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Smart Solutions for Sustainable Cities

Editors

Tom Sanchez, Ralph Hall and Nader Afzalan

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Commentary

From the Garden City to the Smart City

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Abstract
It has been a century since the first Garden Cities at Welwyn and Letchworth were founded and, in the eyes of many, we have entered the age of the Smart City. This commentary briefly reflects upon the origins of Ebenezer Howard's vision in the slums of overcrowded, filthy London and the fire-traps of early 20th century Chicago before outlining some of the main contributing factors to its ultimate failure as an approach: the lack of a robust theory underpinning his ideas, a finance model which was unacceptable to the banks—leading to a compromise which robbed the more idealistic participants of any real power over their schemes—and finally, a dilution of Howard's vision by architects who were more focused on population density than on social reform. A parallel is then drawn between the weaknesses which afflicted the Garden City vision, and those which afflict current Smart City visions, a loose agglomeration of ahistorical techno-utopian imaginaries, whose aims almost invariably include optimising various measures of efficiency using large-scale deployments of networked sensors and cameras, linked to monolithic control rooms from which our shared urban existence is overseen. The evolution (or perhaps more accurately: alteration) of these concepts in response to criticism is then detailed, before some of the less well-known ideas which are now emerging are briefly discussed.

Keywords
garden city; smart city; urban technologies; utopias

Issue
This commentary is part of the issue "Smart Solutions for Sustainable Cities", edited by Tom Sanchez (Virginia Tech, USA), Ralph Hall (Virginia Tech, USA) and Nader Afzalan (Redlands University, USA)

1. Introduction: The Bitter Cry of Outcast London

Returning to London in 1876, Ebenezer Howard, an English clerk who had gone to the United States to work first as a farmer, and later as a journalist, having witnessed the rebuilding of Chicago following a major fire in the 1870s, became convinced that a new departure was required in the planning and construction of cities. Dismaying at the overcrowded, impoverished, disease-ridden capital, and bitterly disappointed by Chicago rebuilding itself according to its previous shape, Howard set to work on a book which in its first edition would come to be titled *To-Morrow*.

Howard recognized that people did not want to live in the overcrowded, dirty, expensive cities of the late 19th century, their living conditions in these rapidly-expanding metropolises having been vividly illustrated by publications such as Andrew Mearns's 1885 pamphlet, *The Bitter Cry of Outcast London* (Mearns, 1883), and that their continuing influx was leading, increasingly, to the depopulation of country towns. However, Howard also recognized that life in the countryside held few attractions for city-dwellers. He was by no means alone in his desire for an alternative: as Schuyler points out (Parsons & Schuyler, 2002, p. 4), "In the 1880s and 1890s, more than 100 utopian and dystopian novels were published in Great Britain", many of them including "visions of a society in which the world enjoyed peace". Howard's thinking was greatly influenced by one of these books in particular, a work by the author Edward Bellamy, entitled *Looking Backward*, which Howard "swallowed whole", having been given a copy by a friend in 1888, and which so moved him that he re-published it in Britain. In the foreword to a later edition of Howard's book—which was first published in 1898 and titled *To-morrow: A Peaceful Path to Real Reform*—F. J. Osborn

makes it clear that "Bellamy's two basic assumptions—that technological advance could emancipate men from degrading toil, and that men are inherently co-operative and equalitarian—were the essence of Howard's own optimistic outlook, in which there was no proletarian resentment or class-bitterness, and not a trace of nostalgic anti-urbanism, anti-industrialism, or back-to-the-landism" (Howard, 1965, p. 20), and Howard himself stated this clearly: "Thus I was led to put forward proposals for testing out Bellamy's principles…" (Macfayden, 1970, p. 22).

2. Utopias, and the Real World

While Howard was certainly inspired by utopian conceptions of future cities, his own vision was firmly rooted in the real world, and in the real and urgent need for an alternative to the industrial cities of late Victorian Britain. This practical approach is evident in the structure of *To-morrow* itself: a great deal of the book is devoted to setting out exactly how one would go about constructing a "garden city", including detailed cost analyses. In these, Howard took inspiration from the model housing projects he had encountered in America. These projects were set up as limited-dividend companies, designed to appeal to investors who felt a moral kinship with ideals of social reform—the lower rate of return on this kind of development made them unattractive to traditional investors, but those who were interested were also actively engaged, often philanthropists, and thus more likely to publicly advocate for the idea, and bring their influence to bear. In Howard's proposals, the higher rental income which would accrue from the development would be used to amortize the initial investment, and later be directly used to fund cultural and social welfare projects (Parsons & Schuyler, 2002, p. 6).

However, Howard's vision, of which the physical layout of the city was only a relatively small component, was never fully realized. In order to understand why this was the case, we must examine three aspects: his "theory", his plans for financing the garden city, and his ability to plan the physical form of the garden city. As Robert Beevers makes clear (Beevers, 1988, pp. 5, 17, 25–6, 31), the primary innovation of Howard's book was in its synthesis of a number of ideas which had hitherto been unconnected: a backlash against the 19th century industrial city, and a questioning of the economic system which underlay it; the emergence of science as a driver of progress, and in particular, of Darwinism as a driver of co-operation combined with a radicalism which was entirely separate from Marxist, revolutionary tendencies (Howard, 1965, p. 86); the 'colonization' of empty lands (which were in plentiful supply outside English cities at that time), inspired by the work of Alfred Marshall; the possibility of reclaiming some of the value of urban land—which had become unaffordable as a result of high migration to cities—through the use of popular legislation; the extension of ideas of co-operative land ownership to co-operative city management. However, while Howard managed to combine these disparate ideas in *To-morrow*, thus soliciting widespread (and, perhaps, unexpected) support, they never cohered into a more complete "theory", capable of answering critics and incorporating compromise and, ultimately, evolving. Howard's pragmatism and straightforward approach resulted in an idea whose underpinnings were ultimately too fragile to withstand their encounter with those who wished to pick and choose the most attractive aspects.

The second aspect is rather more straightforward, and concerns the matter of finance. Common land ownership was a central component of Howard's plan, and was to be incorporated at Letchworth in the form of leases whose value would increase in step with the size of the population and its own wealth. However, the Garden City Association, formed in 1899, was not able to raise sufficient capital to buy the land for Letchworth under these conditions, and was thus compelled to borrow the shortfall, which was considerable. However, the banks would not lend money for houses which could not be sold on the open market. The Association thus had no choice but to acquiesce to modified leases, and this had an additional effect of undoing the co-operative management structure of the garden city: it included a trust, which was to oversee the day-to-day management of the city in concert with its residents, and a board of directors, which was charged with raising the capital to build the city, and thus represented the interests of those who were financing it. As a result of the Association's use of the "standard" type of lease, the board of directors represented the interests of the banks, who had little or no interest in co-operating with, or deferring to the trust.

The final aspect is architectural: the garden city movement was attracting interest from architects, particularly those involved with the Arts and Crafts movement, whose interests dovetailed quite neatly with those of the founding members, and several of them actually joined the Association, encouraged by Howard. Of these, Barry Parker and Raymond Unwin would come to exert the most influence on the built realization of Howard's vision at Letchworth: Howard's physical vision of the garden city had been quite crude, its focus having been on social reform, and this was quickly 'rectified' by Unwin and Parker, who reformulated key aspects of Howard's initial ideas, especially those around urban density.

These changes, which together had significantly altered Howard's vision—even leading to a re-titling of subsequent editions of his book to *Garden Cities of To-Morrow*—coincided with a wider shift towards what was referred to, from 1905 onwards (Parsons & Schuyler, 2002, p. 32) as "town planning". This movement incorporated key aspects of Howard's thinking, but it did not adopt his vision as a totality, and this rather more pragmatic approach led to the proliferation of what became known as "garden suburbs", rather than more garden cities. Thus, while Howard's vision launched a movement

which soon took hold across the UK, and internationally not long after, his original intent—that of real social reform—was never quite realized. This is partially because Howard himself lacked the personal authority to champion his ideals in the face of competing imperatives, driven by financiers (no matter how socially-minded), architects, and town planners.

3. The Age of the Smart City

A century after the garden cities of Letchworth (ca. 1910) and Welwyn (ca. 1919), we have entered the age of the Smart City. No matter which definition, or combinations thereof we choose (Albino, Berardi, & Dangelico, 2015), we must perforce acknowledge that it could not exist without the Garden City: it is both a radical new departure, and an idea whose conception has hitherto been firmly rooted in the kind of utopian thought (Datta, 2015a) which first motivated Howard to write *To-morrow*. However, it also exemplifies the problems which attended the rise of the garden city: the lack of a robust theoretical framework capable of assessing the quality of its own real-world output, which can be subjected to examination and critique, and which can evolve to accommodate change. Rather than inspiring us, the term largely remains a shorthand for any technological intervention in the city, and a purportedly useful term of art for mayors and municipalities wishing to portray themselves as progressive and technically competent, in a familiar reprise of the "densification" projects undertaken in the US in the late 1940s. In place of socially-minded reformers such as Robert Owen and Ebenezer Howard, we have neo-positivist projects run by venture capital companies such as Y Combinator Cities, and behaviourist projects run by technology giants, such as Google's Sidewalk Labs project in New York City's Hudson Yards (Mattern, 2016).

