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Commentary

Urban Big Data and Sustainable Development Goals: Challenges and Opportunities

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Abstract: Cities are perhaps one of the most challenging and yet enabling arenas for sustainable development goals. The Sustainable Development Goals (SDGs) emphasize the need to monitor each goal through objective targets and indicators based on common denominators in the ability of countries to collect and maintain relevant standardized data. While this approach is aimed at harmonizing the SDGs at the national level, it presents unique challenges and opportunities for the development of innovative urban-level metrics through big data innovations. In this article, we make the case for advancing more innovative targets and indicators relevant to the SDGs through the emergence of urban big data. We believe that urban policy-makers are faced with unique opportunities to develop, experiment, and advance big data practices relevant to sustainable development. This can be achieved by situating the application of big data innovations through developing mayoral institutions for the governance of urban big data, advancing the culture and common skill sets for applying urban big data, and investing in specialized research and education programs.

Keywords: urban big data; sustainable development goals; big data public policy; SDG targets and indicators; big data research and education

1. Introduction

Cities represent the microcosm of both global economic development and environmental change and have therefore increasingly gained a central role in applying the discourse of sustainability. Currently, more than half, and by 2050 more than two-thirds, of the world's population is expected to be urbanized [1]. Cities are the engines of economic growth, generating about 80% of the global gross domestic product (GDP) and making significant contributions to the creation of wealth, innovation, and cultural advancement [2]. Cities are also sites of economic dynamism and innovations contributing to sustainable transformations. The densities and scaling relations of cities allow, for example, for higher resource efficiency of buildings, green urban planning, and low-carbon urban mobility [3]. On the other hand, cities are not only key producers of environmental pollutants but also key hotspots of vulnerability to climatic hazards resulting from environmental change. Cities are responsible for 67% of global energy consumption, 76% of greenhouse gas emissions [4], and they present complex challenges for poverty reduction and resilience to natural disasters. According to the UN habitat, about one billion people in cities are still living in slums with extreme poverty, poor infrastructure and lack

of health services [5]. These contrasting roles of cities underline the immense opportunity for cities to utilize their momentum and talents towards more sustainable and resilient development pathways.

There is no surprise, therefore, that we often hear that the battle for sustainable development will be won or lost in cities. Reflecting the essential role of urban areas in our transition to sustainable global development, the 11th Sustainable Development Goal, as the only stand-alone urban goal and subnational focus of the official UN statistical framework, aims to "make cities and human settlements inclusive, safe, resilient and sustainable" [6]. One of the most significant dimensions of the Sustainable Development Goal (SDG) agenda is the emphasis on developing objective targets and scientifically grounded indicators for each SDG to monitor progress, implement strategies, allocate resources, and increase the accountability of stakeholders [7]. While there is broad consensus on the need for targets and indicators, their exact definitions continue to be discussed by the international community. These discussions are aimed at finding the most common denominators in the ability to collect and maintain standardized and globally comparable data relevant to each SDG and to balance their feasibility based on local practices (see discussions by the United Nation's Inter-Agency and Expert Group on Sustainable Development Goals at unstats.un.org/sdgs/iaeg-sdgs). Universally practiced data and standards, however, are difficult to achieve due to a range of practical discrepancies and capacities among developed and developing countries. In this avenue, the UN has called for a 'data revolution' for strengthening statistical systems at urban, regional, and international levels to collect high quality and robust data to ensure the monitoring of sustainable development [8–10]. Developing countries are at the forefront of this development and according to recent surveys [11] have placed more hope in leveraging the emergence of big data innovations for meeting the demands of SDG indicators. Big data innovations do not simply refer to a significant growth in volume, variety, velocity, and veracity of data; instead, they refer to how data is applied and how new innovations are facilitated through big data and diffused throughout society. Given the emergence of urban big data, we believe that urban policy-makers are faced with unique opportunities to develop, experiment, and advance more innovative urban targets and indicators relevant to sustainable development. These efforts can be a significant opportunity for developing countries, especially the least-developed countries, to leverage such innovations and leapfrog complex challenges related to urban safety, resilience, and broader sustainability goals.

