Sustainability as innovation: challenges and perspectives in measurement and implementation

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1. Introduction

Framing sustainability as an innovation allows the analysis of the development of measurement systems for sustainability within an innovation framework. The discussion of sustainability's "wicked" characteristics enables conclusions to be drawn for other complex innovation processes.

Sustainability includes environmental, economic and social aspects, with the latter having received the least attention. Despite its 300-plus years of history, sustainability is a controversial concept. This chapter deals with the development of sustainability measurement as an innovation. The concept of wicked problems is used to structure content complexity and process complexity of the development of measurement systems. Based on documents published online and a case study where the author served as co-coordinator during the development process, examples of measurement are presented and discussed. Critical measurement issues and their impacts are highlighted. Process requirements are identified, including the involvement of multiple stakeholders with diverging perspectives and varying participation. Finally, the need for flexibility and continuous improvement is emphasised. Due to its characteristics, sustainability measurement is extraordinarily suited to serve as an example of complex innovations and the lessons learned can be beneficially applied to other cases.

2. Innovation: definition and framework

In its Oslo Manual, the Organisation for Economic Co-operation and Development (OECD) defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD/Eurostat 2005, p. 46). This definition includes product, process, organisational and marketing innovations. The manual limits its scope to the manufacturing, primary industries and the services sector at the firm level. While relevant to innovation in the primary industries and related firms, public sector innovations, industry- and economy-wide changes (such as the emergence of a new market, development of a new source of raw materials or semi-manufactured goods) and industry reorganisation are not included.

The above definition explicitly states that an innovation requires implementation, meaning it must be introduced into a market or put to actual use in a business.

Although the emphasis on implementation may lead to the perception that research and development (R&D), discoveries and inventions are activities before actual innovation, the Oslo Manual states otherwise. "Innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D

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that is not directly related to the development of a specific innovation."(OECD/Eurostat 2005, p. 47).

How to foster innovation (and the necessary R&D) is subject to scientific analysis and broad discussion. For a long time, the distinction between basic and applied research served as a starting point or fall-back position in government and research institutions in the quest to develop a system for innovation in regions, states or broader economic contexts. Referring to Vannevar Bush, an American engineer who headed the National Defense Research Committee during part of the Second World War, government was held responsible for establishing goals for and funding basic research.

Although the scientific community might prefer to focus on applied research, the strict separation of basic and applied research is attributed to Bush, e.g., by Donald Stokes (1998) who criticised the separation as leading to an incomplete perspective. Stokes' model famously personalised the quest for fundamental understanding with the scientist Niels Bohr as an example and the focus on considerations of use with the inventor Thomas Edison. Stokes added a third component with use-inspired basic research, relating it to the chemist and microbiologist Louis Pasteur.

The basic dichotomy between basic and applied research still holds considerable sway, despite having been shown to be insufficient and unrealistic by several innovation process analyses. For example, Vinsel *et al*. (2013) used the analysis of Nobel Prize winning research over a period of over 50 years to show the interrelated system of scientific research and technology. They found no definite hierarchy or linear trajectory been basic and applied research when analysing the innovation cycle in information and communication technologies.

Whereas Bush's original report (1945) focused solely on the role of academia and government in research and innovation, industry was identified as another important player in the innovation system. The identification of industry's role in the process eventually led to the triple helix model, the founding of the Triple Helix Association and, more recently, the Triple Helix journal. The roles of academia and government or the industry in innovation processes have been subject to many simplified policy recommendations and initiatives, which often neglect other aspects and stakeholders of the innovation system.

Lately, the triple helix model has been extended in a number of different directions, depending on data availability, empirical context and the political agenda. For example, Carayannis and Campbell (2010) expanded the model to the quadruple and quintuple helices. They first focused on (re-)introducing the role of civic society in the innovation system, then added the natural environment to form a quintuple helix. The quintuple helix is, however, often presented as a Venn diagram with the three institutions – government, industry, and academe – in the middle of the two circles of society and the environment, neglecting the time dimension (see Figure 2.1). Based on these models, Leydesdorff (2012) suggested that while the explanation of complex developments may need n-tuple helices or, based on earlier work by Simon, an alphabet of helices, data availability and pragmatic reasons recommend the use of the triple helix for most analyses. He emphasised the possibility for different kinds of chaotic behaviour beyond stabilisation already with the addition of the third helix. For Leydesdorff, market and governance form the first two helices, placing his viewpoint in socio-economic theory rather than the political sphere.