Instead of a new Civics (Geddes, 1904), or a considered study of the ways in which new technologies could thoughtfully be integrated into our urban fabric (Geddes, 1915; Mumford, 1991), there are hundreds of newspaper articles, blog posts, "charters", and best practice guides, many emphasizing the primacy of the "Smart Citizen", in a literal reading of Hill's exhortation that urban innovation must not begin with technology (Hill, 2013). This rhetoric would be ironic, were it not so damaging: in place of innovation which seeks to centre those demographics most likely to benefit (whether they are "citizens", or merely "people"), there is a largely uncritical enthusiasm for the seamless blending of technology with our urban built environment in order to monetise and secure it, with little thought given to the far-reaching secondary effects of these objectives, let alone their potential to reproduce or even exacerbate existing inequalities (Shaw & Graham, 2016).

We have come some way towards attempts to categorise (Hollands, 2008), explain and historicise (Townsend, 2013), and critique (Greenfield & Kim, 2013; Wiig, 2016) the earliest and most egregious results of this tendency, such as New Songdo and Masdar City, and these critiques may in fact be having an appreciable effect: in Europe and North America, the tech companies involved in urban technology projects have refined their rhetoric, moving beyond the language of "disruption" so beloved in Silicon Valley and influenced by what Barbrook and Cameron termed "the Californian Ideology" (Barbrook & Cameron, 1996). This tendency in turn has led to more nuanced critiques (Shelton, Zook, & Wiig, 2014) of the more mundane, retrofit projects which are now seen in smaller cities, and some have begun to examine in more detail the most widely-touted improvements, such as the wide availability of Open Data, and purportedly increased participation in decision-making which lie at the heart of these (Cardullo & Kitchin, 2017; Kitchin, 2013). In the global South (Watson, 2015) and in India, in particular, this more subtle tendency remains absent, the more considered interventions of the past (Goist, 1974)—though they are by no means without their critics (Rao-Cavale, 2016)—having given way to a technocratic megaproject incorporating the "twin logics of industrialisation and corporate urbanisation". Yet here, too, we find critical voices (Datta, 2015b).

4. Beyond Familiar Paradigms

Despite its ultimate failure, the influence of the Garden City remains with us today, and so it may be with current paradigms of the Smart City. Already, new ways of thinking about, and using technology in our cities are emerging: from "playable city" approaches such as that seen in Bristol, to re-purposing the Internet of Things—so often deployed unsuccessfully (Langendoen, Baggio, & Visser, 2006)—as a tool for informal urbanism in Atlanta (DiSalvo & Jenkins, 2017).

It may be that we are on the verge of a movement away from the neoliberal conception of urban technologies which enables what Srnicek terms "Platform Capitalism" (Hill, 2008; Srnicek & De Sutter, 2017), while previously unfashionable approaches to inclusivity and community engagement such as technology networks (Smith, 2014), are once again being investigated as alternatives and complementary approaches to Living Labs. There have been calls for what Campbell refers to as a "radical incrementalism" (Campbell, 2016), echoing Ursula Franklin's entreaty that we should not shy away from large-scale technological interventions, but rather attempt to deploy them in ways that can be rolled back, adapted, and even undone if need be (Franklin, 1993). Plainly, we cannot know what the future holds, or how we will react to its challenges, in particular those engendered by climate change. What is clear, however, is that success lies in cooperation.

Conflict of Interests

The author declares no conflict of interests.

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About the Author

Stephan Hügel is a doctoral researcher at the UCL Centre for Advanced Spatial Analysis. He is interested in urban cybernetics, 20th century urban technology projects—particularly those of the 1980s and 1990s—and urban data visualisation. His research also explores the role of standards bodies and supranational unions in the evolution of urban socio-technical projects.

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Article

Trying to Smart-In-Up and Cleanup Our Act by Linking Regional Growth Planning, Brownfields Remediation, and Urban Infill in Southern Ontario Cities

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Abstract
The reuse of brownfields as locations for urban intensification has become a core strategy in government sustainability efforts aimed at remediating pollution, curbing sprawl and prioritizing renewal, regeneration, and retrofitting. In Ontario, Canada's most populous, industrialized, and brownfield-laden province, a suite of progressive policies and programs have been introduced to not only facilitate the assessment and remediation of the brownfields supply, but to also steer development demand away from peripheral greenfields and towards urban brownfields in a manner that considers a wider regional perspective. This article examines the character and extent of brownfields infill development that has taken place in three Ontario cities (Toronto, Waterloo, and Kingston) since the provincial policy shift in the early 2000s. Using property assessment data and cleanup records, the research finds that redevelopment activity has been extensive in both scale and character, particularly in Toronto where the real estate market has been strong. While the results are promising in terms of government efforts to promote smarter growth that builds "in and up" instead of out, they also reveal that government could be doing more to facilitate redevelopment and influence its sustainability character, particularly in weaker markets.

Keywords
brownfields; contamination; development; infill; smart growth; sustainability

Issue
This article is part of the issue "Smart Solutions for Sustainable Cities", edited by Tom Sanchez (Virginia Tech, USA), Ralph Hall (Virginia Tech, USA) and Nader Afzalan (Redlands University, USA).

1. Introduction

The redevelopment of brownfields has become a core strategy in government efforts aimed at cleaning up past pollution while working towards a more sustainable future. While the initial attention of policy-makers in the 1980s focused narrowly on understanding, assessing, and remediating the risks posed by contamination, the focus began to broaden in the 1990s to redeveloping brownfields in an effort to bring people, jobs, and taxes back to communities afflicted by deindustrialization. As the new millennium has unfolded, policy makers have expanded the socio-economic and environmental benefits that they hope can be gleaned from reusing brownfields, ranging from sustainable remediation and building, to the provision of affordable housing and combatting climate change. Yet the core objective of brownfields redevelopment from a sustainability perspective continues to lie in the strategic reuse of these properties as locations for urban intensification to combat urban sprawl (Dixon, 2007; Kirkwood, 2001).

In Ontario, Canada's most populous, industrialized, and brownfield-laden province, a suite of progressive government policies and programs have been introduced to not only facilitate the assessment and remediation of the brownfields supply by the development industry, but to also steer development demand away from peripheral greenfields and towards brownfields through integrated planning and policy that considers a wider regional perspective. In 2004, Ontario's Ministry of the Environment and Climate Change (MOECC) amended the *Environmental Protection Act* (MOECC, 1977) to estab-

lish a voluntary cleanup regime wherein private landowners, developers, and their environmental consultants were largely responsible for assessing and remediating brownfields to government standards with minimal bureaucratic intervention. The provincial Ministry of Municipal Affairs and Housing (MMAH) also granted municipalities additional land-use and tax tools to facilitate brownfield redevelopment within designated Community Improvement Plan (CIP) areas through the *Planning and Conservation Land Statute Law Amendment Act* (MMAH, 2006a, 2007) and the *Brownfields Financial Tax Incentive Program* (MMAH, 2008). In an effort to drive demand towards brownfields and other infill opportunities, the *Places to Grow Act* (MMAH, 2005a) was passed to allow the government of Ontario to prepare plans for population growth and economic expansion within existing urban zones, while protecting the environment, agricultural lands, and other resources in the periphery. Most attention focused on the fast-growing Greater Golden Horseshoe located along the North and West shore of Lake Ontario, which includes the city of Toronto and other municipalities that account for nine of the province's thirteen and a half million residents.

This paper examines the nature of property development that has taken place on brownfields in a handful of Ontario cities (i.e., Toronto, Waterloo, and Kingston) since the provincial policy shift towards using these sites to deliver smarter growth. Using property assessment data and so-called Records of Site Condition (RSC) submitted by those who assess and remediate brownfields, the present examination investigates the scale, character, and value of redevelopment activity in detail. Although it is not possible to determine the direct extent to which remediation policy, growth management policy, and/or pure market forces contributed to the character of redevelopment activity during this period, the goal of the present study is to trace the type of brownfields redevelopment taking place in municipalities where these smart growth and remediation policies and forces are working together in a coordinated fashion. In North America, where brownfields remediation and redevelopment policies and approaches have been largely voluntary and the issue has been tackled on a site-by-site basis, Ontario provides an example of where upper levels of government have sought to take an approach more akin to the UK and Europe where sustainable development and brownfield policy agendas are more interlinked.

2. Cleaning up Our Act: Brownfields Remediation and Redevelopment Policy in Ontario

The MOECC (2015) defines brownfields as "vacant or underutilized places where past industrial or commercial activities may have left contamination (chemical pollution) behind." Formal regulatory efforts aimed at protecting land resources started with the enactment of the *Environmental Protection Act* (MOECC, 1971), which prohibited the discharge of a contaminant into the environment that may cause adverse effects. The emergence of regulatory challenges associated with brownfields, together with scientific improvement in testing, lead to the MOECC's *Guidelines for the Decommissioning and Cleanup of Sites in Ontario* (1989) and *Interim Guideline for the Assessment and Management of Petroleum Contaminated Sites* (1993), both of which continued to evolve thereafter as pollution standards for new contaminants were added or modified.

