including social equity, but the general point holds.

What makes the Framework distinct is its ambition to incorporate all externalities. As demonstrated in Chapter 8, there are no instances of studies that capture all of the elements of the TEEBAgriFood Framework. In part, this may reflect data limitations but in larger part it reflects the lack of application of a sufficiently broad and systemic perspective on eco-agri-food systems. The TEEBAgriFood Framework thus seeks to encourage more ambitious assessments using the full gamut of economic analysis tools.

The TEEBAgriFood Framework also builds upon the recent momentum in the private sector concerning the disclosure of externalities. As more companies and corporations capture and make such information available, this can support development of, for example integrated profit and loss (IP&L) statements (GIST Advisory 2018) that describe the net economic, environmental and social impact of a business. The original TEEB for Business report (TEEB 2012) highlighted the various environmental risks and opportunities that businesses should address in a resource constrained future, and how businesses can measure, value and report their impacts and dependencies on biodiversity and ecosystem services. Several other works and initiatives such as the WBCSD (2011) Guide to Corporate Ecosystem Valuation, 4-D reporting (GIST Advisory 2018), the NCC (2016a) Natural Capital Protocol (NCP), the Integrated Reporting (IR) framework of IIRC (2013) and the Global Reporting Initiative (GRI 2018) have highlighted the need for better measurement and disclosure of the environmental and social impacts of companies.

The NCP in particular includes a sector guide for food and beverage businesses (NCC 2016b) that provides a more specific guidance in understanding the links of this sector to natural capital. The TEEBAgriFood Evaluation Framework goes a step further by spelling out in more detail the elements that require assessment with respect to natural capital, and the analytical approach to be used in an assessment. In this sense, the TEEBAgriFood Framework can be a complementary tool for companies applying the NCP in the food and beverage sector.

Indeed, the TEEBAgriFood Framework should be seen as complementary to the wide variety of related frameworks and tools. The TEEBAgriFood Framework builds upon existing knowledge and it can provide an evidence base that supports a more comprehensive, systemic and standardised analysis of eco-agri-food systems. It thus represents the next generation of evaluation frameworks. Clearly these goals are ambitious, and data to populate all elements of the TEEBAgriFood Framework for all eco-agri-food systems is not yet available. However, what the Framework does demonstrate is that the wide range of information that is available on the majority of the elements of the eco-agri-food system can be placed in context to support a comprehensive and meaningful assessment of the impacts of the system on sustainability and human well-being.

Notwithstanding the inclusive scope of the TEEBAgriFood Framework, the focus of analysis is on human well-being and hence the Framework reflects an inherent anthropocentric perspective. Thus, the impacts of production and consumption on the 'intrinsic' value of the natural environment, i.e., its value purely as the environment without regard to human connection and use, are not the focus of analysis. For example, the

analysis of biodiversity within the Framework focuses on the ways in which biodiversity supports economic activity and contributes to individual and social wellbeing but does not consider the maintenance and enhancement of biodiversity as a benefit for the environment itself. At the same time, as presented in the following section, the Evaluation Framework has a descriptive component and thus there is the potential to record non-monetary information on changes in natural capital. Such information may help to underpin discussion of the intrinsic values of nature.

6.3 TEEBAGRIFOOD EVALUATION FRAMEWORK

6.3.1 Conceptual basis for the Framework

The TEEBAgriFood Evaluation Framework defines the four elements - **stocks, flows, outcomes** and **impacts -** that support a standardised evaluation of eco-agri-food systems. In providing these definitions and associated measurement concepts and boundaries, the Framework establishes *what* aspects of eco-agri-food systems should be included within a comprehensive evaluation or assessment.

The Framework is designed for use in two complementary but different ways. First, it can be used to describe eco-agri-food systems to ensure that different stakeholders involved – from farmers and manufacturers, to consumers and local communities – have a common understanding of where they are within the system and how that system is functioning. Without a common language to describe eco-agri-food systems, there is limited potential to achieve the integrated, cross-sectoral decision-making that is required. The descriptive use of the Evaluation Framework incorporates the selection and derivation of relevant indicators and metrics to monitor progress with regard to sustainability. For example, metrics might include the composition of production and consumption of an eco-agri-food system, its geographical scope, the components of the value chain and changes in these elements over time. In this respect, the Framework is intended to bring transparency and context to all assessments of agriculture and food systems, and can be used to highlight elements that may have been omitted from an assessment.

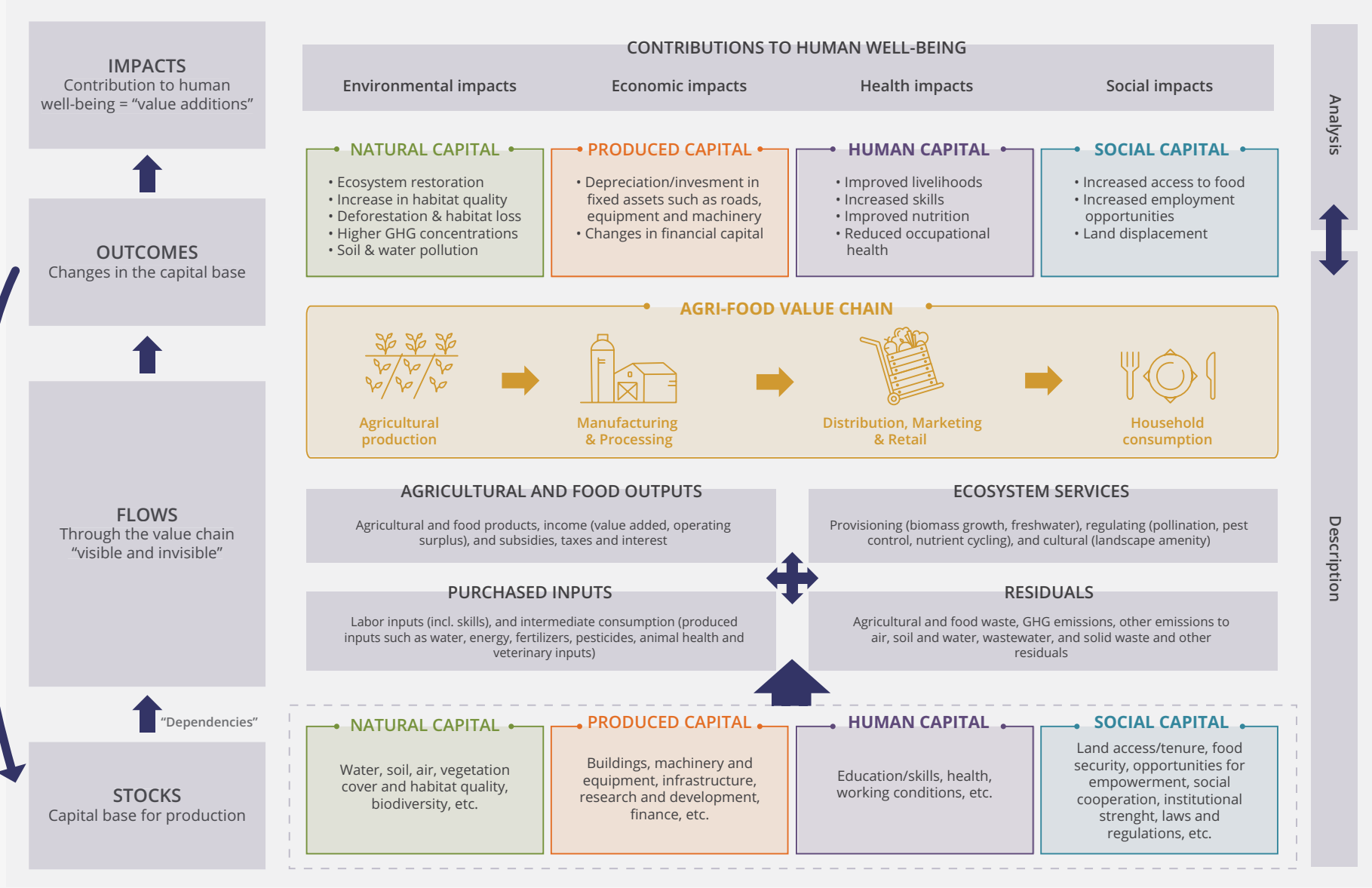
Second, the Framework can be used to support various forms of analysis. For example, the Framework supports the assessment and comparison of trade-offs from agricultural and food policies, analysis of land use and consumption choices, and consideration of decisions concerning public and private investments. The ultimate focus of analysis in the Framework is on impacts to human well-being. Impacts are also referred to as "value-additions" as per the TEEBAgriFood interim report. Methods for estimating the relative value of these impacts are discussed in Chapter 7, including techniques for the assessment of social impacts.

Figure 6.3 shows the core structure of the Framework and its elements. The descriptive use of the Framework will tend to focus on stocks, flows and outcomes. The analytical use of the Framework will tend to focus on outcomes and the impacts of eco-agri-food systems on human well-being. In both uses there is intended to be coverage across all stages of the eco-agri-food value chain, from production through to final consumption and human health. Additionally, the Framework supports assessment across multiple spatial scales, from the local farm level to global supply chains. Section 6.4 describes steps towards implementation of the Framework.

As presented, the Framework may appear to be relatively linear. In fact, there are many and varied connections between the elements of the Framework that cannot be fully described here. The logic for considering these connections is described in Chapter 2, which discusses a systems approach to analysis of the eco-agri-food system. In effect, **Figure 6.3** provides an abstraction of the complexity of any given eco-agri-food system to provide a common starting point for the understanding of each system. While all of the potential connections are not illustrated, special note is made of the link between outcomes and stocks. Outcomes are defined to reflect changes in the extent or condition of stocks (in quantitative and qualitative terms) that arise due to value chain activities. This connection is a key dynamic within the Framework. These changes in stock, recorded as outcomes, reflect changes the capacity of the stock to generate flows of services and hence underpin the ongoing generation of well-being.[3]

[3] In the discussion of the linkages between stocks, flows, outcomes and impacts a range of terms are applied in different ways by the different subject matter experts who have considered these issues. In particular, differences can emerge in the use of the words "stock", "asset" and "capital". In this study, the word "stock" is used in relation to the physical or observable quantities and qualities that underpin various flows within the system. Stocks are classified as being produced, natural, human or social. The word "capital" is used to reflect the economic perspective of the various stocks in which each type of capital embodies future streams of benefits that contribute to human well-being. The word "asset" is not used. While it is clear that there are differences in the use of terms among experts, the authors are satisfied that the conceptual intentions are well aligned.

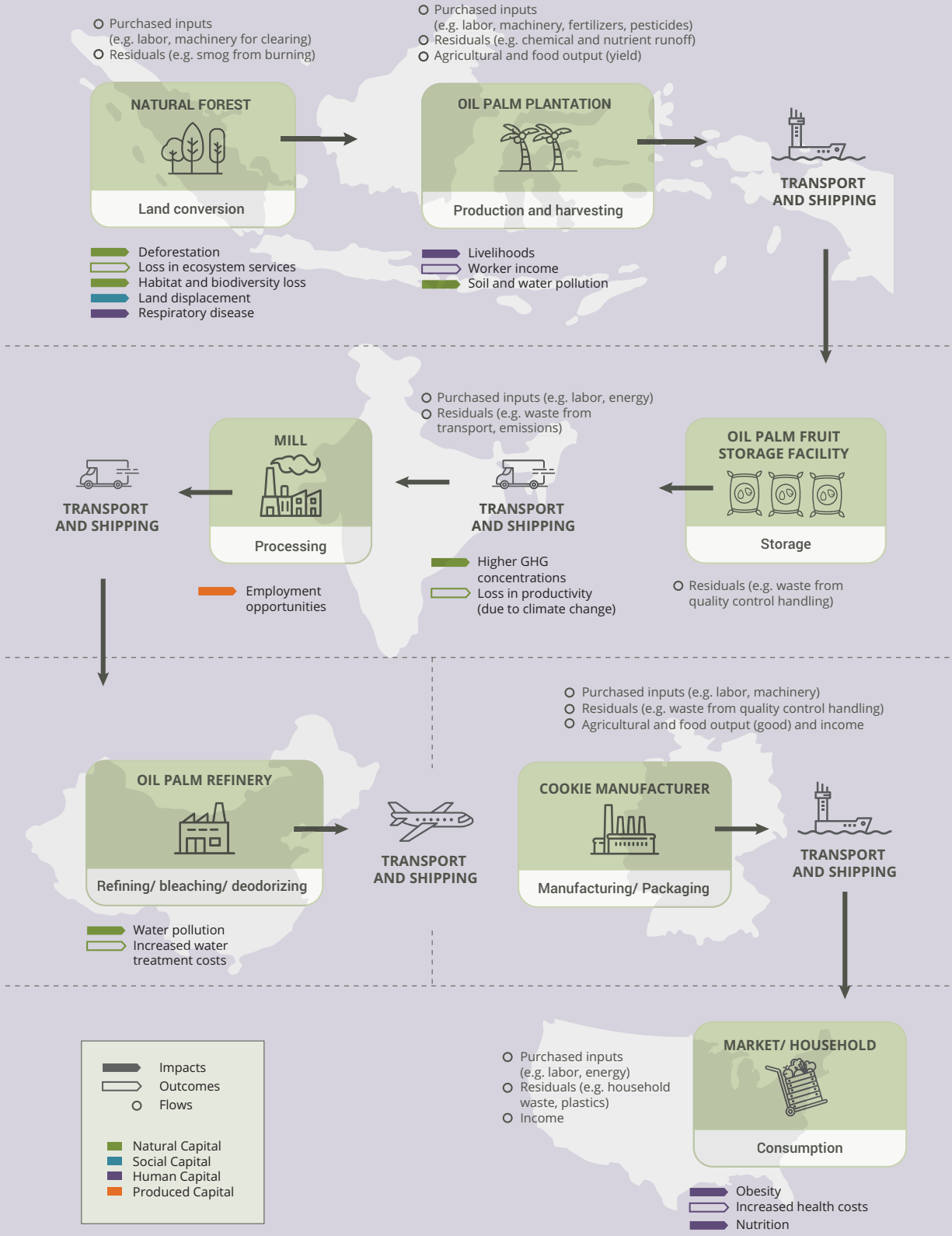
Figure 6.3 Elements of the TEEBAgriFood Evaluation Framework (source: authors)



