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Perspective Essay

# ‘Rage against the machine’? The opportunities and risks concerning the automation of urban green infrastructure

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A B S T R A C T

Contemporary society is increasingly impacted by automation; however, few studies have considered the potential consequences of automation on ecosystems and their management (hereafter the automation of urban green infrastructure or UGI). This Perspective Essay takes up this discussion by asking how a digital approach to UGI planning and management mediates the configuration and development of UGI and to whose benefit? This is done through a review of key issues and trends in digital approaches to UGI planning and management. We first conceptualize automation from a social, ecological, and technological interactions perspective and use this lens to present an overview of the risks and opportunities of UGI automation with respect to selected case studies. Results of this analysis are used to develop a conceptual framework for the assessment of the material and governance implications of automated UGIs. We find that, within any given perspective, the automation of UGI entails a complex dialectic between efficiency, human agency and empowerment. Further, risks and opportunities associated with UGI automation are not fixed but are dynamic properties of changing contextual tensions concerning power, actors, rules of the game and discourse at multiple scales. We conclude the paper by outlining a research agenda on how to consider different digital advances within a social-ecological-technological approach.

## 1. Introduction

The effective provision and management of urban green infrastructure (UGI), including urban trees, parks, blue and green open spaces, and green walls and roofs, have the potential to provide both direct benefits (e.g., ecological connectivity and habitat conservation) and a range of co-benefits to urban societies, thereby delivering on the UN 2030 Agenda for Sustainable Development goals and the Habitat III new urban agenda (Bai et al., 2018). Co-benefits include increased air and water quality, improved technological solutions to storm water management, social cohesion, and increased human health and well-being (Kabisch, Qureshi, & Haase, 2015; Raymond et al., 2017). To realize these benefits in the face of accelerating pressures such as climate change and urban densification, scientists and policy makers are now calling for integrated solutions that operate “at the intersection of social, cultural, digital and nature-based innovation” (European Commission, 2017; also see Eggermont et al., 2015).

In parallel, practitioners are progressively utilizing digital solutions for urban greening in efforts to optimize, and in some cases democratize, the delivery and implementation of UGI (Cantrell, Martin, & Ellis, 2017; DiSalvo & Jenkins, 2017). For example, automation is supporting UGI management in lawn care through autonomous lawn mowers (Grossi et al., 2016), urban forest inventories feature digitally-tagged trees that transmit information to smart phone platforms (Luvisi &

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Lorenzini, 2014), biodiversity assessments are undertaken through gaming (Sandbrook, Adams, & Monteferri, 2015), citizen nature preferences are monitored through Instagram images and hash tags (Guerrero, Møller, Olafsson, & Snizek, 2016), and urban foraging is undertaken with community-developed semi-autonomous drones (DiSalvo & Jenkins, 2017). These technologies are driven by government and business aims at productivity (and profitability), but also creativity and innovation coupled with promises of 'smart' and 'real-time' solutions to environmental and societal demands and challenges (Cantrell et al., 2017; Taylor Buck & While, 2017; Gabrys, 2014). Taken together, these examples represent the kind of rapid technological development suggestive of potential disruption in the field of UGI planning and management.

Automation in nature management, including in UGI, shows no signs of slowing based on the demands of politicians and initiatives of citizens for collaborative and participatory urbanism (Gil-Garcia, Helbig, & Ojo, 2014), and the forecasted productivity-enhancing benefits associated with the adoption of automated resource management (Schwab, 2016). Yet, little attention has been paid to the assumptions, opportunities, and especially risks of these technologies in urban societies and the governance of existing UGI. Moving forward, it is critical to consider not only the potential benefits but also the challenges that accompany such profound change, specifically concerns regarding the transparency, fairness, and technical proprietary of autonomous and semi-autonomous UGI (Galaz & Mouazen, 2017).

This Perspective Essay takes up this discussion by asking *how a digital approach to UGI planning and management mediates the configuration and development of UGI and to whose benefit*? Specifically, what are the social, ecological, and technical opportunities and risks of the uptake of computational technologies in UGI delivery and management? This is done through a review of key issues and trends in digital approaches to UGI planning and management. Given the dearth of discussion of automation of UGI in the literature, we first conceptualize automation by building on insights from the digital geographies, sustainable urban transitions, and UGI governance literature. In this section we briefly review digital innovation in natural resource management. We then discuss the potential implications of these trends and issues for the UGI context by drawing on six mini-case studies outlining major themes in UGI planning and management: Case 1 - wildlife and conservation management, Case 2 - urban food production, Case 3- human well-being, Case 4 - legitimation of citizen knowledge/citizen science, Case 5 - citizen stewardship, and Case 6 - governance (Mell, 2016; Van der Jagt et al., 2017). We conclude the paper by establishing a conceptual framework for the assessment of the material and governance implications of automated UGIs outlining a research agenda on how to consider different digital advances within a social-ecological-technological approach.

