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)

May 2020

GLOBAL ALLIANCE FOR THE FUTURE OF FOOD

FoodSIVI

wbcsd

ECONOMIC THEORY OF CHANGE SUMMARY

Matching supply and demand in markets provides a dynamic to what humans produce and consume. Whether the market is the local farmer market, the supermarket, or the Chicago Mercantile Exchange. Present activities in the food sector that lead to external costs from damaging nature, communities, and human health, are largely determined by markets. The economic theory of change is that factoring external costs into markets leads to changes to food system activities with reduced impact. Factoring external costs into a market is called internalisation.

Internalising the external costs can have winners and losers. Unable to compete, companies and industries that are not able to adapt when external costs are internalised are replaced by new ventures or industries that provide greater value in the adjusted market.

Impact valuation estimates the external costs to inform internalisation. Impact valuation can also indicate who incurred the costs and what food system activities they originate from.

The economic theory of change is a theory. It is not clear how business and consumers will respond to reintroduced costs, and what will be the follow-on effects for other sectors. Removing one food system impact may create another impact which is larger. This is called the theory of second best.

There are many mechanisms for internalisation. From awareness raising to interventions such as taxation. Three categories of internalisation are found relevant to impact valuation and impact reduction:

- No internalisation or already internalised. Reduction is a by-product of pursuing efficiencies in the existing market.
- Internalisation through dependency on capital changes and external costs. Reduction results from an internal correction to the costs and benefits of food sector companies or consumer groups due to the consequences they experience. The food sector adjusts itself.
- Internalisation through value correction or intervention. Reduction results from an external market adjustment.

The aim of harnessing market dynamics is that impact reduction becomes a by-product of efficiencies in an adjusted market.

The report finds it unclear what available efficiencies and present dependencies will contribute to global food system impact reduction targets identified by the scientific community. It recommends research to understand the amount of reduction in impact available through efficiencies and dependencies in the present market, and what must be achieved through interventions. It also recommends more research on: i) dynamic economic modelling of the follow-on consequences from large fiscal or policy interventions in the food system suggested by impact and attribution studies; and ii) economic trajectories for food system transformation.

Realising market corrections requires synergy between a triad of food system science, economics, and users. A short survey of current activity around the triad shows a body of existing activity. Some of the hurdle to realising market corrections lies in establishing a network bringing the triad closer together, and investment that enables the community to develop and promote measures for economic correction of food system impact at scale.

CONTENTS

ECONOMIC THEORY OF CHANGE

That impact valuation can reduce the impacts of food systems rests on an economic theory of change.

In welfare economics the purpose of an economy is to maximise economic value from the utilisation of capital. Economic value has a long philosophical history. Following the approach of the TEEBAgriFood Framework and the Natural and Human Capital Protocols we use economic value synonymously with human well-being and welfare in a broad sense[1]. The conventional sense of welfare is the satisfaction of aggregated individual utilities by produced goods. Even the conventional sense of welfare can indicate that market failures created by the food system can lead to a lower economic value than might otherwise be possible, and that internalisation of the external costs produced by the food system could lead to higher economic value.

Externalities and economic efficiency

Financial markets operate to achieve a market price where the quantity of goods and services supplied matches the quantity of goods and services demanded. Matching supply and demand give financial markets a natural dynamic which can be harnessed.

However, the dynamic of markets, which leads to maximising profit to individual firms and economic value (benefit) to consumers involved in those transactions (market surplus), can lead to increased financial value but may not lead to increased economic value to society.

Capital changes caused by activities associated to transactions may affect others not involved in the transaction. The positive changes in economic value to society from the capital changes are called the social benefits, and the negative changes the social costs. Similarly, positive and negative changes to those involved in the transaction are called the private benefits and costs. A negative externality is when the social costs exceed the private costs to that set of economic actors from capital changes due to their activities, similarly for positive externality. A boundary is implied in an externality, it is external with respect to the set of economic actors involved in the transaction. The external costs and benefits (the difference between the social costs and benefits and the private ones) have been produced by the

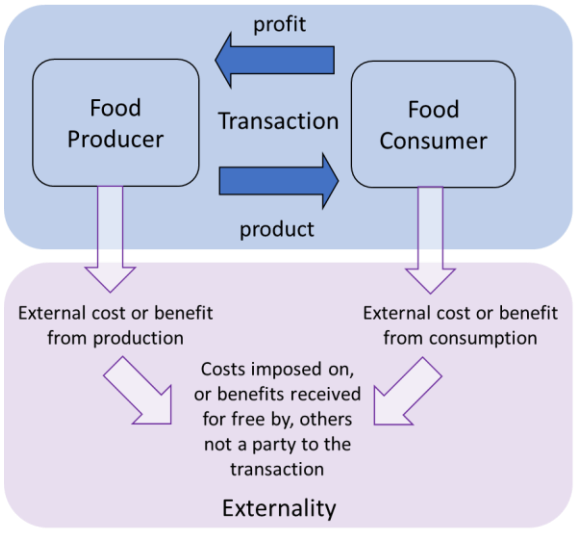

Figure 2: External cost or benefit

[1] p. 6: B. Sandelin, H.-M. Trautwein, and R. Wundrak, *A short history of economic thought*, 3rd ed. (London: Routledge, 2014); J. A. McGregor and N. Pouw, "Towards an economics of well-being," *Cambridge Journal of Economics* 41, no. 4 (2016), https://doi.org/10.1093/cje/bew044; R. K. Turner, I. Bateman, and D. W. Pearce, *Environmental economics : an elementary introduction* (New York-London: Harvester Wheatsheaf, 1994). S. Parks and J. Gowdy, "What have economists learned about valuing nature? A review essay," *Ecosystem Services* 3 (2013), https://doi.org/https://doi.org/10.1016/j.ecoser.2012.12.002. P. Dasgupta, *Human Well-Being and the Natural Environment* (Oxford: Oxford University Press, 2002). The concept of total economic value which includes the broad sense of welfare and intrinsic value is applied in the ISO 14008:2019 standard on monetary valuation of environmental impacts https://www.iso.org/obp/ui/#iso:std:iso:14008:ed-1:v1:en.

activity of a set of economic actors but are not borne by them directly[2].

Economists distinguish between financial, or market, efficiency and economic efficiency. The presence of externalities means that movements to maximise market surplus (a financial efficiency gain) may not lead to increased economic value to society (an economic efficiency gain). A market failure is when a financial efficiency gain from the transactions of a set of economic actors is not an economic efficiency gain.

Externalities are not the only market failures. Poor information means the actors may not realise their own missed private benefits and costs, or actors may not behave in ways that accord with measures of economic value associated to rational behaviour. These factors distort transactions (price, supply, demand in market) so that the dynamics of the market may result in a financial gain which is not a gain in economic value. Healthcare costs as a result of food consumption provide examples of consumer difficulty in assessing economic value to themselves, see footnote 4. Most of the focus of impact valuation is on external costs produced by food system actors, rather than correcting consumer assessment of private costs and benefits.