Box 6.2 Applying the Framework to assess the palm oil value chain

To illustrate the key elements of the Framework, we revisit the stylised palm oil value chain presented earlier in **Box 6.1**

Figure 6.4 Palm oil value chain revisited (Source: authors)



A number of possible impacts, outcomes and flows are described above and below the value chain, and are generally linked to different types of capital, by way of example.

Yields contribute to income, which in turn has positive implications for investments in both produced capital such as machinery (a produced capital outcome), but also human capital, in the form of education (a human capital outcome). Some of the negative flows impacting stocks are also demonstrated – e.g. residual flows of emissions and pollutants from land clearing, which can degrade natural capital through biodiversity loss (a natural capital outcome), and reduce human capital through increasing the incidence of respiratory disease (a human capital outcome). An impact of these various outcomes would be the loss in labour productivity; another would be the loss of life quality for farm workers' families due to respiratory diseases.

Produced capital inputs such as oil mills, ports, and ships, allow for exporting palm oil for further processing and final distribution (B. processing and consumption). While consumption of palm oil can support nutrition and general food security, excess consumption can lead to obesity as a health outcome, which in turn can lead to loss in human well-being. This negatively affects human capital and can have secondary impacts on labour inputs for other sectors.

The systematic framing of the various elements as shown in the palm oil example (**Box 6.2**) allows for comparison between, for instance, traditional palm oil systems and certified sustainable palm oil systems. The Framework supports comparable assessments of the relative impacts on human well-being, extending the focus beyond economic indicators, such as yields per hectare, or environmental impacts, such as measures of biodiversity loss. The Framework can also allow for comparisons between substitutes – for example, between palm oil and other edible oils – to see how they compare not only in terms of economic outcomes, but also environmental, social and health outcomes. Section 6.4 describes the application of the Framework in more detail.

One way of characterizing the difference between a traditional, production-only approach and the systems approach of the Framework is to consider that the production-only approach is generally limited to those stocks, flows and outcomes that are observable or visible in markets and hence are reflected in standard economic statistics. While this is sufficient to support detailed economy-wide and sector level economic modelling, a systems approach more fully captures a significant range of invisible or non-market stocks and flows that must also be considered. These flows may be unpriced and not incorporated into standard macro and sector level economic modelling, but they are undoubtedly real stocks and flows that can be observed and described. The TEEBAgriFood Evaluation Framework is the articulation of a response to this integration challenge.

The underlying conceptual approach used in the Framework is a multiple capitals or accounting approach, commonly described as a wealth accounting approach (see, for example, Arrow *et al.* 2013; Lange *et al.*2018; UNU-IHDP and UNEP 2014; IISD 2016). Inherent in accounting-based approaches is a requirement to articulate the differences and connections between stocks and flows. This is a fundamental requirement in understanding the dependencies inherent within systems in terms of the current condition and composition of stocks and the associated capacity of the four capitals (produced, natural, human and social) to provide flows of benefits into the future.

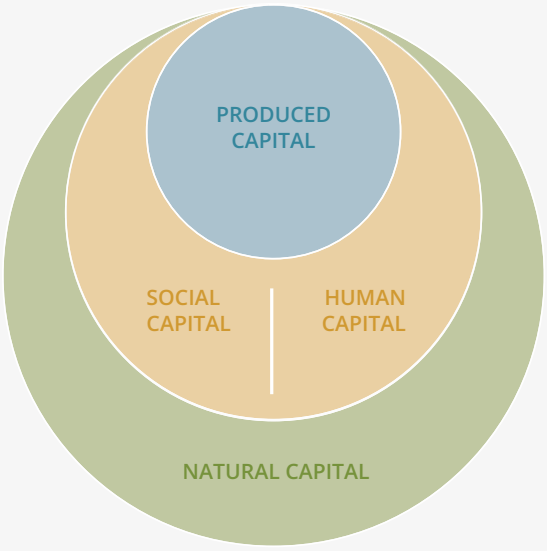
6.3.2 Key elements of the Framework

Stocks

Understanding the quantity and quality of the stocks that underpin eco-agri-food systems is essential in understanding the full range of impacts and dependencies these systems create. Fundamental to the Framework, and consistent with the discussion on systems in Chapter 2, is the notion that there are real connections among: i) the stocks that provide the base for assessment of capital ii) the production and consumption of goods and services, iii) the consequential outcomes and iv) the associated impacts on human well-being from eco-agri-food systems. Historically, the focus has been on the production of agricultural goods with limited connection to understanding the changes in the full range of stocks or the broader outcomes and impacts of productive activity. The development and design of this Framework aims to provide a platform for recognizing the breadth of dependencies and impacts within eco-agri-food systems. To this end, the various stocks are clearly distinguished from the flows of inputs and associated outcomes that they generate. Analysing these distinct elements supports a better understanding of issues such as capacity, sustainability, productivity and efficiency.

In the TEEBAgriFood Framework, the stocks are classified to align with four types of capital following the Inclusive Wealth Report (UNU-IHDP and UNEP 2014) and Forum for the Future (2015). The types of capital are produced, natural, human and social capital, recognizing there is an ongoing discussion on the choice of terms and measurement boundaries. The key point is that *all* capitals are in scope of the Framework. **Figure 6.5** shows the links between these four types of capital, and the following section provides definitions of each of these capitals.

Figure 6.5 Four types of capital (Source: adapted from Forum for the Future 2015)



Definitions of capital

The following definitions of capital provide a basis for discussion of appropriate measurement boundaries in the context of this Framework.

Produced capital[4] incorporates all manufactured capital such as buildings, machines and equipment, physical infrastructure (roads, water systems), the knowledge and intellectual capital embedded in, for example, software, patents, brands, etc., and financial capital.

Since produced capital such as machinery, storage facilities and transport equipment is often under the ownership of individual economic units, it should be recorded for all businesses within the agri-food value chain, including small scale and subsistence producers. In addition, at least conceptually, an allocation should be made concerning capital inputs from built infrastructure essential to the function of the agri-food value chain, for example, from road and rail networks, ports and airports, and dams and irrigation systems, even if such infrastructure was not constructed exclusively for use by agri-food production systems. In many cases this infrastructure will be under public sector ownership and management. Knowledge capital arising from agricultural research and development should be considered a part of produced capital, as it either determines or adds value to the underlying stock in which it is embedded – drought resilient seeds or smarter irrigation infrastructure, for example. Where knowledge capital is embedded in people or communities it should be included as part of human or social capital, for example indigenous ecological knowledge.

The measurement of the stocks and flows associated with produced capital should be aligned with the concepts and definitions of accounting standards (at either corporate or national level, e.g. using definitions from the System of National Accounts).

Natural capital refers to "the limited stocks of physical and biological resources found on earth, and of the limited capacity of ecosystems to provide ecosystem services" (TEEB 2010b) For measurement purposes, following the SEEA, it incorporates the "naturally occurring living and non-living components of the Earth, that in combination constitute the biophysical environment" (UN 2012). It thus includes all mineral and energy resources, timber, fish and other biological resources, land and soil resources and all ecosystem types (forests, wetlands, agricultural areas, coastal and marine, etc.).

Biodiversity at all levels (ecosystem, species, genetic), and in terms of both quantity and variability, is considered a key characteristic of natural capital. Biodiversity underpins ecosystem functioning. Ecosystem services are considered flows generated by natural capital that contribute to production and consumption and, more broadly to human well-being (Díaz *et al.* 2015).

4 The term "produced capital" is used for consistency with the concept measured in the UNU-IHDP Inclusive Wealth Report (UNU-IHDP and UNEP 2014). Other terms such as physical capital, manufactured capital and reproducible capital are also used, sometimes with a different scope from the definition used here. Note that the concept of "produced capital" used here is broader than the concept of "produced assets" as applied in the System of National Accounts.

The connection between natural capital and eco-agri-food systems can be seen from two perspectives: the role that natural capital plays in supporting agricultural production, and the effects that agricultural production has on the condition of natural capital. In terms of supporting agricultural production, the initial focus should be on measuring the natural capital associated with agricultural production namely land, soil and water resources and the associated ecosystems and biodiversity that provide the required ecosystem services. These elements of natural capital may be located on-farm and hence under the management of agricultural units, or they may be off-farm and hence influenced by the management decisions of other units. (Consider, for example, dependence on upland forests for flood control and aquifer replenishment, or on areas of native vegetation providing habitat for pollinators).

For other activities across the value chain, such as food processing and distribution, assessment may be made of the land used by or owned by the companies involved in these activities. Generally, the area of land used by these activities is likely to be small relative to the area of agricultural land, therefore requiring a much lower dependence on ecosystem services as direct inputs.
In terms of recording the effects of eco-agri-food systems on natural capital, a wide range of types of natural capital may be involved depending on the types and locations of production systems. Common areas of focus will be assessing the effect of eco-agri-food systems on water resources, in terms of both quantity and quality, measuring emissions to the atmosphere, and accounting of loss of native vegetation and associated biodiversity.

Human capital refers to "the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being" (Healy and Côté 2001)[5]. It is most commonly considered in the context of inputs to the production of goods and services and hence limited to the skills and experience of the labour force. However, conceptually it can be extended to incorporate, for example, the production of household services such as raising children and managing a household. Human capital will increase through growth in the number of people, improvements in their health, and improvements in skills, experience and education of a population. This includes traditional and indigenous knowledge, which may be of particular importance in agricultural production systems. Human capital depreciates as skills and experience are lost and will be affected by changes in human health conditions.

With respect to eco-agri-food systems, the initial focus in the measurement of human capital should be on the labour force, including the self-employed. It is useful to understand measures of human capital in terms of its composition (e.g. age, gender, migrant status) and in terms of the quality or condition of the capital base including levels of educational attainment, measures of traditional and indigenous knowledge and health status.

A range of other labour related indicators also need to be captured in a complete evaluation, such as information on employment, 'decent' working conditions[6], and occupational health and safety (ILO 2013). In the Framework, employment aspects are captured as direct inputs to eco-agri-food production (see below) while those aspects that relate primarily to the conditions of employment are considered in the context of social outcomes, where they can be directly connected to individual parts of the eco-agri-food value chain.

Social capital encompasses "networks together with shared norms, values and understandings that facilitate cooperation within or among groups" (Healy and Côté 2001). Social capital may be reflected in both formal and informal arrangements and can be considered the "glue" that binds individuals in communities. More broadly, it can be seen as the form of capital that "enables" the production and allocation of other forms of capital (UNU-IHDP and UNEP 2014).

5 Note that knowledge embedded in produced capital (e.g. software, patents) is included under produced capital.

6 In 2008, the ILO adopted a framework of Decent Work Indicators that was presented to the 18th International Conference of Labour Statisticians in December 2008. The Framework on the Measurement of Decent Work covers ten substantive elements which are closely linked to the four strategic pillars of the Decent Work Agenda, that is: i) international labour standards and fundamental principles and rights at work ii) employment creation iii) social protection and iv) social dialogue and tripartism (ILO 2013).

