Urban health and socio-ecological systems: Maintaining livable conditions for a growing population

Extended Abstract

Urbanization has accelerated globally reaching over 50% currently, and expected to rise to 75% by 2050. In particular, sub-Saharan Africa is considered the world's fastest urbanizing region, expecting to double in the next 25 years to close to 1 billion city dwellers (Saghir and Santoro 2018). Driven by these changing demographics, attention has focused more on urban metabolism as it is an effective tool and theory for urban sustainable development analysis, particularly relevant for SDG#11, but also related to many others (e.g., 1, 3, 6, 7, 8, 9, 12, and 13). The concept of urban metabolism was proposed more than 50 years ago to provide a framework and research perspective for understanding cities (Wolman 1965). Many studies have been applied in recent decades with development of a suite of methods for performing the analysis. Specifically, urban metabolism studies quantify the material and energy flows that occur through resource exploitation, transformation into goods and services, and the associated waste emission that are necessary to maintain the living standards of the population within the city. As a result, urban metabolism research integrates the natural system (the environment) that supports all human systems with the human (socioeconomic) system to analyze holistically all aspects of resource utilization and waste production. This approach follows from a growing trend of biomimicry or ecomimicry in which socio-economic systems, such as a city can be seen as an "ecosystem", and its components and interrelations can be modeled as one would model a natural ecosystem. One advantage to this approach is the adherence to first principles such as mass and energy conservation, energy dissipation, production-consumption, biogeochemical cycles, and self-organization. Human agency and demography are driving forces that shape cities, but regardless the actions humans take, there is a biophysical basis to accomplish it that must be met.

Many recent urban metabolism studies have employed network analysis, in particular, network methods derived and developed in Ecological Network Analysis (ENA, see Fath and Patten 1999, Fath et al. 2007) applied to urban case studies. In these studies, the city is partitioned into its main sectors (including households/domestic sectors representing human choice and actions) which become the network nodes, which are then connected by the flow of resources (material, energy, water, money, etc.) between those nodes. For example, Zhang et al. (2011) created a water network of Beijing that had 6 sectors (environment, rainwater, industry, agriculture, households, and wastewater system). They were able to show that the increasing demand and decreasing supply from 2003 to 2007 impacted the ability of producers to provide necessary water resources. A more detailed urban sectoral model was developed for the nitrogen flows Beijing that included 16 sectors (Zhang et al. 2016). The network approach allowed to trace the flows of nitrogen along various direct and indirect pathways such as from environmental flows through agriculture, households, and even pets back to the environment and surrounding water bodies. There was a marked increase in the demand of nitrogen during the study period primarily driven by consumption of food (due to population and urbanization) and increased fossil fuel use. Recently, the approach has been used to track greenhouse gas emissions from various sectors and human activities (Zheng et al. 2017) within the Beijing-Tianjin-Hebei region of

China. They focused on the carbon flows to determine where emissions arose in regions clearly showing the decline in embodied energy emissions from Beijing as industry was shifted to the Hebei region intentionally to improve air quality in the lead up to the 2008 Olympics games in Beijing. This relocation of industry had a positive impact on air quality and living standards in Beijing but now leaving a lasting dirty legacy for the population in Hebei. In all three examples, and there are many more, the physical processes of the city are represented as networks of interacting sectors (nodes). The scale of aggregation of the nodes depends on the question and to some extent is limited by data availability. Deep insight is given about the renewability, sustainability, and organization of the structure of the cities to deliver resource flows to its growing populations.

The urban metabolism approach has been developed primarily with examples in United States and China, with a growing number of studies in Europe. A large project in the past few years focused on African cities (Currie and Musango 2017), but this approach is still novel and getting a foothold in the discourse of population and urban well-being studies. This presentation will overview the key concepts of urban metabolism and layout steps to undertake further studies in the African context. In particular, Egypt and South Africa, as member countries of the International Institute for Applied Systems Analysis, could be good test beds for an expanded cities program at IIASA that includes interdisciplinary teams of demographers and natural scientists.

Lastly, steps will be shown how urban metabolism studies will be linked to the broader issue of human well-being in terms of a newly promoted regenerative economics model (Fath et al. 2019). The importance of urban populations is critical to meet the Sustainable Development Goals and the Paris Agreement among other major international obligations. The African role is critical as it will experience faster transformation during this next period and also bear more impact of a changing climate and demography drivers. In this period, interdisciplinary research is even more needed so that social sciences and natural sciences can develop and implement models and methods that address these issues. While the approach presented here originates from a natural sciences, even ecological perspective, the ability to inform and work with social sciences and population studies is key to success in the present global transition. A main goal of this presentation, at a mostly demographic conference, is to begin to build bridges between the disciplinary communities.

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