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The spatial distribution of development in Europe and its underlying sustainability correlations

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ABSTRACT

The majority of national governments now dedicate themselves to sustainable development as it aims to produce a long-term, positive relationship between civilization and life-supporting planetary resources. By doing so, societies have also embraced indicators as tools to provide comprehensive assessment of the current position, gauge improvement, and help set future development goals; however there remains no unanimous agreement regarding their theoretical foundation, design, nor use. The number of sustainability measures available for quantifying development is overwhelming to planners, scientists, and policymakers, thus clarification of interrelationships, redundancy, and spatial distributions is needed. First, this study reduced and described a set of 30 multi-metric sustainability indices across 36 European nations. A multivariate factor analysis identified five major dimensions (or axes) that conveyed over 80% of the total variation of the original 30 development measures. Second, spatial autoregressive analyses of childhood mortality, endangered species density, and population growth rate revealed statistical correlations with one or more of the five development factors. The five axes of sustainable development are expressions of: prosperity, equality, and governance; quality of life; ecosystem integrity; environmentally efficient happiness; and environmental management. Of these, Factor 1 (prosperity, equality, and governance) explained more than one-third of the total variance, and positively clustered in northwest Europe and negatively in southeast Europe. Results suggest that a few key indicators could be used when evaluating a country's overall development status during continental and global scale sustainability assessments. Lastly, the findings reveal an overall underrepresentation of ecological (biosphere) well-being within current measures of sustainable development.

1. Introduction

Humanity is enduring a period of unprecedented change of economic welfare, social equity, environmental quality, driven largely by exponential population growth and an increased demand for improved human well-being. This increasing demand for material goods and services has limited humankind's capability to safeguard Earth's life-supporting ecosystem services and thus biodiversity (Foley et al. 2005; Butchart et al. 2010; Defries, Rudel, Uriarte, & Hansen, 2010; Godfray et al. 2010; Weinzettel, Hertwich, Peters, Steen-Olsen, & Galli, 2013). Recently researchers have argued that environmental degradation is not due to overpopulation as much as it is direct and indirect overconsumption of resources and pollution by the wealthy (Penn, 2003; Hughes & Johnston, 2005; Weinzettel et al., 2013). Civilization's resource demands, often measured by ecological footprint (EF) at the global scale, have exceeded the planet's biocapacity for the past 40 years, and it has been estimated that humankind will need the land and sea resources equal to two Earths by the 2030s (WWF, 2014). Besides the environmental ramifications associated with population growth and consumption, there remains a prerequisite for an increase in living standards for much of the world (NRC, 1999; Kates et al. 2001; Clark & Dickson, 2003; Parris & Kates, 2003), since over 14.5 percent of humanity remain in 'extreme poverty' (<$1.25 US/day) and lack natural resources to meet their basic survival requirements (WBG, 2014).

Despite its acknowledged shortcomings (see Keiner, 2006; Rogers, Jalal, & Boyd, 2008), the decree of sustainable development by the United Nations World Conference on the Environment and Development (UNCED) in Rio de Janeiro (1992) hallmarked a new era in global awareness. Sustainable development, defined within the Brundtland Commission's *Our Common Future*, was globally defined as: "development that meets the needs of the

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present without compromising that ability of future generations to meet their own needs" (WCED, 1987:43). In general, sustainable development focuses on two key concepts: 1) providing essential needs to the world's poor through overriding priority; and 2) that technology and social organization has limits to the environment's ability to meet humanity's present and future needs. For this study, the term "sustainability" should be viewed as humanity's target goal of human–ecosystem equilibrium (homeostasis), while "sustainable development" refers to the holistic approach and temporal processes that lead us to the end point of sustainability.

Progressing sustainable development is now primarily contingent on applied research and application. Over a decade and a half ago, it was stated that we must get past the lip-service surrounding sustainable development and create initiatives that put theory into practice (Campbell, 2000). As part of this process, a plethora of private and public institutes have generated an overwhelming number of development indicators for assessing sustainability. Indicators and composite indices are increasingly recognized as useful tools for policy-making because they convey information on a country's performance towards their specific goals within the three major divisions of sustainability (economic welfare, social equity, environmental quality) (Shaker & Zubalsky, 2015). In Chapter 40.4 of Agenda 21 the need for indicators was articulated: "indicators of sustainable development need to be developed to provide solid bases for decision making at all levels and to contribute to a self-regulatory sustainability of integrated environment and development systems" (UN, 1992).