While social capital has proved difficult to measure (Giordano *et al.* 2011) and aggregate indicators are not widely agreed upon, various proxies (e.g. indicators of the strength of social networks, measures of trust (Hamilton *et al.* 2017) may give insights into the extent and condition of social capital. Some of these indicators include collective action and cooperation, adherence to norms and regulations, participation in local organizations and groups, and social cohesion and inclusion (Grootaert *et al.* 2002). For example, capturing information on the number of farmer's cooperatives and their functioning across agricultural production systems may provide valuable insights for decision-making. Similarly, understanding the participation and inclusion of women and other marginalized sections across agricultural systems is vital to informed policy-making.

Given the breadth and fluid nature of social capital, determining an appropriate boundary for its measurement in the context of this Framework is difficult. Nonetheless, in line with the other capitals, the initial focus is on the role that social capital plays in production through the eco-agri-food chain, i.e. measures that indicate the extent and condition of social networks, inclusion of marginalised sections of society, and relationships and institutional arrangements that support production. One important perspective on social capital is social equity, which is discussed in greater detail in Chapter 5.

In the context of the Evaluation Framework, the range of issues covered with respect to social capital is focussed on the issues that can be linked directly with specific agricultural production systems and processes along the eco-agri-food value chain. This focus is narrower than would be included in a complete assessment of social capital for a community or country which will also incorporate non eco-agri-food system perspectives, but the themes that emerge in considering this narrower focus are nonetheless very relevant and cover a broad spectrum of concerns.

Recording information on the stocks of capital

In assessing an eco-agri-food system, initial focus should be on recording the stocks of capital, i.e. the available quantity (*extent*) and quality (*condition*) at a point in time, and changes in the stock over time. Changes may result from investment, use or extraction, catastrophic loss or ongoing depreciation and degradation. In order to understand the prospects for sustainable generation of services and benefits from the stocks, it is important to capture information on the physical characteristics of the stocks.

Recording information on physical characteristics may appear most appropriate in the context of natural capital but similar indicators can also be developed for produced and human capital. For example, taking note of the number and average age of farm machinery and the size and education level of the farming workforce will provide valuable information on the produced and human capital base of eco-agri-food systems. For all capitals, information on the distribution of ownership and use, for example, by industry or population sub-group, can also help in understanding the stock of capital.

Knowing the monetary value of different stocks is also important in understanding economic behaviour associated with the use of stocks. For example, monetary values may help explain the extent of return on investment and inform on the level of financial resources required to maintain ownership and management of stocks.

A common concern in the use of monetary values of capitals in decision making is the implication that all capitals are substitutable in the broader ambition to maintain and increase total wealth. That is, in purely monetary terms, substituting between natural and produced capital may appear to be an appropriate strategy. In reality, stocks of natural capital in particular are subject to important non-linearities and threshold effects such that while some degree of substitution may have little effect on the condition of natural capital, ongoing substitution will likely have significant negative consequences. Further, recent research highlights that standard cost-benefit analyses and economic methodologies assume that natural capital can be easily substituted, when in fact it cannot and economic models are ill-equipped to illuminate dependencies between capitals (Cohen *et al.* 2017). Important concerns in the use of these models include:

i) the absence of markets for natural capital thus limiting the potential for appropriate integration with produced capital;

ii) the focus on substitution at the margin which will tend to ignore thresholds in the use of natural capital (i.e. ignoring critical natural capital) and the effects of scale (i.e. that substitutability at large scales need not imply substitutability at local scales) and

iii) the extent to which the potential for substitution changes over time.

The appropriate response to these concerns from an evaluation perspective is to ensure a comprehensive assessment of all information (biophysical, qualitative and monetary) on all capitals. Such an assessment will make clear the extent of substitutability between capitals in any given eco-agri-food system and the associated issues of thresholds in the use of capital.

The measurement boundaries for different capitals may be difficult to apply in practice. For example, depending on the context, knowledge capital may be measured under produced, human or social capital. Therefore, it is sufficient to ensure that all stocks are incorporated under some type

of capital; their omission is of far greater concern than their classification.

At national level, it is recommended that measures of produced capital be compiled in line with the definitions and concepts of the System of National Accounts and that measures of natural capital be compiled in line with the definitions and concepts of the System of Environmental-Economic Accounting. Together, these two UN statistical standards provide a comprehensive and integrated measurement of produced and natural capital. Guidelines for the measurement of human capital have also been developed (see, for example, UNECE 2016), and can be applied for eco-agri-food systems. As noted above, the measurement of social capital is the least developed but progress is being made towards improved guidance for measurement in this area (see for example, OECD 2018 and Siegler 2014). Chapter 5 describes a model for characterizing the relevant elements of social capital in the context of eco-agri-food systems.

In addition to information on the physical characteristics and monetary value of different types of capital, it is increasingly common for the stocks of capital to be considered in relation to concepts such as resilience, diversity, capacity and sustainability. For the TEEBAgriFood Evaluation Framework, these concepts are seen as characteristics of the underlying stocks. That is, there must always be an underlying stock that is resilient, diverse, has capacity or is sustainable.

In measurement terms, some of these concepts are not directly observable but must be assessed by integrating measures of multiple elements. For example, species level biodiversity can be assessed through surveying numbers of different species; but the associated levels of ecosystem sustainability and capacity must be assessed by considering the condition of the associated ecosystem (in providing suitable habitat) and the expected patterns of use of the ecosystem. Since the Framework incorporates measures of these various elements, indicators of resilience, diversity, capacity and sustainability will be able to be derived from the Framework.

Flows through the value chain

The theory of wealth accounting that underpins the description of capitals within the TEEBAgriFood Evaluation Framework also contains a conception of flows that reflects the benefits derived from the use of the various stocks. This embedded discussion of stocks and flows, present in all accounting-based frameworks, underpins a range of analytical choices including the assessment of contributions to well-being.

While the theoretical basis for linking stocks and flows within accounting systems is well established, in practice, the variety of types of flows can make articulation and measurement a challenging exercise. Flows include capital inputs (including inputs from produced capital, labour from human capital, ecosystem services from natural capital and inputs from social capital); flows of goods and services through the agri-food system (including agricultural and food products and manufactured input such as fertilizers, pesticides, fuel and electricity); and residual flows arising from production and consumption activity such as GHG emissions, excess nitrogen, harvest losses and food waste. Mapping these various flows into, within and from the agri-food system allows a full articulation of the pathways by which an eco-agri-food system impacts human well-being.

However, information on each of these types of flows is not equally available. Some flows are visible or final, in the sense of being observed in markets and standard reporting arrangements, while others are intermediate, and often invisible, in the sense of usually being ignored in decision-making. For example, while pollination services are intermediate flows that contribute to yields, since it is yields that are captured in the market, the role of pollination services is often ignored. Therefore, while several of these intermediate flows will be implicitly embedded within final flows, it is important to recognize and record the intermediate flows separately. A primary aim of the Framework is to ensure all flows, and associated stocks, are made visible in decision-making.

With that in mind, and keeping in line with the general structure of statistical and reporting standards, the four key types of flows reflected along the value chain are:

- **agricultural and food outputs**
- **purchased inputs**
- **ecosystem services**
- **residuals**, including food loss and waste along the value chain

It should be clear from **Figure 6.3** that the coverage of the Framework is not limited to recording flows in relation to agricultural production systems. Instead the Framework extends to the full eco-agri-food value chain, encompassing activities of manufacturing and processing, distribution, marketing and retail, and household consumption. The TEEBAgriFood value chain is described later **Table 6.2**; it is sufficient to recognize at this point that the four key types of flows should be recorded in relation to all stages of the value chain. The relative importance of different flows will vary at different stages of the value chain and will depend on the type of eco-agri-food system under consideration. The Framework also supports a focus on particular flows across the value chain. For example, the Framework supports description and analysis of harvest losses and food waste from production through to consumption.

Purchases and sales of investment goods such as machinery, equipment and buildings (i.e. types of

produced capital) may be considered another type of flow. These are not treated as flows in the TEEBAgriFood Evaluation Framework but are instead included as changes in the stock of produced capital and hence recorded as produced capital outcomes.

Agriculture and food outputs

Understanding the flows of agricultural and food outputs along the value chain is fundamental to setting the scope of analysis and to making clear material dependencies and impacts. Understanding these flows also clarifies the relevant spatial scales for analysis since some eco-agri-food systems may be contained at the farm and community scale while others will involve connections around the globe.

Given the length and breadth of multiple branches of the value chain in this Framework, an initial focus on products reflects their primacy of importance. In effect, the logic of the Framework involves tracking the supply and use of 'agricultural and food products' through the value chain. At a macro level, the recording here relates directly to the concept of food balance sheets[7] as developed by FAO (2001). At a micro level, it relates to concepts of traceability.

Since it is not usually meaningful to aggregate quantities across all agricultural commodities, this information should be recorded by type of commodity (e.g. wheat, rice, beef) and classified by type of farm, type of production practice, or other aggregation. Generally, this information would be recorded in tonnes or similar production equivalent. From this base however, conversion using appropriate factors is possible; for example, products might be assessed in terms of the quantity of protein produced, or in terms of micro-nutrients. This nutritional information can help link the value chain to outcomes for human health.

Complementing these flows of output recorded in physical terms are measures of income. Income measures include economic value added in monetary terms, and the return to businesses as operating surplus (profit), as measured at national level in a countries' national accounts and input-output tables (IMF 2007). A complete set of accounts provides a comprehensive set of information as well as visibility for these flows, and will also cover flows of 'subsidies, taxes and interest'. It is not necessary for the Evaluation Framework to list all of these flows in a strict accounting format as such advice is already present in international statistical standards (e.g. the System of National Accounts). It is sufficient to recognize the flows that are likely to be of primary focus in the analysis of the eco-agri-food value chain, such as those just listed.

Data on flows such as income, costs and value-added is relevant for all businesses within scope at all stages of the eco-agri-food value chain. Data will most commonly be recorded in monetary terms and hence can be aggregated across industries within a study. Making comparisons over time will often necessitate adjustment for changes in relative prices (converting data to constant prices / measuring price adjusted volumes). When making comparison among countries, it will be necessary to allow for the differences in purchasing power of different currencies (using purchasing power parities). Furthermore, and especially in the context of agriculture, it is important to include trade barriers, subsidies for inputs, and other market distortions in any evaluation.

Measurement of these variables over time will provide insights into the resilience of producers since income flows in agriculture may be particularly volatile from year to year, depending on prices for agricultural outputs or inputs, and the impacts of climatic events.

Purchased inputs

A complete understanding of the production process across the value chain requires an understanding of the quantities and values of different inputs. The purpose in recording these flows is to recognize where there might be particular pressure points in supply. The focus here is on purchased inputs, comprising 'labour inputs' and also 'intermediate consumption'. Labour inputs refer to paid or salaried work along the agriculture and food value chain and can be measured in monetary terms and also in terms of its characteristics such as skills, experience, etc. Intermediate consumption, following the SNA, refers to the goods and services produced by economic units that are consumed within production processes. Examples include water, energy, fertilizers, pesticides, animal health and veterinary inputs.

Different production approaches for the same commodity (e.g. between intensive and extensive production systems) create differences in the use of purchased inputs. Trade-offs also vary when it comes to the use of purchased inputs and reliance on natural ecosystem services that provide the same type of input, for instance, irrigation versus direct rainfall, fertilizer use versus soil management and pesticide use versus biological pest control. Consistent with the SNA and the SEEA, the measurement boundary for purchased inputs includes all water and energy use whether purchased from suppliers or abstracted/produced on "own-account".

Data on purchased inputs is available mostly from farm level surveys and censuses and can be collated in

7 Food balance sheets provide essential information on a country's food system through three components:
• Domestic food supply of the food commodities in terms of production, imports, and stock changes.
• Domestic food utilization which includes feed, seed, processing, waste, export, and other uses.
• Per capita values for the supply of all food commodities (in kilograms per person per year) and the calories, protein, and fat content

aggregate form in national accounts datasets and related input-output tables in monetary terms. Information on flows of inputs in physical terms is also important for analysis. Key inputs in this regard are water use, energy use (including information on the type energy source, such as renewable energy), pesticide and fertilizer use (N, P, K). For agricultural producers, the SEEA AFF provides guidance and accounting tables to organize relevant information.

