Towards more comprehensive urban environmental assessments

Exploring the complex relationship between urban and metabolic profiles

Aristide Athanassiadis

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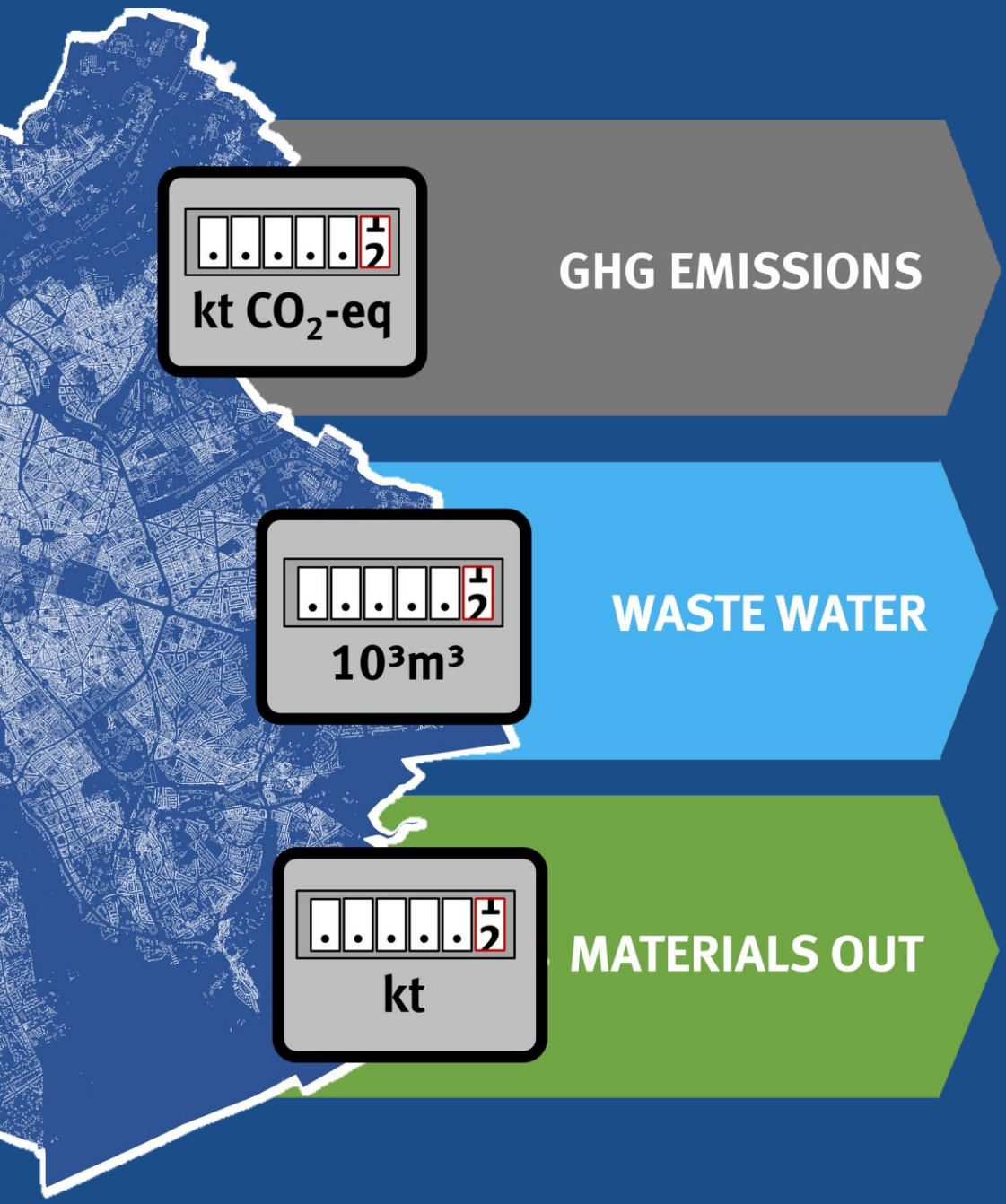

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Aristide Athanassiadis

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Declaration

This is to certify that:

- the thesis comprises only my original work towards the PhD (a list of publications resulting from this work is presented here below),
- due acknowledgement has been made in the text to all other material used,
- the thesis is fewer than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

Signed

Aristide Athanassiadis

Date 22/06/2016

Abstract

Urban areas cover 2% of the Earth's land surface, host more than 50% of global population and are estimated to account for around 75% of CO_2 emissions from global energy use. In order to mitigate existing and future direct and indirect environmental pressures resulting from urban resource use, it is necessary to investigate and better understand resource and pollution flows associated with urban systems.

