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EDITORIAL

Focus on sustainable cities: urban solutions toward desired outcomes

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1. Introduction

Urbanization represents the single most impactful and long-lasting transformation of the Earth system since the dawn of civilization. Cities are simultaneously locations of innovation, social connectivity, and wealth, but they also create local-to-global environmental degradation and socioeconomic disparities. For example, food provision for cities has required significant land-use change and fertilizer input, has altered regional climate, biogeochemical cycles, and degraded marine and landscapes through biodiversity loss, algal blooms and fish kills. To maintain urban livelihoods and the provision of goods and services, cities require vast amounts of energy (e.g. to provide access to transport, cooling systems), which are massive producers of greenhouse gases, the main culprit of global change. Future urbanization will need to be transformative—wholly different from how we have designed, built, and powered cities and towns—so that they can be sustainable and resilient. Should current trends in urban expansion continue—low density and resource and energy intensive—urban energy use will triple between 2005 and 2050 (Creutzig *et al* 2015). Raw material demand will exceed what the planet can sustainably supply (UN IRP 2018) and the safe operating limits that have facilitated the rise of modern civilization will become increasingly at risk of being crossed, leading to a cascade of pressures that would pose dire consequences for and severely disrupt humanity (Rockström *et al* 2009).

The growth of future cities and towns—both newly developed and expansion of those already in existence, as well as how we maintain and retrofit existing urban centers—will determine whether humanity can transition to sustainability. Ideally, decisions about urbanization would be based on science and data-driven approaches that are grounded in specific places but are also generalizable (Bettencourt and West 2010). Although there are aspects of cities that are generalizable, current theories about urban systems are more conceptual in nature and there is limited work that takes into consideration the non-linear and non-local effects of urban systems. Nevertheless, scientific understanding today is sufficient to provide some level of meaningful input as regards benefits and consequences of urbanization. For example, the destruction of infrastructure and loss of life caused by Hurricane Betsy in New Orleans in 1965 led to critical knowledge that structural and social systems were necessary to safeguard the city against future tropical storms. However, 'development outpaced available levels of protection' (Olson 2011), minimizing the possibility of local evacuation, and eventually resulted in the devastating impacts caused by Hurricane Katrina in 2005. Some of the lessons learned post-Hurricane Betsy have yet to be incorporated post-Hurricane Katrina, diminishing the role of scientific understanding vis-à-vis the ostensible necessity for growth.

What is less known, however, is the collective and integrative effect of urbanization that cuts across disciplinary boundaries and holistically characterizes the problems that ensue, or the efficacy of solutions that are necessary, beyond the lens of any singular academic branch. For example, a frequent focus of urban climate modeling studies that examine the efficacy of temperature reduction strategies (e.g. cool and green roofs) is the ability of a particular strategy to decrease the urban heat island (UHI) (i.e. to decrease the air temperature difference between an urban and rural location). The results from such a singular focus can be misleading if it ignores other components of the urban ecosystem or lacks integration. We illustrate why by using Phoenix, AZ, as an example. Phoenix

has a negligibly small, or even negative, daytime UHI, although few would argue that the fifth largest city in the US does not have a serious urban heat burden, when maximum summertime temperatures frequently exceed 43 °C (Chow *et al* 2012). A focus on decreasing the UHI lacks integration by neglecting closely connected environmental and human-oriented consequences that become apparent upon examination of tradeoffs and feedbacks (Seto *et al* 2017, Putnam *et al* 2018, Broadbent *et al* 2021). Indeed, recent work conducted in the Californian city of Los Angeles has demonstrated that the deployment of cool (i.e. highly reflective) pavements raises concerns for the undertaking of outdoor activities (e.g. reduces walkability) as a result of increased pedestrian radiant load (Middel *et al* 2020). This example illustrates a second key concern related to the development of meaningful metrics that are generalizable and help pave the path toward development of urban systems theory that incorporates natural and social elements. Although the utility of a particular metric may have gained traction and become popular, as the often-utilized focus on decreasing the UHI has, it may not result in actionable science. While one may argue that it does for some cities, the lack of generalizability to the majority of cities disconnects this metric from broad societal applicability (Martilli *et al* 2020).

