Valuing the impact of food:

Towards practical and comparable monetary valuation of food system impacts

A report of the Food System Impact Valuation Initiative (FoodSIVI)

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ALIGNMENT OF IMPACT FRAMEWORKS SUMMARY

Impact frameworks outline the basic process for impact valuation. This section examines two leading food system impact frameworks: the TEEB AgriFood Evaluation Framework and the Natural, and Social and Human, Capital Protocols. The Natural Capital Protocol has a Food and Beverage Guide.

This section finds that the impact frameworks are aligned. They identify a process where food system activities, with their upstream inputs and downstream outputs, are identified and measured for factors which drive changes in natural, social, and human capital. Determining the amount of capital change caused by the factors is called attribution. What effect the capital change has on social and human well-being is estimated by a valuation of the capital changes. The three steps linked together: activities, attribution to capital changes, valuation of capital changes, are a valuation of the changes in social and human well-being due to activities of a food system actor. That is, an impact valuation. Quantification of the factors which link activities of the food system actor to capital changes and impact is introduced in the next section under the term footprint. Greater detail within the three steps is considered in the next section.

The previous section argued that comparable and agreed valuations of the major external costs introduced by the food system are likely to have the most effect on reducing impact. Comparable valuation is needed for external correction such as impact investing and government policy. This implies a shared decision process, whereas the Protocols concentrate on a company's internal decision process. The scoping steps in the impact frameworks are considered with this view. The scoping steps that lead to the three steps of impact valuation include system boundaries and value perspectives.

This section finds that comparable valuation will likely involve a limited number of frequent uses. External corrections are resource intensive, limiting their number, and likely to be applied at scale, increasing their frequency of use. The limited number of use cases provides an opportunity to standardise scope for impact calculations. External use cases could base their requirements on the fixed scope. It is recommended to push variation of scope such as non-disclosure of a footprint into the impact calculation. Impact calculations already have variation and uncertainty which needs addressing. Sources of variation and uncertainty are discussed in detail in the next section.

Uncertainty in valuation of impacts from externalities represent risk or opportunity transacted from business to society. Information on, and comparability of, the uncertainty in the monetary value is as important as the monetary value itself. Non-disclosure, through uncertainty in the actor's footprint and the total societal footprint, has a double contribution to uncertainty in impacts and hence risk borne by society.

The section recommends a non-financial capital accounting framework for the food system as an eventual basis for comparable impact valuation. It would specify:

- Issues associated to the major external costs introduced by the food system – which guide what to measure.
- Footprint: what to measure, i.e. what aspects of a business or food system actor's operation; what units; what to disclose (a footprint protocol).
- Capitals: what to measure, i.e. the capital change most relevant to societal impact, intersected with the capital change attributable to food system actors.
- Formalisation of the exchanges and contributions between footprints, capitals, footprint to capital and capital to human well-being relevant to impact (impact pathways).

A first step toward the accounting framework would be a footprint protocol. It is found that the SEEA-EEA, the ecosystem component of the UN System of Environmental Experimental Accounting, and the Sustainability Assessment of Food and Agriculture systems (SAFA) terminology from the UN Food and Agriculture Organization (FAO) offer a blueprint and basis for the accounting framework. A second step would be collating impact pathways presently distributed in literature across different disciplines.

CONTENTS

ALIGNMENT OF IMPACT FRAMEWORKS

Valuation is part of the Measure and Value stages of the Natural and Social & Human Capital Protocols. It also part of the TEEB AgriFood Evaluation Framework under the term evaluation.

Steps to measure and value

The Protocols outline nine steps to understand, measure, value and improve the natural, social and human capital performance of a company (Figure 5).

This report concerns impact valuation of the societal impacts of the food system. The previous section argued that this will fix a list of material issues and the need for comparable valuations. In this section we discuss how this fixes consideration in the Protocols for the scope of the impact calculation.

Under "Measure and Value" are three steps (Figure 6), indicating footprint (Step 05), attribution of changes in the quantity and quality of capital stocks to the incurred footprint (Step 05 to Step 06), and the valuation of the capital changes (Step 06 to Step 07). In the chapter Food System Impact Valuation in Practice we define impact valuation according to footprint, attribution, and valuation, corresponding to the Steps 05-07.

