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On the social shaping dimensions of smart sustainable cities: A study in science, technology, and society

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ABSTRACT

Situated within science of science, this study analyzes the nature, practice, and impact of ICT of the new wave of computing for urban sustainability as a form of science and technology (S&T) within the defining context of smart sustainable cities. Specifically, it probes the ways in which this form has emerged from different perspectives, why it has become institutionalized and interwoven with politics and policy—urban dissemination, as well as the risks it poses to environmental sustainability in the context thereof. To achieve these aims, an analytical and philosophical framework of STS is adopted, which supports analyses and evaluations whose approaches are drawn from a variety of disciplinary and theoretical perspectives. The study shows that smart sustainable cities are discursively construed and materially produced by the socially constructed understandings and socially anchored and institutionalized practices pertaining to ICT of the new wave of computing for urban sustainability. Thereby, such cities are medicated by and situated within ecologically and technologically advanced societies. And as urban manifestations of scientific knowledge and technological innovation, they are shaped by, and also shape, socio–cultural and politico–institutional structures. In addition, the study demonstrates that the success and expansion of smart sustainable cities stem from the transformational power, knowledge/power relation, productive and constitutive force, and legitimation capacity underlying ICT of the new wave of computing for urban sustainability due to its association with the scientific discourse and its societal entailments. This form of S&T is, however, shown to pose risks to environmental sustainability. Therefore, it needs to be reoriented in a more environmentally sustainable direction, as it can not, as currently practiced, solve the complex environmental problems placed in the agenda of smart sustainable cities as a holistic approach to urban development.

1. Introduction

The rapid advances in ICT enabled and fueled by the recent discoveries in computing have transformed the contemporary city by technologizing and computerizing it. The immense improvement in computing and ICT over the past half–century has shaped all parts of society (Kramers et al., 2014). Innovations in computing continue to demonstrate that there is tremendous untapped potential for harnessing the creative and disruptive power of ICT and leveraging it to transform the way the city functions and ultimately the way citizens live—by unlocking the transformational effects of ICT as an integrative and constitutive technology. Indeed, becoming part of the things to which it is applied and deeply embedded into the very fabric of the city, ICT embodies a morphing power manifested in shaping how we create, do, and revolutionize things in connection with almost every urban function, process, activity, and domain. Hence, there is an increasing recognition that ICT constitutes a promising response to the challenge of urban sustainability of our time. The underlying premise is that urban sustainability deals with the complex mechanisms and patterns involved in the interactions between environmental, social, economic, and physical subsystems of urban society, and how these interactions affect the challenge of urban sustainability, and emerging ICT is grounded in the application of the complexity sciences to urban systems and

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problems. Undeniably, urban sustainability has been instrumental in instigating and engendering major shifts in the core practices, primary operations, and central institutions of the city in response to the goals of sustainable development, a transformative process that has been fueled by the recent advances in ICT and the infiltration of computer intelligence into the processes and systems of the city. ICT can be further leveraged in the advancement of sustainable urban development (e.g. Bibri & Krogstie, 2016b; Shahrokni et al., 2015). It has made it possible to approach a range of issues around urban sustainability from a whole new perspective (e.g. Al Nuaimi et al., 2015; Batty et al., 2012; Bibri & Krogstie, 2016c).

Contemporary debate in urban and academic circles is increasingly focused on ICT and sustainability as well as their amalgamation. It has become necessary to find and apply more innovative solutions and more sophisticated approaches to sustainable urban development. Besides, the way cities can intelligently be planned and developed has been of fundamental importance for strategic sustainable development to achieve the long–term goals of sustainability. Put differently, ICT in its various forms (infrastructures, applications, services, and capabilities) is increasingly seen to provide unsurpassed ways to address a range of complex issues and challenges facing cities. In fact, ICT is already enabling cities in many parts of the world to remain sustainable and thus livable in the face of staggering urbanization, growing social mobility, and ongoing transformation. The planning of cities as complex systems towards sustainable development requires innovative ideas and advanced methods (e.g. Rotmans, van Asselt & Vellinga 2000). ICT and sustainability play a key role in smart sustainable urban planning (Bibri & Krogstie, 2016a, 2016c; Bifulco et al., 2016). In other words, ICT development and sustainability awareness has resulted in an opportunity to rethink the way we plan and develop cities (Höjer & Wangel, 2015).

