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Urban infrastructure and natural resource flows: Evidence from Cape Town

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HIGHLIGHTS

- This paper provides the empirical evidence for the theoretical notion of decoupling at the city scale.
- It demonstrates the value of using urban infrastructure as an intervention point for decoupling strategies.
- It shows the potential for achieving sustainable urban development by reducing socio-economic metabolic flows.
- It shows the value of an intermediary for activating successful purposive interventions for sustainable urban transitions.

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ABSTRACT

The current economic development trajectory is fundamentally unsustainable. However, decoupling economic growth from excessive natural resource consumption can be adopted as a means to deviate from this current trajectory. Decoupling enables economic growth and human development through non-material growth, without the environmental and social casualties of the incumbent model. Cities are the current and future context for socio development as well as a significant part of the cause and solution to sustainability challenges. Cities account for the majority of production and consumption activities leading to environmental degradation, and they are also the primary location for economic, institutional, and human capital. Innovative responses to global challenges generally emerge during the interaction between these kinds of capital. This paper presents the case of three of Cape Town's resource flows namely; electricity, water and solid waste, as mediated by networked urban infrastructure, to demonstrate the possibility of urban scale decoupling. Conclusions indicate that while decoupling can occur at the city scale, it is unlikely to be sufficient for the realization of sustainable urban development. Purposive interventions are therefore critical for successful, sustainable urban transitions.

1. Introduction

Environmental degradation, climate change and natural non-renewable resource constraints are symptomatic of the unsustainability of the current resource-intensive global economy. When the challenge of non-renewable resource constraints is juxtaposed alongside the threat of climate change and eco-system degradation, it is clear that an alternative, resource-light approach to development is imperative. The 2008 global economic crisis brought further attention to the necessity of ending a mode of consumption financed by undervalued debt. Reducing consumption by investing in alternative, clean energy and sustainable material resources offers an opportunity for sustained economic growth and development. Infrastructure, as the mediator of resource flows has substantial scope to stimulate a transition to a resource-light economy while the city provides the ideal scale to intervene (Guy et al., 2001). Investments in the *right* networked urban infrastructures provide an opportunity for the continued reproduction of the global economy in an ecologically sustainable manner (Pennell et al., 2010).

Fittingly, the locations of these investments are the urban centres of the developing world. African and Asian cities will house the bulk of future population growth, estimated to be three billion by 2050 (UN-Habitat, 2008). The significance of this lies in the fact that these cities are largely informal and designed in an ad hoc manner. Moreover, they have little, or no services connecting large portions of the population to the socio-economic urban metabolism[1] that underpin the urban economy, and therefore the global economy.

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[1] Urban metabolism is the "…the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste" (Kennedy et al., 2007:44).

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Functioning socio-economic systems are reliant on a complex set of networked infrastructures that convey resource flows (Guy et al., 2001). Networked infrastructures of modern[2] cities are configured in an open-loop linear manner, and due to complex, inefficient throughput systems require a large quantity of inputs (virgin materials and resources), and produce a large quantity of outputs (GHG emissions and solid waste) (Girardet, 2010). This consequently places momentous environmental pressure on both natural resources and ecosystem services during everyday socio-economic activities (Hodson and Marvin, 2010; Martine et al., 2008). Certain processes that enabled the earth to replenish and accumulate stocks of resources in the past have been fundamentally altered (Swilling, 2004). This means that the contemporary configuration of infrastructure, that facilitates socio-economic urban metabolisms, is unsustainable and can no longer be justified. However, flows and stocks of resources are nonetheless required to maintain and service existing cities as well as to connect developing cities to the global socio-economic metabolism. Achieving sustainably of this is the focus of this paper.

It is argued that large investments in certain types of infrastructure and more particularly sustainable infrastructure can stimulate a sustainable urban transition. Sustainable infrastructure promotes eco-system integrity and environmental regeneration, does not contribute to global environmental degradation and adverse phenomenon, and provides economic as well as social goods and services (Swilling and Annecke, 2012; Suzuki et al., 2009; Girardet, 2010; Birkeland, 2008). In practice this translates into the utilization of a combination of renewable resources, and low carbon, eco-efficient and productive infrastructure. Urban transitions refer to a shift from the current state of urban systems to a new and different dynamic state (Hodson and Marvin, 2010).