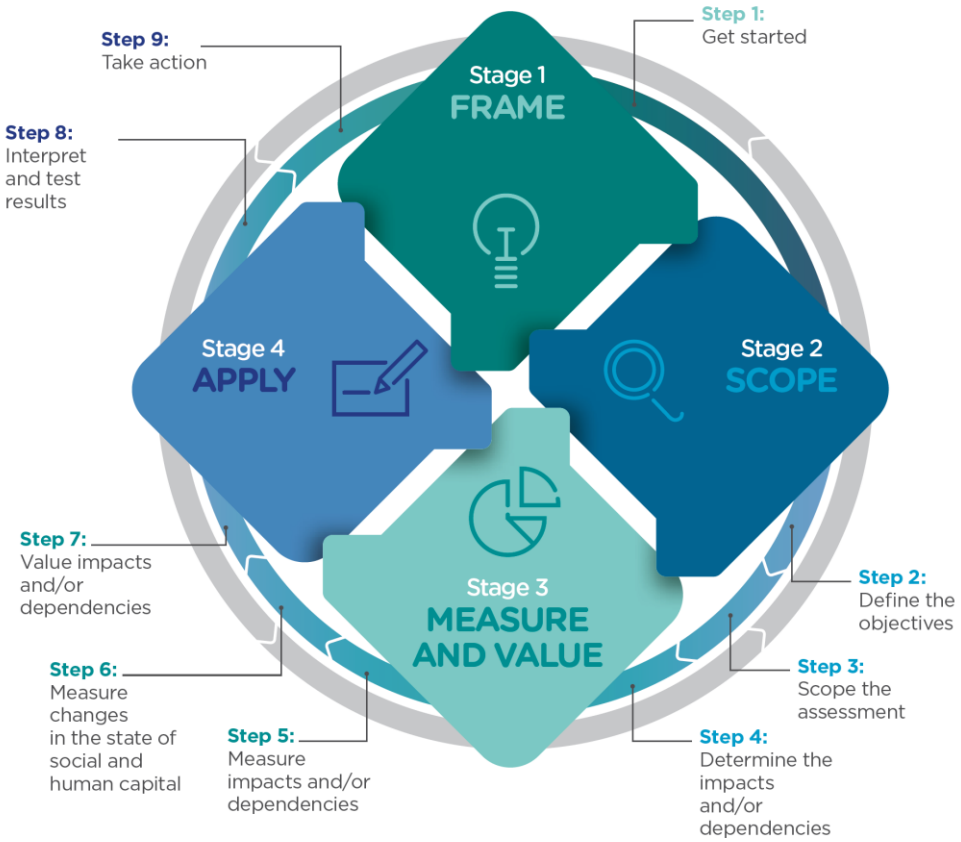

Figure 5: Steps in the Natural and Social & Human Capital Protocols (Source: S&HCC, Social & Human Capital Protocol).

The TEEB AgriFood initiative and the Natural, and Social & Human, Capital Coalitions emerged from an earlier TEEB initiative. The common conceptual basis between flows-outcomes-impacts in the TEEB AgriFood Evaluation Framework and driver-capital changes-values in the Protocols should therefore be expected (Figure 7 and Table 2).

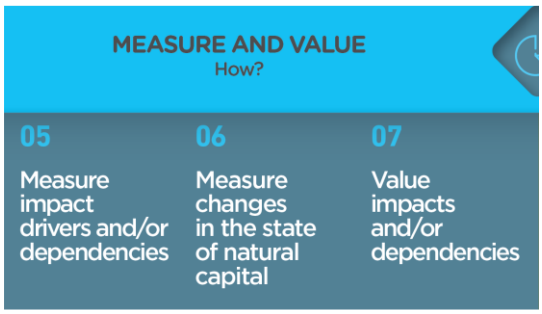

Figure 6: Steps 05-07 in Measure and Value (Source: NCC, Natural Capital Protocol).

Impact in both the TEEB Framework and the Protocols is defined as impact on human well-being[1]. This report uses the terms economic value synonymously with human well-being and a broad measure of welfare. The term impact is also used in some environmental studies to mean impact on capital, which are outcomes in the TEEB terminology.

The trend in environmental impact assessment is converging toward sustainability assessment including socio-economic and well-being indicators[2].

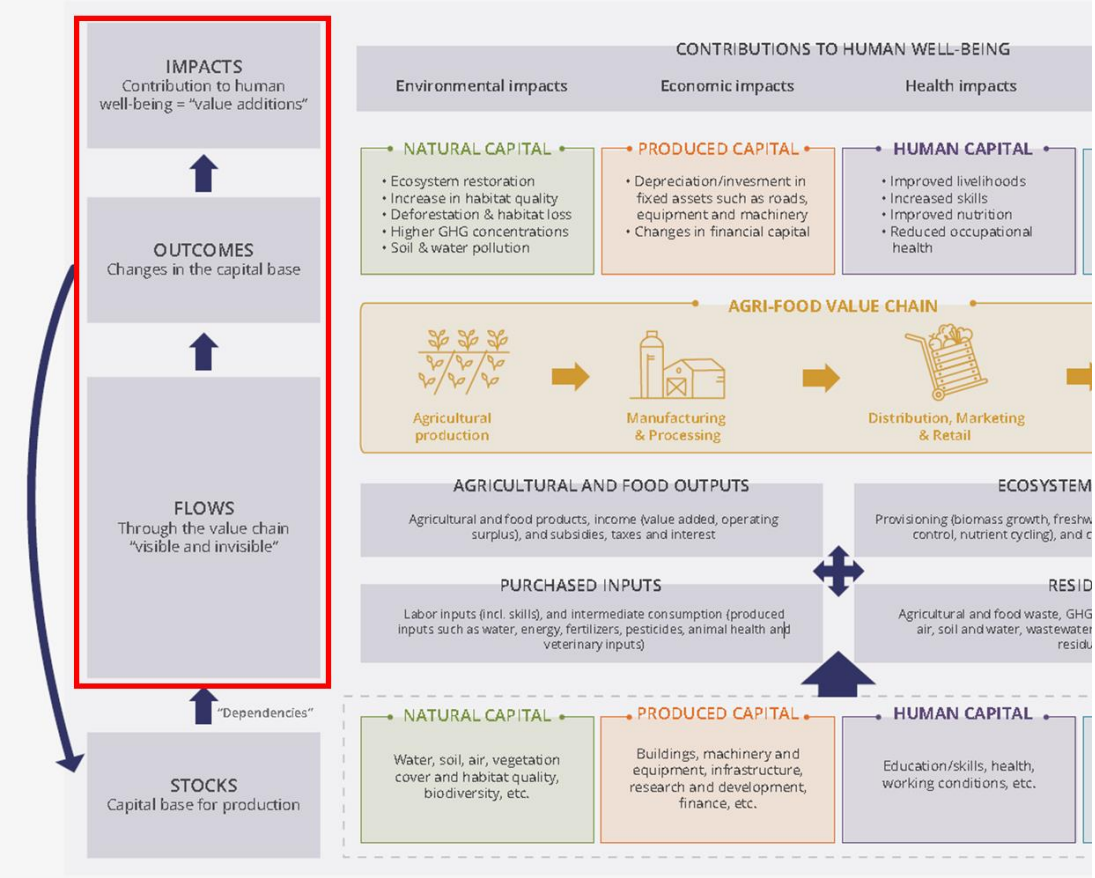

Figure 7: Concepts in the TEEB AgriFood Evaluation Framework, where flows include drivers in the terminology of the Protocols, outcomes include changes in capitals attributable to food system actors, and impact includes value changes due to changes in capital. (Source: TEEB, *TEEB for Agriculture & Food: Scientific and Economic Foundations* p. 238)

[1] A. McGregor, S. Coulthard, and L. Camfield, *Mesauring what matters: the role of well-being methods in development policy and practice*, Overseas Development Institute (ODI) (London, 2015); OECD, *OECD Guidelines on Measuring Subjective Well-being* (2013). P. Dasgupta, *Human Well-Being and the Natural Environment* (Oxford: Oxford University Press, 2002); P. Dasgupta and A. Duraiappah, "Well-being and wealth," in *Inclusive Wealth Report 2012: measuring progress toward sustainability*, ed. IHDP-UNU and UNEP (Cambridge: Cambridge University Press, 2012).