Internalisation reflects the external benefits and costs from the transactions of that set of economic actors back into their private benefits and costs (taxes, subsidies, better information of dependencies on externalities, re-allocation of quantities, etc.). The intention of internalisation, and correcting market failures in general, is that financial efficiency (optimising financial value) in the adjusted market is closer to economic efficiency (optimising economic value), and the natural dynamic in markets is harnessed to produce change that increases economic value.

That is the general theory. We provide examples of externalities and efficiency gains with the food system and food system transformation in mind[3]. A central question is whether internalisation that reduces the impacts of the food sector can be achieved by the food sector itself because of its dependencies on its own external costs, or whether external corrections are required.

Financial efficiency gain in the transactions of food system actors may result in the reduction of food system impacts without internalisation. Changing to LED bulbs saves electricity costs for a firm above the original purchase of the light and produces the same light. This lowers input costs with no change in the quality or quantity of the output products that are consumed. A food processing factory which uses food waste to produce energy is a financial efficiency gain for the company if the saved electricity and waste disposal costs outweigh new infrastructure costs. Voluntary reduction of packaging with lower net cost without losing properties of storage and consumer acceptability is a financial efficiency gain for the company and the consumer. Farmer education where the same yield with the same quality can be obtained with less fertiliser, and so less fertiliser input costs, is a financial efficiency gain for the farmer.

Decreasing food loss and waste, where the cost of the measures to prevent harvest or stock loss and waste are outweighed by the sales value of the saved harvest or stock is a financial efficiency gain for the value chain. An app connecting food consumers to food that would be wasted and saving disposal costs to the producer is a financial efficiency gain for producer

[2] D. W. Pearce and E. Barbier, *Blueprint for a sustainable economy* (London: Earthscan, 2000).
[3] C. Rocha, "Food Insecurity as Market Failure: A Contribution from Economics," *Journal of Hunger & Environmental Nutrition* 1, no. 4 (2007), https://doi.org/10.1300/J477v01n04_02. J. A. Caswell, "Rethinking the Role of Government in Agri-Food Markets," *American Journal of Agricultural Economics* 79, no. 2 (1997), https://doi.org/10.2307/1244166. T. M. Bachmann, "Optimal pollution: the welfare economic approach to correct market failures," in *Encyclopedia on Environmental Health.*, ed. J. Nriagu (Burlington: Elsevier, 2011).

and consumer. The consumer voluntarily changing their demand away from fertiliser and water intensive foods, such as intensively farmed beef and lamb, to lower input foods, at the same time food sector firms have the capacity to voluntarily alter production such that lower input costs cover the cost of transition, is a financial efficiency gain. In all cases, consumers get the same or higher value product, and the producer receives higher total profit. There are wider market implications to these changes, but, for the present discussion, the market is the actors involved in the transaction. Financial and economic efficiency depends on the boundary chosen for the transaction, the parties and activities associated to the transaction, and the calculation of costs and benefits for the parties.

In each of the examples, reduction in external costs associated to food system impact (social costs resulting from CO2eq emissions from production, nitrogen and phosphorus leakage from fertiliser, water use, etc.) occurs as a by-product of a financial efficiency gain in the narrow scope of business input costs and output consumption value. Private benefits are abating social costs.

It is not clear if enough financial efficiency gains are available now or in the future to reduce food system impacts to the targets that science considers sustainable.

Cost to third parties from CO2eq emissions during food production is currently an externality. Cost to third parties from nutrient changes in waterways from fertiliser run-off is an externality. Healthcare cost of consumption borne by public money in a third country to the taxes paid by production are an externality[4]. Cost or benefit to a community from use of infrastructure paid for by business from profits is an externality.

The external effect can be positive or negative. CO2eq emissions can have benefits through increased arability or plant growth in higher latitudes. The net social cost or benefit absorbed into present or future economies is the concern of impact valuation.

The term net already introduces an issue. For example, how can healthcare burden from poor diets paid in Samoa, a negative externality, be substituted by social benefits from taxes and wages, a positive externality, associated to revenue from products sold in Samoa received by parent firms in the United States? Unless the transaction of the purchase of the food products includes social costs and benefits, so that the transfer of an economic value loss in Samoa to an economic value gain in the United States is being accepted in the exchange by the Samoan consumer as the bearer of the negative externality, how is the commensurability of the external cost to one actor and the external benefit to another established? Only when the values are commensurable can one social cost be subtracted from another social benefit to obtain a net social benefit or cost. Economics has for over a hundred and twenty years (there are also references to the concept in Aristotle), and continues to, debate ideas about value and it features in discussions of value in exchange versus value in use[5].

[4] Health care costs borne by the consumer of the food product are a private cost. The potential market failure in private costs to consumers is the lack of information or otherwise impairing the ability of the consumer to weight their own value between pleasure and sustenance in food consumption now and impaired health at a future time. When those private costs become a wider burden on social resources and have social effects, that is the externalised cost. In a publicly funded health system such as the UK NHS, healthcare costs become immediate social costs. An external cost in the US healthcare system would be rising health insurance through pooling risks and private costs, or crime and other social effects to support high private costs.

[5] Sandelin, Trautwein, and Wundrak, *A short history of economic thought*. Substitution between different forms of capital is discussed extensively in sustainable development economics, under “weak” and “strong” sustainability. Weak sustainability, which assumes the ability to substitute between produced and other capitals on the premise that the increased produced capital gains will later allow recover of damage to other capitals is highly contested: K. J. Arrow et al., "Economic growth, carrying capacity,

Valuations of external costs need to be careful about existing boundaries and existing transactions. Externalities and other market failures are well studied[6]. Economic actors pay taxes and governments use revenue to provide public benefits, e.g. an educated workforce and use of public infrastructure. Companies claiming social benefits from tax paid need to account for the social benefits they receive as well. Similarly, companies provide products to society. The value of those products to society (nutrition, pleasure, sustenance, etc.) are reflected in demand. Demand increases the marginal value received for output. Hence the value provided to society by companies is captured, probably in the most part, in revenue. A positive externality, by definition, must not already be captured in private costs or benefits. Asymmetry in positive and negative externalities is a feature of business. Present business practice seeks to capitalise on benefits provided and internalise them into revenue while externalising costs.

If the external costs of food systems outweigh the external benefits, and it is unlikely that financial efficiency gains available in the current market will significantly reduce external costs, then intervention can adjust financial efficiency gain to align with reducing food system impacts. Internalisation may or may not result in an increase in economic value overall, so it is a theory of change[7]. The details and context of the intervention need to be considered.

Internalisation reintroduces (some part of) the external costs into the consideration of private benefits and costs for the transactions of the food system actors that produced the external costs. The food system has long value chains, so where in that value chain and what form the internalisation takes to adjust production, demand and prices requires detailed consideration. It is becoming accepted by progressive businesses and civil society that the “true cost” of food is not being paid. It is still debated who and where in the value chain the “true cost” should be paid.

Subsequent private benefits and costs from a producer and consumer’s own externalities can reintroduce external costs back into their private benefits and costs. If subsequent private benefits and costs are considered, then market efficiency gains may drive changed behaviour to reduce externalities. Examples are when a food company’s outputs are attributed to obesity and diabetes, which raises health insurance (the externality), which raises the costs of health insurance that the food company pays on behalf of employees. The social costs of poor health also create lobbying costs for food companies, which may exceed the opportunity costs of changing production. As another example, a food company’s emissions create environmental change, lowering yields globally of certain commodities which it uses, which increases price from its suppliers due to reduced global supply. The subsequent private benefits and costs would not be present without the external costs (Figure 3 on p. 18).

