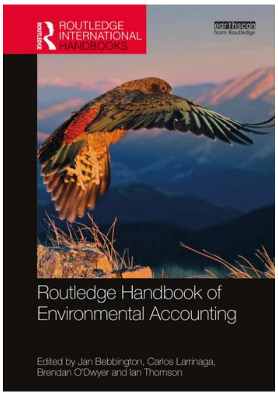

Routledge Handbook of Environmental Accounting

Jan Bebbington, Carlos Larrinaga, Brendan O'Dwyer, Ian Thomson

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Ian Thomson
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DESIGNING ENVIRONMENTAL IMPACT-VALUATION ASSEMBLAGES FOR SUSTAINABLE DECISION-MAKING

Ian Thomson

Setting the scene

The complex process of measurement or valuation of environmental impact involves creating accounts of the consequences of a decision on selected socio-ecological systems. Determining consequences involves a comparison of knowledge of the current nature and driving features within socio-ecological systems as well as the desired outcomes to be attained from the decision. These outcomes are theoretical constructions based on existing data, evidence, assumptions and connections projected forward in time. Paradoxically, the calculation of environmental impacts is designed to prevent them ever happening or to put in place mitigation or restorative measures. Impacts are typically described in terms of impacting on what, impacting on whom, quantification of change, responsibility for the impact, risk and uncertainty, impacting where and when, and legitimacy of impact measurement. Impact-valuation involves multiplying "impact numbers" by "proxy values" derived from selected economic transactions.

There is a plethora of environmental impact measurement methods. Many are covered in this handbook, for example, in chapters on accounting for externalities, carbon accounting, water accounting, biodiversity accounting, material and energy flow accounting and considering animal rights. The problem is that each environmental impact-valuation takes place in a unique time-space configuration that necessitates creating a calculative assemblage or evaluating existing ones. Each environmental impact-valuation is dependent on a series of choices on how to undertake this impact-valuation work. The two challenges of environmental impact-valuation are (1) to know what are the best available practices and (2) how to make informed choices when creating an appropriate calculative space.

Introduction

The premise of this chapter is that accounting could be reimagined and realigned with the rationales of and passionate commitment to sustainability, sustainable governance and sustainability science (Gray 2010; Bebbington and Thomson 2013; Bebbington and Larrinaga 2014). The challenge of developing meaningful environmental impact-valuations lies at the core of sustainability accounting and accountability research and is key to untangling many connected environmental governance, accounting and accountability problems. Central to accounting's future contribution is a capacity to meaningfully measure the consequences and impacts before, during and after any decision. Meaningful environmental impact-valuation measures are critical to holding organisations to account for their past decisions and wider governance and engagement processes.

This chapter provides a framework to evaluate environmental impact-valuation calculative spaces in order to create more sustainable accounting assemblages. This framework borrows and blends from a number of disciplines, including critical accounting studies, sustainability (e.g. Naess 2005), sustainability science (Folke et al. 2010), resilience assessment (Milkoreit et al. 2015), post-normal science (Frame and Brown 2008; Frame and O'Connor 2011) and political projects such as UN Sustainable Development Goals. This chapter will argue that without robust impact-valuation measures, either financial or non-financial, the transformative potential of sustainable governance is diminished.

The purpose of this chapter is not to recommend "the best" technologies, but to present a framework to evaluate impact-valuation methods prior to integration into accounting assemblages. Just as other disciplines naively co-opt accounting logic and techniques, we must avoid the naive co-option of other disciplinary logics or technologies. Some of these techniques, particularly valuation technologies, involve overly simplistic calculative reductions of complex phenomenon that seem destined to repeat the same mistakes that accounting academics are all too aware of.

This handbook is a manifestation of a critically informed engagement with these impact-valuation technologies by the accounting-environmental research community. However, this remains an ongoing challenge. There is a need for positive appreciation of the potential of these techniques as well as their critical evaluation. During these engagements, we should remain vigilant to criticisms as to the impossibility or dangers of environmental impact-valuations (e.g. Hines 1991; Maunders and Burritt 1991; Cooper 1992; Herbohn 2005; Gray 2010).