[2] J. Glasson, R. Therivel, and A. Chadwick, *Introduction to environmental impact assessment*, 4th Edition ed. (London: Routledge, 2013).

Other frameworks for impact valuation include the Impact Valuation Roundtable (IVR) white paper. It is based on the terms input-activity-output-outcome-impact[3]. Here input-activity-output falls within the scope of drivers (Protocols) and flows (TEEB Framework). Outcome and impact have the same meaning as for the TEEB Framework and the Protocols. Impact valuation defined in terms of a measurement of activity attributed to capital change (Step 05), attribution (Step 05 to Step 06) and valuation (Step 06 to Step 07) is common to all frameworks (Table 2). Social return on investment (SROI) is another philosophically aligned framework. It is based on input-activity-output-outcome-impact and seeks to value welfare beyond aggregated individual utility of consumption. SROI is a more abstract framework. It does not factor welfare impacts through a stock and flow construction like natural, and social and human capitals. SROI is not a direct foundation on which to build a non-financial capital accounting structure, unlike the TEEB AgriFood Evaluation Framework. Monetary valuation attached to life-cycle impact assessment (LCIA) has essentially the same presentation as the impact frameworks that have been mentioned[4].

Table 2: Alignment of impact frameworks. The terms are not directly interchangeable, e.g. Flows in the TEEB AgriFood Evaluation Framework is a more general concept than Impact Drivers in the Protocols, but there are either inclusions or basic mappings between them

	Drivers of capital change	***Capital change***	***Value of capital change***
	Step 05	**Step 06**	**Step 07**
Protocols	Impact Drivers (of the business)	Changes in the state of capitals	Value impacts
TEEB	Flows	Outcome	Impact
IVR & SROI	Input-Activity-Output (of the business or project)	Outcome	Impact
E.Valu.A.TE	"Scenarios" and "Activities and Impacts"	Models and Data to quantify changes	Human Welfare Impact and Valuation

Both the Protocols and the IVR white paper make explicit the actors' drivers of capital change. They are less explicit on the other drivers required to calculate how much capital change is attributable to the actor's drivers. For example, the impact from a business's own emissions depends on the total emissions of businesses and society and socio-economic trends into the future. Obesity social costs depend on the nutrient profile and quantity of a produced food (a

[3] Also the model in Social Return on Investment (SROI): A. E. Roest, A. v. Schie, and G. S. Venema, "Using SROI and SCBA for measuring social return of Green Care in Agriculture" (paper presented at the COST Action 866-meeting, Green Care in Agriculture, Witzenhausen, Germany, 24 - 28 August, 2010, Loughborough, 2010). Originating as the Logic Model in planning and evaluation, J. A. McLaughlin and G. B. Jordan, "Logic models: a tool for telling your programs performance story," *Evaluation and Program Planning* 22, no. 1 (1999), https://doi.org/https://doi.org/10.1016/S0149-7189(98)00042-1; D. A. Julian, A. Jones, and D. Deyo, "Open systems evaluation and the logic model: Program planning and evaluation tools," *Evaluation and Program Planning* 18, no. 4 (1995), https://doi.org/10.1016/0149-7189(95)00034-8.; S. Vionnet and J.-M. Couture, *Measuring Value - Towards New Metrics and Methods*, Quantis and Ageco (Switzerland, 2015); IVR, *Operationalizing Impact Valuation: Experiences and Recommendations by Participants of the Impact Valuation Roundtable*, Impact Valuation Rountable (2017), https://docs.wbcsd.org/2017/04/IVR_Impact%20Valuation_White_Paper.pdf.

[4] See for example Figure 9, p. 37: S. de Bruyn et al., *Environmental Prices Handbook EU28 Version*, CE Delft (Delft, The Netherlands, 2018), https://www.cedelft.eu/en/publications/2113/envionmental-prices-handbook-2017.

business output) and on the combination of quantities consumed in diets by subpopulations of society that have different levels of exercise, personal physiology, and biochemistry. Other drivers are a major source of variability in valuations. All the drivers mentioned sit conceptually under flows in the TEEB AgriFood Evaluation Framework.

The Protocols provide examples for performing Steps 05-07 for a food system actor. No emphasis is placed on comparability. The TEEB AgriFood Evaluation Framework describes a stepwise process in Chapter 6 (Figure 8) of the Framework that does not line up directly with Steps 05-07 in the Protocols. They can be mapped to each other. Chapter 7 of the TEEB AgriFood Evaluation Framework presents a common list of valuation methodologies[5]. The Cambridge Institute for Sustainability Leadership (CISL) developed the E.Valu.A.TE process for valuation of environmental externalities. The CISL process is similar to the TEEB AgriFood Evaluation Framework steps in Figure 8.