These reintroductions are called dependencies in the Natural Capital Protocol, see also Section 2.3.2 of the TEEB AgriFood Scientific and Economic Foundations Report[8]. Change in

and the environment," *Science* 268, no. 5210 (1995), https://doi.org/10.1126/science.268.5210.520. G. R. Davies, "Appraising Weak and Strong Sustainability: Searching for a Middle Ground," *Consilience*, no. 10 (2013), www.jstor.org/stable/26476142..

[6] A. Marciano and S. G. Medema, "Market Failure in Context: Introduction," *History of Political Economy* 47, no. suppl 1 (2015), https://doi.org/10.1215/00182702-3130415. J. E. Stiglitz, "Markets, Market Failures, and Development," *The American Economic Review* 79, no. 2 (1989).

[7] The theory of second best means that market corrections in one sector when there are uncorrected market distortions in another sector may not lead to an increase in economic value overall: R. G. Lipsey and K. Lancaster, "The General Theory of Second Best," *The Review of Economic Studies* 24, no. 1 (1956), https://doi.org/10.2307/2296233.

[8] Business will also seek through market efficiency to reduce dependency on the externalised costs of business other than their own. Such a reduction does not necessarily reduce the externality for society. For example, shifting production to another country once capital is degraded (by others) in the present

consumer demand due to raised awareness by civil society is also a dependency, e.g. antibiotic use, deforestation for palm-oil, etc. Externalities borne by economic sectors on which the food sector depends are dependencies. The more direct the dependency of the already monetised produced and financial capital on the external cost, the easier it is to value the externality. The Natural Capital Protocol discusses dependencies of businesses on natural capital with food sector examples[9].

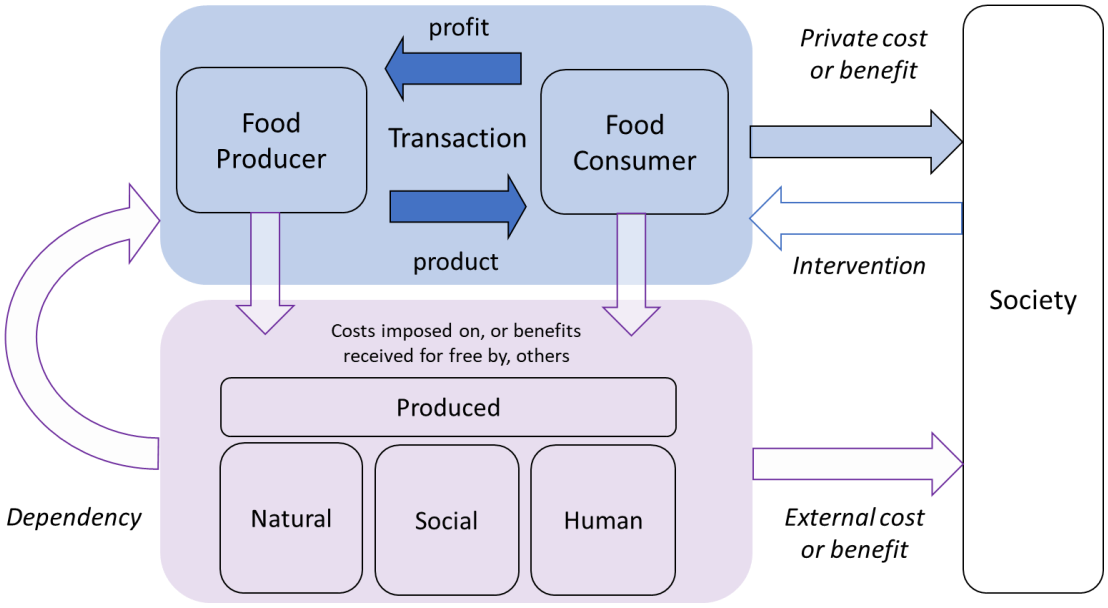

Figure 3: Internalising external costs or benefits through dependency or intervention

It is unclear, as it was for purely financial efficiency gains, if present or future feedbacks created by dependencies are sufficient to reduce food system impacts to the targets that science considers sustainable. With international trade and long value chains, there are many examples in the food system where external costs accrue in one location or community with weak dependency on private benefits in transactions of retailers and food consumers in other locations and communities. In the case of health insurance, the premium rise is pooled across all sectors. The premium rise as a private cost to the food company is unlikely to compare to the revenue from selling the food products.

Reputational damage, demand change, the threat of regulation, and investor concern appear to be the strongest feedbacks presently. Awareness raising of food system impacts by civil society performs a potential economic efficiency gain since demand change connects external costs to private benefits. As the disparity between costs and benefits becomes extreme, e.g. political insecurity in nations bearing external costs begins to create social costs for businesses or consumers receiving private benefits, the dependency strengthens. However, waiting for the dependency to manifest through very large welfare changes is less than optimal for maximising welfare.

When the dependency is a weak signal to revenue and cost the likelihood that the externality will be internalised through dependency is low. In this case market efficiency gains cannot be

location. Loss of taxes and value from production in the original locality which may or may not be compensated by taxes and production in the new locality become part of the cost of the original externality, in addition to the existing capital change. Unless the cost becomes linked to the externality producer, i.e. the externality producer has a dependency on their own externality, market efficiency may not provide a reduction of the externality to society.

[9] NCC, *Natural Capital Protocol: Food & Beverage Sector Guide*, Natural Capital Coalition (London, 2016), https://naturalcapitalcoalition.org/natural-capital-protocol-food-and-beverage-sector-guide/.

harnessed to drive reduction in impact. When externalities accumulate at the societal level, then society intervenes in transactions to create a new dependency or amplifies existing dependencies (Figure 3). For example, the costs of CO2-eq emissions are uncertain and will occur over a long time period. Advocacy by civil society of the accumulated impacts of climate change increases the risk of being regulated or litigated, and reputational harm and revenue loss due to not responding to societal demand and value changes. As another example, a national government introduces an emissions tax, intervening in the market to reduce the externalities at the societal level. Governments and civil society are not the only interventionists concerned with accumulated effects of external costs. Investors experience accumulated effects. In terms of amplifying dependencies, nature intervenes through desertification, droughts, heatwaves, extreme weather. Communities intervene through riots and uprising.

Role of valuations in internalising externalities

Impact valuation estimates the external costs to inform internalisation. Impact valuation can also indicate who incurred the costs and what food system activities they originate from. The estimates can inform the calculation of private costs and benefits of the actors in the food system responsible for the costs. The estimates can also inform market corrections by external actors.

Value is uncertain, and it is estimated rather than known. It is unlikely that market price and proxies to market price are good estimators of marginal value for natural, social, and human capital change of the scale of the impact of the food system.