Pre-study of environmental impacts-valuations

A prestudy into environmental impact-valuations revealed a staggering diversity of measurement techniques, applying methods from artificial intelligence, big data, statistics, satellite imagery, geographic information systems, citizen science, decision science, citizen juries, dialogics, and natural sciences. In addition to quantification methods, environmental impact was valued and made visible through images, art, graffiti, videos, games, confabulations, storytelling and oral testaments.

Searching for "valuing environmental impacts" on Google Scholar came up with 16,900 sources, far too many to review in this chapter. It is enough to state that there is a range of disciplines looking at this problem including economics, development studies, sociology, ecological science, policy studies, climate science, epidemiology, risk, accounting, finance, strategy, geography, ecological philosophy and future studies.

Crudely this domain could be divided into eight categories. These are those seeking or promoting:

- that this can't be done
- that this shouldn't be done

- a single perfect measure or cost
- authoritative multiple-criteria formal decision choice mechanisms
- deliberative multiple criteria models
- mixed, non-integrative quantitative–qualitative methods
- dialogic stakeholder-driven measures and
- alternative environmental art or representation of valuations.

While there was an absence of an authoritative way to measure or value impacts, this prestudy did offer the possibility of technologies that may be appropriable into accounting assemblages. Table 17.1 provides a summary of some these technologies, which complement many others within this handbook.

However, in certain assemblages these technologies may contain incompatible logics, ontological or epistemological contradictions (Mol 1999) that could create dangerous, seductive chimeras wholly inappropriate for sustainable decision-making. It was this observation that led to the consideration of a framework to help make better choices when assembling these technologies for the purposes of sustainable governance, decision-making and accountability.

Assembling environmental impact-valuation assemblages

Any environmental impacts-valuations must be cognisant of the socio-scientific-ecologic-political problems of sustainable development and account for the complex network of challenges and conflicts associated with living within our planetary boundaries. Partial or problematic assumptions of relationships amongst these systems will create problematic impact-valuation.

Even when impacts-valuations are based on "hard", "objective" facts, we have to recognise that these impacts-valuations are unevenly distributed and amplified by structural inequities

Table 17.1 Examples of appropriable environmental impact techniques

Impact Valuation Techniques	Sources and Examples
Multiple criterion decision modelling	Infrastructure Auckland 2004, Frame and O'Connor 2011.
Ecological footprinting	Gallo et al. 2016, Global Footprint Network 2020.
Remote sensing and geographic information systems	Sieber 2006, Brown et al. 2011, Ascui et al. 2018, Denedo et al. 2019, Ecowatch 2020, IMBIE 2020
Sustainable valuation models	Antheaume 2004, Herbohn 2005, Bebbington et al. 2007, Xing et al. 2009, Frame and Cavanagh, 2009.
Product labelling/ environmental profiling	BRE 2008, Cordella et al. 2020, Ecolabel 2020.
SES resilience assessment	Folke et al. 2010, Resilience Alliance 2010.
Environmental impact assessment	UNEP 2004, Carroll et al. 2020, NECR 2020, EPA 2020.
Accounting for biodiversity	Pritchard et al. 2000, Cuckston 2013, 2017, 2019, Natural Capital Alliance 2020.
Sustainable performance frameworks	Russell and Thomson 2009, Allen et al. 2019, Wendling et al. 2018, World Benchmarking Alliance 2020, Futurefit 2020.

or oppressive power dynamics. Environmental impact-valuations cannot be neutral as they are intended to alter our understanding of the past and knowledge of future consequences and aim to draw this new knowledge into organisational decision-making and governance (Unerman and Chapman 2014).

This chapter adapts the analytical approach recommended by Sobkwiak et al. (2020), which builds on Callon's three-stage reflexive framing of a calculable space to understand how socio-technical arrangements create conditions of possibility for meaningful calculations of environmental impact-value (Callon and Law 2005). Any calculative outcome has to be understood as interactions between human calculators, calculative devices and the systems in which they embedded. Any attempt to calculate environmental impact-valuation will require "accountants" to construct a calculative space, extract and appropriate accounts from the calculative spaces of others or become embedded in the calculative spaces of others. However, central to this framework is the recognition of the constitutive agency of those involved in ***choosing*** how measurements are made and used (Callon and Muniesa 2005).

This framework requires consideration of the:

- choices as to how and what things are detached from other systems,
- choices as to the processes of manipulation and transformation, undertaken on detached data and
- choices as to how values are extracted and appropriated into decision processes.