## 2. Conceptualizing the automation of UGI

The automation of UGI has social, ecological, and technological ramifications. At present, however, automation is discussed in the natural resource management literature in purely technical and ecological (Cantrell et al., 2017; Luvisi & Lorenzini, 2014) or social and ecological terms (Guerrero et al., 2016; Kahila-Tani, Broberg, Kyttä, & Tyger, 2016). Below, we develop an analytical framework to bridge the various interfaces of the automation of UGI, discussing the interactions amongst technical innovation, social systems, and ecosystem functions. These system interfaces are labeled accordingly as 'ecological-technological', 'social-technological', and 'social-ecological' (also see Table 1). This approach draws on McPhearson et al. (2016)'s conceptualization of UGI as a system made up of social, ecological and technological interactions.

Beyond these interactions, we also conceptualize how UGI automation is coupled to and impacted by (and impacts on) broader governance settings. Governance in this context is referred to as the collective cross-sectoral steering of decision-making and policy as determined by "the rules of the game, power, actors, and discourses" (Arts, Leroy, & van Tatenhove, 2006). We argue that on a broader-scale, automation mediates the social, ecological, and technological interactions in UGI by shifting the formal and informal terms of decision making, rules and regulations. In turn, existing governance contexts will mediate the impact of automation. Power in this case is conceived as the division of resources between actors and institutions, as well as influence over who determines the rules and sets the dominant narrative; discourses relate to the views and narratives of the actors involved in UGI automation (Liefferink, 2006). Dominant discourses determine norms, values, and problem definitions and solutions. Automation is thus conceptualized as multi-scale digital and computational objects, processes, infrastructures, and assemblages (Kitchin & Dodge, 2011).

### 2.1. Ecological-technological perspective

Automation in natural resource management commonly refers to technical developments in computer hardware and software that make it increasingly possible to remove humans from operational tasks, strategic development, and the execution of simple to complex decision making (Cantrell et al., 2017; Parasuraman, Sheridan, & Wickens, 2000). These interactions are discussed as ecological-technological interactions, whereby technological advancements efficiently contribute to the biophysical cultivation and maintenance of landscapes, from forestry and agriculture to conservation monitoring and management. Robots are deployed for areal seeding and weed control in tropical forests (Elliott, 2016), for the monitoring of vector-borne diseases, plant pests, aquatic pests (Jurdak et al., 2015), and for the collection of water samples in remote areas (Schwarzbach, Laiacker, Mulero-Pazmany, & Kondak, 2014). In agriculture, mobile robots disperse pesticides and herbicides, and produce synthetic foods (Majima, 2014). Robots also support monitoring, for instance of invasive species in harbors (Dunbabin & Marques, 2012), and cover vast territories, as in the case of monitoring the growth and decline of extensive coral reefs (Cantrell et al., 2017). Furthermore, deep machine learning is used to evaluate the qualities and development potential of urban environments (Liu, Silva, Wu, & Wang, 2017). In this interaction, institutional power and agency is held by natural resource managers and or the private sector.

### 2.2. Social-technological perspective

Yet, the automation of natural resource management is more than semi-autonomous ecological steering; it also encompasses social-technological interactions situated within a proliferating network of digital technology (Kitchin & Dodge, 2011). These social and technological networks (Smith & Stirling, 2010) are supported by ubiquitous computing and digital technology such as wireless broadband, analytical software, real-time sensing and feedback, and the Internet of Things. This social-technological fabric is deployed in our urban infrastructure as a network of information and control systems, providing so-called big data used to respond to large-scale problems of climate change, urbanization, citizen engagement, and resource efficiency (Kitchin, 2014). These interactions monitor and manage real-time urban flows, coupled with the mobile computing (smartphones) of everyday users of the city to generate data regarding e.g. peoples' locations and activities (Kitchin & Dodge, 2011). In a social-technological framing of natural resource management automation, social processes shape the development and use of technology and in turn open up new possibilities for social practices linked to institutionally structured market incentives and consumer demands (Smith & Stirling, 2010).

Such examples of automation relate to social-technical interactions between diverse actors in the conservation and management of natural resources. "Smart" governance platforms support ecosystem planning and place-keeping exercises with citizens providing voluntary geographic information (Kahila-Tani et al., 2016). Nature-recreation apps