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A multi-spatial scale approach to urban sustainability – An illustration of the domestic and global hinterlands of the city of Beer-Sheva

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ABSTRACT

Cities have always been dependent on ecological services from their local and regional hinterlands. In recent decades, however, urban population growth and rising material standards of living, in conjunction with technological development and globalization, have compelled cities to become reliant on global hinterlands. It follows that urban sustainability measures should target not only city and regional lands, but also the sustainability of global hinterlands. In this paper we disaggregate the urban hinterland into *domestic* and *global* hinterlands, using the city of Beer-Sheva, Israel as an example. We use a slightly revised ecological footprint analysis to separate the *domestic* and *global* hinterlands associated with various urban activities such as food, materials and water consumption, electricity use and transportation. We found that 94% of the Beer-Sheva footprint is ascribed to the global hinterland and only 6% to the domestic hinterland. We also found that the city's footprint is more than double that of a sustainable carrying capacity at the global scale and nine times more at the domestic level. After analyzing each component of the city's footprint, we identify some potential administrative measures at various scales – from local to global, which can help to minimize the size of the urban hinterland, reduce urban pressure on that hinterland, and thus promote urban sustainability.

Introduction

Cities are presently the dominant form of human habitat, and most of the world's resources are either directly or indirectly consumed in cities (Grimm et al., 2008). As the world urbanizes, the role of cities in determining outcomes of global sustainability grows. Concurrently cities depend on the continued sustainability of the regional and global hinterlands that supply critical ecological services (e.g., materials and food supply, sequestration of greenhouse gas (GHG) emissions etc.) (Alberti, 1996; Rees, 1997; Kissinger et al., 2011; Moore et al., 2013). To analyze the sustainability of a city, and to move toward sustainability, requires understanding of the demands a city places on its local ecological resource base and on resources from a wider geographical area (Rees, 1992; Alberti, 1996; Haughton, 1997; Baynes and Wiedman, 2012; Moore et al., 2013).

In recent years various researchers have highlighted the need to examine cross-scale linkages among nested and complex socio-ecological systems (e.g., Gunderson and Holling, 2002; Young, 2002; MEA, 2005; Cash et al., 2006). Several researchers have called for the need to examine the environment and sustainability beyond municipal and domestic boundaries (e.g., Princen, 1997; Norgaard, 2001; Conca, 2001; Rees, 2004; Dauvergne, 2008; Young et al., 2006; Kissinger et al., 2011). While indeed cities were always dependent on hinterlands to supply their resource needs and to sequester their wastes, urban hinterlands have changed throughout history. In the past human settlements relied primarily on domestic hinterlands (i.e., a hinterland surrounding the city). In recent decades, however, processes of technological development and globalization integrated with growing urban populations have compelled cities to become reliant on global hinterlands. Presently there is hardly any urban area that is not highly dependent on both domestic and overseas hinterlands.

By analyzing reliance on both domestic and global hinterlands, city authorities and residents can better understand their rate of dependence upon and impact on the environment at various scales, realize their vulnerability to overseas environmental changes, and suggest local action or policy guidelines that may increase their urban sustainability. Yet, while the growing literature on urban sustainability suggests that sustainability of cities is shaped and influenced by activities within them (e.g., Beatley, 1995; Alberti, 1996; Newman and Jennings, 2008), we submit that it is highly

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important to acknowledge that their sustainability is also shaped by activities at other scales that is, in other cities, regions and countries.

Despite growing awareness of such cross-scale dependence, to date very few studies have attempted to quantify and analyze urban environmental dependence and impact at specific spatial scales – i.e., local or global (e.g., Warren-Rhodes and Koenig, 2001; Kissinger and Haim, 2008) and to assess the extent to which urban sustainability can be influenced by actions taken at various geographical scales. This paper aims to understand urban sustainability through a multi-scale analysis of one city's hinterland and to use this analysis to highlight potential contributions of changes and actions at various scales to the city's sustainability. We have chosen ecological footprint for our analysis and quantified it for the city of Beer-Sheva, Israel. We then analyzed the relative share of this city's footprint at domestic and global hinterlands and discuss the implications for urban sustainability policy issues.

Background

The city as an ecosystem and its relationships with the hinterland

While cities are commonly explored and analyzed from a social, cultural, political or economic perspective, they should also be seen as ecosystems in which humans are the dominant organisms and human activity is clearly exhibited (Alberti, 1996; Rees, 1997). Similar to the natural ecosystem the urban ecosystem requires inputs of energy and materials and generates wastes that need treatment. However, while both rely on energy from external sources, a natural ecosystem uses renewable sources (e.g., solar) whereas an urban one relies mainly on fossil fuels. Furthermore, the natural ecosystem uses materials mostly from within the system boundaries, while the urban one must rely on a vast hinterland around the world. Finally, while in the natural ecosystem waste is absorbed and recycled internally, urban areas require the external hinterland to absorb their outputs (Newman, 2006; Barrett et al., 2002; Rees, 1997; Alberti, 1996).