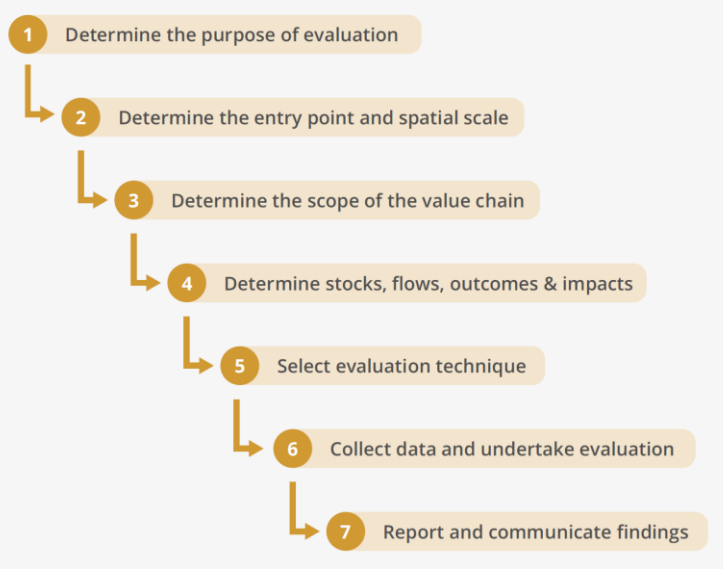

Figure 8: Steps for applying the TEEBAgriFood Evaluation Framework (Source: TEEB, *TEEB for Agriculture & Food: Scientific and Economic Foundations* p. 232). Steps 1-3 are primarily scoping and have the same effect as Steps 02-04 of the Protocols. Steps 4-6 are different to Steps 05-06 in the Protocols.

The TEEB AgriFood Evaluation Framework focusses on all capitals and food system actors. TEEB case studies have focussed on community, regional or national true-cost accounting and valuation[6]. The TEEB Framework comprehensively covers upstream (supply chain) and downstream (population health effects of consumption). The combination of the Protocols covers all capitals and is aimed at business, with case studies of food companies in the Food & Beverage guide. The case studies concentrate on changes due to upstream activities. E.Valu.A.TE considers upstream natural capital changes. Within this scope the E.Valu.A.TE process is clearer than the TEEB AgriFood Evaluation Framework steps in Figure 8.

Comparable and non-comparable valuations have different implications for capturing and transacting the uncertainty in the valuation. Sensitivity analysis for an end decision or application (Step 8 of the Protocol process in Figure 5) is different than the uncertainty in the valuation[7]. A business decision about whether to proceed with produced capital investment is generally less sensitive to different values of, say, the social cost of carbon, than an impact

[5] Section 7.3, p. 255, TEEB, *TEEB for Agriculture & Food: Scientific and Economic Foundations*, UN Environment (Geneva, 2018).; p. 114, UNEP, *Inclusive wealth report 2018 : measuring progress towards sustainability* (Cambridge: Cambridge University Press, 2018).; p. 22, FAO, *Food loss and waste: issues and policy options*, Food and Agriculture Organization of the United Nations (Rome, 2017).; p. 66, M. Schaafsma and G. Cranston, *E.Valu.A.TE: The Practical Guide*, The Cambridge Natural Capital Leaders Platform (Cambridge, UK, 2013).

[6] http://www.teebweb.org/resources/case-studies/

[7] Step 8.3 on p. 65 of S&HCC, *Social & Human Capital Protocol*, Social & Human Capital Coalition, World Business Council for Sustainable Development (Geneva, 2019), https://docs.wbcsd.org/2019/02/Social_and_Human_Capital_Protocol.pdf.; See also Step 5.5 p. 80 in Schaafsma and Cranston, *E.Valu.A.TE: The Practical Guide*.

valuation. If different estimates of the social cost of carbon are used the decision may well be the same. If different estimates of the social cost of carbon are used the impact valuation is not going to be the same.

The previous section argued that comparable and agreed valuations of the major external costs introduced by the food system are likely to have the most effect on reducing impact. Comparable valuation is needed for external correction such as impact investing and government policy. In a shared decision process the impact valuation itself is shared information for a determination of penalties or incentives received by the business (Figure 9).

Uncertainty in valuation of impacts on society due to externalities represent risk or opportunity transacted from business to society. Information and comparability of the uncertainty in the monetary value is as important as the monetary value itself.

The uncertainty and choices behind the impact valuation become relevant to the other party. Ultimately, uncertainty in valuation of impacts on society due to externalities represent risk or opportunity transacted from business to society. Information and comparability of the uncertainty in the monetary value is as important as the monetary value itself in this case.