The emergence of big data is increasingly viewed as having significant ramifications in the urban context [12]. The predictive analysis associated with these innovations has the potential to empower people and change how urban residents interact with each other, their surrounding environment, and urban infrastructures. Urban big data results from the increasing availability of the daily data we generate in the urban environment. These include, for example, data associated with urban sensors, e.g., Internet of Things (IoTs), administrative records, individual- or household-level survey data, geospatial imagery, commercial information, citizen science, and social media. Such data is critical in filling the gap for existing sustainability assessment tools and indicators. While there is no doubt that increasingly large amounts of urban data are being collected, there is less clarity on how such data can be interpreted to address the many wicked problems involved in urban sustainability. The challenges and opportunities of urban big data in public policy have also not been fully understood. In addition to more data access and advanced methodology, as raised in the second international conference on big data [11], we recommend the following three directions for future policy and research.

2. Develop Mayoral Institutions for the Governance of Urban Big Data

The daily data generated in the urban environment can potentially lead to more transparent and efficient urban services, foster innovations through new data-driven businesses, and lead to alterations in decision-making structures and processes. However, urban big data is generated from widely different and at times unstructured sources, each with particular methodological and technological challenges, and researchers need to better understand their associated risks and benefits. Specifically, research on the public policy dimensions of urban big data should focus on how to collect various types

of large data, which actors and stakeholder should be involved, and what incentives and concerns would be relevant in the diffusion of big data technologies. Policy-makers should better understand exactly how urban citizens should be part of the decision-making process in selecting and deploying innovations associated with urban big data and how this process can take into account minority views and their associated challenges. This includes the need to address the potential friction of such innovations with traditional business models. For example, emerging peer-to-peer trade, access-based ownership, frugal innovations, and on-demand services are altering the urban economic marketplace and competitively pressuring traditional business models [13]. In this avenue, policy-makers need to address the interoperability between various data standards, e.g., open vs. proprietary, and the ethical and legal dimensions such as data access and control of such innovations.

To overcome these challenges, urban policy-makers should develop central mayoral institutions which process, govern, unify, and financially support critical urban data sets. The emergence of urban big data demands a long-term vision for its governance which addresses the privacy and ethical dimensions of data without stemming the momentum of its innovative applications. As with other public utilities, e.g., water, electricity, and gas, urban big data requires a framework to govern its expansion and usage. In this avenue, New York City Mayor's Office of Data Analytics (MODA), London's City Data Team, and Chief Technology Officer positions in cities with 'smart city' aspirations such as Amsterdam [14] are perhaps pioneering urban big data innovations. Furthermore, in the face of a governance vacuum at the national level, dedicated mayoral institutions can also create trans-local networks of cities, e.g., the C40 Large Cities Leadership Group, which are the forerunners of developing new sustainable solutions [15]. Such mayoral institutions are also essential in formulating strategies and practices to support open data that facilitate knowledge-sharing and allow more focused development. There is strong and growing evidence that open data can help urban governments in promoting citizen participation, transparency, and the reduction of information inequality among urban citizens [16]. Open data is essential in collectively reflecting and finding solutions to the social, economic, and environmental challenges of urbanization [17].

3. Advance the Culture and Common Skill Sets for Applying Urban Big Data

It is fundamentally flawed to pursue the development of urban big data through a top-down approach whereby we "risk revisiting the urban conflicts of the 20th century that pitted central planners against community activists" [18]. Furthermore, a top-down approach risks knowledge asymmetries between large corporations and local governments and communities. Instead, it is wise to understand how the application of variables relevant to urban resilience is initiated from the bottom up, through the grass-roots inclusion and engagement of urban citizens. Fundamentally, this is achieved by empowering urban citizens through grass-roots-level innovations. Grass-roots-level innovations are community-led initiatives that may have intrinsic or diffusion benefits towards transformations to sustainability [19]. These initiatives are especially useful where often technical and top-down approaches may struggle to contextualize the affordances of a new technology and engage its end-users. While there is a significant body of research on the technical dimensions of these themes, there has been less research on their public policy dimensions—especially on the accessibility of the technology and the active participation of end-users. Such research is essential in the grass-roots inclusion and democratic engagement of urban citizens in decision-making and for applying big data for urban resilience.