Sobkwiak et al. (2020) argue that understanding environmental accounts as three distinct yet interconnected challenges allows for the evaluation of the messy, multi-organisational, multi-disciplinary calculation processes. Given that any environmental accounting is temporary and incomplete, part of a shifting assemblage, it must be subjected to recurring critical evaluation in order to understand the limitations of any particular assemblage. Similar to the post-normal scientific paradigm (e.g. Frame and Brown 2008), this framework recognises any environmental impact-valuation assemblage as imperfect and constantly in flux due to the interaction of power, politics, epistemologies, paradigms or philosophies in its calculations. However, this does not mean that striving for more meaningful environmental impact-valuations in different decision contexts is without merit or purpose.

The framework in this chapter, which takes the form of a series of propositions, privileges epistemological assumptions that the environment comprises interconnected, uncertain and complex natural resource systems that are governed to deliver long-term sustainable environmental benefits to human well-being in a way that does not compromise system resilience or integrity. Therefore, any choices should be evaluated in relation to their contribution to the future resilience of the socio-ecological systems essential for sustainable development (Resilience Alliance 2010).

Making the wrong choices

Environmental impacts-valuations are calculative outputs of accounting assemblages that attempt to present an intelligible narrative of future consequences of actions that encompass invisible, undetectable phenomena, normally reliant on expert knowledge and scientific methods, perceived through different social norms and values (Callon and Law 2005; Callon and Munesia 2005; Sobkwiak et al. 2020). These impact-valuations need to be considered politically legitimate, interpretable by non-experts and meaningfully appropriated in their everyday decision-making in order to trigger appropriate corrective interventions and governance sanctions.

Problematic impact-valuations allow organisations escape responsibility and associated liabilities for environmental damage, continue to externalise risks and harm to others, and avoid regulations or taxes or other sanctions (Beck 1992; Bebbington and Thomson 2007). There is a clear incentive for those causing environmental damages or those benefitting from this abuse of nature or abuse of power to claim it is impossible to accurately measure or value environmental impact (e.g. Gray 2010). Even when effective measures appear to exist, for example, satellite images of disappearing rainforests (Ecowatch 2020), melting polar ice sheets (IMBIE 2020) these can be insufficient to attribute responsibility or accountability to individuals, communities or organisations.

Overly simplistic or overly complex impact-valuations can also construct false cause–effect consequences or knowledge of the impacts (Frame and Cavanagh 2009). Problematic environmental impact-valuations can falsely label a solution as sustainable, when it merely shifts the problem to another domain or forward in time (Beck 1992; Frame and O'Connor 2011). Environmental impact-valuations, therefore, must make visible and thinkable the sustainable governance of economic, ecological and social life, in particular rendering visible and governable the risks of unsustainable consequences (Bebbington and Thomson 2007; Gray 2010) across systems and generations.

Many others have raised concerns that environmental impact-valuations calculatively captured environmental issues and suppressed fields of visibility, forms of knowledge and techniques of governing considered significant for any sustainable transformations (Hines 1991; Cooper 1992; O'Dwyer 2003). Given the above, it is a logical conclusion that environmental impact-valuations require disciplinary and organisational boundary spanning processes, practices and expertise taking into account uncertainty, the severity of any potential hazards, complex interdependencies and incomplete, contradictory evidence and opinions (Frame and O'Connor 2011).

When evaluating any assemblage of environmental impact-valuations, we need to consider its alignment with sustainable development and whether it will perpetuate or accelerate global or local catastrophes and worsening social injustice (Gray 2010), rather than focus on accuracy or standardisability of measurement protocols. This places responsibility on environmental accountants as to how they choose to calculate impacts-valuations and ensure any impact-valuations take account of legitimate problematisations of past accounting environmental techniques and resistance to solutions promoted in other disciplines.

Environmental detachment – cutting the cord with nature

This stage involves exploring the choices made as to how and what is detached from selected socio-ecological systems prior to manipulation and transformation into an appropriable impact-valuation. For example, if we are interested in governing the water pollution from an industrial plant, then this will trigger a series of questions as to what evidence to collect to measure this impact.

- What is our definition of pollution?
- Where would we look for this information?
- Would we use evidence produced by the company?
- Would we collect our own measures of pollution?
- Would we include non-peer reviewed research?
- Would we use media coverage, anecdotes and oral testimony of local communities?