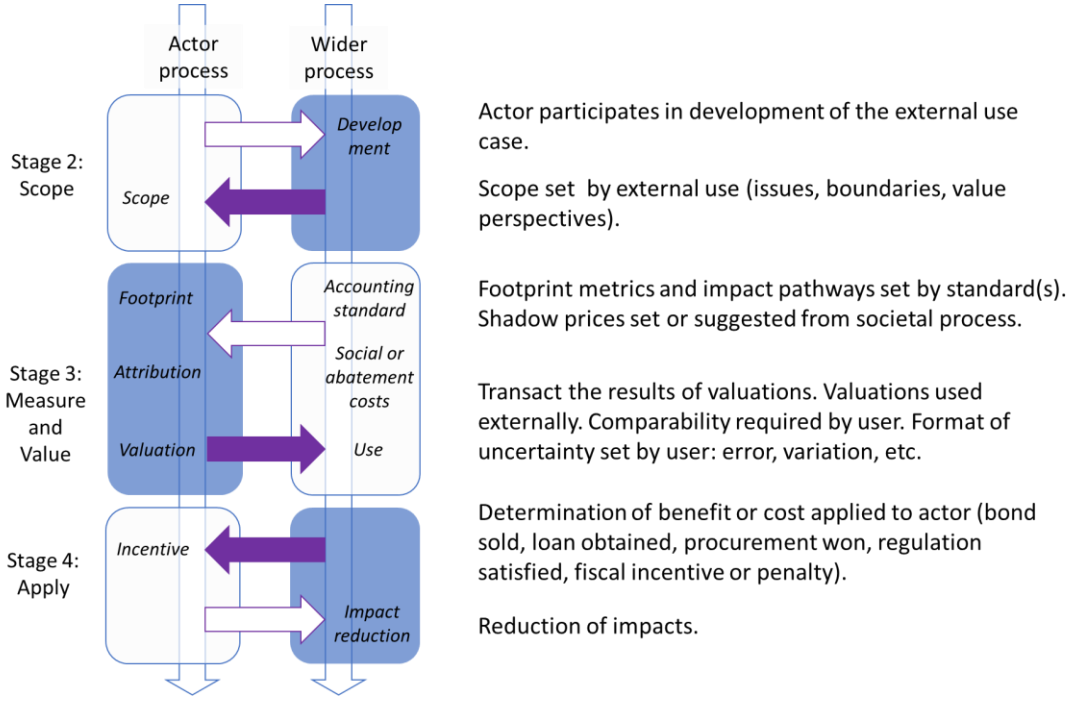

Figure 9: Stages for a shared decision process

Boundary conditions

The business sets the scope of impact valuation in the Protocols. The Protocols discuss material issues to stakeholders relevant to the business decision. An external use case where society is the stakeholder with the purpose of reducing the major external costs introduced by the food system sets the issues of concern. The issues of concern are those associated to the major external costs introduced by the food system (Table 1 in chapter Economic Theory of Change). They and the use case set what to measure, what to include in scope, what are the impact pathways, what to report, what will be the result (Figure 9). We explain that this does not limit the boundaries discussed in the Protocols. It does set the scope of the impact calculation and the value perspective.

The organisational scope is not limited (Figure 10). The social costs from changes in natural, social, and human health capital can be factored into a corporate impact statement or added to the price of individual products as an indicator of their sustainability.

The geographic extent of activities is not limited (Figure 10), the criteria of a material issue for society is the concurrent global impact of local activities. For example, a pollutant in a local waterway not presently threatening planetary boundaries due to its global use, and not especially amplifying the impact of pollutants that are, is a local material issue. Valuation of the impact of nitrogen leaching from a specific locality is still within the scope of a material issue for society because of the concurrent impacts from nitrogen. A local issue with concurrent global impacts will be more costly than if it were a localised material issue. This is evident from the difference between carbon emissions from energy production when the rest of the world is emitting carbon for energy production, versus carbon emission in one locality if the rest of the world were emitting no carbon for energy production at all.

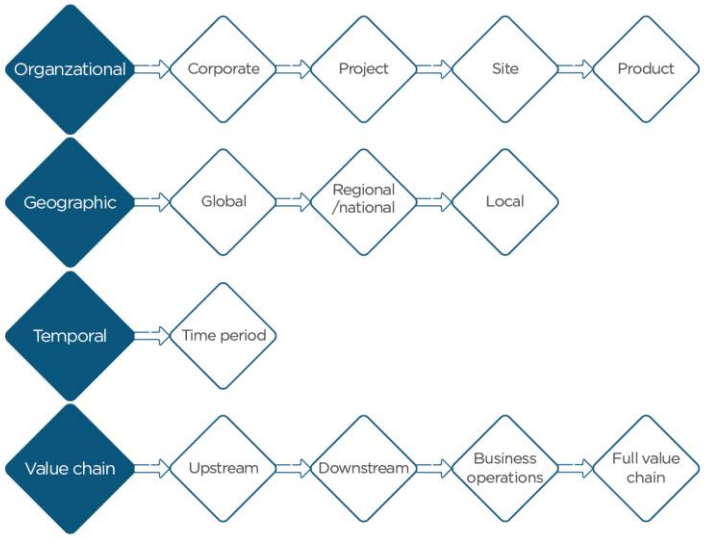

Figure 10: Representation of basic boundaries in the Protocols (Source: S&HCC, *Social & Human Capital Protocol, p. 25)*

Value chain scope of activities can be upstream, downstream, business operations or full value chain (Figure 10). Activities in any of these scopes can contribute to the major external costs introduced by the food system. The use case will fix the scope. Extended producer responsibility is unresolved for food products. It is unclear what proportion of downstream impacts should be attributed to the agricultural producer, the food product manufacturer, or the retailer. Most uses will need a way to account, or transact, impact between actors in the value chain to avoid double counting of impact in the food system. Conceptually this is no different from value adding to determine total market value. Impact is, generally, not linear in footprint. Assumptions are required to use footprint accounting, e.g. lifecycle inventory, to apportion impact.

In summary, comparable impact valuations

- will involve objectives, scope of activities, and boundaries, set by the external use of the impact valuation, not chosen by the food system actor.

This

- specifies scope of the impact calculation not the scope of activities.

Temporal scope of activities is mostly fixed by the use. An impact statement looks at annual period of activity. A procurement might look at the total lifetime of activity of the full value chain

(inputs, production, consumption, disposal). The temporal scope of impacts is total lifetime of impacts. We diverge in the next few paragraphs to discuss this.

Irreversible losses in capital changes caused by present activities are often raised as a problem with calculating total impacts. The impacts may continue to compound into the future making the aggregate impact over the full lifetime 'infinite'. Three factors mediate this in practice.

First, monetary valuation of impact on welfare involves an extended representation of economic value loss or gain against a baseline. Discounting (the creation of value in the future from the capital base outside of the irreversible capital loss or due to consumption of that capital) can make the opportunity loss to future economies of irreversible capital changes from present activities finite when aggregated over the future. A second component of discounting does not assume an increase of value in the future, but that there is an opportunity loss to present economies compared to future ones from not utilising a non-renewable resource. Assumptions about intergenerational welfare create variability in the application of the two components[8]. The ethical choices implicit in impact valuation, including discounting, are discussed further in the chapter Food System Impact Valuation in Practice.