Current urban environmental assessment methodologies enable the quantification of resource use and pollution emissions flows entering, becoming stocked and exiting urban areas. While these methodologies enable to estimate the environmental effect of cities, they often consider urban areas as being static and homogeneous systems. This partial and simplistic representation shadows the complex spatio-temporal interrelationships between the local context and its associated local and global environmental pressures. This characterisation of urban systems is a significant limitation, not only for the urban environmental assessments, but also for the identification of their drivers as it may lead to inadequate urban environmental policies. To overcome this limitation and effectively reduce *glocal* urban environmental pressures, it is necessary to better understand the complex functioning of cities and identify their drivers.

This research developed a comprehensive urban environmental assessment framework that helps to better explicit and understand the complex relationship between an urban system and its environmental profile in a systemic and systematic way. This framework was applied to the case study of Brussels Capital Region (BCR).

Results from the application of this framework show that urban systems are neither static nor homogeneous. In fact, different relationships between the urban and metabolic profiles appear when considering different spatial scales and temporal intervals as well as different urban and metabolic metrics. The establishment of BCR's urban profile showed that components that shape the urban system evolve in an organic way over time. Moreover, the spatial expression of an urban system portrays its heterogeneous aspect and how different metrics of the same urban indicator can reveal distinct facets and challenges for an urban area or a neighbourhood. Finally, it was demonstrated that the relationship between urban indicators is different for each spatial scale and therefore knowledge from one spatial scale is not necessarily transferable from one scale to another. The establishment and analysis of BCR's metabolic profile also underlined the complex functioning of cities as each flow has a different temporal evolution and spatial expression. Due to the multifaceted and intertwined aspect of metabolic flows it becomes clear that no single parameter enables to explain or predict their behaviour.

This leads to the conclusion that a great number of questions still need to be considered, understood and answered before effectively and coherently reducing

environmental pressures from cities. The developed framework proposes a number of concrete steps that enable existing and new cities to better understand their metabolic functioning and ultimately transition towards less environmentally harmful futures.

Publications resulting from work reported in this thesis

Refereed journal papers

1) **Athanassiadis, A., Bouillard, P., Crawford, R.H., Khan, A.Z., (in press).** Towards a dynamic approach to urban metabolism: tracing the temporal evolution of Brussels' urban metabolism from 1970 to 2010. Journal of Industrial Ecology.
2) **Athanassiadis, A., Christis, M., Bouillard, P., Crawford, R.H., Khan, A.Z., Vercalsteren, A., (accepted with revisions).** Comparing a metabolism-based and an input-based approach to assess local and global environmental performance of a city. Journal of Cleaner Production.
3) **Athanassiadis, A., Bouillard, P., Crawford, R.H., Khan, A.Z., (under revision).** L'écosystème urbain de Bruxelles: Passé, présent, futur. Brussels Studies.

Refereed conference papers

1) **Athanassiadis, A., Fernandez, G., Hoekman, P. (under revision).** Comparing the urban metabolism of Brussels, Cape Town and Milan: A discussion on data collection and analysis. Proceedings of ISOCARP 2016, Cities we have vs. Cities we need, 12-16 September, Durban.
2) **Bettignies, Y., Athanassiadis, A., Galán González, A., González Gomez, M. (2016).** Toward Resilient Cities: Brussels Capital Region Case Study. Proceedings of PLEA 2016, Cities, Buildings, People: Towards Regenerative Environments, 11-13 July, Los Angeles (under revision).
3) **Athanassiadis, A. P. Bouillard, R. H. Crawford (2015).** Exploring the relation between Melbourne's water metabolism and urban characteristics. Proceedings of SOAC 2015, State of Australian Cities Conference. 9-11 December, Gold Coast.
4) **Athanassiadis, P. Bouillard, R. H. Crawford (2015).** Overcoming the 'black box" approach of urban metabolism. Proceedings of ASA 2015, Living and Learning: Research for a Better Built Environment. 4-6 December 2015, University of Melbourne.
5) **Galán González, Q. Deltenre, A. Athanassiadis, A. Evrard, S. Trachte, Ph. Bouillard, A. C. Acha Roman (2015).** Preserving Brussels identity: Methodological guidelines for the retrofitting of city blocks. Proceedings of CISBAT 2015, Cleantech for Smart Cities & Building from Nano to Urban Scale, 9-11 September 2015 EPFL-Lausanne
6) **S. Trachte, A. Galán González, A. Evrard, A. Athanassiadis (2015).** B³-Retrotool: Development of a multi-scale and multi-criteria pre-assessment tool for the sustainable retrofit of Brussels Capital Region. 2ème Congrès Interdisciplinaire du Développement Durable, 20-22 Mai 2015. Université Catholique de Louvain.