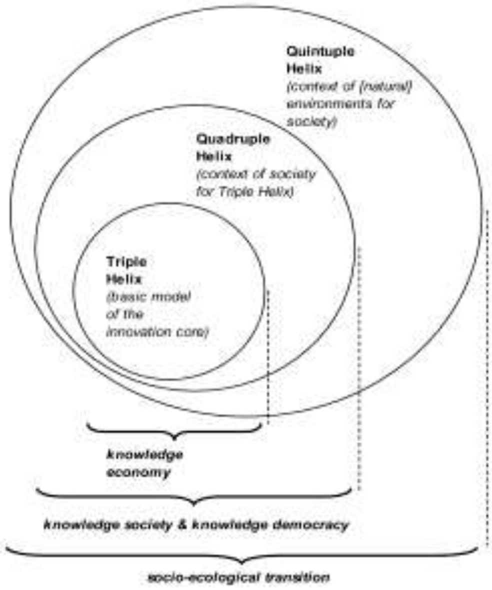

Figure 2.1. Quintuple helix model (based on Carayannis and Campbell 2010).

3. Defining sustainability

The concept of sustainability is attributed to German forest scientist von Carlowitz (1713) while the German term *Nachhaltigkeit* was introduced by Hartig (1795) to convey the basic idea of economically harvesting wood while sustaining the forest for future use. Given the 300-plus-year history of the concept and the historical development of its understanding, it is not surprising that sustainability has entered the public discourse and is used in many different ways to mean a variety of things. Despite the fact that the concept of sustainability has developed into rather sophisticated measurement and certification schemes around the world, the term "sustainable" is commonly used to simply mean "being able to last or continue for a long time".

Reflecting the origin of the concept in forestry, early measurement systems focused on the use of natural resources, in the sense of taking something without using it up. This approach was then applied to the "use" of the environment, which also included the meaning of adding something into the environment (e.g., waste) without depleting the environment's capacity to absorb it. Early examples of these approaches are Carson (1962) raising awareness of the consequences of the use of agrochemicals on the environment and Meadows *et al*. (1972) modelling the limits of growth by exhausting natural resources and the environment's capacity to absorb waste and pollution. Their definitions of sustainability often neglected the earlier economic orientation, under the premise that enterprises – especially private enterprises – would naturally focus on economic benefits, and that economic principles and greed had led to these problems.

It was not until concern for the environment and the overuse of resources reached the public sphere and increasing numbers of environmental groups began organising with citizens around the globe that addressing these issues became part of a political agenda. In December 1983, the General Assembly of the United Nations (UN) asked the World Commission on Environment and Development (WCED), then chaired by Gro Harlem Brundtland, to propose long-term strategies to achieve sustainable development. The commission's final report has had a lasting influence on those working in the field of sustainability, and many cite its definition of sustainable development: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Report, 1987, p. 41). Due to the concern for poor countries and meeting the essential needs of people around the world, the Brundtland Report emphasises not only the environmental dimension of sustainability but the social dimension as well.

Despite the long-standing discussion of the social dimension of sustainability, it was not formally added to the political agenda until the Johannesburg Declaration on Sustainable Development (2002). The declaration includes social goals and reaffirms the indivisibility of human rights and the need for social development. It explicitly mentions women's empowerment and human resource development, among other social causes. Accordingly, the current understanding of sustainability is typically framed as the three pillars concept, which encompasses the social, environmental and economic dimensions of sustainability. Although many suggestions have been made to further expand the concept of sustainability to include more than three dimensions, this chapter will follow Leydesdorff's recommendation to not unnecessarily complicate the notion.