When discussing computing and ICT and thus smart solutions and ideas for cities, reference is made to the evolving concept of smart sustainable cities (e.g. ITU, 2014; Kramers et al., 2014; Adams & El-Zaart, 2015; Rivera, Eriksson & Wangel, 2015; Bibri & Krogstie, 2016a; Höjer & Wangel, 2015). The use of this concept serves to substantiate the growing significance of ICT in enabling smart and sustainable cities to realize their potential by getting smarter as to improving their contribution to sustainability and rising to the pressures of urbanization. In fact, this concept has emerged as a result of a lack of, or very weak, connection between smart cities and sustainable cities, despite the proven role of ICT in supporting cities in their transition towards sustainability, especially in relation to the management and planning of urban systems (e.g. Kramers et al., 2014). In light of this, recent research endeavors have started to focus on how to improve smart city approaches as well as smarten sustainable city models (e.g. Murray, Minevich & Abdoullaev, 2011; Batty et al., 2012; Bibri & Krogstie, 2016b; Kramers et al., 2014) by integrating the two perspectives as urban development strategies. This is an attempt to achieve the required level of operational functioning and planning in line with the goals of sustainable development. This holistic approach holds great potential to address the challenge of, or provide solutions for moving towards, urban sustainability (Batagan, 2011; Murray, Minevich & Abdoullaev, 2011). Therefore, the concept and development of smart sustainable cities has come to the fore, and is rapidly gaining momentum as a holistic approach to urban development and as an academic pursuit, not least in ecologically and technologically advanced societies. Besides, we live in a world where computing and ICT have become deeply embedded into the very fabric of the city, i.e. its systems, processes, and functions are pervaded with computer intelligence and various forms of automation. It follows that it is high time for sustainable cities to smarten up and smart cities to get smarter in an increasingly computerized urban world. This is predicated on the assumption that advanced ICT offers tremendous potential for monitoring, understanding, probing, assessing, and planning the city, which can be leveraged in the advancement of urban sustainability.

Visions of future advances in S&T inevitably bring with them wide–ranging common visions on how cities as social fabrics will evolve in the future, as well as on the immense opportunities and potential risks this future will bring (see Bibri, 2015b). This relates to the role of science and science–based technology in modern society, a half–a–century debate within which the assumptions and claims made in the above discussion are positioned. Here. the focus is on the role of computing and ICT as a form of S&T in advancing urban sustainability. This form of S&T permeates contemporary urban debates, policy and politics, and is seen as key for solving environmental and socio–economic challenges and problems facing the contemporary city. Concurrently, it is increasingly challenged by some scholars, often exposing risks of techno–scientific achievements in the context of the evolving urban development approaches. However, recent discoveries in computing and advances in its ICT applications have given rise to new socially disruptive technologies. Of more prevalence of such technologies, which also represent forms of pervasive computing, are Ubiquitous Computing (UbiComp), Ambient Intelligence (AmI), the Internet of Things (IoT), and Sentient Computing (SenComp) This is manifested in the emergence and dominance of ambient, sentient, ubiquitous, and Internet–of–everything cities (e.g. Böhlen & Frei, 2009; Kyriazis et al., 2014; Shepard, 2011; Shin, 2009; Thrift, 2014). Further, heralding a major technological change, such technologies and their amalgamation are projected to result in a drastic transformation of the technological ecosystem in all its complexity and variety. This will in turn alter how ICT can be applied and used in the city, in particular in relation to sustainable urban development. It has been suggested that as computing and ICT become pervasive, i.e., data sensing, information processing, and wireless communication networking become more and more embedded throughout urban systems and domains and citizens' objects, we can speak of cities getting smarter as to solving environmental, social, and economic problems as well as providing services to citizens to improve the quality of their life (Batty et al., 2012; Bibri & Krogstie, 2016c; Piro et al., 2014; Shepard, 2011; Townsend, 2013). There is a growing recognition that the evolving techno–urban trend, which involves integrating various forms of pervasive computing in the city infrastructure, will bring about further transformational effects as to urban sustainability. This intellectual trend has come to be identified as the discourse of ICT of the new wave of computing for urban sustainability.This discourse has been instrumental in shaping the discourse of smart sustainable cities. The underlying premise is that computing and ICT has significant effects within the contemporary city. As advances of S&T, they are altering long–standing forms of city structures and amplifying existing city transformation models in terms of sustainability and what it entails in terms of the way the city functions and citizens live. Specifically, they are reshaping existing patterned urban arrangements and physical structures as well as ways of addressing the problems of urban sustainability and meeting its required level, which are emergent from and determinant of the actions of many urban actors. In the contemporary city, scientific innovation and its ICT applications are seen 'as indispensable for. . .bringing more advanced solutions for social, economic, and environmental problems and for providing new services to citizens.' (Bibri, 2015b, p. 1) Indeed, major urban transformations are being promised upon the advent of ICT of the new wave of computing on the basis of ICT innovations that have been enabled by scientific discoveries in computing. Unsurprisingly, ICT of the new wave of computing is gaining increasing attention in the ambit of smart sustainable cities, attracting a lot of interest from research institutions, universities, industries, policy makers, and governments, owing to its role in the structural