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Technomass: Linking Urbanisation to the Metabolism of the Urban Ecosystem

Conceptualisation and Empirical Evidence

Habilitation Thesis

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List of Articles

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To Leon, mentor and friend

To my son Damian

TABLE OF CONTENTS

List of Figures

List of Tables

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Résumé

Urbanisation is one of the most challenging issues facing humankind in the 21st century. An increasing number of global issues and increasing scientific concerns about manifold ecological problems, including land degradation, pollution, climate change, loss of biodiversity, etc., can be linked to urbanisation. These negative ecological effects clearly show that urbanisation cannot be considered to be a purely social process. Re-examining the theoretical grounding to provide new transdisciplinary conceptualisations between social and natural sciences can be central in urban research to face the current environmental crisis. However, controversy and conceptual confusion remain regarding urbanisation as a concept, thereby hampering important efforts to advance towards a science of cities and to provide alternative conceptualisations.

The highly complex spatial structure of urbanisation and its spatiotemporal continuity are characteristics that challenge our current conceptualisations and operationalisations. The understanding of urbanisation remains categorical, in which space is characterised as urban or rural. Measuring urbanisation by using categorical indicators lacks the quantitative robustness to account for its complexity in sound assessments. To achieve a scientific measurement of urbanisation, novel indicators based on continuous variables are needed.

This habilitation is framed around technomass, an indicator that measures urbanisation as a continuous variable. By using technomass, urbanisation can be described as a continuous spatiotemporal process without needing the arbitrary assumption that population or land-cover thresholds define a particular space as urban or rural. On the contrary, urbanisation is a continuum, where at the vortex, we find an accumulative process producing the very urban material structure: technomass, defined as humanly processed materials. Urbanisation can be analysed as a spatiotemporal process producing and reproducing a biophysical-socio-ecological transformation of the space; this transformation leaves phenomenological traces in the form of purposive material assemblages. These are the patterns that this habilitation has investigated. Such a material footprint can be measured by weight and/or volume per unit of space (m^2, hectare, or km^2) and time (per minute, per day, or per year). By using technomass, even the smallest traces of urbanisation found in the remaining wild land areas can be accounted for and are therefore linked to urban processes. Technomass can also be used to analyse and measure the environmental impacts of urbanisation on ecological processes, climate and wellbeing.

The articles contained in this habilitation present a set of operationalisations tackling urbanisation as a socio-ecological continuous process that has been tracked, analysed and measured by studying the process of material accumulation. This continuous measurement of urbanisation can describe the broad scope of the spatiotemporal intensities of urbanisation comparably from distant geographies and times. In measuring urbanisation, such spatiotemporal continuity relies on a physical measure that can be linked to particular socio-ecological impacts, thereby opening new doors to analyse and measure how degrees of urbanisation affect human wellbeing and ecosystems. The continuous measurement of urbanisation enables scientifically robust measurements and comparisons of urbanisation and its impacts, thereby helping to overcome the conceptual and methodological challenges posed by cross-spatial and cross-temporal comparisons of urban systems.

The empirical and conceptual contributions presented in this thesis have been published in 13 peer-review, high-rank scientific journals. The thesis frames these contributions in a systematic narrative presented as a synthesis in part one. The conceptual strategy involves the concepts of metabolism and ecosystem. Here, metabolism is a complex and interdependent energy-material process, an ecological-historical process acting as the very foundation of the urban system, not a simple metaphor or an organic analogy to be applied to cities. The word metabolism means transformation, change of matter, thus implying the transfiguration of material elements, producing new entities that are essentially different from their original components. Ecosystems are placed on a continuum on which urbanisation intensities are the defining aspect to deal with the spatial structure and impacts over ecosystems. Ecosystems can describe differential urbanisation degrees that are operationally defined by measuring the intensity of their material accumulation per unit of space and time. Urban ecosystems perform a distinctive metabolism that appropriates fundamental material and energy resources from other ecosystems. This appropriation enables a productive circularity that sustains the urban organisation and structure underpinning the material production and reproduction of urban space: urbanisation. At the core of this understanding is the dialectical interplay between ecological processes and the dynamics of material accumulation, biomass and technomass; this interplay determines the structure, path dependencies and future of ecosystems.

The conceptual ground of technomass is sustained in the central thesis of this habilitation: that urbanisation is a spatiotemporal process arising from the very metabolism of the urban ecosystem. Metabolism can be understood, described and measured using technomass by relying on the conceptual ground of urban ecology and industrial ecology and using spatially explicit methods, such as remote sensing and geographic information systems (GISs), as has been demonstrated in thirteen scientific articles. Technomass is a transdisciplinary bridge linking several scientific disciplines— from urban ecology to urban studies—dealing with urbanisation and urban environments. Therefore, studying technomass not only opens a broad range of scientific possibilities but also contains the necessary substance to support urban planning and design disciplines in incorporating scientific knowledge in policymaking, as we conclude in chapter 4 and several of the articles supporting this habilitation.

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