Value is uncertain, and it is estimated rather than known. In the situation of frequently transacted goods in exchange markets with large amounts of information, and where externalities are mostly internalised (e.g. existing regulation or an established area of litigation), price multiplied by quantity becomes an estimator of value. It is unlikely that market price and proxies to market price are good estimators of marginal value for natural, social, and human capital change for the scale of the impact of the food system. Proxies to market price are derived from valuation methods that estimate the trade-offs of individuals[10]. The trade-off is between the capital change and a monetary amount directly, or between a capital change and market substitutes. When dependencies that affect individuals are uncertain and indirect, and capital changes are occurring simultaneously globally, it unclear that individuals have either the information or the ability to assess trade-offs of equal economic value to society. Valuation of external costs is a challenge. Impact valuation in practice is discussed in the chapter Food System Impact Valuation in Practice.

What is discussed here is that dependencies that are uncertain and indirect are prevalent for food system impact. The connection between those that produce the external cost (the source of impact) and those that bear it (the receiver of impact) is called the impact pathway. Impact pathways for the food system can be long and complex.

Three categories of internalisation for reduction of food system impacts from externalities have been discussed:

[10] National Research Council, "5: Economic methods of valuation," in *Perspectives on Biodiversity: Valuing its role in an everchanging world* (Washington DC: The National Academies Press, 1999). D. N. Barton et al., *Discussion paper 5.1: Defining exchange and welfare values, articulating institutional arrangements and establishing the valuation context for ecosystem accounting. SEEA EEA Revision. Version 25 July 2019.*, United Nations Statistics Division (New York, 2019).

- No internalisation or already internalised. Reduction is a by-product of market efficiency gain in the existing market.
- Internalisation through dependency on capital changes and external costs. Reduction results from an internal correction of costs and benefits for food companies or consumer groups. The food sector adjusts itself.
- Internalisation through value correction or intervention. Reduction results from an external market adjustment to align market efficiency gain with an external calculation of economic gain with a wider sense of welfare.

The implication we conclude from long and complex impact pathways is that it is unlikely internalisation created by present dependencies will provide a major reduction in impact. Intervention to establish more direct dependencies or amplify existing dependencies would increase the contribution to food system transformation.

Internalising the external costs can have winners and losers[11]. Unable to compete, companies and industries that are not able to adapt when external costs are internalised are replaced by new ventures or industries that provide greater value in the adjusted market. Structural change occurs in the sector to manage dependencies or align with the value loss its externalities are creating.

The three categories of internalisation generally involve an increasing investment in change and different sets of actions. It is an open research question how much abatement of the present and future impacts caused by the food system can be achieved through market efficiency gains in the present market.

How much abatement of present and future impacts of the food system can be achieved through efficiencies in the present market is an open research question.

The issues that are creating impact identified by the scientific community (Table 1, p. 23) require actions from existing market efficiency gains, to better information on dependencies, to regulatory or fiscal interventions[12]. Policy options for *prima facie* market inefficiencies such as food loss and waste occupy their own reports[13]. Roughly knowing how much effort needs to go into value correction versus self-correction to achieve targets for food system transformation is important. It is natural for business to err on the side of self-correction and civil society on the side of value correction. It is also important for valuation. Abatement costing depend upon beliefs about actions and their efficacy.

Drivers of globalised impact, or of local or regional impact occurring concurrently globally[14], not being corrected by market efficiency gains in the present market are the ones of concern. They are the issues identified by the scientific community that are believed to be creating most of the external cost[15], see Table 1 on page 23. The issues largely coincide with dependencies

[11] For the discussion on the difference between a Pareto efficiency gain where no economic actor loses and optimality in the context of economic adjustment for carbon emissions, see Box 3.4, p. 227 C. Kolstad et al., "Social, Economic and Ethical Concepts and Methods," in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. O. Edenhofer et al. (New York, NY: Cambridge University Press, 2014).

[12] Chapter 7: IPCC, *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems*, Intergovernmental Panel on Climate Change (2019), https://www.ipcc.ch/report/srccl/.

[13] S. Priestley, *Food waste Briefing Paper CPB07552*, House of Commons Library (London, 2016). M. Vittuari et al., *Recommendations and guidelines for a common European food waste policy framework*, FUSIONS (Bologna, 2016), http://dx.doi.org/10.18174/392296.

[14] E. Mendenhall and M. Singer, "The global syndemic of obesity, undernutrition, and climate change," *The Lancet* 393, no. 10173 (2019), https://doi.org/https://doi.org/10.1016/S0140-6736(19)30310-1.

[15] Sources for Table 1:

that are uncertain and indirect. This is likely why costs have accumulated without correction. The connection of the issues identified in Table 1 to day-to-day market transactions can be complex. Indicative features of the issues include:

- Systemic
    - Significant costs accumulate at the societal level with indirect dependencies or slow feedbacks to the spatial and temporal scale of private costs and benefits. For example, the cost of the carbon emissions or the nitrogen leached from one farm to produce a bushel of corn is not observed until combined with other

Sustainability: TEEB, *TEEB for Agriculture & Food: Scientific and Economic Foundations*, UN Environment (Geneva, 2018). 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. A. Chaudhary, D. Gustafson, and A. Mathys, "Multi-indicator sustainability assessment of global food systems," *Nature Communications* 9, no. 1 (2018), https://doi.org/10.1038/s41467-018-03308-7; P. S. Nathaniel et al., "Sustainable Sourcing of Global Agricultural Raw Materials: Assessing Gaps in Key Impact and Vulnerability Issues and Indicators," *PLoS ONE* 10, no. 6 (2015), https://doi.org/10.1371/journal.pone.0128752. 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; FABLE, *Pathways to Sustainable Land-Use and Food Systems. 2019 Report of the FABLE Consortium.*, International Institute for Applied Systems Analysis (IIASA) and Sustainable Development Solutions Network (SDSN) (Laxenburg and Paris, 2019). S. van Berkum, J. Dengerink, and R. Ruben, *The food systems approach: sustainable solutions for a sufficient supply of healthy food.*, Wageningen Economic Research (Wageningen, 2018).
Environmental: B. M. Campbell et al., "Agriculture production as a major driver of the Earth system exceeding planetary boundaries," *Ecology and Society* 22, no. 4 (2017), https://doi.org/10.5751/ES-09595-220408.
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Climate: M. T. Niles et al., *Climate change and food systems: Assessing impacts and opportunities*, Meridian Institute (Washington DC, 2017); IPCC, *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems*. S. J. Vermeulen, B. M. Campbell, and J. S. I. Ingram, "Climate Change and Food Systems," *Annual Review of Environment and Resources* 37, no. 1 (2012), https://doi.org/10.1146/annurev-environ-020411-130608.; F. N. Tubiello et al., "The Contribution of Agriculture, Forestry and other Land Use activities to Global Warming, 1990–2012," *Global Change Biology* 21, no. 7 (2015), https://doi.org/10.1111/gcb.12865.
Health: IPES-Food, Unravelling the food-health nexus: addressing practices, political economy, and power relations to build healthier food systems, 2017, Global Alliance For The Future of Food and IPES-Food. W. Willett et al., "Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems," *The Lancet* 393, no. 10170 (2019), https://doi.org/https://doi.org/10.1016/S0140-6736(18)31788-4. HLPE, *Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*, Committee on World Food Security (Rome, 2017), http://www.fao.org/3/a-i7846e.pdf.
Social and Economic: National Research Council, *Framework for Assessing Effects of the Food System*, National Academies Press (Washington, 2015); E. Gladek et al., *The Global Food System: An Analysis*, Metabolic. WWF Netherlands. (Amsterdam, 2017), https://www.metabolic.nl/publications/global-food-system-an-analysis/. R. Townsend et al., *Future of food : shaping the food system to deliver jobs*, World Bank Group (Washington, DC, 2017). L. Unnevehr, *Economic Contribution of the Food and Beverage Industry*, Committee for Economic Development of The Conference Board (Arlington VA, 2017). FF&CC, *Our Future in the Land*, Food, Farming and Countryside Comission, RSA (London, 2019).
Food loss and waste: FAO, *Food loss and waste: issues and policy options*, Food and Agriculture Organization of the United Nations (Rome, 2017).

