



National environmental limits and footprints based on the Planetary Boundaries framework: The case of Switzerland

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ABSTRACT

The Planetary Boundaries concept is a recent scientific framework, which identifies a set of nine bio-physical limits of the Earth system that should be respected in order to maintain conditions favourable to further human development. Crossing the suggested limits would lead to drastic changes in human society by disrupting some of the ecological bases that underlie the current socio-economic system. As a contribution to the international discussion, and using the case of Switzerland, this study proposes a methodology to apply the Planetary Boundaries concept on the national level. Taking such an approach allows to assess the environmental sustainability of the socio-economic activities (e.g. consumption) by the inhabitants of a country in a long-term global perspective, assuming that past, current and future populations on Earth have similar "rights" to natural resources. The performance of countries is evaluated by comparing the country limits with their environmental footprints according to a consumption-based perspective. An approach was developed to: i) better characterise the Planetary Boundaries and understand which limits can effectively be currently quantified; ii) identify related socio-economic indicators for which both country limits and footprints can be computed; iii) compute values for limits, footprints and performances (at global and country level); and iv) suggest priorities for action based on the assessment of global and national performances. It was found that Switzerland should, as a priority, act on its footprints related to Climate Change, Ocean Acidification, Biodiversity Loss and Nitrogen Loss. The methodology developed herein can be applied to the analysis of other countries or territories, as well as extended to analyse specific economic sectors.

1. Introduction

Since the 1950s, the extraction of natural resources and related environmental impacts have greatly accelerated worldwide (Steffen et al., 2015a). Human activities now generate ever-more significant pressures on the global environment: climate change, deforestation, biodiversity losses, and decline in air and water quality have been recognised as important issues which need to be addressed (UNEP, 2012).

The concept of Planetary Boundaries (PBs) is a fairly recent one (Rockström et al., 2009). The PBs are a set of nine physical and biological limits of the global Earth system that should be respected in order not to leave a "Safe Operating Space" that would put the planet's human-friendly living conditions in peril. The most known PB is Climate Change, but other global limits have been identified: Stratospheric ozone depletion, Atmospheric aerosol loading, Land system change, Biodiversity loss, Nitrogen and phosphorus inputs to the biosphere and

oceans, Global freshwater use and Chemical pollution. The PBs are the most recent scientific framework to consider global environmental limits; the concept was updated in 2015 (Steffen et al., 2015b).

The PB framework has a strong potential for guiding the environmental policy discussion. To play such a role, the global biophysical information provided by the PBs has to be converted to information related to human activities at the national level. This is essential due to the fact that, while there exists an international environmental governance regime with more than 500 multilateral agreements, actions are led by national governments.

The relevance of PBs to national policies was highlighted in April 2017 during the conference "Making the Planetary Boundaries Concept Work" in Berlin (Keppner, 2017), following international workshops in Geneva (2013) and Brussels (2015) with an increasing number of attendees from political institutions, academia and the private sector, showing the growing interest in this concept.

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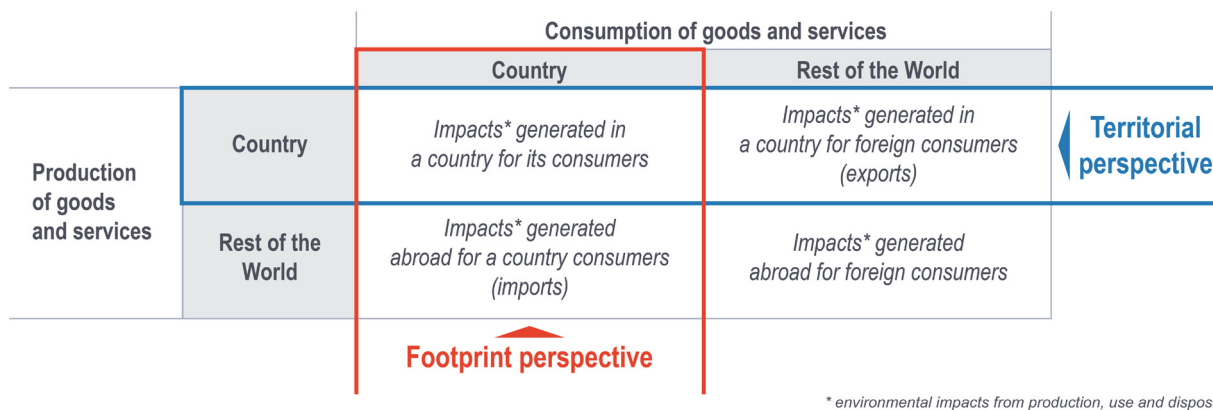


Fig. 1. Territorial versus Footprint (or consumption) approach.