What is chosen to be detached (or excluded) will shape the calculative possibilities of all subsequent stages. Any detachment choice involves some form of reduction of the complexity of the systems to be measured and privileges different dimensions or impacts. Understanding and critically engaging with the theories or conceptual justification for what gets included/excluded is therefore important. It is critical to recognise that there is a contradiction between the detachment needed for valuation and the holistic nature of socioecological systems. Any detachment involves simplification and reductionism; therefore, all calculative choices should reflect on the extent and implications of this detachment.

Detachment choices must also consider the measurement technologies and the institutions controlling access to those technologies. These could include confidential lab results relating to process safety evaluations; radioactivity levels will require access to Geiger counters and trained operatives; satellite images will depend on access to satellites and so on. Given the political and economic sensitivity of many environmental impacts-valuations, it may not be possible to access the raw data. Instead, detachable information may be restricted to carefully curated and politically edited accounts.

Choices will have to be made as to the acceptability of different data sources, particularly when the detachment is secondary, that is, extracting data from existing calculative spaces such the US Toxic Release Inventory (EPA 2020) or UK Office of National Statistics (Sobkwiak et al. 2020). A number of useful insights into how to make these choices can be found in research into assurance, audit and research design (see chapters 9 and 4 of this handbook, respectively)

Brander (2016, 2017) identified the criticality of the attributional/consequential choice in the design of environmental impact-valuations. Attributional environmental measures use prescribed inventories or lists of impacts to be applied. These often relate to regulations, formal or voluntary governance mechanisms or codes of practice (e.g. UNEP 2004; WBCSD and WRI 2004; BRE 2008; DEFRA 2019; Ecolabel 2020; NECR 2020; EPA 2020). Going down the attributional pathway increases the comparability and consistency of impact-valuations and as such is favoured in formal governance and regulatory settings. However, Brander, in the context of climate change, demonstrated that attributional methods do not capture all critical consequences of a decision, which unintentionally increased rather than decreased carbon emissions. He argues that in most cases choosing a life cycle consequential calculation will improve the chances of selecting more sustainable options. Consequential calculations involve exploring different future scenarios and the construction of decision-specific theories of changes or causal chain maps, rather than applying predetermined inventories.

Consequential detachment is more aligned with the essential attributes from leading sustainability science research (Folke et al. 2010; Milkoreit et al. 2015) and sustainable political programmatic discourses, such as the United Nations' Sustainable Development Goals (UN SDGs), Planetary Boundaries; One Planet Economies (e.g. Allen et al. 2019; Keys et al. 2019). Detached data (in whatever form) should represent what happens in a system and how this affects interconnected systems over relevant action timescales. Measuring the impact of any decision taken anywhere in these interconnected systems requires understanding of what may happen at multiple scales and assumptions as to how the organisation plans to respond to innovations and constraints imposed from these overlapping systems. This also requires consideration of geographic boundaries, regulatory regimes, risks, dependency relationships, stakeholders, level of system coupling and connective vectors as well as culture and conflicts, associated with sustainable governance.

The desired outcome of any environmental impact-valuation is also a critical part of any detachment decision. Without some vision of the future state of socio-ecological systems after the decision, it is difficult to reflect on the quality of any calculative choices made. Imagine you were planning to undertake an environmental impact-valuation of your weekly food shopping. Could you meaningfully undertake this without a preference for specific food scenarios? These

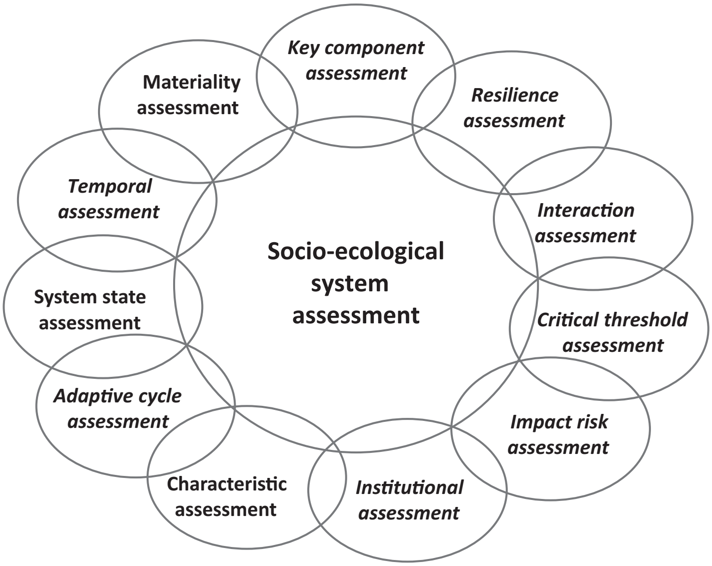

Figure 17.1 Socio-ecological systems assessment. (Source: Authors' construction from Resilience Alliance 2010.)

