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Choosing sustainable technologies. Implications of the underlying sustainability paradigm in the decision-making process

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ABSTRACT

When assessing the sustainability of a particular technology, a number of environmental, economic, and social indicators need to be taken into account. The aim of this paper is to analyze the underlying rationales for the prioritization of all these indicators i.e. the rationale for an integrated sustainability assessment. For this purpose, different alternative paradigms of sustainability are briefly discussed, with the focus on the concepts of *weak and strong sustainability*, which define a spectrum of views on the possibility to replace environmental capital with human-made capital. We conclude that there is a sound case for the *strong sustainability paradigm* and we argue that this conclusion has deep implications for the decision-making processes. Firstly, because it implies that a set of thresholds for a number of environmental indicators would need to be agreed upon. Secondly, because it implies that environmental impacts would no longer be 'tradable' for socio-economic benefits, when they are expected to go beyond the agreed threshold. We suggest that non-compensatory decision-making tools will need to be considered at some point in the process in order to account for the non-substitutability of critical environmental services. Using the concept of *'planetary boundaries'* proposed by Rockström et al. we discuss how such information could be put into practice in decision-making. We suggest that the concept of *planetary boundaries* can provide both a preliminary basis for the prioritization of environmental impacts and a preliminary supporting argument for the definition of environmental thresholds that enable the use of non-compensatory decision-making approaches. Further work in this area is urgently required.

1. Introduction

The progress of the human race has been driven to a great extent by the discovery, development, and diffusion of new technologies. From early breakthroughs such as the discovery of fire or the invention of the wheel, up to the era of supersonic air travel, nuclear power, or the extensive access to the internet, new technologies bear witness to the successes and failures of the human endeavour. Technologies play a central role in modern societies, enabling new capacities for social welfare, presenting new risks and complex ethical dilemmas, and defining how humans interact with the surrounding environment. For these reason, choosing the right technologies is of the utmost importance in order to steer the world along a socially and environmentally sustainable pathway.

Decisions influencing the adoption of a certain technology may happen at different levels of government, business and civil society. At governmental level, decisions are made on the policy support that specific technologies deserve. Conversely, governments can make decisions that hinder further development of certain technologies or aim at reducing their penetration in the market e.g. ban of incandescent light bulbs. Private companies need to make strategic choices on the technologies to which their investments will be directed e.g. for research and development – with new technologies – or to compete for higher market shares, when a technology is already commercially mature. Civil society also plays an important role in shaping the future technological landscape e.g. when organized social groups such as environmental NGOs urge governments to adopt policies supporting specific technologies.

Technology Assessment (TA) emerged as a discipline more than 40 years ago to fulfil the need to assist public decision-makers in evaluating the impact of existing and future technologies in society. Coates (2001) defines TA as *'a policy study designed to better understand the consequences across society of the extension of the existing technology or the introduction of a new technology with emphasis on the effects that would normally be unplanned and unanticipated'*. To meet this goal, a number of sub-disciplines have

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been initiated and several research methods and analytical tools have been developed over the last five decades under the common umbrella of TA. Tran and Daim (2008) provide a review of the work done in this field and a classification of the research methods that have been most widely used to this day. Since its origin, the traditional focus of TA as a discipline was set on forecasting, impact assessment, and policy studies (Van Den Ende et al., 1998). Modern process-oriented approaches such as constructive technology assessment (CTA) were developed later. While traditional TA focuses on the external effects of a technology and the choice between different technological options, CTA shifts attention from the external effects of a technology to the steering of its development (Schot, 1992). CTA emphasizes the need for early involvement of a broad array of actors −beyond governmental agencies − to facilitate social learning about technology and potential impacts (Genus, 2006).

In the last few decades, the world has progressively embraced the ideal of *sustainable development* as the cornerstone of social, economic and environmental policies. In this context, sustainability assessment has emerged as a new scientific discipline that aims to inform all actors in order to steer society towards that goal.

Life Cycle Assessment (LCA) has been in use for many years as a well-established methodology to assess and compare the environmental impact of technologies and products. Several sets of environmental indicators and impact assessment methodologies have been developed (Guinée et al., 2002; Goedkoop and Spriensma, 2001). LCA has been primarily focused on the environmental dimension. However, some attempts at including the economic and social dimensions into LCA have been done (Kloepffer, 2008). Life cycle costing (LCC) aims at assessing the economic costs of products with a 'cradle to grave' perspective. Relevant work is also being done in the field of social life-cycle assessment (SLCA) (Benoît_et al., 2010; Jørgensen, 2008).