Ecosystem services

As is increasingly recognized (Swinton *et al.* 2007), a focus on the marketed outputs and inputs of agri-food systems ignores the significant role of ecosystem services in the production of crops, livestock and other outputs. These services include biomass accumulation, pollination, and water and soil related services. Ecosystems also provide a range of additional services helpful in agricultural landscapes and elsewhere, such as carbon sequestration, water regulation, biodiversity and amenity values. While several classifications of ecosystem services exist (MA 2005; EEA 2018; US EPA 2018), the TEEBAgriFood Evaluation Framework distinguishes between 'provisioning', 'regulating' and 'cultural' services, by way of example[8]. An important role of the Framework is to help assess trade-offs. These include trade-offs between ecosystem services as inputs to production and corresponding purchased inputs (e.g. with respect to fertilizers) and the potential trade-offs between different land use types, such as use of ecosystems to support agriculture versus the supply of other ecosystem services that are of broader public benefit, such as carbon storage and the provision of habitat to support maintenance of biodiversity.

The range of ecosystem services that is relevant as inputs to agriculture varies depending on the production system and output being produced but typical examples include water services (e.g. water absorbed from soil), soil services (including nutrient cycling), grass for grazing livestock, and pollination services (from wild pollinators). Ecosystem services may be supplied by ecosystems located on the farm or by neighbouring ecosystems (e.g. where pollinators live in nearby bush or forest). Recording the source of ecosystem services, including by ecosystem type, helps provide a clear sense of the types of ecosystems that should be maintained to support agricultural production. The ecosystem services considered in a given assessment should be made explicit and use a commonly accepted classification such as CICES as a type of checklist (EEA 2018).

The more details about production processes and agricultural outputs that can be captured, the more useful the Framework will be. The comparison of the mix of purchased inputs and ecosystem services inputs is of particular interest. For example, assessing the differences in outcomes between production approaches using high levels of fertilizers and approaches using more organic means of soil management (and hence increased use of ecosystem services). In this regard, it is important not to limit analysis of ecosystem services and other inputs to the flows themselves, but to extend analysis to consider changes in the underlying capital base (e.g. soil condition, pollinator diversity, off-farm water quality). This will allow an informed assessment of the capacity of farms and farming landscapes to continue to operate in their current fashion.

In addition to the use of ecosystem services as inputs to agricultural production, farming areas supply a range of ecosystem services that benefit other economic units, households and society generally. Examples of these types of services include climate regulation (e.g. via carbon sequestration), soil retention and the amenity values from farming landscapes.

Since these ecosystem services are generally not for sale, their generation by farming areas will not be included in the valuation of production nor will the loss of these services be captured in economic values if the underlying natural capital is degraded. Exceptions will arise in cases where farmers can participate in payment for ecosystem services (PES) schemes, for example where an income is generated from demonstrating increases in the capture of carbon. Overall, recording all flows of ecosystem services generated from farming landscapes is an important part of providing a more complete picture of the eco-agri-food system.

The focus for measurement of ecosystem services inputs in this Framework is on agricultural production only and is not extended to the production of other outputs along the eco-agri-food value chain, e.g. food processing and distribution. It is noted however that where the flow of agricultural products can be traced through the value chain, useful estimates can be made of the effective embodiment of ecosystem services and various stages of production through to final consumption.

Many agricultural production areas comprise a mix of ecosystem types. With regard to individual agricultural holdings there is often a dominant ecosystem type – e.g. cropland or grassland – but there is also often a

8 For the purposes of CICES, ecosystem services are defined as the contributions that ecosystems make to human well-being. Provisioning services include all material and energetic outputs from ecosystems; they are tangible things that can be exchanged or traded, as well as consumed or used directly by people in manufacture. Regulating services include all the ways in which ecosystems control or modify biotic or abiotic parameters that define the environment of people, i.e. all aspects of the 'ambient' environment; these are ecosystem outputs that are not consumed but affect the performance of individuals, communities and populations and their activities. Cultural services include all non-material ecosystem outputs that have symbolic, cultural or intellectual significance (EEA 2018).

mix of native vegetation and other features that create agricultural "mosaics". And, increasingly, farmers are being encouraged to ensure that a portion of their land is allocated to nature conservation, for example by fencing off riparian zones. By recognizing that farmers manage a range of ecosystem types and by recording the associated streams of ecosystem services under their purview that are of public benefit, a more complete estimate of production by farms can be recorded.

Further, the scope of measurement should include ecosystem types that surround agricultural holdings, such as forests and rivers. Each of these, in different ways, provides ecosystem services as inputs, and can be impacted by agricultural activity. It is therefore relevant to monitor flows of ecosystem services from these ecosystems as part of the systems approach of TEEBAgriFood.

The measurement of ecosystem services is a rapidly developing area, with many initiatives underway at local, national and global levels. As yet, however, there is no single authoritative database akin to the availability of data on agricultural production and purchased inputs. Nonetheless, there are reasons to be optimistic about the availability of this information in the foreseeable future.
First, part of the development of the SEEA has involved the integration of measures of ecosystem services and their values within an extension of the SNA. This provides a common platform for bringing together economic and ecosystem data. Through the SEEA Experimental Ecosystem Accounting, there is now a statistical basis to account for ecosystem services, though ongoing research and further development of methods and classifications is still needed.

Second, a range of implementation activities focused on advancing the SEEA based ecosystem accounting framework are taking place around the world. At national level, leading countries in ecosystem accounting include Australia, Canada, Mexico, the Netherlands, the Philippines, South Africa and the US. At international level, there are programs being led by the World Bank (WAVES), the EU for Europe, and UNEP and UN Statistics Division for Brazil, China, India, Mexico and South Africa. Experience in these projects is demonstrating that the logic of ecosystem accounting is directly applicable at farm and local levels, and projects to test ecosystem accounting at these scales are being developed.

All of this work has established a global community on ecosystem accounting that can directly support measurement in this aspect of the TEEBAgriFood Evaluation Framework and, more broadly, in the measurement and valuation of natural capital itself. Further, testing of the TEEBAgriFood Evaluation Framework can contribute to the ongoing advancement of ecosystem accounting and broader recognition of the need for more comprehensive measurement of non-market stocks and flows.

Residuals

Recording residual flows along the value chain is an important part of assessing the overall impact of production and consumption processes. Following the SEEA Central Framework, residuals are "flows of solid, liquid and gaseous materials, and energy, that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation" (UN 2012). The TEEBAgriFood Evaluation Framework aims to record all such residual flows that occur as a result of the activities that take place within the eco-agri-food system.

Recording these residual flows in the Framework does not include a judgement as to whether they have a positive or negative impact on human well-being. Indeed, some residuals may be recovered and recycled within or between establishments and households. Understanding both the gross and the net flows of residuals is important in understanding the overall dynamics of the eco-agri-food system.

Recording residual flows reflects a measure of pressure rather than changes in natural or human capital or impacts to environment or health. Thus, it is important to also consider the resulting changes in the capital base of the "receiving" ecosystems or populations. These are recorded as outcomes in the next part of the Framework. Potentially significant thresholds and non-linearities need to be considered, especially with respect to time since it may take many years for the full effects of the release of residuals to become apparent.

It is also important to distinguish between residual flows and outcomes and to pinpoint their sources (as possible) along the eco-agri-food value chain. This may be more tractable at a local community or landscape scale where the activities of all relevant farms or manufacturers can be considered in aggregate, rather than seeking attribution to individual farms and businesses. Attribution of residual flows at too high a level of aggregation, for example by sector, may miss the reality that the outcomes are often highly specific to location.

Five categories of residual flows are described in the TEEBAgriFood Evaluation Framework as shown earlier in **Figure 6.3**. Detailed definitions and accounting treatments for these flows are described in the SEEA Central Framework and, for agricultural production, in the SEEA AFF. Short descriptions of the categories are provided below.

Agricultural and food waste

A significant proportion of food is wasted or lost along the eco-agri-food value chain, including harvest losses at the farm level, losses during storage, distribution, and

processing of food, and food waste resulting from human consumption (FAO 2013). The explicit inclusion of waste in the Framework is essential. Different parts of the value chain generate waste differently and in varying amounts. Using efficiency measures (tonnes of food waste per tonne of output or consumption) and tracking "weak" points in the value chain – for example, the effectiveness of cold storage facilities for perishable products - can provide significant information helpful to the goal of reducing waste. Food waste is normally measured in tonnes but conversion to monetary value, calories or nutrients can support other areas of analysis and make inefficiencies clearer.

A distinction should also be made between the tracking of food waste through the value chain as described here and the collection and treatment of waste by the waste industry. Despite this distinction, it is relevant where possible, to record recovery and recycling of food waste, for example through composting or the work of food charities to recover surplus food to feed needy people. Furthermore, losses that arise during manufacturing, processing and subsequent transformation should be treated as food waste, except where losses are re-purposed, e.g. for animal feed, in which case there may be only a partial loss of economic value. Capturing this information will help make clearer the net impact of food waste on human well-being.

Greenhouse gas (GHG) emissions

GHG emissions measurements[9] for agriculture should include those produced by process emissions (including enteric fermentation, manure management, rice cultivation, synthetic fertilizers, manure left on pasture, crop residues, manure applied to soils, drained organic soils and burning of crop residues), emissions from energy use, and AFOLU based emissions relating to the management of forests, cropland and grazing land, the clearing of forest land and the draining of organic soils. GHG emissions for other parts of the eco-agri-food system should also accord with the UNFCCC reporting requirements (IPCC 2018).

Other emissions to air, soil and water

Other emissions of agri-food systems may include excess nitrogen (N) and phosphorous (P) from inorganic sources that is released from agricultural land, pesticide and chemical runoff, particulate matter (PM10, PM2.5), heavy metal pollutants, and sulphur dioxide. While measurement challenges exist, there are well-established frameworks for measuring and modelling the transport and fate of several of these at farm, regional and national scale. These can be used as the basis for gathering data in a TEEBAgriFood context.

Wastewater

Wastewater is discarded water that is no longer required by the user and is discharged directly to the environment, supplied to a sewerage facility or supplied to another economic unit for further use. Guidance on the measurement of wastewater is provided in the SEEA Water and the International Recommendations on Water Statistics.

Solid waste and other residuals

This category is designed to encompass all other residual flows not included in the categories above. Examples include solid waste such as packaging waste and discarded equipment.

Outcomes

Outcomes are the third key element of the TEEBAgriFood Evaluation Framework. Within an accounting-based framework, outcomes are fully reflected as changes in the extent or condition of the stocks of capital due to value-chain activities and hence can be described in terms of the changes in the four types of capital – produced, natural, human and social. These changes may be positive, i.e. increases in the stock of capital, or negative. Recording outcomes as changes in the stock of capital embeds the application of the systems approach that is foundational to the TEEBAgriFood approach.

It is not the role of the Framework to articulate all of the possible positive and negative outcomes. Rather, the intent is to provide a means by which all outcomes can be placed in a common context. Thus, through regular and ongoing measurement, it is possible to establish a dynamic picture of change in eco-agri-food systems that allows deeper understanding of the many and varied relationships within the system.

There is a direct relationship between the groupings of capital described above and the groupings of outcomes, noting the many potential connections between each type of capital and the different types of flows. By way of example, in cases where there is a recorded flow of pollution arising from food processing activities making its way into a local waterway, there are possible negative outcomes for both natural capital (a decline in 'water quality') and human capital (declines in 'human health'). Also, for example, activity to restore riparian zones in grazing lands can lead to positive outcomes in terms of improved natural capital conditions and in terms of improved productivity that increase returns to produced capital. Similarly, improvements in public food distribution systems can lead to positive outcomes for social capital

9 Following the System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (FAO and UN 2018) and IPCC (2018).

(through greater 'food security') and human capital ('improved nutrition').

The examples of outcomes provided throughout this chapter are indicative only, and as noted above, the composition, extent and direction of shifts in the stock of capital may vary significantly across different eco-agri-food systems.

It is also important to assess as to how these outcomes may be distributed across stakeholders. For example, establishment of minority self-help groups would empower minority communities in rural areas, improving both their stocks of social and human capital. Similarly, while certain agricultural technologies may increase financial wealth (increasing produced capital base) of farmers, it would be important to assess how this may be distributed across small scale and large scale farmers. Depending on the extent to which information is available to populate the Framework, it would be possible to assess changes in the stock of capitals for small landholders, local communities, food processors, governments, etc. and for different household groups, for example in terms of gender, income, age and location (urban/rural).