could include organic, Fairtrade, closed loop, zero carbon, zero waste, zero plastic and slave-free scenarios. These imagined future scenarios shape the detachment processes. Chapter 6 provides a useful distinction for environmental impact-valuation scenarios, classifying them as business-as-usual, adaptive or transformative. Other examples could include legally compliant, socially acceptable, remediative or restorative. Scenarios need to be explicitly considered and made transparent in how they inform detachment choices and other calculative choices.

The Resilience Alliance (2010) developed a comprehensive, consequentialist approach to assessing socio-ecological system that can inform sustainable detachment choices (see Figure 17.1 for key elements of this methodology).

This consequential assessment method helps identify the questions to ask and frames the responses to those questions in order that detachment choices are aligned with adaptive or transformative outcomes. This interdisciplinary approach can be used to evaluate the suitability of detached data that informs all subsequent environmental impact-valuation calculations. Whilst resilience assessment is built on a number of core concepts, it encourages the creation of contextually relevant assemblages of techniques and customising in relation to the data types and sources. It does not rely on a single set of data or techniques and assumes that any limitations of a single impact-valuation can be mitigated through the curation of other methods within the assemblage. For example, the assemblage could include scientific results of tests of river samples, regulatory breach reports, external social audits, media stories, satellite images, photographic evidence, historical maps and accounts, analysis of local myths, school projects, records of local bird watching clubs, interviews with local communities, discussions with local activists and so on.

The following list of questions is designed to help with data detachment choices:

- What are the outcome, desired scenarios or system configurations?
- What are the relevant disciplines and measurement techniques?

- To what extent is this an attributional or consequential set of techniques?
- What stages of the impact life cycle are included?
- How reliable are individual sources and their collective impact?
- How representative are the views/objectives included?
- How does the data reflect the interest of marginalised systems or communities?
- What systems are included/excluded?
- What is the time frame?
- Does it incorporate risks, uncertainties or system thresholds?
- Does it reflect power, conflicts and governance structures?
- What are the theories of system dynamics and change?
- Does it reflect the interconnections between different systems?
- Does it allow for the evaluation of current and future system states?
- Are there any methodological biases?

Manipulation and transformation – messing around with messy data

The second stage of environmental impact-valuation involves the manipulation and transformation of that which has been detached from socio-ecological systems. Impact-valuation work has now shifted from measuring things like "river", "forest" or "coastline" to processing the data gathered about "river", "forest" or "coastline". This involves manipulating and transforming the data into measurements that should be decision relevant; commensurable; culturally appropriate; aligned with laws, rules and regulations; compliant with disciplinary norms and socially acceptable. Central to this stage are transformation algorithms or protocols. Understanding the cumulative impact of these algorithms or protocols is critical to evaluating the meaningfulness of any environmental measurement assemblage.

Transformation algorithms or protocols often unintentionally exclude "non-compliant" or "non-legitimated" source material. This exclusion could include any qualitative data, "opinions", unknown sources or provenance and/or elements of pollution not subject to regulatory control. Chapters 7, 8 and 10 of this handbook demonstrate how exclusion protocols embedded in the financial reporting transformation algorithms result in manipulated representations of businesses. When evaluating any impact-valuations technique (or assemblage) it is important to identify potential bias, problematic exclusions or representational distortions in the transformation processes.

