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On the rationale and policy usefulness of Ecological Footprint Accounting: The case of Morocco

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ABSTRACT

Ecological Footprint and biocapacity metrics have been widely used in natural capital and ecosystem accounting, and are frequently cited in the sustainability debate. Given their potential role as metrics for environmental science and policy, a critical scrutiny is needed. Moreover, these metrics remain unclear to many, are subject to criticisms, and discussion continues regarding their policy relevance. This paper aims to explain the rationale behind Ecological Footprint Accounting (EFA) and help ensure that Ecological Footprint and biocapacity results are properly interpreted and effectively used in evaluating risks and developing policy recommendations. The conclusion of this paper is that the main value-added of Ecological Footprint Accounting is highlighting trade-offs between human activities by providing both a final aggregate indicator and an accounting framework that shed light on the relationships between many of the anthropogenic drivers that contribute to ecological overshoot.

1. Introduction

Numerous studies have been dedicated in the last few years to Ecological Footprint Accounting (e.g., Bastianoni et al., 2012, 2013; Best et al., 2008; Fiala, 2008; Kitzes et al., 2009a; Kratena, 2008; Senbel et al., 2003; van den Bergh and Grazi, 2013a; Wiedmann and Barrett, 2010), including in this journal (e.g., Jury et al., 2013; Kissinger et al., 2011), examining its ability to quantify a key aspect of planetary limits and the extent to which human activities exceed them. However, Ecological Footprint Accounting (EFA) remains subject to methodological criticisms and discussion is ongoing regarding its relevance in policy making.

Over the years, both Footprint practitioners and critics have identified research priorities for improving national Ecological Footprint Accounting (Kitzes et al., 2009b) and, in few instances, proposed alternative methodological approaches. These include tracking greenhouse gases other than carbon dioxide (e.g., Dias de Oliveira et al., 2005; Walsh et al., 2009); the removal of the carbon component from Ecological Footprint Accounting (e.g., van den Bergh and Verbruggen, 1999); and the incorporation of input–output models (e.g., Bicknell et al., 1998; Lenzen and Murray, 2001; Wiedmann et al., 2006), Net Primary Productivity (NPP) data (e.g., Venetoulis and Talberth, 2008), and emergy (Zhao et al., 2005) or exergy (Chen and Chen, 2007) analyses in calculating Ecological Footprint results. Arguing for the need to focus on the various ecosystem compartments separately (e.g., Giljum et al., 2011), researchers have proposed alternative domain-specific indicators such as the Carbon Footprint (Hertwich and Peters, 2009), Water Footprint (Hoekstra and Chapagain, 2007), Land Footprint (Weinzettel et al., 2013), Nitrogen Footprint (Leach et al., 2012), Material Footprint (Wiedmann et al., 2013) and Chemical

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Footprint (Sala and Goralczyky, 2013). The combined use of Footprint indicators as a *Footprint Family* has also been explored (Galli et al., 2012a, 2013; Steen-Olsen et al., 2012).

According to the 2014 Edition of the National Footprint Accounts (NFA), productive capacity 1.54 times that of Earth was needed in 2008 to meet humanity's demands on nature, this causing humanity to be in ecological overshoot (WWF et al., 2014).[1]

This result has been subject to criticism (e.g., Blomqvist et al., 2013; van den Bergh and Grazi, 2013a), in part based on a misunderstanding of what the accounts are intended to measure, and what the results imply (Rees and Wackernagel, 2013; Wackernagel, 2013). EFA conforms to neither traditional economic nor traditional environmental indicators. Fiala (2008), for instance, argued that the Ecological Footprint represents "*bad economic and bad environmental science*." A competing perspective, however, might be that the accepted fragmented paradigm of separating economy and environment is deficient. As such, could the Ecological Footprint bring value as an accounting tool at the interface between economy and the environment? Moreover, van den Bergh and Grazi (2013a) have highlighted "*the lack of specific connections with policies in the EF approach*," a view shared by Wiedmann and Barrett (2010). But, could it be that many of the assessment tools and indicators upon which our policies are built are not relevant to measure and monitor sustainability, as argued by Costanza et al. (2014), Pulselli et al. (2008), Tiezzi and Bastianoni (2008) and Wackernagel (2013)?