farms and other food sector activities. Combined emissions and leaching result in ecosystem or atmospheric effects. The impact on public health costs accumulate from individuals consuming meals and combinations of food products (diets).

  - Impact is dispersed system wide by dynamic processes. This increases the distance, not only spatially but also conceptually, jurisdictionally, and fiscally between the original activity and the borne costs. Attribution of impact and comparison of benefits and costs across economies separated by the dimensions listed is difficult. Action or feedback across these boundaries is equally challenge. Often the only link is the chain of market transactions. For example, consumed food products are combinations of thousands of commodities sourced globally in long value chains. The ability of the consumer or food retailer to communicate with the original producer, to be able to identify impacts, to be able to obtain credible assessments of impacts, to redress impacts, reduces as the value chain lengthens.
  - Impact is the result of the business or consumer activity combining with biophysical systems, the behaviour of other business and government actors, other socio-economic trends, e.g. urbanisation, and societal values and choices. Despite being dispersed system wide, significant correlations exist between the impacts. For example, even though carbon emissions and nitrogen leaching occur from many farms across the globe, largely the same biophysical process is responsible for impacts. If science has underestimated the effects of that biophysical process, then the fact that there are numerous point sources of emissions and leaching does not “average out” the error. Similar correlations exist in global human health effects due to the increasing concentration of agricultural commodities in diets.
- Intergenerational
  - Long timeframes, or delay, in the occurrence of impact from an activity today. Some food system impacts, e.g. climate change and obesity, have lock-in effects for future generations as well as present ones.

The difficulty in measurement and attribution along impact pathways reduces the visibility and feedbacks between impacts and business and consumer activity. It also compounds the uncertainty in measurement and attribution. Uncertainty in complex biophysical and socio-economic processes combines with ambiguity in the comparison of economies and costing impacts that have not occurred yet. Accumulation of impacts can either reduce or increase uncertainty depending on the correlation between the individual impacts being aggregated. The challenges uncertainty poses for impact valuation are discussed further in the chapter Food System Impact Valuation in Practice.

Dependencies being complex, a weak direct signal to revenue and cost, uncertain, and yet the external costs which accumulate are, or will be, evident and large, are features of the impact created by the food system.

The implications are that:

- Impact valuation for the food system’s impact on society is challenging. Market prices and existing exchange markets are poor estimators.
- For major reduction in impact, impact valuation is more likely needed for external corrections to private benefit and cost calculations. This will require practical and comparable valuations rather than internally determined and incomparable valuations.

Food system issues associated to food system impact

Indicative list only. Issues are not generally footprints, capital changes or impacts themselves, and not independent; they represent a collection of drivers and impact pathways believed by the scientific community to be creating most of the impact from food systems. Issues labelled 'environmental' or 'social' do not cause only natural capital, resp. social & human capital, changes. Issues are often negative impact, and positive contributions from actors toward addressing issues can be viewed as abatement. Compiled from references in footnote 15.

Table 1: an indicative list of material issues for society for food systems

	Issue	*Pathway via*	*Capital changes*	*Reference*
environmental	Climate change	CO2-eq emissions, land-use	Global, affecting terrestrial systems, biosphere, and through this agricultural and marine production, all economic sectors, social stability, and human health.	IPCC, *2019*
	Nutrient pollution	Run-off or processing water pollution, air pollution from erosion, soil processes and application	Health effect, ecosystem degradations. Economic losses and inefficiency in fertiliser overapplication.	Campbell, et al. *2017*
	Ecosystem collapse	Biodiversity loss (pesticide and nutrient application), land-use and land degradation, atmospheric and terrestrial changes, pollution, water extraction.	Pollinator services, soil services, erosion, water and air services, feedback with climate change, other primary based economic sectors, pleasure in nature, cultural loss	IPBES, *2018*
	Water scarcity	Water-use and quality changes of water.	Water services, health, ecosystem degradations, economic losses, conflict	OECD, *2012*
social	Safety and non-harm	Accidents Child labour Toxicity exposure in production or consumption Antibiotic use Exotic pathogens	Health, human development, communities, economic losses.	TEEB, *2018*
	Exploitation and social equity	Child labour, accidents and exposure compared to other sectors, pay rates, price fluctuations, power imbalance, control of inputs	Human development, poverty, institutional loss through conflicts and migration, suicide, cultural loss, rural development.	TEEB, *2018* NRC, *2015*
health	Nutrition and Malnutrition	Consumption of food products in diets in subpopulation context (income, activity level, age, etc)	Food security (availability, access, utilisation). Human health and development. Obesity, diabetes, hunger, stunting, human health changes with corresponding social and economic losses.	IPES-FOOD, *2017* Willet et al., *2019*
economic	Economic value of food sector, livelihoods and employment	Value add, growth, investment, competitiveness, efficiency, employment, wages, taxes	Produced and financial capital, provision of livelihoods, welfare through consumption, contribution to society of taxes, sustenance, pleasure. Consumption of human education and time, infrastructure, natural resources, etc.	NRC, *2015* Townsend, *2017*
inefficiency	Food loss and waste	Inefficiency of production and consumption. Embedded emissions, water use, land-use, nutrient pollution, exposure. Pollution and exposure via waste.	As per embedded footprint. Economic losses, nutrition losses in the case of subsidence, and costs of treatment and disposal.	FAO, *2017*

Evidence of the theory of change

Impact valuation estimates social and abatement costs attributable to food system actors. That it will contribute to reduction of the impacts of food systems identified by the scientific community[16] through an economic theory of change is a series of hypotheses.

Economic theory of change:

- Food system impacts are due to market inefficiencies and external costs of food system actors [hypothesis]
- Internalising the external costs will reduce impacts through market dynamics [hypothesis]
- Enough externalities can be internalised to transform the food system to scientific targets [hypothesis]
- Internalising causes reflection and value change [hypothesis]

Food system impacts are due to market inefficiencies and external costs of food system actors

The scientific studies mentioned in footnote 15 discuss attribution of environmental (IPCC, IPBES), social (TEEB), and health (GBD, Eat-Lancet, Food-Health Nexus) impacts to the production and consumption of food in addition to the scale of the impacts. This hypothesis is well evidenced by the literature.