Throughout the handbook, examples are provided of how transformation problems or exclusions are often problematically black boxed. For example, current UK Financial Reporting guidance on how to transform attributional data on carbon emissions into financial reporting disclosures contains a number of exclusions (Ascui and Lovell 2011; Brander 2016, 2017; DEFRA 2019; see also Chapter 26). These "carbon emissions", which are proxies for business's contribution to global warming, are limited to scope 1 and 2 emissions (WBCSD and WRI 2004). The exclusion of scope 3 was the result of a choice to align reported carbon disclosures with the UK's carbon reduction commitment and international climate change conventions.[1] However, this choice results in carbon emissions embedded in purchased goods, assets, fuel, waste, travel, leased assets, product use and end-of-life being excluded from mandated financial disclosures.

These scope 1 and 2 carbon emissions are restricted to a scientific politically determined set of greenhouse gases (GHG) and do not include all global warming gases. A further exclusion relates to the cocktail of chemicals emitted with these GHG that damages human health, buildings and ecosystems. Choosing only to measure GHG volumes also excludes consideration of the inequitable social and geographic distribution of the harms of global warming.

The current UK manipulation and transformation of company actions into 'financial-reporting-carbon-emissions' is appropriate in the context of UK regulations to reduce carbon emissions. However, these exclusions make this measure inappropriate for other carbon-related decisions (Brander 2016, 2017). Excluding the full life cycle consequences, social impact and associated air pollution when calculating a climate change impact potentially allows short-term low-carbon, but socially unsustainable, options to be inappropriately evaluated as sustainable. However, this process resulted from a ***choice*** of a range of options as to how to detach and transform carbon emissions. This range of options includes life cycle carbon consequential methods that are aligned with sustainable outcomes, governance and system resilience (Brander 2017).

As discussed earlier, single-dimensional impact transformation algorithms or protocols are unlikely to provide useful insights into the multidimensional challenges associated with sustainable transformation or adaptation. Algorithms or protocols associated with multiple criterion models are more suitable to sustainable challenges as they enable interdimensional trade-offs or intersectional deliberative processes that are more visible, transparent and democratic (Frame and O'Connor 2011). Who is invited and when they participate in these processes will change the impact-valuations (Brown et al. 2011; Frame and O'Connor 2011; Denedo et al. 2018). Generally speaking, the less representative and the later participants are involved, the more likely the measure will contain bias or privilege the powerful.

There is an epistemic bias in environmental accounting to transform uncertain, future estimates of complex, multidimensional data into a single normalised figure, as either a score or financial value. This tendency can be problematic if it results in an oversimplification of complex chains of impacts or designed to minimise dissent or force consensus, particularly in relation to controversial topics. This tendency should also be recognised as a choice privileged in accounting calculations and there are many other ways to transform and manipulate data. These involve reporting ranges, contingent values, scenario outcomes, disaggregated data or profiles.

Bebbington et al. 2007 (see also Frame and Brown 2008; Frame and Cavanagh 2009; Xing et al. 2009; Fraser 2012) provide an example of a multidimensional consequential calculative assemblage that produces profiles of the positive and negative externalities associated with different activities. This approach allows greater transparency of the complexity of impacts and the possibility of more nuanced commensuration and decision-making.

Figure 17.2 represents two such profiles (framed as "signatures") which otherwise could have been represented by single numbers (e.g. the net sum of the total impacts above and below the line – or some variant thereof) with an attendant loss of information of the distribution of values across social, environmental, resources and economic dimensions. This approach to data decomposition and presentation, therefore, enhances the possibilities that the distribution of impacts can be brought into decision processes. It should be noted that each "stack" of impacts are themselves composites of multiple other values and this visual presentation of impact-values provides greater informational content and is less dependent on protocols/algorithms designed for informational reductionism.

To sum up this section, in addition to evaluating detachment choices there is a need to evaluate transformation and manipulation choices, in particular exclusions and potentially distorting calculative reductionism. However, there are calculative transformation protocols and algorithms that are more dialogic, transparent, inclusive, multidimensional, multidisciplinary, culturally sensitive and aligned to sustainability sciences. If choices are made to incorporate these protocols or algorithms in environmental impact-valuation assemblages, then the lower the probability of privileged, problematic impact-valuations (Bebbington and Thomson 2007; Frame and O'Connor 2011).