A clear assessment of Ecological Footprint Accounting can help reduce confusion about the specific research questions that it addresses and the methodology used to calculate Ecological Footprint and biocapacity results. This in turn can help ensure that these results are properly interpreted and used effectively in evaluating risk and in developing sustainable solutions and policies. This paper aims to explain the rationale behind Ecological Footprint Accounting, address some misconceptions about the methodology, and, through a case study, initiate a discussion on the potential policy implications that can be derived from the Footprint application. While this is not a direct response to recent critical reviews of the Ecological Footprint (e.g., Blomqvist et al., 2013; Giampietro and Saltelli, 2014; van den Bergh and Grazi, 2013a), the paper touches on some of the key concerns these reviews have raised.

2. Methodology

2.1. *On the rationale behind Ecological Footprint Accounting*

Created in the 1990s by Mathis Wackernagel and William Rees (Wackernagel and Rees, 1996), Ecological Footprint Accounting (EFA) is comprised of two metrics, the *Ecological Footprint* and *biocapacity*.

As with all accounting systems, EFA is historical rather than predictive, tracking past human pressure on the biosphere's capacity to supply *resource provisioning* and *regulatory* ecosystem services (MEA, 2005). While nature provides many ecosystem services, the rationale for including these particular services is that they directly compete for Earth's biologically productive surfaces and can thus be measured in terms of the biologically productive area necessary to provide them.[2] They compete for space if the provision of one renewable resource excludes growing a different resource, or is in contradiction with leaving biomass un-harvested to support carbon sequestration. Each biologically productive surface is thus considered to be serving a single mutually exclusive function. This does not imply that bio-productive surfaces are unable to provide a number of services simultaneously but that only the primary function of such surfaces is captured by EFA to avoid double counting (Monfreda et al., 2004; Wackernagel et al., 1999). Moreover, although conceived to track resource provisioning and regulatory services in their entirety (Wackernagel et al., 2002), data availability limits current EFA tracking at the national level to only the provision of animal (including fish) and plant-based food, fiber and wood products as well as climate regulation through sequestration of anthropogenic CO_2 emissions (Borucke et al., 2013).

Biocapacity, the "availability" side of EFA, refers to the capacity of Earth's biologically productive surfaces to provide renewable resource-provisioning and climate-regulation ecosystem services. For each nation, biocapacity (BC) is calculated as in the equation below:

$$BC = \sum_{i} A_{N,i} \cdot YF_{N,i} \cdot EQF_i$$

where $A_{N,i}$ is the bioproductive area that is available for the production of each product *i* in the nation, $YF_{N,i}$ is the nation-specific yield factor[3] for the land producing products *i*, EQF_i is the equivalence factor[4] for the land use type producing each product *i*.

Biocapacity is meant to reflect prevailing technologies and resource management practices and it thus tracks the current, actual productivity of ecosystems rather than the theoretical productivity these ecosystems would have without human intervention (Goldfinger et al., 2014).

At its core, biocapacity reflects the actual ability of autotrophic organisms to capture energy from the sun via photosynthesis, and then use this energy to concentrate and structure matter into resources, the latter defined as any form of biomass that humans find useful. The exclusive consideration of products (and services) that are directly useful to humans reflects the anthropocentric underpinnings of EFA

[1] The term *overshoot*, is commonly used in ecology to indicate the state in which a population's demands exceed its environment's ability to support those demands (its *carrying capacity*). In Footprint terms, ecological overshoot occurs when a population's demand on an ecosystem exceeds the capacity of that ecosystem to regenerate the resources it consumes and to absorb its wastes leading to liquidation of natural capital stock (Monfreda et al., 2004). See also Catton (1980) and Odum (1997) for further details on the *overshoot* concept.

[2] As indicated by Wackernagel et al. (2002), those services that cannot be measured in terms of biologically productive surfaces are excluded from EFA.

[3] Yield Factors (YFs) capture the difference between the actual productivity of a given land type in a specific nation and that same land type's actual productivity at world-average level.

[4] Equivalence Factors (EQFs) capture the difference between the productivity of a given land type and the world-average productivity of all biologically productive land types (see Galli et al., 2007).