Internalising the external costs will reduce impacts through market dynamics

If market efficiency gains are not enough to reach scientific targets for food system transformation (which has been argued to be unlikely), then internalising external costs could contribute further to reaching targets. That internalisation will result in impact reduction is an assumption. It assumes that the market adjustment will be accepted, and that consumption will respond to price changes that result from the adjustment. Even if accepted and not compensated for by circumventing regulation, shifting production, or absorbing price increases, there is no guarantee that the internalisation mechanism will not create external costs for society of similar magnitude to the reduction, i.e. unintended consequences. It is still not clear what internalisation, of the scale required to achieve significant reduction in food system impacts, will do to the price of food staples or livelihoods in some communities[17]. There are many impact and attribution studies now of the food system suggesting large fiscal or policy interventions, and other changes that amount to internalisations. Detailed dynamic

[16] The IPCC, the IPBES, the Global Burden of Disease, TEEB, the Eat-Lancet Commission on Food, Planet, Health, etc. Impact reduction targets and footprint reduction targets are discussed further in the chapter Food System Impact Valuation in Practice.

[17] A. Kehlbacher et al., "The distributional and nutritional impacts and mitigation potential of emission-based food taxes in the UK," *Climatic Change* 137, no. 1 (2016), https://doi.org/10.1007/s10584-016-1673-6. X. García-Muros et al., "The distributional effects of carbon-based food taxes," *Journal of Cleaner Production* 140 (2017), https://doi.org/https://doi.org/10.1016/j.jclepro.2016.05.171. L. Scherer et al., "Trade-offs between social and environmental Sustainable Development Goals," *Environmental Science and Policy* 90 (2018), https://doi.org/10.1016/j.envsci.2018.10.002. P. Smith et al., "How much land-based greenhouse gas mitigation can be achieved without compromising food security and environmental goals?," *Glob Chang Biol* 19 (2013), https://doi.org/10.1111/gcb.12160. P. Smith, "Delivering food security without increasing pressure on land," *Global Food Security* 2, no. 1 (2013), https://doi.org/http://dx.doi.org/10.1016/j.gfs.2012.11.008; S. A. Wood et al., "Trade and the equitability of global food nutrient distribution," *Nature Sustainability* 1, no. 1 (2018), https://doi.org/10.1038/s41893-017-0008-6. Chapter 6 and Section 7.5.6 7-80 in IPCC, *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems*.

economic modelling of the follow-on consequences is less complete in the literature[18]. Internalisation may produce higher prices for inputs, for commodities, or for consumers, in the short to medium term. The implications of internalisations that reduce food system impact will be a stumbling block to dialogue with policymakers without detailed answers.

Enough externalities can be internalised to transform the food system to scientific targets

Assuming internalisation can reduce impacts, then internalisation mechanisms will be more, or less, effective for some issues and in some contexts. There are opportunity, political and reactionary costs to internalisation. Regulation will impact livelihoods, requiring time to transfer knowledge and labour between industries. To transform the food system requires that enough impact reducing mechanisms come online, become accepted and operational, in enough time, to avert environmental, social and human health impacts[19]. Whilst maintaining overall economic stability of the food sector and provision of food security and livelihoods. This hypothesis needs further applied research. Studies are required on mechanisms available and potential economic trajectories of internalisation to achieve scientific targets. While CO2-eq marginal abatement cost curves have critics[20], they have allowed climate science to engage in policy and economic dialogue. As clear an economic presentation does not exist for food system transformation[21].

Dynamic economic modelling of the follow-on consequences from large fiscal or policy interventions suggested by impact and attribution studies, and merit order curves and economic trajectories for food system transformation through internalising externalised costs, need further applied research.

Internalising causes reflection and value change

The hypotheses are not rigid in time but can be reassessed and updated. Feedback has the potential to accelerate the change. Internalisation, which is occurring with carbon taxes, carbon offset markets, and carbon disclosure, raises societal awareness, regulatory risk, prompting value changes whereby opportunity and political costs lessen. Awareness, regulatory and reputational risk act as additional internalisation measures whereby reduction of external costs become voluntary market efficiencies. Positive feedback 'lowers the bar'. It becomes more likely internalisation will reduce further impacts and the momentum bring new or more of the same mechanisms online.

[18] M. M. Rutten, "What economic theory tells us about the impacts of reducing food losses and/or waste: implications for research, policy and practice," *Agriculture & Food Security* 2, no. 1 (2013), https://doi.org/10.1186/2048-7010-2-13. FOLU, *Growing Better: Ten Critical Transitions to Transform Food and Land Use, The Global Consultation Report of the Food and Land Use Coalition.*, Food and Land Use Coalition (New York, 2019), https://www.foodandlandusecoalition.org/global-report/.

[19] FABLE, *Pathways to Sustainable Land-Use and Food Systems. 2019 Report of the FABLE Consortium.* Box 9, p 7-79 in IPCC, *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems*. C. Béné et al., "When food systems meet sustainability – Current narratives and implications for actions," *World Development* 113 (2019), https://doi.org/https://doi.org/10.1016/j.worlddev.2018.08.011.

[20] F. Kesicki and P. Ekins, "Marginal abatement cost curves: a call for caution," *Climate Policy* 12, no. 2 (2012), https://doi.org/10.1080/14693062.2011.582347.

[21] M. T. Niles et al., "Climate change mitigation beyond agriculture: a review of food system opportunities and implications," 33, no. 3 (2018), https://doi.org/10.1017/S1742170518000029. L. Bockel et al., *Using Marginal Abatement Cost Curves to Realize the Economic Appraisal of Climate Smart Agriculture Policy Options*, Food and Agriculture Organization of the United Nations. (Rome, 2012).

Climate change has become a cultural and ideological battleground with deep inertia in some business sectors, demographics, conservative governments, and vested capital. The debate on climate change is instructive; those communities have subscribed against the hypotheses, especially one and two. Firstly, that impacts of climate change exist or will be net negative for economies, or that they can be attributed to human economic activity. Secondly, even if the impacts were net negative and due to externalities, that internalisation would create more economic costs than are reduced. If hypotheses one and two are false, then there is no optimal economic trajectory into the future other than absorbing the impacts. Despite scientific consensus for the first two hypotheses in the case of climate change and all economic sectors, summarised and updated in IPCC assessments, the inertia remains.

Triad of food system science, valuation, and users

The theory of change is being acted upon. This section indicates current activity around a triad of food system science, valuation, and users (Figure 4). More detail on food systems[22] and economic valuation[23] is referred to other reports and literature.

To summarise the role of impact valuation in an economic theory of change of food system impacts (Figure 4): food system science indicates a loss of economic value and sets scientific targets like climate science sets targets such as 2 or 1.5 degrees. Valuation provides an account of the value loss that is presently not costed into the economic system. Valuations inform internalisation leading to movement to targets for impacts. By having agreed and credible changes in value the economic system re-forms or is reformed around the value change. The process is iterative until optimal, i.e. the economic trajectory of most value becomes the impact neutral (or sustainable) trajectory.