This Special Issue (SI) was focused on the discovery of urban solutions aimed at accelerating the transition to economically, socially, and environmentally resilient cities through integration of desired outcomes as an organizing framework. The SI papers collectively published, totaling one research agenda-setting perspective and 15 research studies (table 1), take an important step forward by:

(a) integrating across disciplines such as hydrology, meteorology/climatology, ecology, geomorphology, economics, environmental management, environmental sciences, geography, GIScience, and urban planning, thereby explicitly acknowledging the multifaceted qualities of sustainability that each field contributes to;

(b) developing new metrics in assessing sustainability (e.g. Chertow *et al* 2019, Stokes and Seto 2019, Krueger *et al* 2020);

(c) considering an explicit multi-scalar approach when evaluating urban sustainability solutions across temporal and spatial dimensions (Aragon *et al* 2019, Chakraborty *et al* 2019, Fan *et al* 2019, Jeong 2019, Meerow 2019, Pregitzer *et al* 2019, Carmen *et al* 2020, Grêt-Regamey *et al* 2020);

(d) examining coupled interactions between various urban system aspects, such as climate-energy, food-energy, and on industrial waste with energy production and consumption, with respect to desired sustainability outcomes through detailed scenario assessment (e.g. Lipson *et al* 2019, Warziniack and Brown 2019, Dukes *et al* 2020).

Collectively, the articles in the SI also point to four gaps in knowledge:

(a) The need for more theory—Stokes and Seto (2019) reconceptualize the urban landscape in a process-based manner that is directly connected to sustainability. The explosion in data analytical tools (e.g. machine learning, data mining), data (e.g. remote sensing, cell phone records), and computing infrastructure (e.g. parallel and cloud computing) offers an unprecedented opportunity to expand this type of analysis globally, to include other processes, and paves the way toward improved characterization and monitoring of urban areas, including large-scale urban population dynamics (e.g. Tuholske *et al* 2019), to guide the transition to sustainability.

(b) The need for replicability—are the results consistent across urban sites using the same methods but with different data? Pregitzer *et al* (2019) demonstrate the importance of improved characterization of urban forests, including their composition and structure in order to better inform both policy and management, enable provision of ecosystem services and to establish a reference against which *what-if* (e.g. canopy expansion) scenarios can be examined.

(c) Generalizability—are the results applicable in other urban contexts? Can inferences be made in other urban areas using results from one study? For example, how and under what conditions do the findings of Chakraborty *et al* (2019)—who find that poorer neighborhoods experience elevated heat exposure—apply to smaller cities around the world outside of their 25 case studies? Perhaps even more important is to understand how generalizable are the underlying conditions and processes that gave rise to these outcomes. Likewise, under what conditions can urban agriculture supply 90% of annual consumption of produce, as shown in Phoenix (Aragon *et al* 2019) and what are the implications for local food insecurity?

(d) Scalability—there is an urgent need for solutions to be scalable. It is valuable that some case studies in the SI demonstrate innovation and provide pathways to increase resilience, but can other cities achieve similar outcomes with significantly fewer human and financial resources?

The papers also underscore the need for rethinking the metrics we are using to measure outcomes connected to urban sustainability. For example, given the potential of ISP for reusing a city's industrial waste and byproducts, there is an opportunity to develop metrics that examine a city's capacity to improve resource use efficiency. Likewise, there is a need to develop and improve tools that examine a spectrum

Table 1. Summary table of papers included within this Special Issue, including the principal academic discipline, urban areas examined, the spatio-temporal scales of analysis, and the emergent theme for urban solutions and the desired sustainability outcome(s).