Even though the Ontario government maintains the right to order the cleanup of a property, the MOECC began to favor a voluntary approach wherein a landowner was only required to remediate their property when they opted to. In general, someone interested in acquiring, remediating, and/or redeveloping a brownfield in Ontario typically embarks on the following. First, to ascertain the possibility of pollution risks, a qualified person (QP) conducts a Phase I Environmental Site Assessment (ESA) that usually includes a review of historical records to identify past risks and may also include a site visit and interviews with past/present owners/occupants. If concerns are identified, tests are then performed at the site as part of a Phase II ESA to determine the location, type, and degree of contamination. In Ontario, the Phase II ESA also includes, if necessary, a report describing the cleanup approach taken along with confirmation that the site meets applicable provincial standards (often referred to as a Phase III ESA in other jurisdictions).

Cleanup standards used in Ontario to assess whether a site is contaminated and to guide cleanup can be based on: (1) background (pristine nature) levels, which are somewhat unrealistic for urban environments; (2) generic levels wherein soil standards are based on (eco)toxicological exposure risks considered safe for different forms of land use (residential and park standards are higher than industrial, retail, and commercial ones); or (3) Site-Specific, Risk-Based, levels where standards are based on the tolerance and risk exposure associated with a particular project to be developed at a particular location. In the 1990s, the MOECC found itself increasingly involved in the review of site remediation plans and after a lengthy process of back and forth consultation the property owner ideally received a "letter of concurrence" from the Ministry to assure them that the site had passed standards and that no future remedial work would be necessary (Fishlock, 2011).

To facilitate remediation, the province began amending its brownfield policy in 2001 (MOECC, 2001) with the Ontario Regulation 153/04 (Record of Site Condition Regulation) officially coming into force on October 1, 2004 (MOECC, 2004a, making further revisions in 2007, 2009 and 2011). The overarching goals were to establish clearer requirements for site assessments, provide some protection from environmental liability, and improve environmental site condition standards. The amendments enhanced and formalized the so-called Record of Site Condition (RSC), which is a report submitted by a property owner outlining the environmental condition of a

property at a particular point in time based on ESAs and also contains information related to property ownership, location, and other supporting documents. The amendments also obliged property owners to file a RSC when land use changed (from industrial/commercial to residential/parkland) and outlined the requirements for the QP responsible for completing ESAs and for submitting RSCs to the Ministry. Only in the case of a risk-based cleanup is the QP required to provide information from Phase I and II ESA results and a public communications plan to the Ministry for approval prior to conducting and submitting a RSC. Otherwise, completed RSCs are submitted by the QP to the province, where they are checked for administrative and technical errors and then filed on the Environmental Site Registry.

During the same period, Ontario's Ministry of Municipal Affairs and Housing led provincial efforts to support brownfield redevelopment through policy and technical assistance. In 2005, the Ministry established the Office of the Brownfields Coordinator to facilitate its work and to support municipalities. Government amendments to the *Planning Act* (MMAH, 2006b) allowed municipalities to create Community Improvement Plans (CIP) in order to help developers manage brownfields in CIP areas by offering them financial incentives (e.g., Feasibility Study Grants to support ESAs, Remediation Grants to support cleanup activities, Municipal Fee Grants to reimburse application fees, Tax Increment Grants to help property owners undertake projects, etc.). Research undertaken by MMAH (2010, p. 5) revealed that 44 Ontario municipalities had adopted CIPs containing brownfield provisions. According to that study, the City of Kingston was an early adopter, with its CIP approved in 2006 for part of its municipality and offering incentive programs related to tax assistance, tax increment equivalent grants, study grants, and grants for miscellaneous fees. The City of Toronto's CIP approved in 2008 covers the entire municipality and allowed for tax assistance, tax increment equivalent grants, and development charges reductions/exemptions, but only for employment uses. The City of Waterloo just introduced its CIP in 2013, however the regional municipality of Waterloo has had one since 2005 that allowed it to offer various incentives within the plan area.

3. Smartening Up: Growth Management Policy

Passed in 2005, the *Places to Grow Act* responded to decades of concern from urban stakeholders regarding the costs and negative consequences of urban sprawl and marked the government's overarching commitment to sustainability and smart growth. The first growth plan under this legislation was the *Growth Plan for the Greater Golden Horseshoe* (Ministry of Infrastructure, 2013) that focuses urban and suburban growth into already built up areas, while the *Greenbelt Plan* (MMAH, 2005b) protects agricultural greenfields and ecological systems that frame the region. The *Growth Plan* (Ministry of Infrastructure, 2013, p. 12) explicitly states that it "envisages increasing intensification of the existing built-up area, with a focus on urban growth centres, intensification corridors, major transit station areas, brownfield sites and greyfields."

The *Growth Plan* builds on a long history of regional planning in Toronto that dates back to the late 1940s. According to White (2007, p. 5), however,

> the ambitions of the new Growth Plan are historically unprecedented" because it "proposes not just to plan the region, but to change it: to re-direct development from the urban-edge into existing urban areas, to encourage new suburbs to be built as 'complete' live/work communities [not just 'bedroom' communities] and to establish a multiplicity of new corridors that do not exist yet.

White notes that while the province's regional planning program in the 1950s and 1960s succeeded in realizing its physical planning objectives for metropolitan Toronto, the lofty regional planning goals put forward in the late 1960s and early 1970s failed to materialize as municipal autonomy gained strength. Regional growth planning efforts were resurrected again in the early 2000s as growth pressure from Toronto (2.5 million) and the surrounding suburb (2.5 million) pushed into the environmentally-sensitive Oak Ridges Moraine North of Toronto and the Conservative provincial government of the time, despite being anti-interventionist, embraced populist support for smart growth planning. The stage was therefore set for the newly elected Liberal government in 2004 to quickly embark on what White (2007, p. 44) refers to, as "an ambitious program of regional planning."

The other cities examined in the present study also have strong regional growth planning traditions. Officially established in 1973, the Waterloo Region has a population of over half a million residing in the cities of Cambridge, Kitchener, and Waterloo as well as various townships. The Regional Municipality of Waterloo embarked on the development of a growth strategy in 2001 focused on sustainability and liveability, which led to the formal adoption of the Regional Growth Management Strategy in 2003 that seeks to accommodate the majority of new growth in existing urban areas. The region also prepared a *Guideline for the Review of Development Applications Involving Known and Potentially Contaminated Sites* (Region of Waterloo, 2009) to balance intensification targets and the promotion of brownfield redevelopment with the protection of municipal water supplies and public health by outlining procedures to align remediation with the planning review process. The city of Kingston embarked on an urban growth strategy study in 2002 soon after undergoing an amalgamation in 1998. The strategy included considerations such as the urban boundary, phasing, commercial development, smart growth, density, infilling, alternative development standards, greenhouse reduction commitments and related issues (City

of Kingston, 2004). The study found that the projected growth rate could largely be accommodated in the existing community development area in the core of Kingston via increased residential density and mixed land use. The strategy was approved in 2006 and results formally incorporated with requirements of the provincial Growth Plan via the municipal Official Plan.

4. Literature Review

International research that includes Canada has argued that there is an ongoing convergence in policy-making both within Canada and within the US and Western Europe as governments become more cognizant of the types of costs and risks they must share with the private development sector to solve the problem effectively (Adams, De Sousa, & Tiesdell, 2010). Kirkwood's (2001) conceptual framework, based largely on the US experience, explains how the theory and practice of brownfield redevelopment has evolved and converged in three phases. The first phase experienced a theoretical and practical focus on the science of environmental cleanup spurred by pollution disasters such as Love Canal. This was followed by a second phase beginning in the late 1980s, with a theoretical focus on economic development and a practical focus on redevelopment aimed at building up the economic base of communities that ultimately led to new federal policy efforts in the 1990s. In the third and most recent phase, Kirkwood (2001, p. 5) claims that the practice of brownfield redevelopment in the US has yet to catch up with the theory that has become situated in integrated planning models that stress wider regional concerns.

The evolution of brownfields regeneration policy in Europe and the UK is much further along in terms of aligning brownfields redevelopment with wider regional concerns and, more specifically, the sustainable development policy agenda. Dixon (2007, p. 2381) notes that since 1997 the UK government has used brownfield recycling to underpin urban regeneration and firmly linked it with sustainability. This has been enshrined in English national policy and underwritten in planning policy guidance in which brownfield housing targets by the late 1990s required half of all new homes to be built on reused sites (raised to 60% by 2008). Indeed, research has found that the relative proportion of new homes built on brownfields rose from 56% in 1997 to 64% by 2003, and more aggressive efforts to assemble brownfield land and strengthen housing markets in city centers have made brownfields redevelopment increasingly lucrative since, reaching 123,000 units by 2005 (Adams, 2011, p. 953). More recent research by Sinnett, Carmichael, Williams and Miner (2014) found that regional governments have identified capacity for at least one million new homes on brownfields, with sites having existing planning permission able to accommodate more than 405,000 homes and a further 550,000 on other suitable vacant or derelict sites, including at least 146,000 in London.