4. Challenges in developing a measurement system

As with other complex problems, Batie (2008) subsumes sustainability with the so-called wicked problems that sciences not only find challenging to solve, but for which complete solutions cannot be developed. Contrary to tame problems, wicked problems are overly complex and controversial to be fully addressed through normal science (Kuhn, 1996). The term wicked problem was introduced in the late 1960s to describe problems that cannot be fully defined and separated from their context, as well as from other problems on different levels. Each attempt at a solution changes the problem definition. Wicked problems also change over time. Causality is muddled and difficult or impossible to model. There are no final solutions to wicked problems; they only can be managed for better or for worse. Because every wicked problem is unique, management and solution approaches cannot be transferred from one problem to another but must be specifically adapted to the problem at hand (Churchman, 1967; Kreuter *et al.*, 2004; Mitroff and Sagasti, 1973; Rittel and Webber, 1973; Weber and Khademian, 2008).

With respect to sustainability and the development of measurement systems for sustainability in particular, another aspect of wicked problems is critical: the involvement of multiple actors and stakeholder groups. Actors and stakeholders dealing with wicked problems hold differing and even contradictory perspectives, beliefs, values and goals. They do not agree on the facts or the definition of the problem. They also do not agree on trade-offs, possible actions, the evaluation of actions or a suitable process to approach the problem. Their participation varies and is ambiguous. Because wicked problems will not be solved, the termination of the process is controlled by stakeholders, political forces and resource availability (Batie, 2008; Kreuter *et al.*, 2004; Rittel and Webber, 1973; Stoppelenburg and Vermaak, 2009; Weber and Khademian, 2008). Whereas other fields, including civil engineering, management science, public administration and computer sciences, have embarked on incorporating the peculiar characteristics of wicked problems in research projects and applications, applied economics still focuses mostly on tame problems. However, the development of sustainability measurement systems requires considering the issue's complexity.

4.1. Deductive approach to measurement

The development of a measurement system typically includes at least three stages or is presented on three levels, despite the recursive process of system development. On the first level, the legitimisation of the system is based on general principles, often agreed upon in international treaties, standards or agreements, such as the United Nations Universal Declaration of Human Rights, the more recent UN Global Compact or the OECD Guidelines for Multinational Enterprises.

One example of these shared principles with a social dimension is the "protection of human rights" (Example 1). On the second level, principles are broken down into a catalogue of criteria to frame concrete areas of action. For most principles, several criteria will be required. An example of a criterion for Example 1 is "no child labour" (Example 2). While actors and other stakeholders involved in the development process are more easily able to agree on general principles, settling on criteria shows diverging perceptions and interests. On the third level, criteria must be translated into measurable indicators. At this stage of the process, diverging values and conflicts between stakeholders involved become more visible and at times development efforts fail. An example of an indicator for Example 2 is "only employees 18 years of age and above" (Example 3). As this example shows, differing societal value systems, actors' perspectives and trade-offs between agreed upon goals lead to a greater potential for conflicts as the development process moves increasingly towards concrete measurement. For example, how is the suitable age for work be determined? How is the right to work, even for minors, especially in countries with limited formal social security systems, to be factored in? How should the right to education, including professional education, figure in? Emotionalising terms, such as "exploitive child labour" do not provide answers to these questions. Answers may differ in different regions and societies and depend on their economic situation and development.

The final set of decisions regarding indicators will determine costs and applicability of a measurement system. Once general principles are broken down into criteria and have been solidified into measurable indicators, the actual measurement protocol must be determined. The measurement protocol describes the specific data collection approach. Data collection can include the full range of direct onsite primary data collection (e.g., interviewing employees), indirect onsite data collection (e.g., reviewing files), data reporting to a central institution and companies reporting compliance without specific data. Additionally, measurement specificity and precision are issues (see also Genier *et al*., 2008).