Paper and urban area examined	Primary discipline	Spatial scale	Temporal scale	Emergent theme for urban solutions and desired sustainability outcome
Moy de Vitry *et al* (2019)/NA; perspective essay	Hydrology	NA/perspective essay		Consideration of risks embedded within smart urban water systems, and the role for future research having a dual role as both creators and critics of novel water resource solutions.
Carmen *et al* (2020)/four cities: Coimbra (Portugal), Genk (Belgium), Leipzig (Germany), and Vilnius (Lithuania)	Environmental sciences/ecology	City-wide (regional-scale)	[a]Based on stakeholder survey data collected in 2019–2020	Assessment of which ecological, economic, and social metrics are selected by cities as urban green space indicators that enhance urban resilience and sustainability.
Dukes *et al* (2020)/ Baltimore City, Maryland, USA	Ecology	Census tract (local-scale)	Annual; one year (2016)	Development of new approach to examine multi-scale spatial patterns of community nitrogen footprint for urban sustainability through improved monitoring of urban food and energy consumption.
Grêt-Regamey *et al* (2020)/two cities: Zurich, Switzerland; Singapore	Ecology/urban planning	Variable up to 1 km^2 pixels; city-wide (regional-scale)	Combination of datasets	Assessment of urban densification on urban ecosystem services, including air pollution control, water flow regulation, microclimate regulation, carbon sequestration, and recreation, for a temperate and tropical city.
Krueger *et al* (2020)/seven cities on four continents	Sustainability	City-wide (regional-scale)	Combination of datasets	Development of a new framework that integrates security, resilience, and sustainability of urban water supply systems.
Lipson *et al* (2019)/ Melbourne, Australia	Meteorology/ climatology	City-wide (regional-scale)	Yearly-decadal; present day until 2100	Examination of climate-energy interactions under various scenarios of climate, urban infrastructure and technological change to project future urban electricity and gas demand.
Meerow (2019)/three cities: New York City, USA; Los Angeles, USA; Manila, Philippines	Geography/ GIScience	Census tract (local-scale)	Annual; combination of yearly/multi-year datasets	Demonstrated utility of a generalizable mapping tool for the assessment and comparison of spatial trade-offs and synergistic 'hotspots' to enhance green infrastructure planning.
Jeong (2019)/Phoenix Metropolitan Area, USA	Hydrology/ geomorphology	City-wide (regional-scale)	Yearly-decadal; mid-20th century until present day	Improved modeling of ex-urban hydrological sediment load in desert catchments for enhancing urban flood control structures in rapidly growing desert cities.

(Continued.)

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Paper and urban area examined	Primary discipline	Spatial scale	Temporal scale	Emergent theme for urban solutions and desired sustainability outcome
Fan *et al* (2019)/Taipei City	Urban planning	250 m pixels; city-wide (regional-scale)	Annual; one year (2015)	Development of a framework for measuring compactness and urban green accessibility in a high-density transit-oriented metropolis based on the urban compactness index (UCI) and urban green accessibility index (UGAI).
Chakraborty *et al* (2019)/ 25 major cities; global distribution	Geography/ GIScience	1×1 km pixels (neighborhood scale)	Annual; combination of yearly/ multi-year datasets	Assessment of neighborhood level urban heat exposure, using satellite and census data, for 25 global cities to characterize the extent to which poorer neighborhoods experience elevated temperatures.
Aragon *et al* (2019)/Phoenix, Arizona, USA	Geography/global studies	Building lots/rooftops (neighborhood to regional scale)	Annual; combination of yearly datasets	Contribution assessment of urban agriculture deployment over underutilized exterior spaces (i.e. unpaved vacant lots, flat rooftops, and building façades) towards city-specific sustainability goals.
Tuholske *et al* (2019)	Geography/ GIScience	City-wide (regional to large-scale)	Combination of datasets from 2000, 2015, and 2016	Utility of multiple datasets to estimate the change in Africa's urban population between 2000 and 2015, within and between countries, and across moisture zones.
Pregitzer *et al* (2019)/New York City, USA	Ecology/ GIScience	Urban plots (neighborhood scale to regional scale)	Annual; combination of yearly datasets	Enhanced scalar assessment of urban forest stands— spatial extent, structure, and composition—to accurately represent different urban forest types that inform effective policy and management.
Warziniack and Brown (2019)/conterminous United States	Hydrology/ economics	Water basin (regional to large-scale)	Every five years: 1985–2070	Examination of future changes in water yield and demand and their effect on the likelihood of water shortages in the absence of groundwater mining.
Chertow *et al* (2019)/Mysuru City (Mysore), India	Environmental management	City-wide (regional-scale)	Annual; combination of yearly datasets	Development of a new metric— industrial symbiosis potential— for sustainability via linking of private production and public infrastructure to improve urban resource efficiency.
Stokes and Seto (2019)/909 Urban Areas in the USA	Geography/ GIScience	1×1 km pixels (neighborhood scale)	Annual; combination of yearly datasets	Development of a new language and classification schema for urban areas based on objective measures of the built and natural environment that are comparable across and within urban areas.