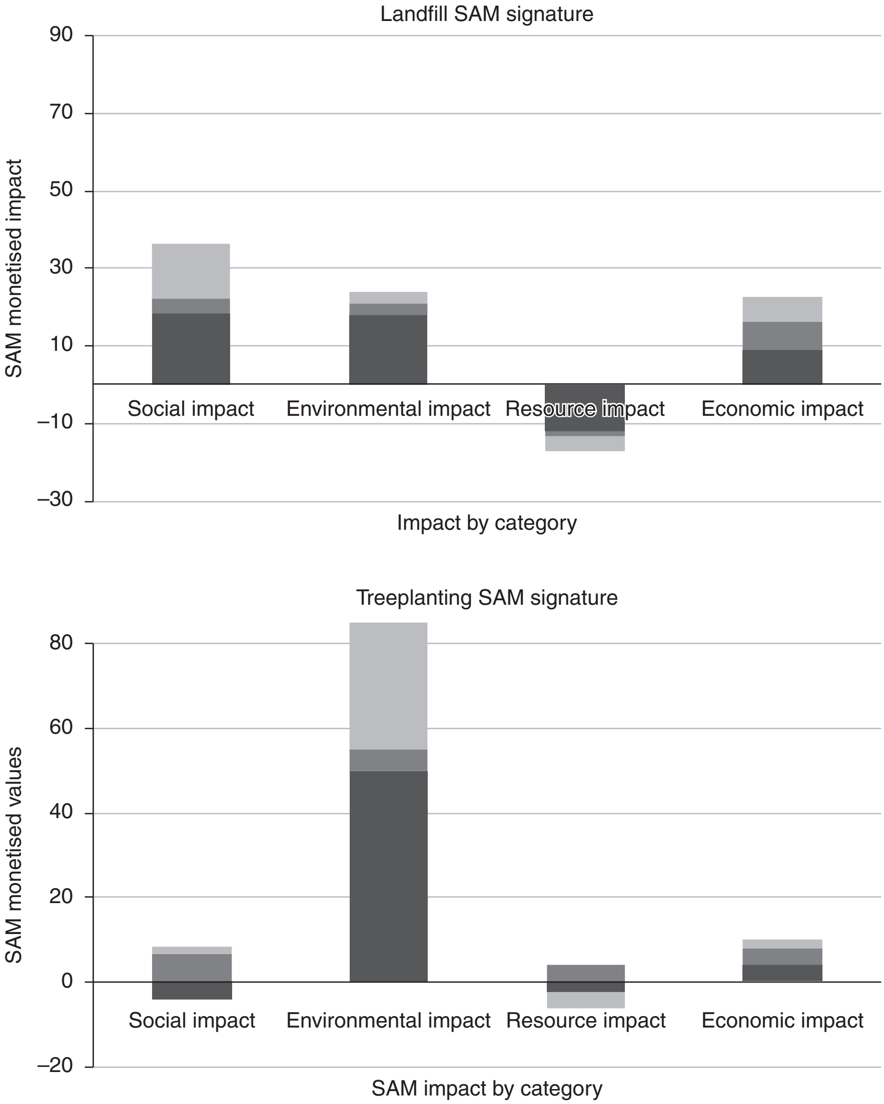

Figure 17.2 Examples of the output of the Sustainability Assessment Model. (Source: Provided by Jan Bebbington.)

In addition to the questions in detachment sections (many of which are applicable here), there are also some specific questions to inform the choice of environmental impact-valuations manipulation and transformation protocols or algorithms.

- What detached data is excluded?
- Are there any (sub)systems excluded in the impact-valuation?
- Are the impact-values co-produced with communities, non-expert or natural system advocates?

- How transparent, auditable, justifiable, understandable or accountable are the calculations?
- Are there any methodological or disciplinary bias in how data is transformed or manipulated?
- How is intragenerational and intergenerational equity taken into account?
- Are there risks of political interference?
- How are critical thresholds, adaptive capacity or systemic risks incorporated in the process?
- What information content is lost in calculative reductions or data visualisations?
- What is the logic underpinning the choice of impact-valuation results (e.g. point estimates, profiles or contingent values).
- How does the process deal with uncertainties, multiple scenarios or contradictory outcomes?
- How well does the assemblage deal with limitations in individual techniques?
- What underlying theories are used to justify transformation protocols?

Extraction and appropriation – pulling the right rabbit from the right hat

The third stage is shaped by choices as to what to extract from the impact-valuations created by the manipulation and transformation stages for input into decision processes (Callon and Muniesa 2005). Extracting and appropriating inappropriate impact-valuations into other decision-making models could trigger ineffective corrective interventions, increasing the risk of environmental harm or allowing problematic behaviours to persist (Russell and Thomson 2009).