Other methodologies to assess different aspects of sustainability at product level (different initiatives of eco-labelling, carbon footprinting, etc.), at corporate level (Global Reporting Initiative, Dow Jones Sustainability Index, etc.) or even at macroeconomic level (genuine progress indicator, green GDP, ecological footprint, etc.) are already in place or in implementation stages (Singh et al., 2009). However, a widely accepted methodology to perform integrated[1] sustainability assessments of technologies is still missing.

Most definitions present the idea of *sustainable development* as a three dimensional concept where environmental, social and economic aspects have to be taken into account. Each of these so-called dimensions is the result of considering a number of very diverse underlying criteria e.g. GHG emissions, water consumption, toxicity, labour conditions, costs, economic growth, etc. Besides, these three dimensions of sustainability are not only multifaceted but also dependent upon each other. Given these conditions, assessing the sustainability of a certain technology becomes an extremely complex task to address.

Furthermore, as it will be discussed in Section 2, the concept of Sustainable Development is still in dispute. There are different legitimate ways to look at this ideal that result in implicit assumptions about what has to be considered in a sustainability assessment − the choice of indicators − as well as the relative importance of each of them.

When making a choice for a particular technology, a number of environmental, economic, and social indicators need to be taken into account in the decision-making process. The aim of this paper is to analyze the underlying rationales for the prioritization of all these indicators i.e. the rationale for an integrated sustainability assessment. For this purpose, different alternative paradigms of sustainability are briefly discussed focusing on the tension between the *weak and strong sustainability* paradigms. Next, the consequences of opting for one of these underlying paradigms to inform decision-making are analyzed. These include the definition of thresholds, the alternative rationales for weighting sustainability indicators, as well as the implications in terms of the scope of applicability of different decision-making methodologies.

2. Sustainability paradigms and decision-making

2.1. Alternative paradigms of sustainability

Probably the most widespread definition of Sustainable Development is 'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (UNWCED, 1987). This ideal is the result of the historic evolution of notions such as progress, growth, development and sustainability in different social, economic and philosophical contexts (Du Pisani, 2006). However, the concept is still subject to various legitimate interpretations based on different value orientations. Several authors have explored this diversity of views around the ideal of sustainable development, e.g. (Jahnke and Nutzinger, 2003; Hueting and Reijnders, 2004; Robinson, 2004; de Vries and Petersen, 2009) among others.

2.1.1. Sustainable development as justice

This wide spectrum of possible interpretations becomes apparent when we look at Sustainable Development from an ethical viewpoint, through the lens of intergenerational and intragenerational justice. Gosseries (2005) illustrates how Brundtland's definition, although widely cited and publicly accepted, is only one out of many legitimate views, and therefore scientifically contestable. He points out that Brundtland's 'sufficientarian' approach to sustainable development − i.e. the objective to improve the situation of those people who are worst off − fails to meet principles expressed in egalitarian theories such as Rawls' Theory of Justice (Rawls, 1999). In a similar fashion, other theories of justice such as utilitarianism or libertarianism have to face equally legitimate critiques. In sum, there is to this day no commonly agreed way of materializing the underlying ethical requirements of the ideal of sustainable development into scientifically incontestable operational principles. In other words, the ethical component of Sustainable Development, as well as its practical implementation, still belongs to the realm of politics.

2.1.2. Sustainable development as preservation of capital

When the concept of Sustainable Development is approached from an economic standpoint it can be defined in terms of a comparison between the present and future capacity to create welfare. According to this view, Sustainable Development can be defined as '*development that does not decrease the capacity to provide non-declining* per capita *utility for infinity*' (Neumayer, 2003). The capacity to produce utility[2] is directly dependent on the stock of capital, be it in the form of available natural resources, as 'manufactured' (human-made) capital or in the non-material forms of capital e.g. accumulated knowledge. The idea behind the concept of capital is that it is a particular type of stock with the capacity to give rise to flows of goods and/or services (Ekins et al., 2003). Goodland (1995) defines environmental sustainability as the *'maintenance of*

[1] Including the environmental, social and economic dimensions.

[2] The terms 'utility' and 'welfare' are used indistinctly in this work, following the same criterion of Neumayer (2003). *Weak versus Strong Sustainability: Exploring the limits of two opposing paradigms.*