As noted in the discussion on stocks, an important consideration in understanding eco-agri-food systems is the extent of their vulnerability and resilience to systemic change and shocks. In the TEEBAgriFood Evaluation Framework, concepts such as vulnerability and resilience are embedded in the concept of capital and the underlying stock. Thus, the resilience of a specific eco-agri-food system will be reflected in the condition of its stocks and their balance or composition. In turn, changes in resilience will be reflected in the measurement of outcomes. Thus, measures of outcomes will embody the non-linear and dynamic descriptions of the state of eco-agri-food systems.

For example, the resilience of a small scale maize producer to climate change will, among other factors, be reflected in the condition of the soil and access to water. To the extent that changes in natural capital can be measured, then the measured outcomes will show the changing resilience of that specific production system and also reflect the non-linear and dynamic effects that take place.

Overall, recording outcomes in the Evaluation Framework is a fundamental to describing all eco-agri-food systems in a comprehensive way using a common platform. The set of information obtained from recording stocks, flows and outcomes will support a wide range of economic and other analysis, as well as the development of indicators and metrics to monitor progress towards goals such as sustainability.

Impacts – contributions to human well-being

Recording stocks, flows and outcomes provides a complete description of eco-agri-food systems but does not provide a standardized interpretation of the relative differences among various systems with respect to human well-being. Moreover, since we aim to compare farm systems across their economic, social, and environmental dimensions, it is important to integrate these dimensions in a meaningful way that can inform policy and business decision-making. Using a single, common approach allows for consistent and coherent comparisons.

Several analytical tools are available to assess eco-agri-food systems and their impacts on human well-being. These include, for example, cost-benefit analyses, integrated profit and loss statements, ecosystem services valuation, and measures of inclusive wealth. In practice, these tools are often partial in coverage and there is a need to account for social and environmental considerations that are often left out. For example, while cost benefit analyses may include direct social and environmental impacts, they often do not include comprehensive assessments of ecosystem services, nor broader social equity considerations. Such factors are not naturally incorporated into economic valuation approaches premised on the existing distribution of wealth and capital.

For the TEEBAgriFood Evaluation Framework, we propose a value addition-based approach to more holistically assess the impacts of eco-agri-food systems in terms of their balance of contribution to human well-being. Following the TEEBAgriFood interim report, 'value addition' reflects the idea that it is possible to change the state (space, time, and characteristics) of a product to make it more valuable to humanity. Standard metrics for measuring value addition focus on visible or market price-based measures. Thus, at the business level, value addition is a measure of operating profit, i.e. sum of factor returns and surplus generated by firms over and above their purchases from other firms. At the national level, the System of National Accounts (SNA) incorporates value addition through the income approach of calculating the Gross Domestic Product (GDP) indicator, which is the sum of compensation of employees, taxes less subsidies on production, and the operating surplus of the producer.

However, such metrics generally ignore the economically invisible flows that form important components of eco-agri-food systems. To address this gap, the coverage of value addition is broadened to incorporate the contribution of invisible and visible flows to human well-being through their positive (or negative) impacts along the agricultural value chain.

For example, while malnutrition is a human capital outcome, it can also have significant material impacts on productivity. Similarly, while biodiversity loss is a natural capital outcome, this can lead to reduced supply

of ecosystem services and thus negatively impact agricultural yields and returns to produced capital. **Table 6.1** provides a series of examples of the links between different outcomes and impacts. Note that these examples are hypothetical, and the actual impacts for a particular eco-agri-food system will depend on the specific context.

Using the techniques and methods described in Chapter 7, and based on the descriptive information on stocks, flows and outcomes, the broad ambition of the TEEBAgriFood Evaluation Framework is to assign values, either positive or negative, to the significant (material) impacts of eco-agri-food systems and hence evaluate the relative impact of different eco-agri-food systems on human wellbeing. There is no doubt this is a challenging goal. Indeed, while a range of economic, health and environmental impacts can be valued using established methodologies, other impacts, in particular social impacts, do not easily lend themselves to monetary analysis. For example, the impacts of social capital outcomes such as food security may be very difficult to capture quantitatively, let alone in terms of 'value addition'. The complete evaluation of impacts therefore should accommodate qualitative assessments of some variables. This will involve presenting information on impacts relating to, for example, food security, access to nutritious food, gender equity in land holdings etc., utilizing the information reflected in other parts of the Evaluation Framework.

Table 6.1 Examples of outcomes and impacts, as expressed by value addition (Source: authors)

Outcome Type	Potential Outcome Details	Potential Impact (expressed by value addition)
Natural capital outcome	Higher GHG concentrations	Productivity losses through increased drought/ flooding
Natural capital outcome	Deforestation	Loss in relevant ecosystem services inputs, leading to productivity losses
Natural capital outcome	Higher water yields	Improved crop yields due to increased water availability
Natural capital outcome	Improved condition of tree belts and hedgerows	Increased amenity values
Natural capital outcome	Eutrophication of water ways	Reduced income from fish catch
Social capital outcome	Land displacement	Reduced income and qualitative indicators concerning equity, including gender equity
Social capital outcome	Increased access to food	Assessed health benefits and qualitative indicators concerning equity
Social capital outcome	Increased opportunities of employment for women in rural areas	Qualitative indicators on equity and community networks
Human capital outcome	Improved nutrition	Decrease in health costs/ increased productivity
Human capital outcome	Reduced occupational health due to pesticide poisoning	Increased health costs due to higher disease burden
Human capital outcome	Improved skills	Higher income due to increased skills set
Produced capital outcome	Investment in agricultural machinery	Improved farm incomes and productivity
Produced capital outcome	Loss of road infrastructure	Increased transportation costs and higher consumer prices

Stages of the eco-agri-food value chain

Beyond extending the assessment of eco-agri-food systems to encompass all types of stocks, flows and outcomes and to evaluate economic, health, social and environmental impacts, the TEEBAgriFood Evaluation Framework also seeks to extend assessment across the complete eco-agri-food value chain. Smaller sections of this chain are already being analysed. From an economic and corporate perspective, the analysis of value and supply chains is relatively common (Dania *et al.* 2016), for example using general equilibrium modelling in the analysis of international trade. In the area of food security, analysis commonly considers the connection between the supply of food products and the consumption of food products (e.g. FAO food balance sheets [FAO 2001]). In health fields, there is ongoing research into the link between dietary patterns and health outcomes.

However, the TEEBAgriFood Evaluation Framework is unique in connecting all of these parts in order to study the full effects of the eco-agri-food value chain, i.e. the production chain, the link to consumption and the final link to outcomes for human health. Within the Framework, the stages of the eco-agri-food value chain have been broken into four main groups – agricultural production; manufacturing and processing of food products; distribution, marketing and retail; and household consumption. These four groups are intended to provide a complete coverage of the value chain. **Table 6.2** presents the four groups of the TEEBAgriFood value chain and relevant sub-groups.

Table 6.2 The TEEBAgriFood value chain (Source: authors)

Agricultural production	
	Cropping activity
	Livestock activity
	Other agricultural production
	Agricultural supply activities
Manufacturing and processing of food products	
Distribution, marketing and retail	
	Transport and storage
	Wholesale
	Retail
	Hospitality (restaurants, etc.)
Household consumption	
	Food consumed at home
	Food consumed at restaurants, etc.

While other parts of the value chain are important and may be used as starting points, it is the production processes at the farm level that provide the most useful point of departure. Describing the value chain thus commences with the production of agricultural outputs including crops and livestock. While potentially applicable in other primary production contexts, at this stage the focus excludes forestry, fisheries and aquaculture activity, except to the extent that this takes place in conjunction with agricultural activity (for example, in rice-fish farming systems).

Within the context of this boundary for agricultural production, it will be relevant to identify different types of producers (subsistence, small scale, commercial), different commodities, different production systems (e.g. intensive, extensive) and different locations, for example

based on agro-ecological zones. Understanding these features will be highly relevant in comparisons between impacts as assessed by different studies.

The eco-agri-food value chain moves in two directions from the farm level. The first direction concerns those businesses that supply goods and services to agricultural producers. Key industries in this part of the chain include water suppliers, manufacturers of fertilizers, pesticides, seeds, animal feeds and medicines, etc., and energy suppliers (of electricity and fuel). For each of these businesses the Evaluation Framework encompasses measurement of their output, value added and other economic flows; their production of outputs; the inputs of water and energy; and potentially the associated outcomes associated with these industries, i.e. changes in their stocks of produced, natural, human and social capital. For ease of exposition, these supplying industries are presented as being within the agricultural production sector as one top-level part of the value chain.

This part of the value chain will also encompass connections between agricultural producers, for example farmers growing fodder crops to support livestock production. Depending on the analytical questions of interest and data availability, these different sub-parts of the agricultural production sector can be separately identified.

It is possible to envisage that the value chain for farmers might extend to include those ecosystems that supply ecosystem services as inputs to agricultural production. While possible in an accounting context, for the purposes of the TEEBAgriFood Evaluation Framework, the value chain is limited to connections between economic units, including households.

The second direction concerns the movement and transformation of agricultural output from the farm gate toward household consumption. The value chain in this direction includes the subsequent stages presented in **Table 6.2** (above) namely:

- Agricultural production
- Manufacturing and processing of food products
- Distribution, marketing and retail
- Household consumption

The concept of household consumption aligns with the definition of consumption in the System of National Accounts and hence covers purchases of food for consumption within the household, purchases of food supplied by restaurants and the hospitality industry more generally, and consumption of food grown at home (on "own-account").

Analysis of household consumption will be supported by breakdowns of consumption by income group, gender, age, types of food and diets. In particular, this detail will support analysis of the impacts of consumption on human health. In some cases, it will be relevant to consider the extent to which governments and international organizations purchase food on behalf of households or otherwise manage the supply and distribution of food to particular population groups.

As noted in the discussion of production and consumption, in making the connection between agricultural production and human health it will be relevant to consider multiple sources of food, e.g. imports of food, at least in cases where the population group of interest is not self-sufficient in food production. In understanding the flows of food products through the value chain, imports may need to be recorded at different stages including as imports of raw materials, through various stages of processing and on to distribution chains.

In keeping with the general "cradle-to-grave" philosophy of TEEBAgriFood, the value chain does not end with final consumption. It also includes recording the flows of food losses and waste that are associated with food production and consumption. The recording of losses and waste should take place at all stages of the value chain, and should highlight the role of the waste management industry in collecting and managing this flow.

In practice, the description of, and boundaries between, the different stages of the value chain should be aligned with the descriptions that underpin the collection and presentation of economic statistics in the International Standard Industrial Classification (ISIC). This classification (or national variants) is used by countries around the world and is the basis for the compilation of input-output tables that are a fundamental source of information for economic modelling. Data on employment and the labour force (and hence human capital) and also on environmental stocks and flows (following the SEEA) are also presented according to the ISIC. Alignment of the TEEBAgriFood Evaluation Framework with the definitions in these core datasets thus provides the strongest basis for the integration and comparison of data across countries and provides a consistent means of benchmarking at the corporate level.

6.4 APPLYING THE FRAMEWORK

The TEEBAgriFood Evaluation Framework intends to be useful to a range of stakeholders, including policymakers, farmers, businesses and citizens groups, and regarding a range of different issues, such as the effects of climate change, urbanization, and dietary change. This section introduces some potential applications and entry points to the Framework. It also presents steps that can be followed to undertake evaluations and places analytical tools in context. Finally, this section describes some remaining considerations relevant to the application of the Framework.

While it has been developed and discussed by experts, it must be recognised that the Framework described here represents a starting point in the development and implementation of more comprehensive and universal assessments of eco-agri-food systems. It should be expected that, over time, as this version of the Framework is tested in different settings, and as the theory underpinning integrated measurement frameworks expands, there will be revisions that take these developments into account.

6.4.1 Applications and entry points

The Framework is intended for use in an interdisciplinary manner, where the questions to be analysed, the options to be compared, the scale, scope, and most relevant variables can be determined before the appropriate assessment and valuation methods are selected. This section presents some of the potential applications and entry points for the TEEBAgriFood Evaluation Framework. Practical demonstrations of the ways in which the Framework may be applied are provided in Chapter 8.

Families of applications

To portray the potential applications of the TEEBAgriFood Evaluation Framework, five families of applications have been defined – agricultural management systems, business analysis, dietary comparison, policy evaluation and national accounts for the agricultural sector. The intention is that the Framework provides a common articulation of different eco-agri-food systems and hence can be used to support all of these applications, as shown in **Figure 6.6**. This intention mirrors the largely established situation for macroeconomic statistics where multiple applications are based on a single framework of data presented in the national accounts covering the full range of industries, sectors and countries.