7) **S. Trachte, A. Evrard, A. Galán González, A. Athanassiadis (2014).** Sustainable retrofit of the old part of dwellings stock in Brussels Capital Region. Proceedings of PLEA 2014, Sustainable habitat for developing societies, 16-18 December, Ahmedabad
8) **Galán González, A. Athanassiadis, A. Evrard, S. Trachte, Ph. Bouillard, A. De Herde (2014).** OLD BUILDINGS, NEW CITIES: Energy renovation strategies for the historic residential stock of Brussels. Proceedings of WSB 2014, World Sustainable Building Conference, 28-30 October 2014 Barcelona
9) **Athanassiadis, A. Galán González, A. Evrard, S. Trachte, Ph. Bouillard, A. De Herde (2014).** Assessing the energy use of the pre-war residential stock of Brussels Capital Region at a neighbourhood scale. Proceedings of WSB 2014, World Sustainable Building Conference, 28-30 October 2014 Barcelona
10) **Athanassiadis A. and Bouillard P. (2013).** Contextualizing the Urban Metabolism of Brussels: Correlation of resource use with local factors. Proceedings of CISBAT 2013, Cleantech for Smart Cities & Building from Nano to Urban Scale, 4-6 September 2013 EPFL-Lausanne

Refereed conference abstracts

1) **Stephan, A., Athanassiadis, A. (2016).** Mapping the material stock of City of Melbourne's buildings using a bottom-up approach and open data. Proceedings of ISIE 2016, International Society for Industrial Ecology (SEM) section Conference, 28-30 September. Nagoya, Japan.
2) **Athanassiadis, A., M. Christis, P. Bouillard, R. H. Crawford, A. Vercalsteren (2015).** Comparing an Urban Metabolism-based and an Input-Output-based approach. Assessing direct and indirect resource use and environmental impacts at the city level: The case of Brussels, Belgium. Proceedings of ISIE 2015, International Society for Industrial Ecology Conference, 7-10 July. Surrey, UK.
3) **Athanassiadis A, Ph. Bouillard, A. Z. Khan, R. H. Crawford (2014).** Towards a more complex Urban Metabolism: the case of Brussels. Poster presented in GRC Conference on Industrial Ecology: Transforming the Industrial Metabolism, 1-6 June 2013 Lucca
4) **Athanassiadis A, Ph. Bouillard (2013).** "Multi-scale analysis of energy and material urban flows as a methodological tool for urban planning and territorial ecology" at the poster session: "*What transversal approaches to integrate sustainable development in research*" organised by Higher Education & Research Awards for future generations

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1) **Athanassiadis, A., Merckx, B., Noel, L., Paolini, F., (2015).** Métabolisme de la Région de Bruxelles-Capitale: identification des flux, acteurs et activités économiques sur le territoire et pistes de réflexion pour l'optimisation des ressources. Institut Bruxellois de Gestion d'Environnement, Brussels, p. 305.
2) **Athanassiadis, A. (2014)**. Représentations et Visions Ecosystémiques de Bruxelles. Vulgarisation book about urban ecosystems in the framework of the Paul Duvigneaud Award, p. 56.
3) **Athanassiadis, A. (2013)**. Evaluation of the Urban Metabolism: Urban Metabolism scope and purpose definition, p. 23.
4) **Athanassiadis, A. (2013)**. Evaluation of the Urban Metabolism: Data repository and neighbourhood metabolism, p. 30.

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