By agreeing to the sustainability challenge, nations have designated indicators as quantifying tools for cultivating development (Moran, Wackernagel, Kitzes, Goldfinger, & Boutaud, 2008). Literally hundreds of indices have been created for measuring progress towards sustainability at the country scale, making the application process overwhelming to scientists, planners and policymakers. Many of the complex sustainability indices have been, and continue to be, created with similar methods and from similar data sources (e.g., World Bank, World Health Organization). Accordingly, the amount to which indices differ in their results using the same data is due to their assumptions, biases, and methodological differences, creating great misunderstanding for the sustainability effort (Mayer, 2008). Sustainable development indicators available to practitioners has also been said to be "voluminous" and "not very well focused," and lie heavy on environmental assessment while underrepresenting social and economic evaluation (Moldan, Hák, Kovanda, Havránek, & Kušková, 2004; Moffatt, 2008). To end, Shaker and Zubalsky (2015) found many common sustainable development indices too complex for assessing progress in the emerging nations that may need it most.

2. Approach

Although it has been more than two decades since Agenda 21 first called for sustainable development indicators, there remains no unanimous agreement regarding their theoretical foundation, design, nor use. In the growing sustainability literature on measuring development, two leading approaches have emerged: single indicator use or multiple indicator use. Some analyses propose that inconsistency surrounding sustainable development assessment could be resolved through the application of several balancing measures (e.g., Mayer, 2008), and others suggest a holistic consensus is found through employing many different metrics simultaneously (e.g., Shaker & Zubalsky, 2015). On the other hand, studies have advocated that the establishment or selection of a single key indicator would be best for measuring development progress towards sustainability (e.g., Moffatt, 2008). To date, there are no agreed upon methods for assessing development nor attaining sustainability across spatial scales of planning (Keiner, 2006). Thus, policymakers have encouraged researchers to create innovative methods that integrate various techniques for new sustainable development planning (Grosskuth, 2007). To further elucidate indicator complexity and usefulness, this study quantitatively examines 33 sustainable development indices across 36 European nations through an applied geographical approach.

Traditionally, it has been thought to employ a wide range of indicators to characterize the different dimensions of sustainable development being studied (Maclaren, 1996). Based on a review of roughly 70 different frameworks for evaluating sustainability by Singh, Murty, Gupta, and Dikshit (2012), indicator creation has taken an inclusive approach to measuring sustainable development similar to true-cost accounting rather than an operational one. Theoretically, this has been supported (i.e., Mayer, Thurston, & Pawlowski, 2004; Mayer, 2008) because sustainability has long been recognized as too broad a topic for being captured by just a few specific indicators. However, there is a lack of empirical justification for discrediting a reductionist approach to measuring sustainable development that leads to holistically accurate, justifiably simple, and operational indices. Phillips (2015) recently supported this idea by stating that evaluations of global sustainability have been based predominately on subjective or professional judgment, rather than quantitative approaches.

While other studies have investigated interrelationships between sustainability indicators, few have openly attempted to simplify a set of development measures into a small number of canonical variables to further understand sustainable development. Building upon preceding studies that scrutinize relationships between measures of sustainability, the present research investigates 33 indices for the majority of European nations. The spatially explicit database of development indices was compiled for two purposes. First, this study attempts to identify and analyze to what degree a collection of sustainability metrics are interrelated, and if they can be simplified into key underlying development factors for an improved understanding of sustainable development. Secondly, this study investigates the spatial distribution of childhood mortality, endangered species density, and population growth rate, and to what degree the aforementioned development factors correlate with their distributions. Empirically, the following two null hypotheses are tested: (1) no underlying dimensions of sustainability exist within 30 multi-metric indices of development; and (2) the three distinct development indicators-childhood mortality, endangered species density, and population growth rate-do not individually capture all dimensions of sustainable development. By openly distinguishing quantitative and spatial patterns of development, this study intends to elucidate multifaceted human-environmental relationships that impact humanity's progress towards sustainability. This research also aims to deliver sustainability scientists, policymakers and regional planners tools for thoroughly analyzing a country's development status during continental and global scale sustainability assessments.

3. Data and methods

3.1. Selected measures of development

The present empirical investigation of sustainable development indices takes place across 36 of the roughly 50 countries of Europe (Fig. 1). Nation states were included in this study if they were represented in Prescott-Allen's (2001), *The Wellbeing of Nations: A Country-by-Country Index of Quality of Life and the Environment*, first global assessment of sustainability. The 36 European sovereign states or dependent territories were represented only on the basis of data availably, not by choice. The study area nations (roughly