Impact neutral is defined by valuations of externalities and economic optimality. A food system on an impact neutral or sustainable trajectory is distinguished from a food system with no impacts on natural, social, and human capital. As an example, an optimal amount of food loss and waste in an economic system is unlikely to be none[24]. How impact neutral accords with other theories of change and measures of food system impact, e.g. ethical and moral, depends on the definition of economies and what values they represent. Monetary valuation informs internalisation, but it is not internalisation *per se*. Value changes in society can internalise

The process is iterative until the economic trajectory of most value becomes the impact neutral (or sustainable) trajectory.

[22] Vermeulen, Campbell, and Ingram, "Climate Change and Food Systems."; P. J. Ericksen, J. S. I. Ingram, and D. M. Liverman, "Food security and global environmental change: emerging challenges," *Environmental Science & Policy* 12, no. 4 (2009), https://doi.org/http://dx.doi.org/10.1016/j.envsci.2009.04.007. P. J. Ericksen, "Conceptualizing food systems for global environmental change research," *Global Environmental Change* 18, no. 1 (2008), https://doi.org/http://dx.doi.org/10.1016/j.gloenvcha.2007.09.002.

[23] Dasgupta, *Human Well-Being and the Natural Environment*. K. J. Arrow et al., "Sustainability and the measurement of wealth," *Environment and Development Economics* 17, no. 3 (2012), https://doi.org/10.1017/S1355770X12000137; National Research Council, "5: Economic methods of valuation." S. Faucheux and M. O'Connor, eds., *Valuation for Sustainable Development* (Cheltenham, UK: Edward Elgar Publishing, 1998). E. Gómez-Baggethun et al., "The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes," *Ecological Economics* 69, no. 6 (2010), https://doi.org/https://doi.org/10.1016/j.ecolecon.2009.11.007. R. B. Howarth and R. B. Norgaard, "Environmental Valuation under Sustainable Development," *The American Economic Review* 82, no. 2 (1992). Y. E. Chee, "An ecological perspective on the valuation of ecosystem services," *Biological Conservation* 120, no. 4 (2004), https://doi.org/https://doi.org/10.1016/j.biocon.2004.03.028.

[24] E.g. p. 12 FAO, *Food wastage footprint: full-cost accounting*, Food and Agriculture Organization of the United Nations (Rome, 2014).

externalities directly through demand changes. Through iteration and the fourth step of the theory of change valuations and value changes work to the same end. Value changes become valuations and valuations can result in value changes. There is conceptual flexibility in what is economic value, exploited in the foundation of environmental, ecological and welfare economics. Defining economic value is part of the process of doing impact valuation, as discussed in the chapter Food System Impact Valuation in Practice.

Starting with food systems and moving clockwise we provide examples of current activity around the triad (Figure 4):

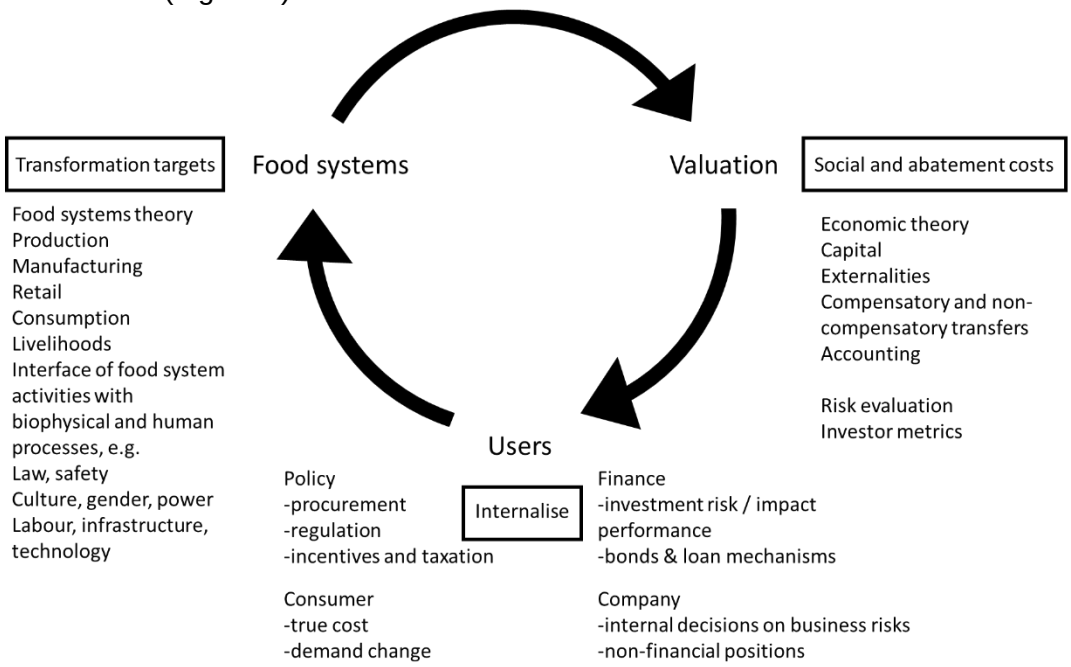

Figure 4: A triad of food system science, valuation, and users. *Food system science* indicates a loss of economic value and sets scientific targets like climate science sets targets such as 2 or 1.5 degrees. *Valuation* provides an account of the value loss that is presently not costed into the economic system. Valuations inform *internalisation* leading to movement to targets. By having agreed and credible changes in value the economic system re-forms or is reformed around the value change. The process is iterative until optimal, i.e. the economic trajectory of most value becomes the impact neutral (or sustainable) trajectory.

For food system science that links food system impacts to value loss on capitals we mention the TEEB AgriFood Framework and the Natural Capital Food & Beverage Sector guide, noting other frameworks[25]. For transformation targets we mention the UN Sustainable Development Goals (SDGs), the EAT-Lancet Commission on healthy diets from sustainable food systems footprint targets, and the FABLE Consortium targets and pathways[26].

[25] TEEB, *Measuring what matters in agriculture and food systems*, UN Environment (Geneva, 2018). NCC, *Natural Capital Protocol: Food & Beverage Sector Guide*. FAO, *Sustainability Asessment of Food and Agriculture Systems (SAFA) Guidelines*., National Research Council, *Framework for Assessing Effects of the Food System*. Zurek et al., "Assessing Sustainable Food and Nutrition Security of the EU Food System—An Integrated Approach." 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.

[26] FAO, *Transforming food and agriculture to achieve the SDGs*, Food and Agriculture Organization of the United Nations (Rome, 2018), http://www.fao.org/3/I9900EN/i9900en.pdf. Willett et al., "Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems." FABLE,

Accounting gets used in two senses for non-financial capital. It can mean just to account, to bring to consideration, to record[27]; true-cost accounting in this sense highlights what is happening with non-financial capitals for food system activities. And accounting[28] – a formal reporting system of financial and, in this case, non-financial transactions, expenditures and revenues (changes to value flows) and current and non-current assets and liabilities (present and locked-in future changes to what contributes to value flows). An example of the latter type of accounting is natural capital accounting, which refers to quality and quantity of natural capital stocks. Monetary amounts pair readily with quantities and qualities for produced and financial capital. It is an additional step for non-financial capital. There is merit in distinguishing non-financial capital accounting for an inventory of capital assets and valuing that inventory. Valuing non-financial capital absolute quantities is contentious, e.g. the total value of all ecosystems on earth[29]. The value of produced and financial capital should be products of relative changes in non-financial capital. Value of non-financial capital to human activity should also be treated in relative terms[30]. Aggregation of non-financial capital to obtain 'totals' is different than financial capital.