[a] Correspondence with lead author.

of spatially-explicit environmental indicators, patterned after the nitrogen footprint tool (Dukes *et al* 2020) which permits environmental impact assessment of the aggregate activities and consumption patterns of distinct urban regions. Additionally, there is a need to develop measures of urban landscapes that link to multiple dimensions of sustainability (Grêt-Regamey *et al* 2020, Krueger *et al* 2020), including energy demand (Lipson *et al* 2019), flood control structures (Jeong 2019), assessment of tradeoffs and synergies that enhance urban resilience (Meerow 2019) and extend beyond the conventional focus

on land use change. Understanding how city governments plan, manage and evaluate existing urban green spaces to maximize delivery of ecological, economic, and social benefits is necessary in order to make practical contributions to urban resilience (Carmen *et al* 2020). Finally, retrofitting existing cities and development of new urban clusters in a society based upon information technology offers prospects for breakthrough changes but also brings unique challenges with respect to privacy and cybersecurity (Moy de Vitry *et al* 2019).

Collectively, the articles in the SI advanced the knowledge base on cities and sustainability. They also revealed considerable opportunities for future research that advance the development of pathways to urban sustainability. Especially important is the potentially critical role of innovative policy, management, and technological solutions that facilitate locally-established desired outcomes that are generalizable, integrative, and scalable. Development of new conceptual frameworks, metrics and tools, and integration across disciplinary boundaries that holistically characterize and help prioritize science and policy concerns, can help inform a convergent research agenda that paves the way to transitioning to sustainability in an urban century.

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References

Aragon N U, Stuhlmacher M, Smith J P, Clinton N and Georgescu M 2019 Urban agriculture's bounty: contributions to Phoenix's sustainability goals *Environ. Res. Lett.* **14** 105001

Bettencourt L and West G 2010 A unified theory of urban living *Nature* **467** 912–3

Broadbent A M, Declet-Barreto J H, Krayenhoff E S, Harlan S L and Georgescu M 2021 Targeted implementation of cool roofs for equitable urban adaptation to extreme heat *Sci. Total Environ.* 151326

Carmen R, Jacobs S, Leone M, Palliwoda J, Pinto L, Misiune I and Ferreira A 2020 Keep it real: selecting realistic sets of urban green space indicators *Environ. Res. Lett.* **15** 095001

Chakraborty T, Hsu A, Manya D and Sheriff G 2019 Disproportionately higher exposure to urban heat in lower-income neighborhoods: a multi-city perspective *Environ. Res. Lett.* **14** 105003

Chertow M, Gordon M, Hirsch P and Ramaswami A 2019 Industrial symbiosis potential and urban infrastructure capacity in Mysuru, India *Environ. Res. Lett.* **14** 075003

Chow W T, Chuang W C and Gober P 2012 Vulnerability to extreme heat in metropolitan Phoenix: spatial, temporal, and demographic dimensions *Prof. Geogr.* **64** 286–302

Creutzig F, Baiocchi G, Bierkandt R, Pichler P P and Seto K C 2015 Global typology of urban energy use and potentials for an urbanization mitigation wedge *Proc. Natl Acad. Sci.* **112** 6283–8

