United Nations University
Institute for the Advanced Study of Sustainability

POLICY BRIEF

No. 12, 2017

Sustainable Smart Cities: Applying Complexity Science to Achieve Urban Sustainability

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Highlights

Smart city approaches promise technology-based opportunities to build sustainable urban futures. However, it is unclear how current market-led approaches can contribute to achieving relevant Sustainable Development Goals (SDGs). Applying complexity science helps to develop smart city policies for urban sustainability.

Policymakers at the national and city levels should:

- Develop an ethical framework for urban data and new information and communication technologies (ICTs).
- Beware of the limitations of new urban ICTs and realise ICT-enabled opportunities alongside existing initiatives.
- Ensure an "open data landscape" for cities and adopt transnational standards for interoperability with maximum stakeholders at all times.
- Appreciate the co-evolution of technology and governance to create sustainability-focused, ICT-enabling landscapes and new models of multi-level governance.
- Use new technologies to empower civil society and engage the public in future decisions.

Can Smart Cities Deliver Urban Sustainability?

The attraction of smart cities lies in the idea that increasing information and communication technology (ICT) and data-informed activities will lead to more efficient, better-connected, and more creative cities. However, the ongoing technological transformation is largely driven by the desire to develop ICT-led markets. Common themes across the early leaders in the field are the creation of positive business environments with institutional collaboration and citizen-centric service delivery. Although smart cities have the potential to make a significant contribution to the urban sustainability agenda, this has not yet been realised. The New Urban Agenda (UN 2017) explicitly mentions the role of smart cities in facilitating a paradigm shift in city management, yet pathways to achieve urban sustainability remain unclear. This brief presents an alternative understanding of smart cities, big data and the internet of things (IoT), and identifies specific policy actions to address urban sustainability in the context of the Sustainable Development Goals (SDGs), focusing on goals 11 and 13.

Smart City Opportunity Areas

The smart city label is being used by several cities and institutions in attempts to define a smart agenda around

big data and a rapidly growing urban IoT.

Big Data

This term refers to large amounts of data that cannot be analysed using traditional methods. It results from the exponential growth in machine-readable data generated by users, businesses, and governments through ICTs such as mobile phones, digital cameras, sensors, and cloud storage. Big data processed using techniques such as data mining and machine learning facilitates the collection, organisation, and analysis of large data sets in order to discover patterns and inform decision-making.

The Internet of Things

In 2008, the internet of people was overtaken by the IoT (Ashton 2009). "Things" can refer to a wide variety of devices such as identifier-tagged street lights, transport location sensors, heart rate monitors, and operational aids for industry. By 2020, an estimated 50 billion devices are likely to be connected to the internet (Evans 2011).

Making new long-term and real-time urban data open to governments, service providers, and civil society can create opportunities in three areas:

- Development of innovative new digital markets (e.g., the development of new products and service models).
- Management systems to respond to unexpected disruptions, work towards optimised service provision, and find efficiencies in use (e.g., in urban infrastructure).
- More informed citizens and greater civic participation in governance (e.g., participatory decision-making for local budgets or urban planning).

The Dangers and Difficulties in Regulating Smart Cities, Big Data, and the Internet of Things

Ill-considered implementation of smart city initiatives can degrade core societal values and has the potential to cause great societal harm (Kitchin 2014). Potential unethical outcomes include technological exclusion of segments of society that are not in a position to engage with new ICT developments; misuse of sensitive data resulting in intrusion and control of services; governments violating privacy rights of citizens; and prioritisation of business interests above social and environmental issues.

Large technology companies typically provide one or more "city data platforms" as part of smart city development. These platforms serve as data collection and access hubs with various degrees of access control for different users. The concentration of information in this manner heightens the danger of private technology companies having access to, and control over, the data of governments and private citizens.

The speed of ICT development creates unprecedented opportunities and risks. It can make it practically impossible for governments to develop appropriate regulation in order to avoid dangerous outcomes.

Limitations of Optimisation for Innovation and Sustainability

The majority of smart city initiatives are based on economic corporate models, and are aimed at finding cost efficiencies within existing systems. Directly linked to resource management, there are numerous initiatives aimed at optimising existing urban infrastructure. Examples of smart parking solutions, smart highway speed controls, smart refuse collection, smart water infrastructure, and smart energy grids are now commonplace. These short-term efforts towards resource efficiency are attractive to governments and play a role in both improving service provision and reducing environmental impact. However, there are clear limitations to the efficiency gains possible in any existing system. Even exceptional gains of up to 25% — demonstrated in one case of sensor-based energy savings — are simply minimising waste through information feedback and clever redistribution.

Greater improvements and longer-term sustainability cannot be achieved through optimisation alone. They require transformative changes ranging from innovative ICTs that can revolutionise future transport and mobility practices, to informed decision-making and collective behaviour change in civil society. In order to influence such innovations towards societal goals, the complexity of the processes of development and transformation in the ICT ecosystem must be clearly understood.

Beyond Regulation: Complex Co-evolution between Governance and ICT

The complex dynamics between ICT development and ICT governance can be described as co-evolution. Rather than playing the role of clients for technology companies, cities should be partners and enablers in ICT development, regulation, incentivisation, and implementation. Essential in the co-evolutionary process will be the development of appropriate new governance structures to ensure that socio-technological development is guided towards societal goals.