4.2. Requirements for indicators

While indicators are agreed upon during the development process of a sustainability measurement system, they do not necessarily meet requirements for indicators as suggested by the scientific community (see, for example, National Research Council, 2010). A prerequisite for successfully involving multiple stakeholders in the development process are the understandability, credibility and audibility of indicators. Indicators must be understandable by non-experts, even if measurement itself requires expert knowledge. The involvement of a well-rounded group of stakeholders in the process and access by the public for input is another prerequisite, as many decisions involve value judgements that require broad dialogue and cannot be left solely to experts (see also Busch, 2009).

Additionally, the measurement itself directs the focus of attention and therefore has value implications. Decision making and assessment takes into account what is measured. An important example, which is also a point of contention and potential outcome manipulation, is the definition of the system to be measured. As pointed out by Thompson (2007), "the definition of system borders involves a value judgement that frames the empirical assessment of sustainability" (p. 7).

Although many specific requirements for indicators are discussed in the literature (National Research Council, 2010), much of the current focus in research and development evolves around their feasibility. While the scientific community has an interest in comprehensive detailed measurement, practical requirements demand cost effective measurement. Many existing measurement systems meet specific needs within a narrow agronomic, economic and ecological context, but are not applicable beyond that context (Thompson, 2007). The feasibility requirement asks for applicability in a broader context, or at least the possibility for comparison across contexts.

Furthermore, it must be possible to measure and assess indicators in a timely manner, as well as show changes over a period of time. When priorities or situations change, indicators must also be adaptable and the measurement system be able to take into account other indicators. Moreover, the measurement system must be targeted and goal-oriented, taking trade-offs and complementarities into consideration.

5. Examples of measurement of sustainability in agricultural value chains

Despite the challenges outlined above, hundreds of sustainability assessment and measurement systems have been proposed and introduced worldwide. Few industries are as inundated by varied measurement schemes as agriculture. In agricultural value chains, a cornucopia of systems have been proposed, ranging from single crops and villages to global use. There are several examples of a classification of the measurement systems by their origin. As the different actors and stakeholders in the agricultural value chain are not able to exercise similar power regarding the adoption of a particular system, systems are categorised into three main groups: systems originating in retail, systems originating in the input industry, and systems originating in agricultural production. Whereas some retailers and some input providers hold enough market power to not simply suggest but rather coerce other actors into implementing their respective systems, others must opt for a comprehensive approach covering different stakeholders along the chain from the beginning. Some of the most widespread and successful systems turned out to be multi-stakeholder initiatives. However, those originating in agricultural production have not yet reached that level of acceptance.

Both multi-stakeholder and standalone approaches have originated in retail. Individual companies, including SYSCO, Walmart and Unilever, developed codes of conduct for their suppliers many years ago. Another standalone approach was the development of proprietary sustainability labels by individual retailers. An example of this latter type is the Pro Planet label developed by the REWE group, a German retail chain. Whereas such labels are aimed at consumers, the most widespread multi-stakeholder initiatives work on a business-to-business basis and consumers or citizens may not even be aware of their ubiquity. Examples of such multi-stakeholder initiatives include the Ethical Trading Initiative (ETI) with over 120 corporate members with thousands of suppliers worldwide; the Business Social Compliance Initiative (BSCI) with over 1500 members; and GLOBALG.A.P. with a focus on certification of agricultural practices. Since its 2007 revision, GLOBALG.A.P. includes criteria for worker health and safety as well as animal welfare. Currently, GLOBALG.A.P. certification is carried out by over 140 independent accredited certification bodies in more than 100 countries. In practice, GLOBALG.A.P. certification acts as a gatekeeper to major retail chains around the world.

The input industry seems to favour standalone approaches. For example, BASF and Bayer seem to work mostly within company boundaries and have developed proprietary approaches, which limit stakeholder input and public scrutiny. A relatively early approach in that regard was BASF's eco-efficiency analysis. The method aggregates economic costs and environmental costs of product alternatives based on comparable customer benefit levels. The assessment of the environmental costs is based on a so-called ecological fingerprint, which considers energy consumption, resource consumption, toxicity potential, risk potential, land use and emissions. In some cases, the eco-efficiency analysis is expanded to include social components. The expanded analysis is called socio-eco-efficiency analysis or SEEBALANCE. SEEBALANCE includes working conditions for employees, considerations of the international community (e.g., child labour), future generations and consumers, as well as considerations of the local and national community. An example of a measurement approach with a basis in agricultural interests is the Stewardship Index for Specialty Crops (SISC) in the United States (US). The SISC is a multi-stakeholder initiative including specialty crop growers, suppliers, buyers, environmental and public interest groups, agencies and experts working to develop a system for measuring sustainability throughout the supply chain. Currently, its focus is on the US and on agricultural production, although it plans to include the value chain from farm through processing and distribution to retail and food service.