The risk that an innovation may inadvertently disadvantage segments of a society may also be true for the emergence of urban big data innovations. To address such a risk, it is essential that we better understand the common skill sets, knowledge, and educational curricula required for designing and managing urban big data innovations. The wide inclusion and participation of all segments of society in these informational innovations is essential in promoting a human-centered and grass-roots approach for serving technology to people [20]. Inclusive and human-centered urban big data allows for the maximization of the collective intelligence of society. These issues point to the

broader perspective of the limits of top-down approaches and the need to empower urban citizens to act as agents of their own change. As urban economies function through individual actions of their residents, urban big data should be developed to promote pluralism and to build what Helbing and Pournaras [21] term as digital democracies. A pluralistic approach is especially key in advancing broad, diverse, and crowd-sourced indicators [22] which can help urban citizens to compare and measure their progress in tackling urban sustainability challenges. This requires policy-makers to address common skill sets required by urban citizens. Specifically, how can cities ensure people have the knowledge and capacity to fully participate and benefit from these innovations? Furthermore, research needs to address the accessibility and affordability of these innovations so that vulnerable citizens are not inadvertently disadvantaged or excluded.

4. Invest in Research and Education on Urban Big Data

The design, planning, and adoption of innovations arising from urban big data may too often not meet any rationalistic and top-down explanation. Instead, we should approach the emergence of urban big data through what Ciborra [23] terms the lens of 'hospitality'. Through this lens, we are able to extend courtesy to the unknown and at times alien affordances of urban big data and are able to implement its advantages and better understand its disadvantages. The location for this hospitality is best achieved in research institutions and universities which can use cities as both laboratories and classrooms. These entities are in a position to readily host the emergence of urban big data and seek new solutions and processes relevant to urban sustainability challenges—especially in developing new metrics for measuring the progress of their cities towards urban sustainable developmental targets. A critical challenge for urban big data research is how to deal with the complexities and compatibilities of different methodologies, data formats, data analysis procedures, data governance and ownership, and data security. Some international research organizations have advocated for a systematic approach to integrate various sources and types of data, e.g., quantitative, qualitative, spatial, simulated, and visual, to support sustainable urban planning and management. For example, the International Council for Science, in cooperation with the United Nations University and the Interacademy Medical Panel, has launched a 10-year global program, Urban Health and Wellbeing in the Changing Urban Environment (www.urbanhealth.cn). Moreover, by investing in research and education on urban big data, we will be able to train a new generation of transdisciplinary researchers and practitioners with an emphasis on urban sustainability issues and the ability to explore creative uses of data in solving real-world problems. Pioneering research and education programs in this area, such as the Center for Urban Science and Progress at New York University and the Amsterdam Institute for Advanced Metropolitan Solutions, can provide urban sustainability stakeholders with a professional and social learning channel through offering massive open online courses on big data techniques and practices.

5. Conclusions

Cities are perhaps the most important arena for sustainable development and as reflected in the 11th SDG, they are one of the key developmental dimensions. The ideas presented in this commentary are intended to stimulate a dialogue on situating the emergence of urban big data and the urban sustainable developmental goals. Big data is not a 'magic bullet' and requires investment in 'data infrastructure' before realizing the potential benefits. While the emergence of urban big data has the potential to advance objective targets and indicators for future SDGs, we urge urban policy-makers to situate the application of these innovations through developing mayoral institutions for urban big data governance, advancing culture and common skill sets for applying urban big data, and investing in specialized research and education programs.

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