Dixon (2007) develops a conceptual framework for understanding the evolving policy agenda associated with brownfield regeneration and the role of the private development industry. He first describes the popular POST model wherein the process of redeveloping brownfields encompasses: a 'policy push' aimed at getting redevelopment to achieve key sustainability benefits (i.e., urban regeneration, environmental improvement, greenfield protection); 'development frictions' caused by the costs, risks, and regulatory obstacles affecting remediation and redevelopment; and an 'opportunity pull' seeking the realization of benefits to all stakeholders in creating sustainable urban communities (i.e., developer profit, attractive locales for residents and employees). He then expands this conceptual framework by integrating it with the triple bottom line concept of sustainability in an effort to better understand how developers engage with sustainability at the local level to achieve a broader array of economic, social, and environmental goals. In a review of several development cases, he found that while developers seem to be adapting to POST's brownfield dynamic, they are struggling to come to terms with sustainability in all spheres and despite some success, there is continued skepticism over the sustainability agenda and the ability to approach it in an integrated way via brownfield regeneration projects.

North American researchers have also devoted growing attention to the relationship between brownfields, smart growth, and sustainability, albeit to a lesser degree than the Europeans and largely focusing on the site/project scale. Early reports by the US Environmental Protection Agency (1998, 1999) were some of the first to argue that communities needed to make significant advances toward sustainability by reusing brownfields. Several books by Greenstein and Sungu-Eryilmaz (2004), De Sousa (2008), Sarni (2009), and Hollander, Kirkwood and Gold (2010) review the issue of brownfields and sustainability and provide many examples and best practices, but are light on the role of policy to advance the issue at broader geographic scales. Numerous studies assess the contribution of brownfield projects to sustainability by examining individual indicators, such as the highly-cited work by Deason, Sherk and Carroll (2001) that found that 1 acre (0.405 ha) of brownfield land could accommodate the same development as 4.5 greenfield acres (1.8 ha). Others propose and/or employ a broader array of sustainability indicators to track redevelopment outcomes (De Sousa, 2002a; Nagengast, Hendrickson, & Lange, 2011; Wedding & Crawford-Brown, 2007). The work by Leigh and Hoelzel (2012) however, finds smart growth pursuits to be somewhat problematic in that they encourage the conversion of industrial brownfields to other uses, which weakens the urban economic base, reduces the supply of employment land, and contributes to industrial-sector suburban sprawl.

Scholarly research on brownfield redevelopment activity in Canada is both limited and dated. Research quantifying redevelopment activity in Toronto in the 1990s

found that it was robust despite limited government intervention because of that city's strong residential and commercial real estate market and the willingness of the municipal government to plan for and support urban revitalization efforts through rezoning employment land and increasing density (De Sousa, 2002b). Work by Hayek, Arku and Gilliland (2010, p. 389) examining redevelopment efforts in London, Ontario (pop. 360,000), found through qualitative interviews that "despite the availability of financial incentives, the overall private sector participation in brownfield redevelopment is low due to barriers such as competition from greenfields [clean sites], risk, cost, negative public perception of brownfields, and complex remediation processes." The researchers also noted (2010, p. 392) that limited brownfield redevelopment activity was taking place in the city despite proactive municipal policy, with only 12 properties being subject of remediation since 2006 with most properties converted to high-density residential units and office spaces.

A recent paper by De Sousa (2015) found that private-sector brownfield stakeholders in southern Ontario continue to be motivated largely by real estate fundamentals (profit, market, location) and many felt brownfields redevelopment had become a standard transaction that is viable if the market permits. Interestingly, several developers also noted that public policy was driving them to brownfields because acquiring greenfields was becoming increasingly complicated. Other major obstacles included non-institutional barriers related to cost, liability, time, weak market demand, contamination, and a lack of available funding, while institutional barriers presented themselves at the provincial (e.g., duration/complexity of regulatory process and risk assessment) and municipal levels (e.g, limited municipal expertise on brownfields, complex development approvals). To maintain interest in strong markets and stoke it in weaker ones, interviewees called for more intervention from governments both indirectly, through the improvement of existing regulatory processes and tools, and directly, through greater funding and technical support.

While a greater number of scholarly studies have examined the nature of brownfield remediation and redevelopment activity in United States through their voluntary cleanup programs (e.g., Alberini & Sigerson, 2002; Blackman, Darley, Lyon, & Wernstedt, 2010; Guignet & Alberini, 2010; Wernstedt, Blackman, Lyon, & Novak, 2013), municipal surveys conducted by the US Conference of Mayors every few years since 1993 provide perhaps the best known snapshot of the scale and extent of redevelopment in that country. In the most recent survey (United States Conference of Mayors, 2010), 116 cities noted the redevelopment of 2,667 sites for a total of 11,096 acres into the following: 20,856 retail projects or individual retail units; 25,004 housing development projects or individual housing units; 1,328 mixed use projects; 260 commercial projects; 120 industrial projects; 223 parkland projects or acreage, and 63 other projects (e.g., educational facilities, government buildings, etc.). Their report (US Conference of Mayors, 2010) examining activity from 1993 to 2010 also summarizes information on the number and acreage of brownfields redeveloped in numerous small to large cities located near southern Ontario, including Akron, Ohio (12 sites/24 hectares), Allentown, Pennsylvania (10/25), Binghamton, New York (2/14), Bridgeport, Connecticut (50/6), Cincinnati, Ohio (5/12.5), Columbus, Ohio (19/81), Indianapolis, Indiana (44/81), Kalamazoo, Michigan (30/42), Milwaukee, Wisconsin (90/81).

5. Methods

Data for the present study was gathered from several sources. First, information on the location of assessed and remediated brownfields was obtained from RSCs filed by property owners to Ontario's Environmental Site Registry between October 1, 2004 and June 30, 2011 (MOECC, 2004b). This time period was chosen for two reasons: (1) it considers projects conducted from the beginning of Ontario's new cleanup legislation in 2004 to where legislation was amended in 2011; and (2) given that the most recent property assessment data available for analysis was for the 2013 tax year, it allowed some time for projects to be built out. Each RSC report contains an array of information about the property, although the present study utilized it solely for data about location and ownership. For the city of Toronto, a total of 1000 RSCs were used from this period, with 415 collected and transcribed manually from online reports and 585 entries provided in a database by the MOECC. RSCs for Waterloo and Kingston were collected and transcribed manually from online reports. The city of Toronto was selected for examination because of its industrial legacy, large population size, strong property market, political status as the provincial capital, and, most importantly, its central focus in Ontario's growth plan. The city of Waterloo is a small city with a brownfields legacy that is part of the GTHA growth plan, but lies on its outer edge over 100 kilometers from Toronto. Kingston was selected because it is an older smaller city well outside of Toronto (265 km and 290 km from Montreal) with experience in both brownfields redevelopment and growth management.

The second phase of data collection involved the retrieval of information about assessed value (land and buildings), building area, and tax class of property for Tax Year 2013 (based on assessments conducted in 2012). For Waterloo and Kingston, 2013 tax assessment information was purchased from the Municipal Property Assessment Corporation. For Toronto, more detailed property assessment information was collected manually by student researchers from the Municipal Property Assessment Corporation (MPAC) City of Toronto public terminals from September 2014 to June 2015. In addition, Toronto property data maps, urban planning staff reports, market reports and development real estate websites were used to determine the number of floors and units in residential buildings. Out of a total 1000 RSCs in

Toronto from 2004 to 2011, five RSCs were removed from the analysis because the property addresses could not be found and/or the spatial coordinates were incorrect. Access to additional information from Toronto made it possible to perform a more in-depth market analysis of residential redevelopment, which was found to be particularly prevalent during the study period. The residential types were coded as single family detached, semi-detached, row/townhouses, apartments, condominiums and mixed. Mixed classification included a combination of the aforementioned residential types, but the number of units could not be isolated through online resources. Therefore, 16 RSCs with the residential classification of Mixed were removed creating a total of 452 RSCs that were used to estimate number of units, square feet/acres and property value. Based on market reports from CBRE Canada, Canadian Home Builders Association (CBHA), Toronto Real Estate Board (TREB), the Globe and Mail, the Toronto Star and online real estate blogs, the average price and size of a residential dwelling was estimated to get an average price per square foot. The average price per square foot was multiplied by the total number of residential units to determine the building area and property value created by dwelling type. Data on average persons per household by dwelling type from the 2011 Census of Population and Statistics Canada (by Census Metropolitan Area) was used to estimate the number of people accommodated in residential units for each of the cities examined. It should be noted that this estimate is limited however, because the size of the sample is inferred from group data, which includes older and larger housing stock. For the City of Toronto (2015), a planning report based on Statistics Canada's National Housing Survey was also used to estimate the population in residential units because it contains 2011 data on average persons per household by dwelling type for newer housing stock (built from 2006–2011), which is more accurate and comparable to the projects examined in the present study.