For accounting standards, we note the UN System of national accounts Environmental Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA)[31].. The SEEA-EEA's scope includes both accounting of quantities and qualities of capital and valuation. The current revision of the SEEA-EEA likely offers the best conceptual discussion for accounting for non-financial capital that can underpin or be adapted for a food system non-financial accounting standard[32].

For economic valuation theory we mention direct valuation and valuation proxies. Case studies in the chapter Case Studies of Food System Impact Valuation indicate the current activity for impact valuation. Details on existing methods for impact valuation mentioned through this report are summarised in the chapter Inventory and Development of Methods. Valuation proxies imply a loss of value in the eventual internalisation of food system externalities and a proxy estimate using financial indicators like investment and credit risk[33].

Pathways to Sustainable Land-Use and Food Systems. 2019 Report of the FABLE Consortium. M. Obersteiner et al., "Assessing the land resource–food price nexus of the Sustainable Development Goals," *Science Advances* 2, no. 9 (2016), https://doi.org/10.1126/sciadv.1501499. C. Hawkes and B. M. Popkin, "Can the sustainable development goals reduce the burden of nutrition-related non-communicable diseases without truly addressing major food system reforms?," *BMC Medicine* 13, no. 1 (2015/06/16 2015), https://doi.org/10.1186/s12916-015-0383-7.

[27] https://www.lexico.com/en/definition/account

[28] https://www.lexico.com/en/definition/accounting

[29] M. Toman, " Why not to calculate the value of the world's ecosystem services and natural capital," *Ecological Economics* 25, no. 1 (1998), https://doi.org/10.1016/S0921-8009(98)00017-2.

[30] UNEP, *Inclusive wealth report 2018 : measuring progress towards sustainability* (Cambridge: Cambridge University Press, 2018).

[31] A4S CFO Leadership Network, *Natural and Social Capital Accounting*, Accounting for Sustainability (2014); OECD et al., "System of Environmental Economic Accounting 2012 : Experimental Ecosystems Accounting," (2014), https://doi.org/10.1787/9789210562850-en.

[32] https://seea.un.org/content/seea-experimental-ecosystem-accounting-revision

[33] Francisco Ascui and Theodor F. Cojoianu, "Implementing natural capital credit risk assessment in agricultural lending," *Business Strategy and the Environment* 28, no. 6 (2019), https://doi.org/10.1002/bse.231 FAIRR, *Factory farming: asessing investment risks*, Farm Animal Investment Risk & Return (London, 2016). FAIRR, *Plant-based profits: investment risks & opportunities in sustainable food systems*, Farm Animal Investment Risk & Return (London, 2018).

For users and uses we mention corporate reporting and impact frameworks[34], business risk and opportunity[35], and finance initiatives and directives such as the Natural Capital Declaration[36]. Civil society reports on the true cost of food and taxation act as internalisations by stimulating demand change and regulatory risk[37]. There are already private and public fiscal incentives to reduce food system impacts[38]. For the issue of climate change, policy and market interventions are detailed in Chapter 7 starting p. 7-33 of the 2019 IPCC report[39].

The next section describes the impact valuation process in the TEEB AgriFood Framework and the Natural Social & Human Capital Protocols. The section after concentrates on doing food system impact valuation.

Needed are the vision, the inspiration, the credible pathway of systemic change through internalising the external costs as much as the methods and the data are needed.

As well as practical impact valuation and accounting, realising transformation in the food system through internalisation requires consideration of the full range of regulatory, market and financial options and examples of them[40]. Needed are the vision, the inspiration, the credible pathway of systemic change through internalising the external costs as much as the methods and the data are needed. Uses drive development, and drive credibility, agreement, and comparability. In turn, development and alignment of methods and tools reduce barriers and opens the territory to more, or more effective, uses. The process accelerates the closer the triad comes together. Synergy between the triad of food system science, economics and users requires a

[34] T. Singer, *Total Impact Valuation. Overview of Current Practices. Research Report R-1661-18*, The Conference Board (2018). J. Unerman, J. Bebbington, and B. O'Dwyer, "Corporate reporting and accounting for externalities," *Accounting and Business Research* 48, no. 5 (2018), https://doi.org/10.1080/00014788.2018.1470155. P. Conradie and D. de Jongh, "Realising the vision of Integrated Reporting: A critical viewpoint," *Journal of Economic and Financial Sciences* 10, no. 2 (2017), https://doi.org/10.4102/jef.v10i2.18.

[35] B. Caldecott, N. Howarth, and P. McSharry, *Stranded assets in agriculture: protecting value from environment related risks*, Oxford University - Smith School for Enterprise and the Environment (Oxford, 2013). J. Poore and T. Nemecek, "Reducing food's environmental impacts through producers and consumers," *Science* 360, no. 6392 (2018), https://doi.org/10.1126/science.aaq0216. WBCSD, *True Cost of Food: Unpacking the value of the food system*, World Business Council for Sustainable Development (Geneva, 2018). CISL, *How businesses measure their impact on nature: a gap analysis*, University of Cambridge Institute for Sustainability Leadership (Cambridge, 2017).

[36] Natural Capital Declaration, *Towards Including Natural Resource Risks in Cost of Capital, State of play and the way forward*, World Bank, Global Canopy Programme, UNEP FI (Geneva, 2015). A. Millan, B. Limketkai, and S. Guarnaschelli, *Financing the Transformation of Food Systems Under a Changing Climate.*, CGIAR Research Program on Climate Change, Agriculture and Food (Wageningen, the Netherlands, 2019), https://hdl.handle.net/10568/101132. B. Scholtens, "Why Finance Should Care about Ecology," *Trends in Ecology & Evolution* 32, no. 7 (2017), https://doi.org/10.1016/j.tree.2017.03.013.

[37] I. Fitzpatrick and R. Young, *The Hidden Cost of UK Food*, Sustainable Food Trust (Bristol, 2017). S. Henderson et al., *The real cost of food: examining the social, environmental and health impacts of producing food*, Food Tank (Chicago, 2015). GAFF, *On true cost accounting & the future of food*, Global Alliance for the Future of Food (Toronto, 2018).

[38] D. Helm, "Agriculture after Brexit," *Oxford Review Of Economic Policy* 33, no. suppl1 (2017), https://doi.org/10.1093/oxrep/grx010. CISL, *Modelling better business: Nestle trials natural capital premium with UK dairy farmers*, Natural Capital Impact Group (Cambridge, 2018). https://www.fairr.org/

[39] IPCC, *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems*.

[40] Chapters 9 and 10 of TEEB, *TEEB for Agriculture & Food: Scientific and Economic Foundations*. discuss building networks and uses to affect change.

network and investment that enables the community to develop and promote measures for economic correction of food system impact at scale.

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PREVIOUS SECTION: 3. INTRODUCTION AND GLOSSARY

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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NEXT SECTION: 5. ALIGNMENT OF IMPACT FRAMEWORKS