This paper is set out in the following way. Cities are contextualized within this discussion. Decoupling is then argued to be the framework through which sustainable urban transitions can take place and evidence of this is provided. The case of Cape Town is used to demonstrate how trends in the energy, water and waste infrastructure sectors can help cities find a baseline and begin to measure achievements in decoupling endeavors when urban infrastructure is the intervention point. Lastly, lessons are drawn from the case that furthers understanding of urban scale transitions and the conditions required for success. It is important to note that this paper provides a high-level overview of the empirical findings of several research projects conducted over several years.[3]

2. Decoupling at the urban scale

The only way to resolve the contemporary social and ecological challenges of 21st C. urbanism is to adopt a development paradigm that is able to reconcile resource consumption and economic growth with environmental restoration and human development. Unlike the current paradigm, the notion of decoupling undermines the assumption that human development, as measured by economic growth (GDP), necessarily occurs via the increase of resource consumption (Fischer-Kowalski and Swilling, 2011). This is not to suggest that infinite growth is reconciled with environmental sustainability but rather that a different type of economic growth, that promotes ecological restoration, can assist developing countries reach a level of development that supports the aspirations of its citizens.

Decoupling refers to a condition when economic growth and population growth is present while the demands on natural resources and ecosystem services are decreased (Fischer-Kowalski and Swilling, 2011). Economic growth and development via non-material growth thus becomes possible within the resource-constrained economy (Gallopin, 2003; Hyman, 2011). Decoupling is either *absolute* or *relative*. Absolute decoupling is applicable when the rate of resource consumption is stable or decreasing while the economic growth rate is increasing. Relative decoupling is applicable if resource consumption is increasing but at a lower rate than economic growth (Fischer-Kowalski and Swilling, 2011; Schepelmann et al., 2010; Haberl et al., 2004). Urban decoupling would reflect a measured decrease in the socio-economic metabolic flows of natural resources through the urban system while achieving a sustainable improvement in economic development and human well being within that particular urban context. Using the principles of decoupling one is able to imagine the possibility of development that limits environmental degradation and the negative social externalities of the incumbent mode of economic growth.

In this way decoupling provides a way to reduce urban socio-economic metabolic resource flows. This is critical as trends indicate that the material resource flows through the global economy will continue to increase with catastrophic consequences without aggressive intervention (Fischer-Kowalski and Swilling, 2011). This is despite targets having been identified for material extraction and carbon equivalent emissions. The IPCC (2007) recommends that to keep within a 2 degree Celsius temperature increase, total carbon emissions per capita per annum should average 2.2 tons. The International Resource Panel complements the IPCC's recommendation and shows that that a sustainable and equitable global metabolic rate would depend on contracting material extraction to an average of 6 tons per capita per annum (Fischer-Kowalski and Swilling, 2011). Although both of these targets are difficult to implement in practice, and in particular the latter, they demonstrate the major task at hand. It reflects a decrease from the current 4.5 tones of carbon related emissions and 8 tones of material resources. More critically however, is the highly unequal distribution of metabolic rates across countries that will require a multiplicity of strategies to address resource and emission reductions suited to vastly different contexts.

Different stages of development and different consumption patterns mean that while some countries will have to significantly decrease their socio-economic metabolic rate, others are likely to increase it in order to improve their quality of life. Consumption patterns therefore will have to be fundamentally restructured because sustainable development[4] is unachievable without reducing the resource requirements and material throughput of the global economy (Bringezu et al., 2004). Restructuring urban resource flows in cities provides an intervention point to achieve this.

Modern cities are however constructed in a linear fashion as a result of the worldview that an infinite supply of resources is available and resources are infinitely substitutable. Linear urban systems require large quantities of virgin materials and non-renewable resources, and due to complex, inefficient throughput systems, they produce a substantial amount of waste (Girardet, 2010). This accounts for cities' generally high metabolic rate. They consume 70% of materials and produce 80% of GHG globally (Hodson and Marvin, 2009). The quantity and quality of material flows through urban systems are directly linked to the way urban network infrastructures are configured (Guy et al., 2001). Materials flows are distributed across the urban landscape via large, complex socio-technical systems that determine the urban metabolism (Guy et al., 2001).

When examining a city through the lens of networked infrastructures – the roads, bridges, tunnels, conduits, and wires – that connect the city and bring it into being, "…modern urbanism emerges as an extraordinary complex and dynamic socio-technical *process*" (Guy et

[2] Refers to those cities developed during and after the industrial revolution (Girardet, 2010).

[3] For deeper empirical evidence and analysis please see Swilling and Annecke (2012), Hyman (2012), Engeldow (2007), Pithey (2007) and Sustainable Energy Africa (2007).

[4] Sustainable development is widely considered as development that allows the current generation to meet their needs and improve their quality of life in an equitable manner without infringing on the future generations' ability to do so (WCED, 1987; Mebratu, 1998; Gallopin, 2003).