In practice, it will be some time before this ambition can be seen as standard and indeed the evidence from the assessment of current examples in Chapter 8 highlights the degree of variation in approach that currently exists. Nonetheless, the TEEBAgriFood Evaluation Framework sets this ambition to provide a goal and rationale for future measurement and development.

As far as possible, the elements of the Framework have been defined in such a way as to be compatible with international statistical standards and guidance. Therefore, in the application of the Framework there is the potential to build strong partnerships with relevant statistical and technical agencies. The alignment of measurement with analysis within a single framework also enhances comparability of assessments and encourages more extensive and open dialogue among all stakeholders. For instance, the descriptive elements of the Framework represent a means by which information and data on progress towards the SDGs can be collected and organised.

Perspectives of different stakeholders

From the perspective of **governments**, it is clear that the policy landscape interacts with eco-agri-food systems in various ways such as in the case of land use and spatial planning, import/ export regulations, subsidies and taxes, and investments in agricultural research and development. All of these factors influence the way in which we produce, process, distribute and consume food (Rosegrant *et al.* 1998; Mogues *et al.* 2012)[10]. It is envisaged that central and local governments will be able to use the Framework in conjunction with related measurement and analytical tools to account for a complete range of costs and benefits for various public investments and expenditures across different farming systems. In particular, the Framework supports government incorporation of agricultural outcomes together with associated costs and benefits related to human health, GHG emissions, ecosystem functioning and other public goods. Further, the Framework provides a means to consider broad, systemic policy challenges such as climate change and urbanization.

Also, the Framework supports examination of the potential influence of eco-agri-food systems within development agendas, in particular the United Nations Sustainable Development Goals (SDGs) (UN 2015). Certain eco-agri-food systems generate greater positive impacts than others, for example, in relation to food security, employment and income generation, social cohesion, and conveying working capital to women. Since the Framework identifies these types of outcomes and

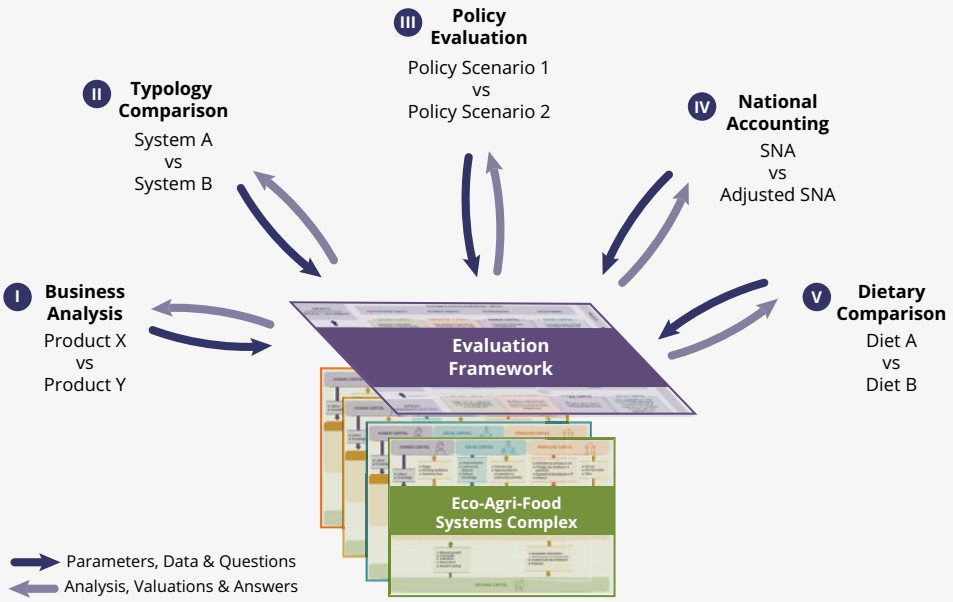
10 For example, Rosegrant *et al.* (1998) analyze time series (1969-90) data from Indonesia for rice, maize, cassava and soybean-demonstrating that 85 per cent of the growth in rice, 85 per cent growth in maize, 93 per cent growth in cassava, and 71 per cent growth in soybean crops can be attributed to research, extension, and irrigation investment while remaining by output, input, and factor price changes (Mogues *et al.* 2012).

evaluates the associated impacts on wellbeing, it can help to highlight entry points for enacting agricultural policies that contribute to these development goals.

Farmers can use the Framework to both understand and demonstrate their role beyond food production – for example, in preserving traditional knowledge and landscapes, contributing to food security, and supporting other allied sectors. Farmers can also use the Framework to demonstrate how changes in other sectors, such as the energy sector, would impact their farms and businesses, and not only in economic terms. This evidence can then be used to influence policy makers or raise awareness around the importance of farming activities.

In terms of farm management, the Framework may help with information gathering to better support more sustainable farm practices and to improve reporting on outcomes at the farm level for certification and compliance purposes. Finally, particularly with respect to ecosystem services, the data on ecosystem services recorded in Framework can underpin the development of markets in ecosystem services and/or the development of payments for ecosystem services (PES) schemes. Objectively measuring flows of ecosystem services, especially water regulation, carbon sequestration and sediment retention at the farm level can help convey the importance of these services and the role of farmers in supplying them.

Figure 6.6 Applications of a universal evaluation framework (Source: authors)



Businesses, particularly agri-businesses and the food and beverages industry, face environmental challenges and changes in social expectations which present various risks and opportunities - operational, regulatory, reputational, market and product, and financing. Describing and accounting for contributions to wellbeing across their value chains using the Framework can allow businesses to better identify these risks and opportunities, and to take action. For example, businesses can use the Framework to determine environmental, health and social sustainability criteria in purchasing and sourcing decisions.

Citizens and consumer groups working in domains of health, food safety, and environment can use this Framework to assess food choices, organize information to hold public and private decision-makers accountable, highlight and encourage community and citizen engagement in local farming, and support production approaches that generate net positive impacts. An entry point for consumer groups may be to assess a particular food product. Here an assessment would aim to understand the extent to which the output from a particular farm (and associated agricultural practice), group of farms (e.g. in a region) or of a specific commodity has positive and negative impacts across the economic, social and environmental domains. Other assessments might focus on consumption perspectives considering current or ideal diets, or specific dietary components, such as protein.

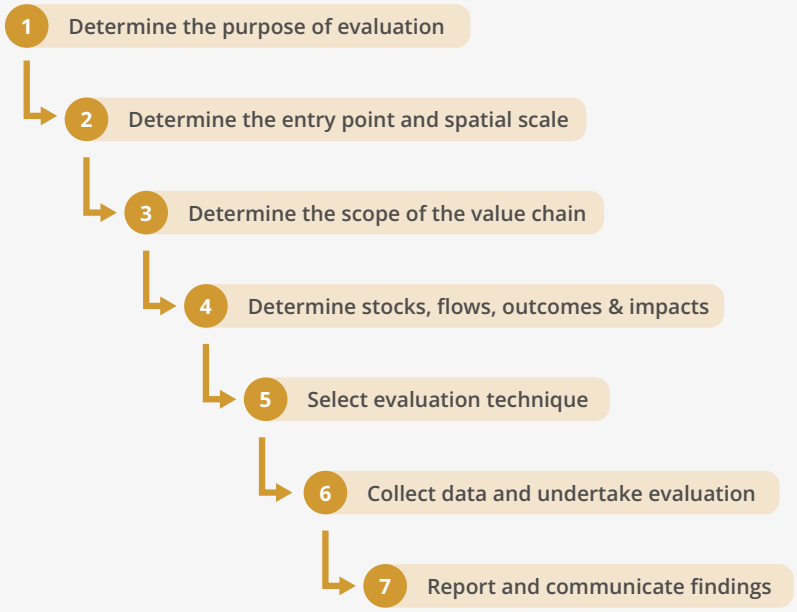
6.4.2 Basic steps in applying the Framework for evaluation

This section presents the basic steps in applying the Evaluation Framework. As discussed earlier, the potential to describe eco-agri-food systems in terms of stocks, flows and outcomes allows all stakeholders, in their particular context, to assess a given eco-agri-food system in its totality, understand the material impacts and contextualize the analysis. Annex 6.1 provides a summary of how the Framework may be used, along with examples of the elements that may be part of an assessment. The annex may also be considered a standalone document since it also recapitulates the rationale and scope of the Evaluation Framework discussed in earlier sections of this chapter.

The analytical approaches described in Chapter 7 involve a comparison of different eco-agri-food systems in terms of their net contribution to human well-being in monetary terms. In concept, this approach can be applied relatively readily for economic, health and environmental impacts, noting a range of practical measurement challenges. However, in the space of social impacts the application of value addition is not possible. Thus, to provide a comprehensive analytical approach, value addition should be combined with other techniques, such as multi criteria analysis (see Chapter 7), to consider the overall contribution to human wellbeing.

To apply the Framework there are seven steps and associated decision points that should be appropriate for any assessment. These steps are depicted in **Figure 6.7** and described below.

Figure 6.7 Steps in applying the TEEBAgriFood Evaluation Framework (Source: authors)



1. Determine the purpose of evaluation

Different stakeholders, including government agencies, farmers and rural communities, businesses and civil society, will have different purposes for using the Framework. To facilitate exchange and dialogue it is important that the organisation or stakeholder leading the assessment is clear about the questions of interest and the anticipated role that the assessment will play.

2. Determine the entry point and spatial area for assessment

In determining the purpose of the evaluation, questions concerning the entry point and spatial scale for the analysis will inevitably arise. By entry point, it is meant that the evaluation must start from a particular point or perspective of eco-agri-food systems. Generally, the entry point will relate to a specific area of policy, business or research interest and will vary depending on the stakeholder. Examples of entry points for government include: agricultural production of a single commodity, sources of food waste, GHG emissions, obesity and water scarcity. For business, example entry points include analysis of sector and industry performance, value chains for a specific company and activities of individual business divisions. In addition to determining an entry point, the spatial area and scale of analysis needs to be considered. Evaluation might be undertaken at a global,

regional, national, sub-national or community level, or for particular water catchments, climatic zones or soil types, or other combinations of spatial areas.

3. Determine the scope of the value chain

Determining the entry point provides the basis for determining how many parts of the value chain – upstream and downstream – are to be included in the evaluation. The intent in the design of the Framework is that no matter what part of the value chain is being evaluated, it should be possible to understand the linkages to other parts of the same value chain. The use of consistent language and measurement boundaries to define the value chain is central to this design feature.

In practice, the use of different datasets and methods will mean that alignment between evaluations will not be straightforward. Nonetheless, the ideals of the Framework will provide a common reference point for comparison. In determining the scope of the value chain, it will also be important to map out the likely spatial distribution of the value chain to ensure that all relevant connections are recognised and informed choices can be made on the appropriate scope of the evaluation.

4. Determine the appropriate focus on specific stocks, flows, and outcomes

Depending on the type of question under consideration, it may be relevant to focus more heavily on particular types of capital: for example, consideration of water related questions will likely involve a more in-depth assessment of natural capital, and related flows, outcomes and impacts. As a general starting point however, it will be relevant for all evaluations to work through the relevance and materiality of the different stocks, flows, and outcomes to provide a rationale for their inclusion or exclusion.

Of particular interest in the context of TEEBAgriFood are stocks of natural capital and associated flows of ecosystem services on which eco-agri-food systems are dependent. It is likely that a degree of iteration will be required to ensure a coherence and alignment within the evaluation itself. In effect, discussion of each of these different components of an evaluation facilitates a comprehensive description and enables different evaluations to be placed in a common context.

5. Select evaluation technique for assessing impacts

The first four steps provide a complete framing for an evaluation project but it remains necessary to describe how evaluation of impacts will be undertaken. For TEEBAgriFood, the focus is on a value-addition based approach to assessing impacts as contributions to human well-being. Chapter 7 provides a thorough description of the value addition approach and also an introduction to a range of other evaluation methodologies, such as life cycle assessment and value chain analysis, and various modelling tools and techniques including partial and general equilibrium models and system dynamics. Generally, these other approaches will focus on parts of an eco-agri-food system rather than being comprehensive in scope. In that sense, the Evaluation Framework can support understanding the differences between results derived from different methods by providing a common framing for comparison.

As discussed in detail in Chapter 2, and as presented in the Framework, eco-agri-food systems are dynamic in nature, with numerous interacting parts. Any robust evaluation therefore should take a systems view. This is discussed further in the key considerations section below, and Chapter 7 discusses the types of tools that can be used to take a systems view.