Many environmental indicators are already produced by countries as part of their reporting obligations to international agreements. These indicators at national scale are in their vast majority examining the environment from a territorial perspective; e.g., reporting on domestic greenhouse gas emissions under the Kyoto Protocol. Footprints, or consumption-based indicators applying a Life Cycle Perspective, provide a complementary approach to the Sustainable Development Goals and other sustainability monitoring particularly relevant for the evaluation of the performance of countries with respect to global issues.

Such a perspective (Fig. 1) is increasingly relevant in our interlinked global economy (Friot, 2009) since an increasing part of the impacts within a given country or territory is generated to satisfy consumers in other countries.

This is especially the case for small, open and service-oriented economies such as Switzerland. More than half of the environmental impacts induced by the consumption of Swiss residents occur abroad (Jungbluth et al., 2011; Frischknecht et al., 2014). This proportion has been rising from 1996 to 2011 (Frischknecht et al., 2014), and can be explained to a large extent by the fact that Switzerland is a growing economy with a high share of services, but one relying on other parts of the world for production of the goods consumed internally.

This is true for most developed countries. The EU also largely relies on the rest of the world for its consumption as shown by its carbon, water and land footprints. Other countries such as Brazil or China are, on the contrary, providing their resources to other countries (Tukker et al., 2014).

In this paper, we present the first consistent methodology to guide national governments in their reflection about the potential of environmental indicators based on the PB framework. The resulting indicators offer an indication of the environmental sustainability of the socio-economic activities induced by the consumption of the inhabitants of a country in a long-term global perspective.

Our present research was developed with the aim that the down-scaling of Planetary Boundaries and the quantification of the impacts of consumption can be replicated for any country or territory.

It builds up on a preceding partial assessment for Sweden (Nykvist et al., 2013), which was the pioneer study applying the PB framework at the national level. They applied this framework to Sweden to address four policy questions, and thus were applied to four PBs using both territorial and consumption analysis. Fang et al. (2015) proposed another assessment, covering 28 countries, but they identified as a limitation of their study a lack of consistency in the choice of the system perspective, concluding that in future assessments both numerator (current footprints) and denominator (limit value) should be either production-based (territorial) or consumption-based.

Two other studies used the PB framework and its extension of social well-being, known as "the Safe and Just Operating Space" (Raworth, 2012). One at the national level for South Africa (Cole et al., 2014) is

based on national data sets and experts' judgements, while Dearing et al. (2014) produced an analysis for two low-income rural communities in China. These studies consider regional rather than global sustainability. The environmental processes and the limits considered are loosely connected from the original Planetary Boundaries. A study in Europe (Hoff et al., 2014) applied a straightforward equal per capita allocation of the Planetary Boundaries and a consumption based quantification of the European environmental impacts, but did not address the historical responsibility of the footprints.

By consistent methodology, we imply: a) the proposition of several types of indicators considering yearly limits and limits over time; b) the consideration of people and countries' needs; c) the conversion of biophysical indicators into indicators that can be related to socio-economic activities enabling the computation of limits and of footprints; and d) the computation of performance indicators relying on quantitative results and long-term trends.

This new methodology can be used for computing limits at the national level as well as for estimating the current status of the impacts induced by each country, not only on their territory, but also through the consumption of its inhabitants (footprints). As this research began in 2014, it uses the references and terminology from the initial PB framework as developed by (Rockström et al., 2009). The subsequent PB framework from (Steffen et al., 2015b) provides several improvements and updates, but was published at a stage where the current research was already too advanced. Also, for adapting the PB concept to national entities, the indicators needed to be adapted by moving up in the causal chain, e.g. if we use the DPSIR framework from States (Green House Gases (GHG) concentration and radiative forcing) to Pressure (emissions of GHG).

2. Limits of the planet: review from concepts to integration into policy

2.1. Evolution of the international awareness

International awareness of the limits of our planet has been increasing since the 1950s and warnings have been expressed about the dead ends of continuous growth on a finite planet (Boulding, 1966).

In the early 1970s, the report from the Club of Rome "The Limits to Growth" (Meadows et al., 1972), using dynamic models, and Georgescu Roegen, who applied the laws of thermodynamics to the economy (Georgescu-Roegen, 1979, 1971), both denounced the impossibility of continuous economic growth based on natural resources. During this same time, international recognition of the importance of the environment took off. For example, the Ramsar Convention on Wetlands was signed in 1971, and the United Nations Conference on the Human Environment was held in 1972 in Stockholm, leading to the creation of the United Nations Environment Programme (UNEP) the same year.

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