It was also possible to have research assistants gather information to conduct a pre-post analysis for the city of Toronto. This fourth phase of data collection compared the assessment value of Tax Year 2013 with the Tax Year 2003, which was manually collected at the Toronto Archives from September 2014 to July 2015. Given the large magnitude of data collection for this study, gathering 400 RSCs for both Tax Years 2003 and 2013 was considered to be a significant sample size at $\alpha = 0.01$ with a 5% margin of error and 99% confidence interval. Using the DigDB roll up function in Excel, 409 RSCs were matched between the two tax years. The 2003 tax year values were adjusted using an average annual inflation rate of 1.79% over a 10 year period according to the Bank of Canada.

Several challenges and limitations affected the ability to gather data for the present study. First, the cost of obtaining property assessment data from the Municipal Property Assessment Corporation is prohibitive for an academic institution using this data for research purposes. The procedure to collect older data was difficult and while researchers were able to access the Toronto archives, this was not an option for the other municipalities. In terms of GIS data, partnering with municipalities was often laborious and while most municipalities have free online GIS data, the information available and file versions were sometimes limited and dated. Furthermore, the absence of accessible public information regarding the use of public incentives to support individual brownfield projects made it impossible assess their application.

6. Results

6.1. Toronto

A total of 1000 Records of Site Condition were filed in the City of Toronto from 2004–2011. The RSCs (979) with data on site area addressed 926.7 ha (2,290 ac) of land, with an average per RSC of 0.9 ha (2.3 ac) and a median of 0.2 ha (0.5 ac). While most RSCs (69.1%) applied to the entire property, 30.9% of them were only filed for a portion of it. As expected, most RSCs were filed for brownfields that were commercial (46.9%) and industrial (25.0%) properties, although many were also filed for residential (16.9%), institutional (2.8%), community (2.8%), agricultural/other (2.1%), and parkland (1.4%) uses (2% n.a.). The most common "intended" use identified in the RSCs was residential (66.2%), followed by commercial (12.1%), community (6.8%), parkland (4.8%), industrial (4.3%), institutional (3.7%), and agricultural/other (0.1%) (2% n.a.).

As for site assessment and cleanup, 16.3% of properties only filed a Phase 1 ESA. Most filed a Phase 1 and 2 ESA (77.1%) involving generic standards and only a small share (6.6%) employed risk-based procedures. Interestingly, most brownfield properties intended for residential use either required a Phase 1 ESA (14.7%) or applied a Phase 1 and 2 ESA (83.2%) utilizing the more conservative generic standards, with very few opting for a risk-based approach (2.4%). It should also be noted that while only a few dozen RSCs outlined a specific cleanup approach, the vast majority of projects involved the excavation and removal of soils (63% of Phase 1 and 2 ESAs and 55% of RA sites) and/or deposited soil (30% of Phase 1 and 2 ESA and 48% of RA sites) pointing to the high application of so-called dig-and-dump as in the UK.

Merging the RSC dataset and the property assessment records for Toronto required the elimination of the five records that lacked spatial coordinates, while another thirty-five were retained but could not be used to the full extent because the building was not yet built or had no tax information. These 995 projects reused 1,161 hectares (2,868 ac) of property. Slightly under half of this took place in downtown core of the old City of Toronto (47%, 546 ha/1,349 ac) and the remainder in the surrounding inner suburbs that were amalgamated with the

old City of Toronto in 1998 (257 ha/636 ac in Scarborough, 180 ha/447 ac North York, 126 ha/312 ac Etobicoke, 33 ha/81 ac East York, 17 ha/43 ac in York) (See Figure 1). A total of 86,843 units were redeveloped on these properties with most in central Toronto (55,220) and North York (15,423) followed by the lower density inner suburbs (Etobicoke 7,210, Scarborough 7,041, East York 1,142, York 807). The lion's share of these units are residential (83,020; or 84,187 if residential units in "mixed" developments are included) with most in the central Toronto (53,286) followed by North York (15,319), Etobicoke (6,945), Scarborough (5,585), East York (1,113) and York (772). Interestingly, the City of Toronto (2016, p. 3) recently reported that 14,338 dwellings were completed per year on average from 2006–2015, which one could use to infer that dwellings on brownfields represented about 70% of this total.

Using 738 records from which building story information could be gleaned, it is possible to visualize the density of brownfields development, which has been largely residential with some offices (commercial). As Figure 2 illustrates, density has concentrated in the downtown core within Toronto's provincially designated Downtown Urban Growth Centre, as well as along the city's historic North/South arterial route (Yonge Street and subway that lies beneath it) that traverses the provincially designated growth centers of Downtown Centre, Yonge-Eglinton, and North York. Dense growth has also taken place along the main highways and along the major East/West transit corridors (Bloor subway/St. Clair streetcar).

As mentioned, a more in-depth analysis of residential brownfields redevelopment was conducted in Toronto due to data accessibility. 452 RSCs were used to estimate the number of units, property area, unit area, and property value. In total, 84,187 residential units were constructed with 84.5% in condominium apartments, 8.1% in row/townhouses, 4.9% rental apartments, 0.9% single family homes, 0.3% semi-detached homes, and 1.4% in mixed unit developments. Given the difficulty of isolating housing units in mixed-unit developments (1,167 units), those 16 RSCs were removed from further analysis leaving 83,020 units. Overall, condominium apartments represented most of the redevelopment with 71,079 units on 529 ha (1,307 ac) of reclaimed land. Using average size and price data, it can be estimated that condominiums added 5,289,369 m^2 (56,934,297 ft^2) of living space and $28B in property value to the Toronto market. The 4,109 rental apartments reclaimed 31 hectares (76 ac) of land and accounted for 305,772 m^2 (3,291,309 ft^2) and $763,168,165 in market value. In terms of ground-related housing, row/townhouses were increasingly popular during this period with 6,820 units constructed on 219 acres (89 ha) of reclaimed land and adding an estimated 887,038 m^2 (9,548,000 ft^2) of living space and $3,656,965,840 in value to the market. The smallest share of units were single family (772) and semi-detached (240) houses, which accounted for less area (14ha/35ac and 3ha/7ac) and square feet (143442 m^2/1,544,000 ft^2 and 29,208 m^2/314,400 ft^2), but added significant market value ($769,506,440 and $171,878,400). In all, it can be estimated that 148,551 to 222,152 people have been accommodated in the 83,020 housing units on reclaimed brownfields during the study period. As mentioned, the low estimate is based on a Toronto planning report containing 2011 average persons per household by dwelling type for newer housing stock (built in 2006–2011), which takes into consideration the smaller physical size of newer units (the population would be 176,937 if dwelling age is not considered), while the high estimate is based on Statistics Canada persons per household approximations in 2011 for the Toronto CMA (range by dwelling type = 119,413

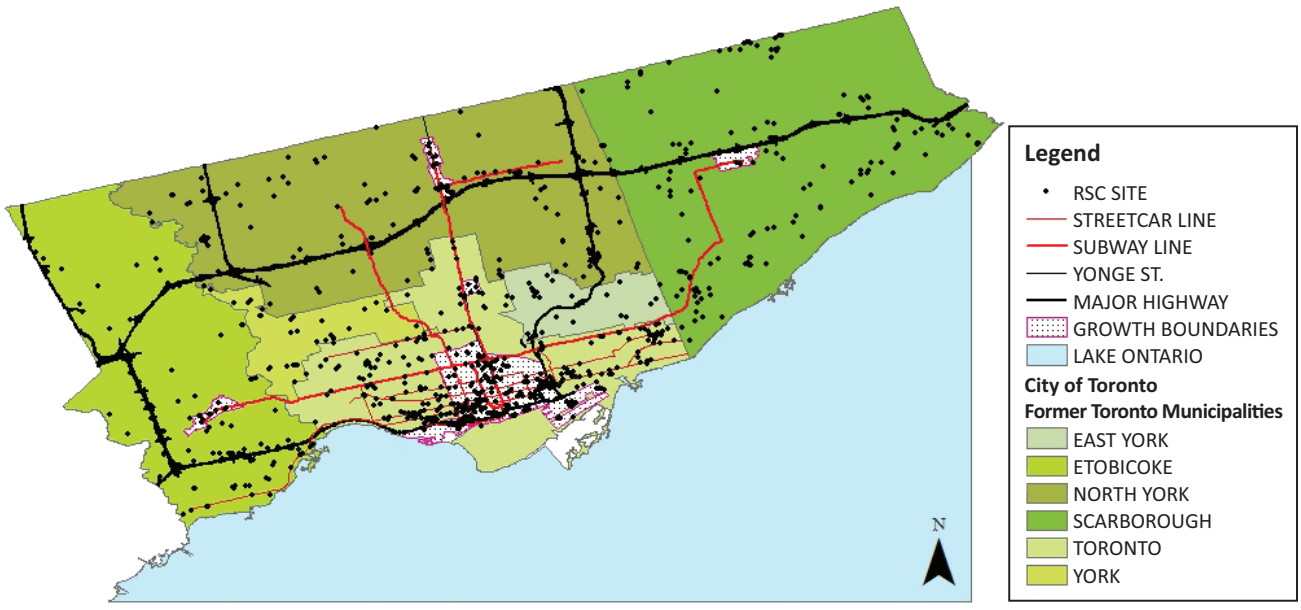

Figure 1. City of Toronto (995 RSCs 2004–2011).