6. Collect data and undertake evaluation

Although summarized here in one step, the likelihood is that most effort will be placed into this part of the evaluation process. It is essential however to complete steps 1-5 so that the actual collection of data and evaluation is completed with a clear context and goal. There is a significant risk that evaluations are completed on the basis of only the information that is readily available, in effect meaning that the framing of the assessment is determined retrospectively. This risk must be actively managed. It may be that, in practice, evaluations must be limited due to a lack of data. Nonetheless, by completing steps 1-5, the implications of a lack of data can be understood and can provide a motivation for identifying and filling information gaps.

7. Report and communicate findings

Communicating the results of the evaluation exercise should be seen as an essential part of the process and not an after-thought. Further, since it is anticipated that these evaluations will involve multiple sectors and stakeholders, it is appropriate to see this final stage as the culmination of an ongoing process of engagement and discussion. Particular note should be taken of the need to develop a range of outputs to suit different audiences including politicians and business leaders, technical experts, farmers and local communities and the media. The reporting process should include providing a clear expression of the context and framing for the evaluation; the Framework should provide the rubric for such expression.

6.4.3 Key considerations

The Framework presents a universal set of elements that should be considered for a comprehensive assessment. It also provides multiple entry points and a consistent basis for evaluation using value addition, thus allowing it to be used for a diversity of purposes and audiences. However, given the complexity and diversity of eco-agri-food systems there are several considerations to keep in mind when employing this Framework.

Spatial and dynamic considerations

Key challenges arise from the fact that agricultural systems are dynamic, with components that change and influence each other over varying spatial and temporal scales. The components of the Framework – the various stocks, flows, outcomes and impacts - do not exist or function independently of each other. For example, in considering stocks, the state of natural capital may have implications for human capital (e.g. water scarcity can impinge negatively on human well-being). Similarly, human capital in the form of traditional knowledge of seed saving or livestock rearing can maintain stocks of genetic diversity, thereby enhancing stocks of natural capital. This can in turn have implications for resilience.

Further, flows may interact with each other – several ecosystem services are intermediate flows that support final ecosystem services. For instance, regulation of freshwater flows is an intermediate service that impacts the final provisioning of agricultural output. Some of these interactions may also be "feedback loops" – water scarcity can impact yields, but also impact human capital, which can in turn reduce labour inputs into the farm, further reducing the yields, and so on. In some analyses, these connections are referred to as leakages, for example where "positive" environmental actions to increase riparian areas within one farm system have an on-balance negative impact from a broader perspective as other farms clear land to maintain the level of food production (assuming constant productivity per hectare). In all cases, the description of the various feedback loops and leakages will be based on a range of assumptions and experiences. It is thus fundamental for informed decision making that these connections and relationships are recognized, captured and understood – something that the Framework supports and that a complex systems analysis helps to identify and model.

There are however two additional dimensions that need to be kept in mind. The first of these relates to time. There can be flows that are part of the system that, over time, reveal themselves or take effect as changes in stocks. For instance, nutrient runoff from a farm to a water body may not lead to eutrophication if the levels of runoff are within ecological thresholds, allowing for dissolved oxygen to be replenished. Over time however, if the ecological threshold for eutrophication is reached, fish kills and depletion of aquatic life may result. Therefore, once the natural or human capital outcome of interest is established (see previous section on entry points), scientific literature can help determine appropriate time horizons to consider. For a natural capital outcome, the appropriate time scale may be informed by the type of farm or ecosystem. Different thresholds apply depending on for instance, the type of water body and the transport pathways for the pollutant. Similarly, if a food and beverage company is assessing its operational risks from climate change, it should account for appropriate time horizons for each particular environmental risk – such as water scarcity, desertification, or sea level rise. Scientific literature can guide these choices as well.

The second dimension is that of space. Here, it is important to understand that the spatial scale appropriate for assessing biophysical stocks and flows may be different from the scale at which stocks and flows would be assessed from an economic perspective, for the same product. For example, hydrological services are often measured at the watershed level, and this is appropriate if focus is on an individual food manufacturer's use of water in a given location. However, as an evaluation widens to consider additional components of the Framework and additional parts of the value chain, it will be necessary to integrate additional and potentially higher spatial scales. For example, if much of the labour employed in a factory comes from outside the watershed, but working conditions and employment generation are attributable to the factory's location, it will be necessary to consider how to reflect changes in the human capital base outside the watershed. Moreover, if the production from the watershed is exported to another country, the health benefits or costs of consumption will have their own sets of impacts on stocks of human capital outside the producing country (Bassi 2016). Here too the purpose of the evaluation and mapping of the value chain should guide the selection of appropriate spatial scales.

Risk and resilience

From a systems perspective, the concepts of risk and resilience are central if often difficult to quantify. The assessment of these concepts in the context of the Evaluation Framework is most directly considered in relation to the different capitals. In essence, many issues concerning risk and resilience, for example, the risks of climate change and the resilience of local communities, can be discussed reasonably readily in terms of different capitals and their capacity to provide services and associated contributions to human wellbeing into the future.

By framing risk and resilience in the context of the four capitals, as is possible to clearly relate issues of risk and resilience to observable measures of stocks, flows and

outcomes. Further, in a situation of perfect information, the degree of risk faced by different stakeholders and their level of resilience will be embedded in the prices derived for the measurement of impacts in a value additions approach. Since information is not perfect, it is necessary to be clear about the assumptions being made in valuation and to provide information about the extent of exposure to risk and the degree of resilience of a given eco-agri-food system whenever possible.

Commensurability

The next key consideration is that of commensurability of the Evaluation Framework components. The Framework allows assessment of both economically invisible and visible flows. Various economically invisible flows however can ultimately become economically visible. For instance, consider an almond farm and an adjoining forest. The pollination service provided by the forest is an economically invisible flow that has a bearing on the final provisioning of almond yields. While pollination services are not recorded in standard reporting, the yields are, and the Framework identifies and incorporates assessment of both of these flows. But why bother examining pollination services from the forest when their value is implicitly captured in the almond yield? The reason is that recording only yields does not provide us with any information on the future ability of the ecosystems to support existing yields, or to understand the relative value of the forest as a stock of natural capital. This information can be critical for resource management. Therefore, it is important to examine both ecosystem services and yields although it would be incorrect to simply add the value of these flows together to obtain a total impact, since that would reflect double counting.

Since the Framework includes stocks and flows of that are very different in nature – economic flows and cultural flows for example – sometimes it may not be possible to aggregate even if it would seem useful for reporting purposes. As mentioned earlier, the use of multi-criteria analysis is important when applying the Framework.

Uncertainty

In measurement, it is also necessary to take uncertainties into account. This is especially true when establishing causal relationships between two variables in evaluating a specific impact. For example, attributing obesity to a particular diet is not straightforward – there are various factors such as genetics, lifestyle choices, and access to food that impact an individual's or a community's health outcomes. Assessing these relationships should take these uncertainties into account. Similarly, while dose-response functions describe the changes in an organism caused at varying levels of exposure to certain foods or environmental stressors, they cannot take account of all local environmental or social factors, and often are accompanied by uncertainty measurements.

A particular set of uncertainties emerges in the assessment of capital since it is necessary, in assessing, for example, the sustainability and capacity of capital, to consider the likely future generation of services and benefits - a process prone to forecasting errors. A specific challenge in this context is incorporating the effects of climate change on the eco-agri-food system.

More broadly, consideration of uncertainties must extend to unknown outcomes and impacts arising from past and current patterns of production and consumption. For example, the health impact of genetically modified crops is an area of considerable uncertainty at present (Hilbeck *et al.* 2015). The existence of uncertainty on the basis of current knowledge inherently supports the application of the precautionary principle in decision-making (TEEB 2010a).

6.5 CONCLUSIONS AND PATHWAY FORWARD

This chapter has described a comprehensive and universal framework for the assessment of eco-agri-food systems, applicable for multiple purposes, different stakeholders coming and a variety of entry points. The accessibility of the Framework to all stakeholders in eco-agri-food systems is essential in promoting and embedding a common understanding of the challenges to and the viability of alternative pathways and solutions. As a comprehensive framework, the TEEBAgriFood Evaluation Framework takes into consideration all forms of capital that underpin economic and human well-being – produced, natural, human and social capital. The Framework also recognises all of the relevant flows and outcomes – visible and invisible; positive and negative. The comprehensive nature of the Framework provides a basis to meaningfully describe and compare different eco-agri-food systems; understand the materiality of different stocks, flows and outcomes in different systems; and provide a standardised context for analysis.

To meaningfully evaluate different eco-agri-food systems, it is also necessary to find a common basis for assessment. The analytical approach proposed in TEEBAgriFood utilises comparisons based on contributions to human well-being. Measurement of these contributions can be standardised using the concept of value addition for many aspects of eco-agri-food systems in terms of assessing impacts on economic, health and environmental impacts. To encompass social impacts and to incorporate risk and resilience into an evaluation, additional analytical techniques will need to be used, albeit still within the common framing of contributions to human well-being. Chapter 7 describes relevant techniques.

Importantly, the TEEBAgriFood Evaluation Framework builds on the latest understandings of integrated measurement and evaluation, particularly accounting frameworks and integrated systems thinking. Of course, many integrated decision-making challenges remain. However, in providing a comprehensive scope and universally applicable framing, the Framework provides a strong platform for advancement.

Four particular areas of research merit further investigation. First, the Framework uses accounting principles as its basis. While these principles are well established, their full application to areas such as social capital and accounting for biodiversity requires additional discussion and development.

Second, there is a need for ongoing discussion on the development of statistical standards, including terms, definitions and classifications, to support production of coherent data sets. When working in an integrated information space, i.e. across data silos, the need for such harmonisation becomes apparent very quickly. At the same time, relevant statistical standards have been developed in many areas of the Framework and thus the challenge is to look for synthesis and integration.

Third, notwithstanding the potential to describe systems in terms of stocks and flows, there remains a broader challenge of recognising that eco-agri-food systems are nested spatially and also need to be considered dynamically.

Finally, research needs to continue towards bringing all of these parts together with an integrated analytical approach. The discussion in Chapter 7 presents the state of the art in terms of integrated analysis but greater understanding of specific aspects is needed, particularly in the social dimension.

Chapter 8 presents a range of case studies of evaluation of eco-agri-food systems with different entry points in terms of agricultural products, sectors (both public and private) and purposes. However, all of the case studies are partial in the context of the comprehensive approach described in the TEEBAgriFood Evaluation Framework. Testing of some complete case studies must therefore be a priority.

The TEEBAgriFood Evaluation Framework provides a strong basis for comprehensive assessment of eco-agri-food systems around the world. Applying the Framework gives stakeholders a means to extract and combine data from different data sets and supports discussion of the integrated challenges of the eco-agri-food system. It is only by revealing the reality of the full impacts of different systems that progress towards long-term, sustainable solutions can be made.

ANNEX 1

HOW CAN ONE USE THE TEEBAGRIFOOD EVALUATION FRAMEWORK TO ASSESS AN ECO-AGRI-FOOD SYSTEM?

Why use the TEEBAgriFood Evaluation Framework?

Most current assessments of agricultural and food systems are partial and ignore a number of important relationships that eco-agri-food systems have with our economy, society, environment, and health. Examples of partial assessments include farm level assessments of productivity on the basis of yield per hectare only or assessments of environmental efficiency that cover the agricultural production chain but focus only on water or energy use. Such assessments, while clear in scope, leave out broader issues of sustainability and equity that are fundamental considerations in assessing food systems.
Thankfully, discussion is growing around new approaches to assessing eco-agri-food systems including the use of sustainability indicator sets, the measurement and valuation of ecosystem services as inputs to food systems, and the assessment of the connections between food and population health. The perspective of the TEEBAgriFood Evaluation Framework is that these types of approaches need to be integrated in order to better inform policy decisions. Assessments that are context specific and which consider a comprehensive set of interactions, as described in the Framework, will ensure that decision making about food systems captures all material interactions between environment, economy, society, and health and covers interactions from the farm to household consumption.

What does the Framework include?

The Framework includes four elements - stocks, flows, outcomes and impacts - which capture the set of interactions (see **Figure 6A.1**). The stocks of eco-agri-food systems comprise the four different "capitals" – produced capital, natural capital, human capital and social capital. These stocks underpin a variety of flows encompassing production and consumption activity, ecosystem services, purchased inputs and residual flows. The dynamics of an eco-agri-food system lead to outcomes that are reflected in the Framework as changes in the stocks of capitals, both quantitatively and qualitatively. In turn, these outcomes will have impacts on human well-being.

By providing key definitions and associated measurement concepts and boundaries, the TEEBAgriFood Evaluation Framework establishes what aspects of eco-agri-food systems may be included within a holistic evaluation. The chapter does not focus on how assessments should be undertaken, nor does it prescribe methods for assessments. The choice of methods will depend on the focus and purpose of any given assessment, the availability of data, and the scope of analysis.