Second, future irreversible capital losses are uncertain. If we assume that economies of the future will compensate for the value loss at some stage then the issue is not an 'infinite' valuation, but what is the behaviour of the tail in a distribution of valuation estimates toward infinity. A distribution of valuation estimates is illustrated in the discussion of the social cost of carbon (Figure 14 in the chapter Food System Impact Valuation in Practice). Assuming that economies of the future will compensate for the value loss is routinely done. It is implicit in the climate change discussion that there is a zero chance that future economies will not overtake in value the loss of non-renewable fossil fuels utilised for present welfare. Understanding a distribution of valuation estimates is one of the reasons why communication and comparability of not only the valuation, but the uncertainty in the valuation, is needed. Society, as the ultimate stakeholder and bearer of externalities, including catastrophic irreversible losses, needs to attribute those possibilities to the activities of the externality producer. 'Fatter' tails in distributions of valuations involving long-term impacts will mostly be due to catastrophic irreversible losses as discount rates kills more certain, time limited and smaller scale economic impacts[9].

Third, unless the irreversible capital loss, of the kind where economies of the future will not compensate for the value loss (e.g. planetary loss of human life-support services), is certain to occur from activities within the temporal scope of activities (e.g. annual emission), then an infinite social cost calculation is not necessarily required to sponsor a finite abatement cost. The social cost need only be, in practice, finite but sufficiently large. Equivalently, the assumption is future economies will abate such losses, i.e. social optimism[10]. For example, the loss of territorial lands of an indigenous people through environmental degradation may be associated to irreversible welfare loss in their economy. The staggering costs of a utilitarian

[8] P. Dasgupta, "The Stern Review's economics of climate change," *National Institute Economic Review* 199, no. 1 (2007), https://doi.org/10.1177/0027950107077111.

[9] M. Weitzman, "Fat-tailed uncertainty in the economics of catastrophic climate change," *Rev. Environ. Econ. Policy.* 5 (2011). R. S. Pindyck, "The social cost of carbon revisited," *Journal of Environmental Economics and Management* 94 (2019), https://doi.org/https://doi.org/10.1016/j.jeem.2019.02.003.

[10] K. Schweizer and R. Schneider, "Social optimism as generalized expectancy of a positive outcome," *Personality and Individual Differences* 22, no. 3 (1997), https://doi.org/https://doi.org/10.1016/S0191-8869(96)00219-X. T. Sharot, "The optimism bias," *Current Biology* 21, no. 23 (2011), https://doi.org/https://doi.org/10.1016/j.cub.2011.10.030. E. M. Markowitz and A. F. Shariff, "Climate change and moral judgement," *Nature Climate Change* 2, no. 4 (2012), https://doi.org/10.1038/nclimate1378.

parity calculation of, say, compensation (the cost per capita of moving the UK or Switzerland's population if the equivalent capital loss occurred in those economies), would likely be a sufficient lower bound on social cost to sponsor abatement.

A belief amongst parties that activities within the temporal scope of activities (e.g. this year's emissions) will result in certain destruction of non-renewable capital with a non-zero chance of irreversible intergenerational welfare loss invalidates the three mediations described. Moral and ethical discussion of, and action on, irreversible welfare losses under such assumptions is outside the scope of valuation theory and the economic theory of change[11].

The three factors discussed can produce finite impact estimates from the full lifetime of impacts. Uncertainty in the impact valuation is increased by including full lifetime of impacts. The uncertainty introduced is less than the error that would be introduced by omitting future impacts. Variation and uncertainty in impact valuation is discussed in the chapter Food System Impact Valuation in Practice.

The recommendation in this report is that scope and boundaries for comparable monetary impact valuations be fixed by uses, and that variations, including non-disclosure of information within that scope, be pushed into the uncertainty in the impact calculation. For example, an investor sponsored protocol for standardised corporate reporting of food system impacts might include calculating the annual company impact from non-renewable water extraction. A company might not have data on non-renewable water extraction. If the company omits the contribution of non-renewable water extraction to the impact valuation, the investors cannot compare the impact valuation with other companies that have the data. The investors have set the scope through the protocol. They can compare all companies at the same scope and the same boundaries by putting a non-renewable water extraction figure in for the company that omitted it. The maximum figure amongst all the other companies scaled for market share or total production volume is one way to penalise non-disclosure. This makes the impact valuation of the company that did not disclose uncertain but comparable.

Scope of impact valuation for reducing the major external costs of the food system

Comparable valuation of impacts with the purpose of reducing the major external costs introduced by the food system narrows the scope of the impact frameworks, which are more general.

We phrase limitation of scope in the terminology of the Protocols' Stage 2: Scope.

Step 02: Define the objective will be fixed by the use case of the valuation where comparison is required, for example an impact statement. Step 03: Scope the assessment sets boundary conditions and whose value perspectives[12].

Value perspective

For comparable impact valuations with the purpose of reducing the major external costs introduced by the food system the value perspective is "impact on society". What impact on society means in practice is specification of impact pathways according to the issues of concern in Table 1 in chapter Economic Theory of Change, specification of economic value or

[11] S. Rose-Ackerman, "The Limits of Cost/Benefit Analysis When Disasters Loom," *Global Policy* 7, no. S1 (2016), https://doi.org/10.1111/1758-5899.12279.

[12] D. W. Cash et al., "Scale and cross-scale dynamics: governance and information in a multilevel world," *Ecology and Society* 11, no. 2 (2006), http://www.ecologyandsociety.org/vol11/iss2/art8/; G. Midgley, "The sacred and profane in critical systems thinking," *Systems practice* 5, no. 1 (1992), https://doi.org/10.1007/BF01060044.

welfare, the ability to forecast economic trajectories with and without impact, and the choice of parity and discounting. We discuss these factors further in the chapter Food System Impact Valuation in Practice.

Comparable valuation that contributes to food system transformation will likely involve a limited number of frequent uses. Internalisations that involve external corrections are generally resource intensive, limiting their number, and likely to be applied at scale, increasing their frequency of use. The limited number of use cases provides an opportunity to standardise scope. We recommend pushing variation of scope into the impact calculation.