Dukes E S, Galloway J N, Band L E, Cattaneo L R, Groffman P M, Leach A M and Castner E A 2020 A community nitrogen footprint analysis of Baltimore City, Maryland *Environ. Res. Lett.* **15** 075007

Fan P, Lee Y C, Ouyang Z and Huang S L 2019 Compact and green urban development—towards a framework to assess urban development for a high-density metropolis *Environ. Res. Lett.* **14** 115006

Grêt-Regamey A, Galleguillos-Torres M, Dissegna A and Weibel B 2020 How urban densification influences ecosystem services—a comparison between a temperate and a tropical city *Environ. Res. Lett.* **15** 075001

IRP 2018 Re-defining value—the manufacturing revolution. Remanufacturing, refurbishment, repair and direct reuse in the circular economy. Nabil Nasr, Jennifer Russell, Stefan Bringezu, Stefanie Hellweg, Brian Hilton, Cory Kreiss, and Nadia von Gries *A Report of the International Resource Panel* (Nairobi: United Nations Environment Programme)

Jeong A 2019 Sediment accumulation expectations for growing desert cities: a realistic desired outcome to be used in constructing appropriately sized sediment storage of flood control structures *Environ. Res. Lett.* **14** 125005

Krueger E H, Borchardt D, Jawitz J W and Rao P S C 2020 Balancing security, resilience, and sustainability of urban water supply systems in a desirable operating space *Environ. Res. Lett.* **15** 035007

Lipson M J, Thatcher M, Hart M A and Pitman A 2019 Climate change impact on energy demand in building-urban-atmosphere simulations through the 21st century *Environ. Res. Lett.* **14** 125014

Martilli A, Krayenhoff E S and Nazarian N 2020 Is the urban heat island intensity relevant for heat mitigation studies? *Urban Clim.* **31** 100541

Meerow S 2019 A green infrastructure spatial planning model for evaluating ecosystem service tradeoffs and synergies across three coastal megacities *Environ. Res. Lett.* **14** 125011

Middel A, Turner V K, Schneider F A, Zhang Y and Stiller M 2020 Solar reflective pavements—a policy panacea to heat mitigation? *Environ. Res. Lett.* **15** 064016

Moy de Vitry M, Schneider M Y, Wani O F, Manny L, Leitão J P and Eggimann S 2019 Smart urban water systems: what could possibly go wrong? *Environ. Res. Lett.* **14** 081001

Olson S 2011 *Increasing National Resilience to Hazards and Disasters: The Perspective from the Gulf Coast of Louisiana and Mississippi: Summary of a Workshop National Research Council* (*Washington, DC*)

Pregitzer C C, Ashton M S, Charlop-Powers S, d'Amato A W, Frey B R, Gunther B and Bradford M A 2019 Defining and assessing urban forests to inform management and policy *Environ. Res. Lett.* **14** 085002

Putnam H, Hondula D M, Urban A, Berisha V, Iñiguez P and Roach M 2018 It's not the heat, it's the vulnerability: attribution of the 2016 spike in heat-associated deaths in Maricopa County, Arizona *Environ. Res. Lett.* **13** 094022

Rockström J, Steffen W, Noone K, Persson Å, Chapin F S, Lambin E F and Foley J A 2009 A safe operating space for humanity *Nature* **461** 472–5

Seto K C, Golden J S, Alberti M and Turner B L 2017
    Sustainability in an urbanizing planet *Proc. Natl Acad. Sci.*
    114 8935–8
Stokes E C and Seto K C 2019 Characterizing and measuring
    urban landscapes for sustainability *Environ. Res. Lett.*
    14 045002

Tuholske C, Caylor K, Evans T and Avery R 2019 Variability in
    urban population distributions across Africa *Environ. Res.
    Lett.* **14** 085009
Warziniack T and Brown T C 2019 The importance of municipal
    and agricultural demands in future water shortages in the
    United States *Environ. Res. Lett.* **14** 084036