Until the industrial revolution most hinterlands of human settlements were local. Only a few larger cities relied on more complex relationships between a local and wider regional hinterland supplemented by global sources of goods and services. The combined effects of population growth, growth in standards and quality of living, developments in production, shipping and transportation methods and technologies, and processes of economic globalization, have all resulted in declining abilities of growing cities to supply their own needs from local sources. These processes have led to growing hinterlands that in many cases stretch all over the world (Grimm et al., 2008; Decker et al., 2000; Alberti, 1996; Rees, 1992).

Modern cities have thus become dependent on flows of energy, materials and food products from all over the world. Furthermore, while in the past most urban waste disposal was concentrated within cities (in the form of air pollution for example) or adjacent areas (in the case of solid waste), urban waste now reaches the global scale, increases the pressure on remote eco-systems and contributes to processes of global environmental changes (Grimm et al., 2008).

Various authors have elaborated on aspects of urban dependence on multi-scale hinterlands for resource supply and waste sinks. Borgstrom (1972) used the concept of 'Ghost Acreage' to emphasize the 'invisible' imported cropland required as a supplement to local farmland. Odum (1975) identified extra land areas required by cities in energy terms. Cronon (1991) presents the idea of 'nature's metropolis', discussing Chicago's historic dependence on its surrounding nature and its environmental implications. Wolman (1965), Baccini (1997) Kennedy et al. (2007) and others have developed the concept of 'urban metabolism'. Metabolism studies attempt to quantify the amounts of materials and energy that flow through a city from domestic and distant sources. Such analysis allows identification of major loads and potential points of intervention for reducing urban impacts on the environment (e.g., Kennedy et al., 2010; Lenzen et al., 2003; Hendriks et al., 2000).

These studies and concepts suggest that urban areas and populations generate a certain environmental 'load' not only on their own local ecosystems but also on ecosystems around the world. However, very few attempts have been made to assess the degree of such load. In order to bridge this gap Rees (1992), Rees and Wackernagel (1994) and Wackernagel and Rees (1996) introduced the idea of 'Ecological Footprint Analysis' (EF), a quantitative tool that estimates material consumption and the related 'load' that human populations impose upon ecosystems around the world. The concept emphasizes the importance of distant hinterlands in the context of urban dependence on supporting lands. It estimates the area of productive terrestrial and aquatic ecosystems required for urban metabolism to take place. EF also enables comparisons between current urban metabolic demand and available biophysical carrying capacity, both regional and global (Wackernagel and Rees, 1996; Chambers et al., 2000).

Domestic vs. global hinterland

The domestic urban hinterland has different characteristics from the global one. While the impact on domestic hinterlands is often visible to local residents and authorities, it is much harder for them to see the extent of their impact remote international hinterlands. For example we may relate urban air quality to specific sources such as transportation or industry in the city. However, it is much more difficult to relate local food consumption to processes of land degradation overseas, or to identify the exact overseas consequences of greenhouse gas (GHG) emissions from a particular city. Local policy makers and city residents are neither sufficiently aware of the remote consequences of their local actions nor are they capable of generating action to remedy such consequences. Thus while policy and planning can contribute to minimizing negative impacts on the domestic hinterland, reducing the pressure on overseas hinterlands is challenging as actions are often beyond the jurisdiction of local government. Still, as the sustainability of cities is highly dependent upon and impacts overseas hinterlands, it is crucial to acknowledge the local-global connections, and to explore directions in which cities can reduce their impacts on those remote hinterlands.

One aspect of such an acknowledgment is highlighted in the growing interest in and actions by various urban authorities around the world to reduce their GHG emissions (e.g., ICLEI-Local Governments for Sustainability GHG Emissions Analysis Protocol or LGSEC – Local Government Sustainable Energy Coalition). However, urban leaders and residents alike should acknowledge that more than local GHG emissions must be reduced. Both the ethical perspective of global equity and justice, and the sustainability implications of the degradation of various global ecological services (MEA, 2005), suggest that cities should also act to reduce their material dependence and impact on overseas hinterlands. Further, they should manage their processes of development within the limits of the planet's carrying capacity. This action can be promoted by measures such as increasing efficiency of material and energy use at the city scale, promoting nationally-based environmental policy compelling cities to measure their materials and energy throughput. All these require a thorough understanding and documentation of the extent to which a city relies upon both local and overseas hinterlands, exploration of ways to assess