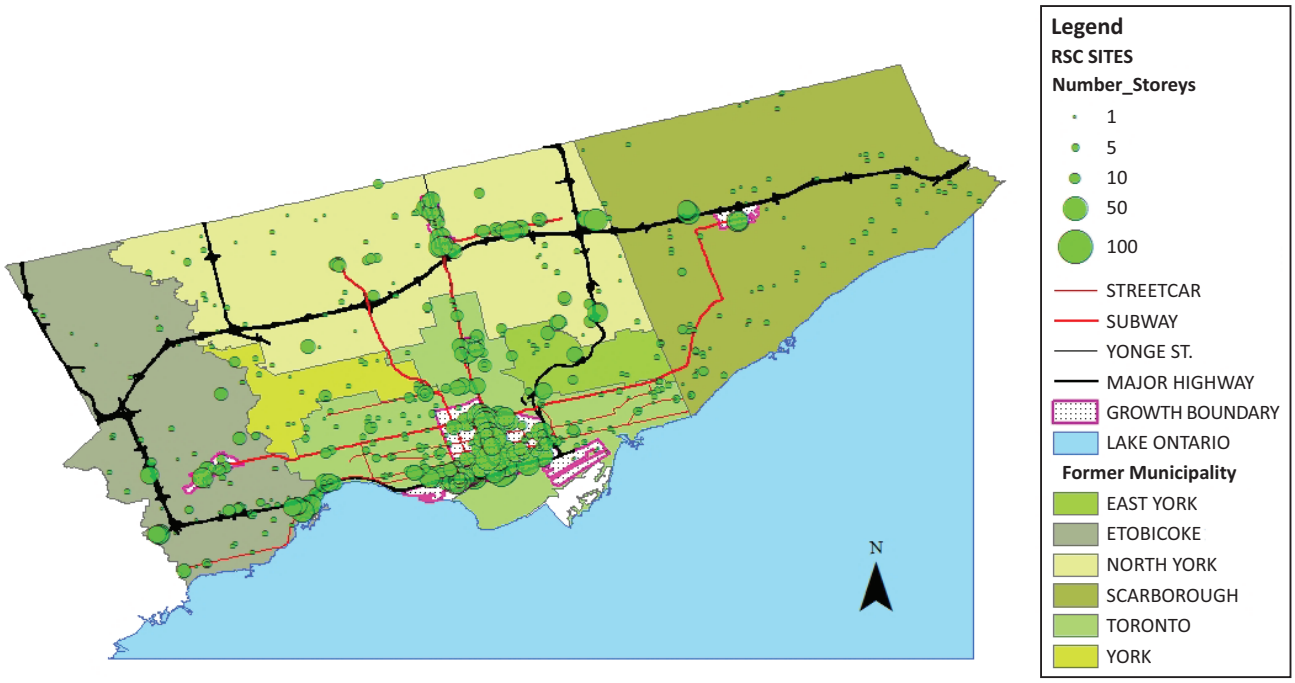

Figure 2. Building density and storeys, City of Toronto (738 RSCs 2004–2011).

to 191,913 in condominiums, 6,903 to 8,629 in rental apartments, 19,301 to 18,414 in row/townhouses, 2,239 to 2,548 in single family dwellings, and 696 to 648 in semi-detached dwellings; based on 452 RSCs).

Overall, the total assessed property value for all brownfield properties in the 2013 tax year was $37.1 billion dollars, with the greatest value in central Toronto ($22.7 billion) followed by North York ($6.6B), Scarborough ($4.7B), Etobicoke ($2.7B), York ($0.3B), and East York ($0.2B). Access to archived tax information made it possible to estimate the value of a sample of these developments in relation to what they would have been worth had site assessment, cleanup and redevelopment not occurred (409 RSCs were matched between Tax Years 2003 and 2013). Adjusting 2003 information to "current values" (using an average annual inflation rate of 1.79%) and comparing it to actual 2013 tax values revealed that assessed value increased most in Toronto's downtown core ($9.8B) over the 10-year period, particularly along the waterfront, followed by the inner suburbs (North York $2.2B, Scarborough $1.4B, Etobicoke $1.2B, York $0.2B, East York $0.1B). In terms of percentage change, relative property tax value between 2003 and 2013 increased significantly in all locations (central Toronto 1,314%, Scarborough 1,026%, York 877%, East York 706%, North York 631%, and Etobicoke 499%). Interestingly, while the bulk of the assessment value was unlocked in the downtown waterfront, the highest percent change in property values occurred in older warehouse industrial and low-density residential communities near the downtown as density and demand spread into those areas. As for the residential subset of projects (452 RSCs), the average price per dwelling was estimated at $394,504 for a condo (801 ft^2/74 m^2), $536,212 for a row/town house (1,400 ft^2/130 m^2), $715,160 for a semi-detached (1,310 ft^2/122 m^2), and $996,770 for a single-family dwelling (2000 ft^2/186 m^2). Although data were not gathered in a manner that allows for an analysis of residential affordability, the City of Toronto (2015, p. 19) did find that affordability for homeowners remained fairly stable between 1995 and 2010 because price increases were balanced by income growth and lower interest rates, while rental housing affordability improved slightly as the rent-to-income ratio fell. That said, the report (p. 19) also notes Toronto's housing affordability problems are "growing due to income disparity, limited rental supply, low vacancy rates, single income households, and tight market conditions." It should also be mentioned that while only a small share of RSCs directly affected residential sites (16.9%) and may have caused displacement, the large-scale conversion of commercial, industrial, and other uses to satisfy the higher demand for residential development does raise concerns regarding declining affordability, lost employment opportunity, and gentrification in surrounding areas.

6.2. Waterloo

Twenty-four RSCs were filed in the City of Waterloo from 2004 to 2011 with 18 of those applying to the entire property (see Figure 3). The total land area reclaimed was 15.5 hectares (38.3 ac) with an average per record of 0.65 ha (1.59 ac) and a median of 0.28 ha (0.69 ac). Over half of the sites (13 or 54%) were previously commercial followed by industrial (5 or 20.8%), residential (3 or 12.5%), and one each for community, parkland, and agricultural. Most of the brownfields were intended for residential (17 or 70.8%) and commercial (4 or 16.7%)

use according to the RSCs, followed by industrial (2 or 8.3%) and community (1 or 4.2%). In terms of site assessment and cleanup, a large share only filed a Phase 1 ESA (5 or 20.8%), while most undertook a Phase 1 and 2 ESA (75%) and only 1 project employed risk assessment. Only a quarter of the projects noted the removal or deposit of soil.

The 24 RSCs generated 29 assessed properties for the tax year 2013 (5 being mixed use) and resulted in the redevelopment of 58 hectares (143 ac) with an average of 2.3 ha (5.7 ac) and a median of 0.8 ha (2 ac). Interestingly, the property use was more mixed than Toronto with 31% (9 projects) residential, 24% (7) retail, 14% (4) office, 14% (4) industrial, and 10% (3) other commercial. Four of the projects were still vacant parcels, with three being actively farmed and a fourth with a large condominium project under construction at the time of writing. Of the nine residential projects, five are condominiums, one is a rental apartment, one is a row of townhouses and two are semi-detached homes. In terms of units, 85% were in condominiums, 8% apartments, 6% row/townhouses, and 1% semi-detached. Geographically, the bulk of activity has taken place within the CIP area and in the older part of the city near the downtown core and along the central corridor (King Street) (see Figure 3).

The overall assessed value amounted to $147,642,271 with an average of $4,921,409 and a median of $1,997,875. The majority of this value is in residential (58.5%) and retail (20.7%), with a relatively equal amount going to office and other commercial (9.4% each) and in industrial and vacant/farm (1% each). Of the residential projects, 81.2% of value is in condominium apartments, 12.4% rental apartments, 5.4% row/townhouses, and 1% detached dwellings. The vast majority of value lies in the new buildings constructed (94.8%) versus properties that were rehabilitated (4.2%) or vacant/farmed lots (1%). Based on census 2011 averages it can be estimated that 491 persons reside in these residential units (82.1% Condo, 7.8% row, 8.4% rental apartment, 1.6% semi).

6.3. Kingston

A total of 45 Records of Site Condition were filed in the City of Kingston from 2004 to 2011 (see figure 4). The land reclaimed amounted to 69.7 hectares (172.3 ac), with an average per RSC of 1.5 ha (3.8 ac) and a median of 0.3 ha (0.8 ac), with almost all RSCs covering the entire property (82.2%). Most of the former brownfield sites were used for commercial (57.8%) purposes, followed by industrial (17.8%), residential (15.6%), community (6.7%) and institutional (2.2%). As in Toronto, the most common intended use for these properties outlined in the RSCs was for residential use (75.6%) followed to a much lesser extent by commercial (17.8%) and institutional (6.7%). In terms of site assessment and cleanup, 13.3% of RSCs only completed a Phase 1 ESA, whereas 82.2% filed a Phase 1 and 2 ESA and only 4.4% used risk-based procedures. All of the ten projects that included information about cleanup noted that they removed soil exceeding standards and deposited it in an authorized landfill, while 60% of RSCs noted the removal of some soil as part of the project.