- Placing the value perspective, or the definition of welfare, into the model of the economies, is in-line with social and abatement costs in welfare economics. Many other boundary conditions, including value judgements (e.g. choice and quality of model and data, choice of discount rate), are already inside the valuation calculation[13].
- These considerations require an agreed and credible process. They should not validate by economics the destruction of an ecosystem in one part of an 'economically' unimportant part of the world (substitution of economic value). Present approaches for business impact valuation still permit this, especially in adding up 'total value'. For the issues of concern to society, society, as risk bearer of the externalised costs, needs to set the value perspective. Valuation components such as shadow prices and their uncertainty, and the choices of spatial and temporal parity should be, in the end, the result of a societal scientific process.
- Even if a business uses software to perform a valuation that, in its simplest form, requires as input a standard list of footprints from the business's own operations (for example a lifecycle inventory) and provides as output a valuation, for comparability the business or software will need to report on the assumptions underlying the calculation. This does not appear onerous. If society, through internalisation, requires of business comparable valuations, business demands of the software vendor a button to export appropriate metadata on the calculation. The metadata should allow a recalculate the valuation. The discussion in later sections of this report indicates the kind of metadata needed.
- Business should be users of marginal valuations such as the social cost of carbon, not developers. The potential frequency of use of comparable impact valuations needs to sponsor the societal development (by a consortium of intergovernmental and institutional actors and experts, in collaboration with the food sector) of the valuation factors.
- Putting uncertainty from scope into the impact calculation introduces uncertainty into the impact valuation. Impact valuations will already have considerable uncertainty from other factors, described in the chapter Food System Impact Valuation in Practice. Some of those uncertainties are irreducible. There does not seem a credible way of avoiding measurement and valuation of the uncertainty[14]. Uncertainty exists in both marginal social and abatement costs[15].
- The complication of dealing with distributions of variation estimates is placed on the societal development. Business do not need to deal with the distributions, only

[13] M. Fleurbaey et al., "The Social Cost of Carbon: Valuing Inequality, Risk, and Population for Climate Policy," *The Monist* 102, no. 1 (2018), https://doi.org/10.1093/monist/ony023.
[14] Dasgupta and Duraiappah, "Well-being and wealth." argue that the shadow prices will never be "right", they are fundamentally uncertain.
[15] D. Helm, *Carbon valuation in UK policy appraisal: a revised approach and peer reviews. Peer review Dieter Helm.*, Natural Capital Comittee. UK Department of Energy & Climate Change. (London, 2009), https://www.gov.uk/government/publications/carbon-valuation-in-uk-policy-appraisal-a-revised-approach.

numbers – but that number could include the cost of a risk premium to society from the uncertainty in the valuation.

- Valuations already deal with uncertainty of impacts on the value of produced and financial capital where there are limited markets for exchange and infrequent transactions, e.g. catastrophe bonds, and terrorism and cyberattack insurance. The uncertainty in valuation of non-financial capital changes is large and more complicated, indicating a higher premium, as befits the risk society bears when business and society alike cannot estimate with accuracy the impacts of externalities.

We have not been very specific on uncertainty. The division of risk and uncertainty attributed to Knight is common in financial and economic disciplines. Risk is a measure of observed variation in the Knight view. Risk in the ISO31000 view is uncertainty in the distribution of impact, which may include representation of epistemological uncertainty (lack of knowledge) as well as aleatory uncertainty (randomness)[16].

How adding a risk premium to an impact valuation might work practically is discussed in the chapter Food System Impact Valuation in Practice.

Non-financial capital accounting frameworks for food systems

A non-financial capital accounting framework for food systems based on the issues associated to the major external costs would consolidate the scope further and provide a standard basis for uses. The System of Environmental-Economic Accounting (SEEA) is an example of an accounting framework that includes non-financial capital accounting. It is designed for national accounts. The resolution is too coarse to act as an accounting basis for most internalisation mechanisms and it is not specific to food systems. A non-financial capital accounting framework for food systems at a resolution that aligns with the internalisations that have the potential to create the most change does not yet exist.

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In the Protocols, Step 04: Define the impacts lists material issues, a consideration of how they result in impact, called an impact pathway, and prioritization of issues according to impact. This step for comparable valuations is fixed by the issues associated to the major external costs introduced by the food system. A standard list of issues can be extracted from the large amount of scientific literature on food system impact and consolidated through a societal process. The FAO Sustainability Assessment of Food and Agriculture systems (SAFA) Guidelines and the EU SUSFANS project are examples of consolidation of literature on which a food system specific accounting framework could be based[17]. The list of issues would already be prioritised according to societal impact. Trade-offs across the activities of the food system that contribute to these issues means that impact valuation should include the full range of capitals, rather

[16] S. F. LeRoy and L. D. Singell, "Knight on Risk and Uncertainty," *Journal of Political Economy* 95, no. 2 (1987), https://doi.org/10.1086/261461; M. E. Pate-Cornell, "The Engineering Risk Analysis Method and Some Applications," in *Advances in Decision Analysis*, ed. W. Edwards, R. F. Miles, Jr., and D. Von Winterfeldt (Cambridge, UK: Cambridge University Press, 2007); Standards Australia and Standards New Zealand, *AS/NZS ISO31000:2009 Risk management - Principles and guidelines*, IEC (Geneva, Switzerland, 2009).

[17] FAO, *Sustainability Asessment of Food and Agriculture Systems (SAFA) Guidelines*, Food and Agriculture Organization of the United Nations (Rome, 2014), http://www.fao.org/3/a-i3957e.pdf; M. Zurek et al., "Assessing Sustainable Food and Nutrition Security of the EU Food System—An Integrated Approach," *Sustainability* 10, no. 11 (2018), https://doi.org/10.3390/su10114271.. The SUSFANS project is more specific on metrics.

than concentrate on natural or on social and human. For example, climate change, human health and agricultural livelihoods involve intertwined impact pathways.