What is the purpose and role of the Framework?

With these considerations in mind, the Framework identifies and characterizes all relevant elements of our eco-agri-food systems. Of course, eco-agri-food systems are heterogeneous with significant variation in terms of types of outputs, the nature of production systems and value chains. Further, there will be different purposes and perspectives for each assessment. By way of example, while health impacts at consumption stages for corn produced for corn syrup may be material, this would not be the case for corn produced for ethanol for use in biofuel production. Thus, not every possible combination of elements covered by the Framework will be relevant and material in every assessment.

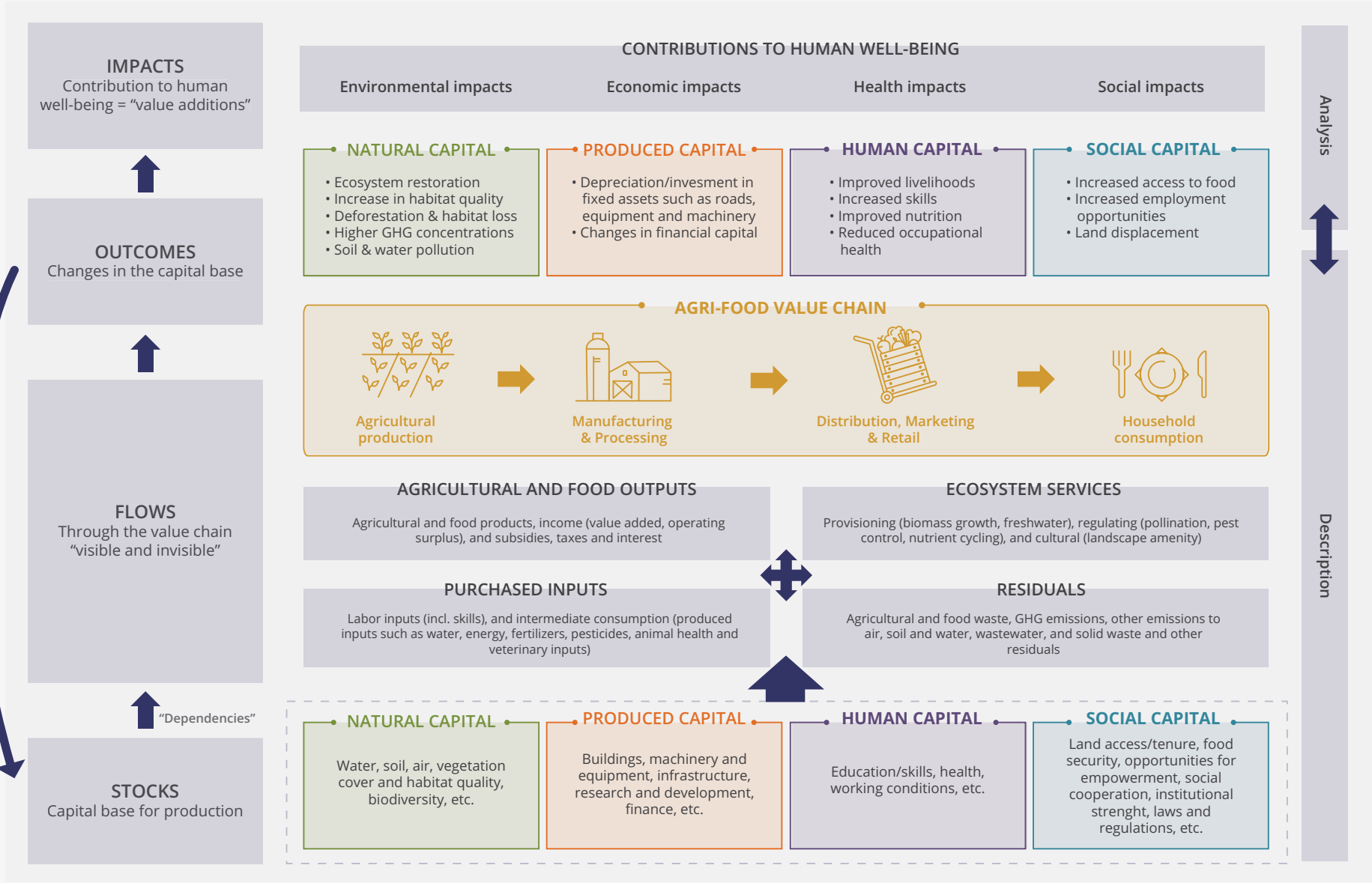
The Framework has thus been designed to provide broad categories of all interactions that may exist within a given eco-agri-food system. This provides a clear and common starting point for all assessments as they work towards identifying the elements that are most material in their context.

While all assessments will have somewhat different coverage, it is also expected that all TEEB AgriFood based assessments have the following features. They should:

- be broad and systemic in nature,
- reflect the contributions of all four capitals and
- examine connections along the full value chain, including assessing the impacts of food consumption on human health.

If these three features cannot be demonstrated, then the assessment would be considered a partial assessment and not consistent with the spirit of the TEEBAgriFood project.

Figure 6A.1 Elements of the TEEBAgriFood Evaluation Framework (source: authors)



How can the Framework be used for an evaluation or a study?

To demonstrate how the Framework may be used, the following steps may be followed:

1. **Determine the purpose of evaluation.** The purpose of the evaluation exercise may differ within and across groups such as researchers, businesses, or consumer groups. A clear articulation of purpose should be used to scope an assessment.

2. **Determine the entry point and spatial scale of analysis.** The entry point would depend on the research interest or focus of the study. Relatedly, appropriate spatial boundaries would need to be defined – within or across regions, countries etc.

3. **Determine the scope of the value chain under analysis.** This requires the researchers to understand the system and bring together relevant literature and sources to support their description of the value chain – from production to consumption.

4. **Determine the stocks, flows, outcomes and impacts most relevant for the purpose of the study.** The relevant aspects that should considered through literature review and research are:

At each and every value chain boundary, identify the flows outlined in **Figure 6A.1**. It is important to understand that these flows can help identify pathways through which the four capitals contribute to agri-food value chains, and how in turn agri-food value chains may impact the capital stocks. These may include waste or emissions generated along the way. This of course requires certain level of knowledge and research of the given system in question.

- At each and every value chain boundary, identify the social, produced, natural, and human capital related outcomes of the system (Table 6A.1 provides some examples). This of course requires certain level of knowledge and research of the given system in question.

- Evaluation of these two aspects requires an understanding and mapping of the spatial scales at which these interactions are happening – ecosystem services used at the farm level may be generated beyond the farm, for example. Similarly, health outcomes of a particular food product may happen well beyond the farm, especially if there is international trade.

- Given these considerations, the assessment must identify the impacts that it is choosing to address and the ones it is excluding, and provide appropriate reasons.

5. **Select evaluation techniques.** While the first four steps provide the framing and scope of the evaluation, the next step is to choose the techniques that would help one assess and measure the interactions within a given system. For TEEBAgriFood, the focus is on assessing impacts as contributions to human well-being. Other evaluation methodologies may include life cycle assessment and value chain analysis, and various modelling tools and techniques including partial and general equilibrium models and system dynamics.

6. **Collecting data and undertaking the evaluation.** Once the context and methods for evaluation are set, efforts can be made to collect data. While data availability can be an important factor in defining the scope of assessments, by completing steps 1-5 prior, the implications of lack of data can be understood and can provide motivations for identifying and filling information gaps.

7. **Reporting and communicating findings.** Communicating the results of the evaluation exercise should be seen as an essential part of the process. Particular note should be taken of the need to develop a range of outputs to suit different audiences including politicians and business leaders, technical experts, farmers and local communities and the media.

To support the application and implementation of the Framework and the associated discussions among stakeholders, it may be useful to use the tables and text from Section 6.3 of the chapter that explain the various components of the Framework. With this in mind, the table below provides a stylised version of the Framework in the form of a checklist that can be used by researchers and decision makers to consider the relevant interactions and to ensure awareness of those aspects excluded from an assessment.

Table 6A.1 comprises two main sections: i) stocks/ outcomes (changes in capital stocks) and ii) flows. Several of these elements may be measured differently – for example, in qualitative, quantitative or monetary terms. Impacts (value addition) elements are excluded from this table since the scope of measured impacts will relate directly to the scope of capital stocks, outcomes, and flows that are included in an assessment. The methodologies for assessing impacts are presented in the TEEBAgriFood 'Scientific and Economic Foundations' report, Chapter 7.

It is important to note that several of these elements would require a more detailed description and measurement depending on the scope and context of the assessment being conducted. For example, depending on the assessment, water may include coverage of both

surface and ground water resources. Furthermore, quality indicators of water may include several other elements such as habitat quality or nutrient profile. Finally, it is not always the case that all components receive the same type of evaluation and measurement. Thus, in using the table to assess the coverage of an assessment, it will be relevant to distinguish as to whether a component is being assessed descriptively, quantitatively or in monetary terms.

How does the Framework guide researchers, decision-makers (public or private), local communities, farmer groups and other users?

Utilising a comprehensive and universal Framework provides a common basis to compare assessments, a tool for decision-makers to understand what information is missing, and a means to identify areas of further research.

Since it includes all categories of material interactions in a given food system, the Framework can offer entry points to many people – for example, researchers focusing on social impacts of food systems, can use social capital related outcomes as a starting point, and then make linkages to the other three capitals. Similarly, decision-makers can start at the economic elements, but then identify how these may be related to other capital stocks and flows. The Framework can also help decision-makers quickly identify any blind spots in the information base used to support decision-making. In essence, no matter what the starting point or purpose, the Framework can allow researchers to contextualise their assessments within the broader set of interactions that their food system has. This not only brings transparency to their assessments, but also highlights the opportunities to link their work with other research.

The TEEBAgriFood Framework can also be a starting point for identifying the material elements of particular systems, and thus can lead to the development of guidelines on comparable assessments. For example, similar firms, in terms of size and products, in the food and beverage sector could use this Framework to identify the main impacts and dependencies of their sector's operations. Similarly, organisations such as farmer cooperatives, consumer protection groups and local governments could elaborate the impacts and dependencies most relevant from their perspective. We encourage the adoption and adaptation of the Framework by diverse groups, and hope that over time, sector specific guidelines can emerge from the TEEBAgriFood Framework.

Further, the Framework is intended for use in an interdisciplinary manner, where the questions to be analysed, the options to be compared, and the scale, scope, and relevant variables included are determined in an open and participatory way. This engagement should occur before the appropriate assessment and valuation methods are implemented.

Overall, the Framework also allows for a broadening of our understanding and conversations around agricultural and food systems. Our aim is that international policies and targets increasingly begin to recognize the interlinkages, in terms of impacts and dependencies that food systems have with our economies, societies, health, and environment. In this task, using the Framework and its language can allow for the next generation of agricultural and food research to provide a more comprehensive basis for decision-making.

Table 6A.1 Sample checklist to assess coverage of a given eco-agri-food system application (Source: authors)

Example of a checklist to asses coverage of a given eco-agri-food systems						
			Value chain			
			Agricultural production	Manufacturing & processing	Distribution & marketing	Household consumption
Stocks / Outcomes (change in capital stock)						
	Natural capital	Water (incl.quality, quantity)				
		Soil (incl. quality, quantity)				
		Air				
		Vegetation cover and habitat quality				
		Biodiversity				
		Other				
	Produced capital	Buildings				
		Machinery				
		Infrastructure				
		Research and development				
		Finance				
		Other				
	Human capital	Education/skills				
		Health				
		Working conditions (decent work)				
		Other				
	Social capital	Land access/tenure (private, public and communal)				
		Food security (access, distribution)				
		Opportunities for empowerment (gender and minority)				
		Social cooperation (incl. networks/unions)				
		Institutions				
		Laws and regulation (e.g. child labor)				
		Other				

Flows						
	Agricultural and food outputs	Agricultural and food products				
		Income: value added, operating surplus				
		Subsidies, taxes and interest				
	Purchased inputs	Labour inputs (incl. skills)				
		Intermidiate consumption (produced inputs such as water, energy, fertilizers, pesticides, animal health and veterinary inputs)				
	Ecosystem services	Provisioning (e.g. biomass growth, freshwater)				
		Regulating (e.g. pollination, pest control, nutrient cycling)				
		Cultural (e.g. landscape amenity)				
	Residuals	Agricultural and food waste				
		GHG emissions				
		Other emissions to air, soil and water				
		Wastewater				
		Solid waste and other residuals				

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