The aim is to advance quantitative measurements in multiple areas of sustainability to enable chain participants to benchmark, compare and communicate their performance, rather than to provide standards to determine whether or not a practice is sustainable. The author has served as a co-coordinator during part of the development process for SISC, specifically regarding social and economic sustainability. Metrics currently in pilot use are limited to the ecological dimension and include water use efficiency, energy use, nitrogen use, phosphorus use and soil organic matter.

Metrics under development currently target biodiversity and ecosystem, greenhouse gas, as well as irrigation efficiency. From early on in the project, ecological criteria were outlined in greater number and differentiation than criteria in other dimensions. Reasons appear to be that – albeit complicated – ecological criteria are less controversial and less subject to societal and personal values than others. In addition, the ecological criteria are more likely to be accessible to quantitative measurement. Criteria in the social and economic dimensions, originally deemed just as important as the environmental dimension, are currently not being pursued further.

6. Critical issues in the development of measurement systems and conclusions

Due to the wickedness of sustainability, a number of critical issues ensue in the development of measurement systems both with respect to the system and the specific measurements, as well as with respect to the process in which the system is first developed and then implemented, sustained and further adapted. According to Genier *et al*. (2008), the sustainability impacts of measurement systems in use are often questionable and there is a lack of evidence that standards and codes are effective tools in increasing a particular user's sustainability. This is due to the inherent inflexibility of standards and the neglect of complexity by many systems. Inflexibility and rigid bureaucracy limit the implementation of sustainability, as is the case with other innovations. During the adoption and diffusion process, further continuous improvement is required. For sustainability measurement, the need for improvement will continue for the foreseeable future. Accordingly, accompanying the implementation of measurement systems with rigorous scientific assessment can greatly benefit the further development of such systems. But the data collection needs for scientific assessment compete with feasibility and at times involve high costs that not all potential users are able to bear. Genier *et al*. (2008) have pointed to structural impacts of the widespread implementation of measurement systems that are too costly for small producers by food retailers on a business-to-business basis. In this way, sustainability measurement has become a gatekeeper to market access with unintended consequences for agricultural production.

For the initial development process and the continuing improvement of a system in use, stakeholder involvement is paramount. Several other authors (see Bokelmann – Chapters 4, Ekelund – Chapter 7, and Stenger *et al.* – Chapter 8) have discussed examples of different approaches to stakeholder involvement and the related challenges and opportunities.

Sustainability's wickedness, especially due to the lack of a definitive solution, means that stakeholder participation during the process varies and some stakeholders use their participation strategically, e.g., threatening withdrawal when the process is not going in the direction they want. As such, procedural rules and agreed upon criteria for suitable indicators will support the development process. Although establishing rules and agreeing on criteria may constitute an additional challenge in the beginning, they are likely to contribute to sustaining the process and lead to the implementation of the resulting measurement system. Trust building and stabilising participation are both required for a successful development process and outcome on which future efforts can be built. As situations change, new knowledge becomes available and societal priorities change, achieving greater sustainability will not only require meeting current benchmarks, but relentless efforts of industry actors, stakeholders and the wider society working together towards a moving target.

The characteristic challenges of sustainability measurement are well suited to provide lessons for the development, adaption and diffusion of complex innovations in agriculture and beyond. In many ways, sustainability measurement can serve as an example for the challenges to expect and how to address them in other similarly complex cases. Of the common challenges, the degree and organisation of stakeholder involvement in the process might well be the most significant.

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