A new on-line lookup tool allowed more up to date 2015 tax data to be gathered for Kingston. In all, thirty-eight properties with property assessment information addressed 102.3 hectares (254.3 ac), with an average per property of 0.6 ha (1.4 ac) and a median of 2.7 ha (6.7 ac). In terms of the area reclaimed, the bulk of brownfield land was put back into reuse with within the CIP area, near the downtown core and in inner suburbs along the main arterial (Highway 2) and along the St. Lawrence River North, with very little in the outer suburbs (see Figure 4). Property use could be discerned for forty of the projects, with 23 (58%) residential, 7 (18%) vacant, 3 (8%) retail, 3 (5%) office, 2 (5%) general commercial, 1 (3%)

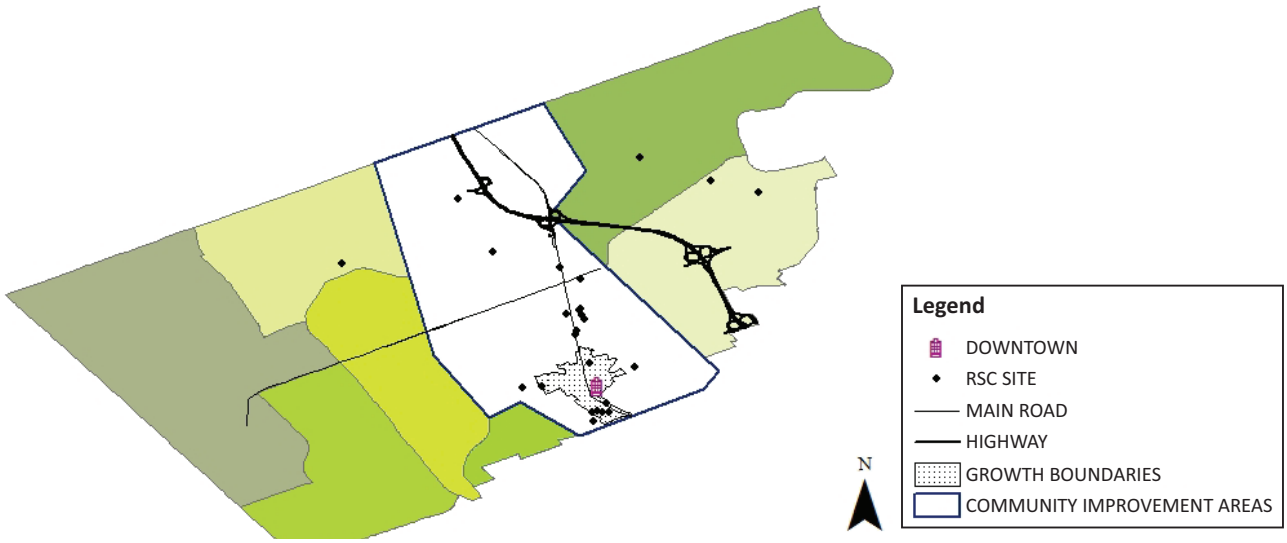

Figure 3. City of Waterloo (24 RSCs 2004–2011).

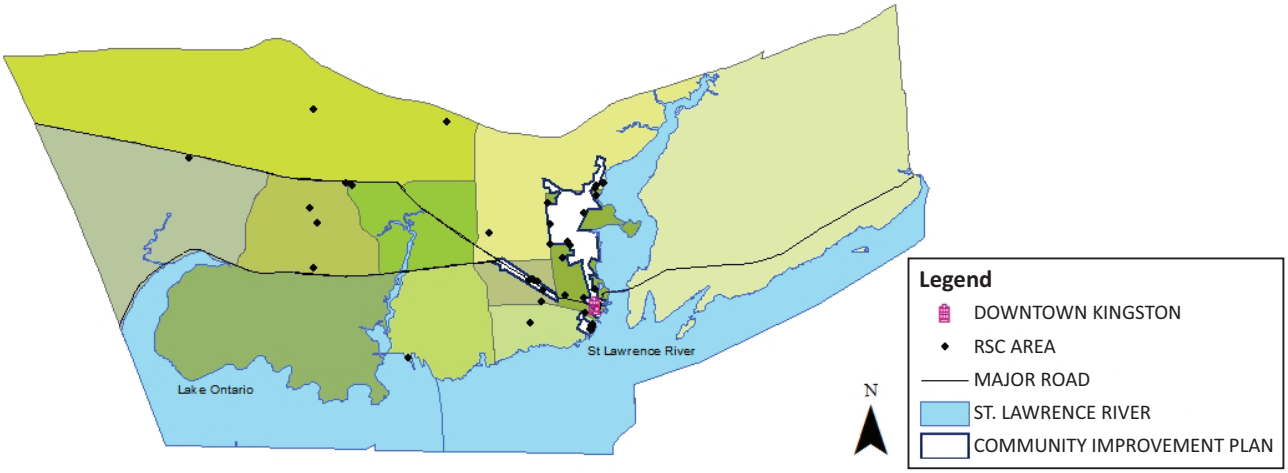

Figure 4. City of Kingston (45 RSCs 2004–2011).

industrial and 1 (3%) institutional. Of the 25 residential projects, 8 are rental apartments, 8 are row houses (some rental and some own), 4 are condominium apartments, 4 single family projects, and one semi-detached. In terms of residential units, the greatest share of the 1,350 units are for rental apartments (65% 884), followed by condominiums (17% 236), row/townhouses (189 14%), single family dwellings (3% 40) and a semi-detached unit. A review of the residential projects also reveals that 83% of the units were newly constructed, while the remainder involved renovation. In terms of units, virtually all of them were located in the downtown core and inner suburban neighborhoods. Given that Kingston had 5,532 dwelling starts from 2005–2011 (790 per year), one can infer that dwellings on brownfields represented under one sixth (17%) of the total (Canadian Mortgage and Housing Corporation, 2015, p. 17).

Overall, the 2015 assessed value of thirty-nine brownfields with assessment data amounted to over $315,959,088 dollars, with an average of $8,024,685 and a median of $1,133,198. The majority of this value is in residential (67.9%) and retail (22.5%) projects, followed by much smaller shares in commercial (5%), office (3.5%), vacant (0.7%), industrial (0.4%), and institutional (0.1%). Of the residential projects, 40.8% ($87.6 of $214.5 million) is in condominium apartments, 28.8% in rental apartments, 20.2% in row/townhouses, 10.1% in single family dwellings and 0.1% in the detached dwelling. The vast majority of this value lies in the new buildings constructed (91%), followed by upgraded apartments (7.4%), rehabilitated buildings (0.8%) and vacant lots (0.5%); with the geography of this value follows the units. Using per person approximations for different dwelling types from the 2011 Census of Canada (CMA) 2,371 people reside on former brownfields.

7. Discussion and Concluding Remarks

Analysis of the RSCs and property assessment data reveal that brownfields redevelopment activity has been rather extensive in scale, character, and value during the time period examined, particularly in Toronto where it seems significantly higher than nearby US cities and more akin to residential development witnessed in England. Dense redevelopment also seems to be occurring in locations identified by the provincial growth plan, thus aligning with the prime sustainability objective of growing in-and-up instead of out. Unlike in England however—where national targets were established, regional councils assess land availability to proactively identify brownfields suitable for housing and economic development, and local authorities generate and maintain public registers of brownfields available for housing—the approach taken for Toronto seems less defined and more reactive with the province setting population density targets for urban growth areas and the city seeming to allow market demand to protrude in those areas supported on a project-by-project basis through rezoning and density allowances. This, along with the Province's less intrusive voluntary cleanup approach, seems to be dealing with the 'development frictions' (costs, risks, and regulatory obstacles) associated with cleanup and redevelopment. The high degree of land conversion from commercial to residential use does expose the "blind side" of this reactive approach to smart growth planning (Leigh & Hoetzel, 2012), which might be better served by the English approach that more directly includes economic development considerations in identifying and assessing land supply. As for higher order sustainability goals, Toronto introduced a Green Standard in 2010 requiring 'all' new planning applications to comply with so-called Tier 1 environmental performance measures akin to the green building requirements needed to achieve LEED (Leadership in Energy and Environmental Design) silver certification. While this forces developers to deal with environmental sustainability issues beyond sprawl, it does not incorporate economic or social sustainability spheres, which is also a challenge to private development in England as Dixon (2007) found. In terms of cleanup, pressure is also mounting in Ontario to reduce waste going

to landfills and to treat contamination on-site, but most developers still prefer to dig-and-dump, as in the UK, to remove the risks and liabilities along with the contaminated soil.