A non-financial capital accounting framework for the food system would specify

- Issues associated to the major external costs introduced by the food system – which guide what to measure. Measuring all the difference from capital changes caused by activities of the food system would be difficult and unnecessary. The issues identified represent scientific consensus about what components of activities are believed to produce the most difference in welfare in economies of concern. Working with these issues restricts measurement and specifications to what is believed to be most of the impact.
- Footprint
    - What to measure, i.e. what aspects of a business or food system actor's operation
    - What units
    - What to disclose
- Capitals
    - What to measure, i.e. the change in value flow from which capitals is most relevant to societal impact, intersected with the value flow from which capitals is attributable to food system actors.
    - Stocks
    - Quantity and qualities
- Formalisation of the exchanges and contributions between footprints, capitals, footprint to capital and capital to human well-being relevant to impact (impact pathways).

Capital changes are relevant to national accounting of assets, e.g. natural capital accounting in the UK, and processes to determine and update social and abatement costs.

Reconstructing what footprints and impact pathways are relevant proceeds in reverse. The scientific literature starts with value loss and deconstructs what changes in the capital base produce it, what changes in the capital base are due to the food system, and then what aspects of business or food system actor operation need to be measured in a prioritised sense of a feasible set covering most of the value loss.

The TEEB AgriFood Evaluation Framework lists material issues and what conceptually to measure. It is not prescriptive on metrics and units, and, to retain universality across a range of evaluation approaches, does not formalise impact pathways. It is not an accounting framework in the above sense.

The SEEA has a component for Agriculture, Forestry and Fisheries, SEEA-AFF. It concerns national aggregates and is environmentally focussed, but it provides a baseline for accounting.

A capital accounting framework fixing the measurement and disclosure scope, which use cases could base their own requirements on a subset of if necessary, is the eventual requirement for comparable valuations. Arguments why a footprint has not been included in the scope become part of disclosure. Non-disclosure should be pushed into the uncertainty in the valuation. The rationale is the same as before: society bears the risk of business externalities and risk has increased through lack of information. Note that disclosure does not just affect a business' own determination of attribution for the valuation, but the calculation of shadow prices depends on information from the sector, and other economic sectors, as a whole. Non-disclosure has a double contribution to uncertainty in the impact valuation, and hence risk to society.

In suggesting what a non-financial capital accounting framework for food systems should include above, we have covered inventory accounting. In the System of Environmental

Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA), this corresponds to Chapters II, III, IV. Even though SEEA-EEA is designed for national accounts it needs geospatial context to do so. The SEEA-EEA recognises that the spatial resolution of capitals, capital changes and impacts does not accord with national boundaries. This is also essential for accounting for food system impacts. The spatial resolution at which to measure footprint for food system impact valuation will be a major consideration through the next section. This is discussed further in the chapter Food System Impact Valuation in Practice. The SEEA-EEA includes both accounting of quantities and qualities of capital, and valuation (Chapters V, VI) in its scope. The current revision of the SEEA-EEA offers a conceptual discussion on non-financial capital accounting that could underpin a version for food systems[18].

Impact pathways are illustrated in the next section and in the chapter Case Studies of Food System Impact Valuation. Impact pathways for food systems for the issues associated to the major external costs have yet to be collated. Collating impact pathways that are presently distributed in literature across different disciplines and matching the beginning of the pathways to the footprint protocol is a step toward an accounting standard.

An accounting framework should also consider

- Standardised scenarios for the assessment of non-current non-financial assets and liabilities, and value changes over time.

Valuations of food system impacts will vary greatly depending upon assumptions about the future; the social cost of carbon is evidence of this. Social and human capital also have intergenerational effects[19]. Using the example of the social cost of carbon, the impact of an actor's carbon equivalent footprint now depends on the rest of the economy's footprint now and into the future (called RCPs in climate science[20]), and the socio-economic drivers into the future which might coincide with those radiative concentration pathways (called SSPs[21]). The combination of an RCP and SSP provides exogenous specification to calculating the social cost of carbon[22]. Calculating the social cost of carbon and scenarios are discussed further in the next chapter.

[18] OECD et al., "System of Environmental Economic Accounting 2012 : Experimental Ecosystems Accounting," (2014), https://doi.org/10.1787/9789210562850-en. Discussion papers for the SEEA-EEA revision include crop cultivation and fisheries https://seea.un.org/content/seea-experimental-ecosystem-accounting-revision

[19] C. G. Victora et al., "Maternal and child undernutrition: consequences for adult health and human capital," *The Lancet* 371, no. 9609 (2008), https://doi.org/https://doi.org/10.1016/S0140-6736(07)61692-4; K. L. Whitaker et al., "Comparing maternal and paternal intergenerational transmission of obesity risk in a large population-based sample," *The American Journal of Clinical Nutrition* 91, no. 6 (2010), https://doi.org/10.3945/ajcn.2009.28838.

[20] B. C. O'Neill et al., "A new scenario framework for climate change research: the concept of shared socioeconomic pathways," *Climatic Change* 122, no. 3 (2014), https://doi.org/10.1007/s10584-013-0905-2.

[21] D. P. van Vuuren et al., "A new scenario framework for Climate Change Research: scenario matrix architecture," *Climatic Change* 122, no. 3 (2014), https://doi.org/10.1007/s10584-013-0906-1.

[22] Despite the RCP and SSP specification, which has been used by thousands of studies, and the hundreds of calculations of the social cost of carbon, there does not appear to be a standard association between discount parameters and RCP and SSP combinations. Implicit in SSPs are rates of economic growth and marginal utility, and by the action or inaction on climate change are implicit preferences for intergenerational welfare.

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PREVIOUS SECTION: 4. ECONOMIC THEORY OF CHANGE

Valuing the impact of food:

Towards practical and comparable monetary valuation of food system impacts

A report of the Food System Impact Valuation Initiative (FoodSIVI)

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