Editorial

WM&R

Waste Management & Research
2021, Vol. 39(2) 197–198

DOI: 10.1177/0734242X21989173
journals.sagepub.com/home/wmr
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Circular economy in urban systems: How to measure the impact?

Urban areas are considered the home of prosperity and development, but also large consumers of resources, which generate pollution, unsustainable growth, and social inequality. In this sense, urban areas are responsible for 75% of the planet's resource and energy consumption and 80% of global CO_2 emissions. This situation will be aggravated in the future if we consider that currently around 50% of all inhabitants live in cities, and it is estimated that this number will reach 80% in 2050, although this future increase in urban population might be partially affected by pandemics.

A leading cause of excessive resource consumption and high emissions in cities is due to the longstanding and now traditional linear economy, based on ingrained consumer practices of 'take-make-dispose'. This economic system creates multiple problems arising from the pressure that the combination of population growth, urbanisation and industrial development has put on natural resources (which are finite) and the sustainability of cities. For this reason, governments are taking action focused on sustainability, and the circular economy is one alternative economic model that has been promoted most strongly in recent years.

The circular economy is a global concept that has emerged from integrating disciplines ranging from economics to natural sciences. Its main foundation is based on the development of systems that promote the responsible and cyclical use of materials and energy, maintaining the value of resources as long as possible in the economy. In recent years, the circular economy concept has been widely accepted by progressive governments and leading industries as a policy tool to minimize burdens on the environment while still supporting a robust economy, to decouple economic growth from the extraction and use of natural resources. In this sense, cities provide the default metabolism for circular economy initiatives, given the concentration of resources, knowledge, and economic activity in a finite geographical area. However, there is an ongoing debate on how cities and regions should adopt circular economy strategies, and on what makes a circular city. In this respect, the multiple definitions of the circular economy, scales of application, methods for defining what and how to measure, lack of scientific progress in developing countries, absence of specific policies, among others, make it difficult to develop models of circular economy at the city level. In this sense, the ISWA's Circular and Low Carbon Cities (CALC) Project is a remarkable initiative, which has the goal to research, develop, test and support the basic metrics of circularity and low-carbon cities through the development of an open-access calculator.

Given the dependence of urban areas on energy, water and material resources, cities will only stress the problems posed by the linear economy if a paradigm shift is imposed. In this sense, cities could play a key role in the transition towards sustainability, including circular economy models, minimizing waste generation and improving waste management systems. This will allow the simultaneous optimization of water and energy use, the avoidance of food loss and waste, the provision of space for low carbon innovations, and the facilitation of integration of the circular economy principles in green public procurement. Circular public procurement plays a role in achieving the Sustainable Development Goals defined by the United Nations, especially in Goal 12 on responsible consumption and production.

In general, every urban system has some potential to become circular, given its particular social, economic and environmental characteristics. Recent studies have analysed circular economy initiatives, identifying several cities around the world that promote circular economy, but with different objectives and interests. In all studies, waste management has been the most cited theme among circular economy strategies, which is in line with the traditional view of circular economy as a model oriented towards waste and resource recovery and a tool for creating policies for waste and resource management.

This vision has been one of the main approaches in developing countries, which has led to the development of circular economy initiatives almost exclusively towards municipal solid waste management and recovery. To a lesser extent, other initiatives have focused on energy issues, recycling of construction materials, and wastewater reuse, among others, which demonstrates the diversity of circular economy applications, expanding across different issues and urban objectives. Despite the wide diversity of circular economy strategies identified at the urban level, few studies substantiate their level and sector of application in terms of environmental impacts and/or effects on natural resource consumption. In this sense, different nations have adopted circular economy models and measuring their effects is a fundamental step in evaluating the success of those plans and policies. However, what should be measured in circular economy is a matter of debate, as the definition remains ambiguous and indicators may lead to different or even inconsistent conclusions. Generally, monitoring the progress towards attainment of a circular economy at the urban level includes methods using material flow analysis (MFA), energy analysis, and input-output analysis. However, when the measurement is performed at the level of specific city issues, such as households, products, energy or solid waste management, several authors recommend life cycle assessment (LCA). The LCA methodology, which allows the environmental impacts of a product or process to be quantified throughout its entire life cycle, is at the

heart of the European Union's Action Plan on the Circular Economy. Furthermore, it has been widely used in the calculation of city-related footprints, because waste flows from cities generate environmental impacts beyond city limits. While the circular economy seeks to minimize resource use and environmental impacts, social effects have been little considered in the research. Furthermore, the lack of links between circular economy and sustainable development has been highlighted in several scientific articles, where little evidence of the impact of the circular economy on social equity is found. These social issues are considered in the social life cycle assessment methodology and its social indicators can be used to assess the social impact of the circular economy. However, the studies have mainly focused on economic prosperity and environmental impact. Furthermore, most of the literature on the circular economy has now focused on industrialised countries and consumer societies, leaving aside the issues and priorities of developing countries.

Finally, social, environmental and resource impact assessment of circular economy strategies implemented at urban level is a fundamental requirement, especially in developing countries. Many of the strategies associated with sustainable development and the circular economy in developing countries are carried out more for a political aim than on a country-specific scientific basis to support their implementation. For this reason, it is necessary to advance research on this subject. Large urban systems, where human activity is more concentrated, play a key role in the environmental management of present and future urban centres, and should move towards a more sustainable model of organisation. Therefore, it is clear that cities need to develop models that help reduce the consumption of resources and energy, increase the possibility of recycling and reusing, seek a greater degree of self-sufficiency concerning the use of natural resources, and improve the quality of life of their inhabitants.

Waste Management & Research serves as a forum for exchanging research expertise and scientific ideas supporting the development and application of a circular economy to improve sustainability in cities. To this end, *WM&R* invites researchers to submit manuscripts that focus on this topic for catalysing the discussion that will lead to implementation of a circular economy in urban centres.

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