Smart city development occurs in the context of wider societal transformation. New governance should retain traditional sources of intelligence from outside the ICT domain to attenuate negative technology-led path dependencies.

New governance structures must adapt to remain relevant in a rapidly evolving ICT context. Such structures will have the knowledge and ability to guide smart city developments towards sustainable urban futures. The co-evolution of ICTs and governance is essential due to the bi-directional dependency between them.

Beyond Optimisation: Working with Complex Emergent Processes

Partnership approaches to smart city development are primarily based on market-led technological innovation. Typical smart city initiatives involve one or more large technology partners developing digital city platforms for, or in partnership with, local authorities. These platforms serve as data hubs that safely open up previously inaccessible, sensitive, or unformatted data to ICT-connected industries to encourage data mining and the extraction of some form of intelligence and utility.

However, innovative outcomes can only result from the spontaneous generation of new products and services, through interactions between government, large technology-service providers, related industries, smaller operators, and consumers. In the field of complexity science, this is called emergence — a process resulting in the spontaneous development of new forms in self-organised systems. As urban ICT development is a system with thinking and cognizant participants, it is possible to create conditions more likely to result in emergent outcomes related to urban sustainability than others.

Policymakers can influence emergent outcomes from ICT development in smart cities towards urban sustainability, in relation to SDG 11 and other SDGs. The dialogue between government and technology developers around societal problems and priorities is essential to this process.

Policymakers must create an enabling landscape for synergies between initiatives in specific directions. For example, to encourage ICT innovations focused on environmental sustainability, policymakers need to prioritise the acquisition and release of data related to air quality (SDG 3: good health & well being); energy consumption (SDG 7: affordable & clean energy); emissions (SDG 13: climate action); waste and recycling (SDG 12: responsible consumption and production); and transport, occupancy, and urban development (SDG 11: sustainable cities and communities).

Widely accessible, transparent, and well-documented datasets with high levels of detail are essential for analysis and reuse. Experimental development aimed at climate change mitigation and adaptation needs to be incentivised. Useful innovations should be further supported through appropriate governance in terms of scalability and adoption.

Policy Recommendations

- At the national level, it is crucial to develop an ethical framework for data collection, use, and dissemination. There is significant potential for misuse in the implementation of new technologies involving data collected from multiple sources, including agencies and individual citizens. There is a need to create a culture of transparency, in which permission for use is willingly given based on identifiable individual as well as societal benefits. The security, safety, and privacy of all stakeholders must be guaranteed. If mistrust of data-based technologies develops in civil society, it will be impossible to achieve hoped-for new initiatives towards sustainable urban futures.

- Policymakers must recognise the dangers of technological positivism or exclusive reliance on new digital technologies, and the possibilities of technological exclusion of certain segments of society. The strength of new urban ICT data lies in the ability to augment existing urban initiatives and concerns with evidence, and in developing new areas of action based on intelligence gleaned from new types of urban data, collected with increased frequency. It is important to retain existing non-digital services in parallel with new ICT provisions and to complement evidence used for decision-making with traditional research.

- It is essential to drive an open data landscape for cities. Policymakers must ensure that development of city data platforms follows transnational standards (such as ISO and ITU-T recommendations) for interoperability and avoid technological lock-in by large technology providers. The creation of an open market is essential and any intended or unintended alignment with large, private-sector stakeholders will create barriers for sustainability. Interoperability of ICT standards is essential — not only between government stakeholders and technology providers, but between countries for

transferable technologies to support later developers and to share knowledge. It is important to keep in mind that open innovation is dependent on cooperation frameworks.

- A new multi-level model of governance is necessary to develop and maintain a vibrant, sustainability-enabling landscape. Policymakers must be proactive in prioritising the availability of accurate and well-documented real-time and long-term urban data on energy use, air quality, transport, and emissions (with sufficient detail) to enable development of new services. Adaptive governance calls for the co-evolution of ICT and governance. Incentives must be provided to promote urban sustainability as a priority area for intelligent experimentation by digital developers. Government accountability and capacity to respond to new opportunities arising from these actions is essential for achieving genuine change. Such actions can link SDGs such as goals 11 and 13.

- The inclusion of civil society should go beyond information dissemination. User-friendly digital interfaces providing accessible real-time urban data on affordable housing, basic services, disasters, and sustainable transport systems are needed to enable informed choices in the short-term. Long-term participation in city planning, in cultural and natural heritage preservation, and in the creation of green and public spaces is essential to empower civil society. Investment in ICT should link urban, peri-urban, and rural communities in order to strengthen related societal networks.

Note

This policy brief is a joint output of UNU-IAS and the ESRC Strategic Network Data and Cities as Complex Adaptive Systems (DACAS). DACAS connects researchers from different disciplinary backgrounds who work with a common complexity theory framework to address urban transformation in a digital age.

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Sustainable Smart Cities: Applying Complexity Science to Achieve Urban Sustainability
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ISSN: 2409-3017

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Publisher
United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS)
Tokyo, Japan