There are two important consequences of this observation. First, the detachment, manipulation and transformation processes should be informed by an understanding of the decisions that need to be taken as part of sustainable governance. These stages need to consider the likely consequences of any numbers extracted in different decision contexts. For example, a "low willingness to pay" number for anthropocentrically unattractive keystone species, such as wasps or weevils, could result in decisions that reduce their population size below critical thresholds collapsing whole eco-systems.

Second, caution must be taken when extracting a value from one context and appropriating into decision processes without knowledge of potential limitations accruing from prior detachment, manipulations and transformation choices. An example would be investors assuming the amortised value of capitalised R&D in waste reduction technology is a measure of the innovative capacity of a business in relation to the environment. Without knowing how that figure is calculated (e.g. what is included/excluded; internal accounting transformation protocols; national accounting standards; professional disciplinary norms; regulatory implications; debt covenants; tax write-off potential; income smoothing choices; historic knowledge of investor reactions), this number should not be naively appropriated in a decision to "green" an investment portfolio.

It is important to remember that any environmental impact-valuation emerges from a complex sequence of diverse calculative practices, which cannot transcend any underlying limitations (Mol 1999; Callon and Muniesa 2005). Choices made at the detachment, manipulation and transformation stages *will* affect the usability of the impact measures.

Choices made as to how any impact-valuations are extracted are also important, particularly if that extraction is partial or ignores methodological or other known limitations. For example, the biodiversity value of a tropical forest (Cuckston 2013) could be an aggregation of separate values for:

- purification and regulation of water flows
- regulation of climate
- provision of food, fuel and fibres
- biological control of pests and disease
- prevention of soil erosion
- maintenance of soil fertility
- regulation of air quality
- oxygen production
- cultural services
- spiritual experience
- inspiration for art
- tourism.

However, the availability of these impact-valuations does not require any data users to extract all of these values. Choices will need to be made as to which values to extract and are appropriate based on different logics to that which informed the calculation of that number. For instance, to what extent is it valid to include a value that only aggregates *cultural services, spiritual experience, inspiration for art, and for tourism* for inclusion in a cost–benefit analysis for a forest conservation project? However, the existence of separate values, rather than reducing a forest's eco-system benefits to a single number, does enhance the possibility for more sustainable extraction and appropriation.

The more the detachment, manipulation and transformation stages embrace the attributes identified earlier, the greater the potential for meaningful extraction and appropriation. This potential will be enhanced, if extraction and appropriation is undertaken in a similar transparent, inclusive fashion. This will not remove the possibility of problematic decisions arising from structurally unsustainable decision processes or governance regimes, but incorporating these attributes into impact-valuation assemblages will reduce these risks.

Key questions for evaluating extraction choices include the following:

- How do values reflect complexity, adaptive capacity or uncertainty?
- How do they take into account different scenarios, power imbalances or time scales?
- What detached and transformed data is excluded?
- Do the extracted values obscure contradictory or contested measures?
- Do the extracted values help decision-makers learn about the problem and enable inclusive dialogue?
- Is the extraction process transparent, justifiable and accountable?
- How representative of the range of results are any extracted values?
- Are users able to apply their preferences, values, risk thresholds, outcomes or extraction protocols and decision rules?

Conclusion

We exist in a time of apparently unresolvable social and environmental problems. Unlocking them is a challenge and if environmental accounting is to play a meaningful role in this process, then researchers need to build capacity to evaluate, problematise and engage in designing environmental impact-valuation assemblages appropriate for sustainable transformation. This includes an understanding of what is allowing unsustainable practices to persist and why certain decision-makers are unable or unwilling to imagine sustainable solutions. Environmental impact-valuations have to consider where different unsustainable drivers come from, how they collide, interlock and intersect, in order for more effective targeted interventions and sustainable solutions. This requires a more holistic and inclusive measurement of decision consequences. This chapter has presented a framework with which to interrogate how any environmental impact-valuation is calculated in order to avoid known pitfalls and build in attributes that have been found to increase the chances of more sustainable governance and decision-making.

Note

1 These conventions only apply to scopes 1 and 2 ostensibly to avoid double counting of carbon emissions.

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