The brownfields story is also positive for the smaller cities of Waterloo and Kingston, although its contribution to achieving sustainable growth objectives is much less robust. While building higher-density housing in core urban areas is part of their urban planning playbook, it is clear that there is less demand for such housing despite the fact that both municipalities have growth plans, brownfield support tools, and share the same voluntary cleanup regime. The more interventionist English approach identifying brownfields suitable for redevelopment—along with stricter controls on greenfield sprawl—might be better suited for smaller cities, where the market preference for low-density residential product and a plentiful supply of greenfields does not seem to be compelling the private sector to overcome development frictions and build most new supply on brownfields. In addition to having a limited impact on supporting sustainable growth, the ability to compel brownfield developers to engage more profoundly with sustainability becomes even more challenging and unless it is applied to all development equally, it will place them at a further disadvantage to greenfields.

In sum, the number of projects being undertaken and the high level of participation by the private market does point to brownfields reuse and redevelopment being a smart solution for sustainable cities. Though still more challenging than developing on clean greenfield sites, the data reveal that there is a growing comfort with Ontario's regulatory approach for assessing and remediating brownfields that is allowing developers to unlock land supply opportunities where the market demands it. It is also clear that strong growth pressure in large cities combined with provincial policy aimed at limiting sprawl and identifying locations for population density seems to be achieving the prime sustainability directive of growth management, while municipal requirements can also be used to force all development to engage with sustainability at a deeper level. While the English example of mandating development targets and identifying specific sites to achieve them might be perceived as too interventionist for Canada—especially given growing protest about current efforts in Toronto making prices unaffordable—a more intentional, interventionist, and coordinated approach by all levels of government might actually facilitate development from both a quantity and quality perspective. By being more coordinated and proactive, governments in Ontario could go from suggesting broad targets and permitting what comes, to more strategically identifying development objectives and properties for growth that could be facilitated by public infrastructure investment along with allowances and incentives to spur private investment. This would, however, require governments and the public to be on the same page in terms of how we grow as a sustainable city and region, something that different political parties, levels of government, and low-density loving Canadians are still having trouble with. Regardless, aiming for the model of urban development recently set out in the UN General Assembly's *New Urban Agenda* (2016) that integrates all facets of sustainable development and seeks to prioritize renewal, regeneration, and retrofitting, compels governments and citizens to keep planning smart and to grow in-and-up or risk striking out.

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Conflict of Interests

The author declares no conflict of interests.

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Article

Making Smart and Sustainable Infrastructure Projects Viable: Private Choices, Public Support, and Systems Constraints

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Abstract
Sustainable cities will require major infrastructure investments coupled with widespread behavioral change. Examples of smart, green technologies abound, but evidence for actual use lags. This partly owes to the tension between public support and private choices: individuals thinking as members of the public may see solutions as smart for the city, but thinking of their private interests may see those same solutions as not smart for themselves. This also owes to the disconnect between private and public choices, on the one hand, and the workings of complex systems, on the other. Even if public and private interests align, existing built environment systems may resist change. This article examines public perception and use of the Atlanta BeltLine, a pioneering sustainability initiative to transform the auto-dependent city into a greener, denser city. Analyzing a general public survey reveals widespread support for the BeltLine alongside reticence from residents to change their commute or greenspace use. The findings also show that drivers of public support and prospective use of the BeltLine differ. Public support may be insufficient if individual use decisions do not follow. Yet, private adoption decisions may not follow until and unless the systems in which they are embedded are already changing.

Keywords
behavioral changes; green space; public perception; public transit; smart solutions; urban infrastructure; urban sustainability

Issue
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1. Introduction

Urban population and areas are expanding rapidly in the past few decades (Angel, Parent, Civco, Blei, & Potere, 2011). Due to their significant influence on both regional and global environment (Alberti, 1996; Grimm et al., 2008), sustainability issues at the city level have gained increasing importance in the planning literature. Cities can promote sustainable development in several fields, such as housing, energy, employment, and environmental quality (Camagni, Capello, & Nijkamp, 1998).

Infrastructure and technologies are a key dimension in urban sustainability (Alberti, 1996). Serving as “material mediators between nature and the city” (Kaika & Swyngedouw, 2000), urban infrastructure systems (UIS) share many key common characteristics, such as large social investments in facilities, networked physical components, and long economic return period (Nielsen & Elle, 2000). Once in place, urban infrastructure is difficult to reverse, and its longevity often leads to a path dependency with regard to energy use and climate change adaptation strategies (Seto & Shepherd, 2009). From an engineering perspective, sustainable UIS means that the energy and materials flow through the system and the residuals generated by the system should be minimized to the extent possible (Sahely, Kennedy, & Adams, 2005).

Recent research explores the prospects for innovative UIS to promote sustainable urban development. For instance, Kramers, Höjer, Lövehagen and Wangel (2014) discuss the potential to use information and communication technology solutions for energy conservation in cities. Borén et al. (2017) explored the Swedish GreenCharge Southeast project as an example of sustainable urban transport systems.

In assessing the sustainability of UIS, researchers have particularly emphasized its social dimension: innovative technology leads to sustainable regime change when it is actually used and competitive (Kemp, Schot, & Hoogma, 1998). Sahely et al. (2005) propose evaluating UIS with criteria including public awareness, participation, and acceptance of UIS. Social factors like user groups and providers of infrastructure services are also important in Monstadt's (2009) urban infrastructure regime analysis. Another strand of literature in urban sustainability follows Hughes (1987) and adopts the "systems" perspective. It considers urban infrastructure as socio-technical systems co-produced by technical apparatus and social components (i.e., organizational, economic and political actors and structures) (Fiksel, 2006; Hodson, Marvin, Robinson, & Swilling, 2012). Cities worldwide are seeking to develop change in the socio-technical organization of their infrastructure networks, which can be characterized as "systemic transitions" (Hodson & Marvin, 2010).

While sustainable and smart cities are conceptualized with multiple dimensions of technology, people, and institutions (Camagni et al., 1998; Nam & Pardo, 2011), the complex interrelationship among technological systems, private behavior, and public choice in bringing about sustainability has yet to be explored in depth. To add more empirical evidence on some of these relationships, this paper uses the Atlanta BeltLine project as an empirical example to understand the social and systemic dimension of UIS.

The adoption and implementation of UIS for sustainable cities involves both collective decisions and private actions. To bring about changes in the social and technological systems that make up the city requires public decisions and public investment. Long-term success of those changes depends critically on the behavior of private individuals, often acting as consumers. If the two are not aligned, if individual behavior does not fall in line with the intentions behind public choices, even the best crafted public project may fail: you may build it, but they will not come.

One source of this misalignment can be found in the tension between public support and private choices: individuals thinking as members of the public may see solutions as smart for the city but, thinking of their private interests, may see those same solutions as not smart for themselves. Accounting for the behavior of private individuals, especially the possibility of a kind of decentralized resistance to public policy, is by no means simple. At one level, insight from the environmental psychology literature indicates that apparently pro-environmental attitudes may not be reflected in behavioral changes (Kollmuss & Agyeman, 2002). For sustainable urban projects, individuals' *ex ante* political support and ex post use may diverge for various reasons. Designing UIS with both strong public support initially and pro-environmental behaviors/utilization remains a challenge for smart solutions in urban development.

Another source of misalignment, and one much more difficult to detect and to alter, is the disconnect between private and public choices, on the one hand, and the workings of complex systems, on the other. Even if private interests and public support were to align in favor of a smart infrastructure project, the existing systems of the built environment may resist any effort to bring about change, or deflect such efforts in unexpected directions.

More deeply, the behavior of individuals and the values, attitudes, and beliefs that shape that behavior are in turn shaped by the social and technological systems within which individuals live and pursue their various projects. These constraints can work in two directions: from the outside in and from the inside out (Kirkman, Noonan, & Dunn, 2012). From the outside, living within systems provides opportunities for and imposes constraints on individual conduct; it creates paths of least resistance. From the inside, systems also create and impose structures of meaning and value that shape what individuals imagine and what they strive for.

Take as an example the system of transportation based on ownership and use of private automobiles. As a complex technological system, it includes social and technical components (Hughes, 1994): cars, roads, gas stations, oil refineries, licensing bureaus, highway departments, oil cartels, and so on and on. Among the social components are ways of making sense of the world that may limit in advance the capacity of individuals to think and choose freely. This aligns with what Bijker (1995) calls a "technological frame".

In this paper, we consider urban residents, their perception and behaviors as a critical component in the sustainable urban transformation process. We conducted a novel survey of the general public in order to better understand the interplay of public support, behavioral change, and systemic change in sustainable urban initiatives. We argue that public decisions leading to changes in the technical components of urban systems cannot, in themselves, succeed in bringing about more sustainable cities. Instead, public processes must somehow grapple with the resistance likely to be offered by private behavior as it is conditioned by systems.

The empirical case we study is the BeltLine project in Atlanta, United States (see Figure 1 for a map of the project and the city). The city of Atlanta has a typical American urban form, characterized by auto-dependence and urban sprawl. Like many other metropolises in the world, Atlanta is in dire need of a transformation for sustainability. The BeltLine project represents a major effort to transform the auto-dependent city into a greener,

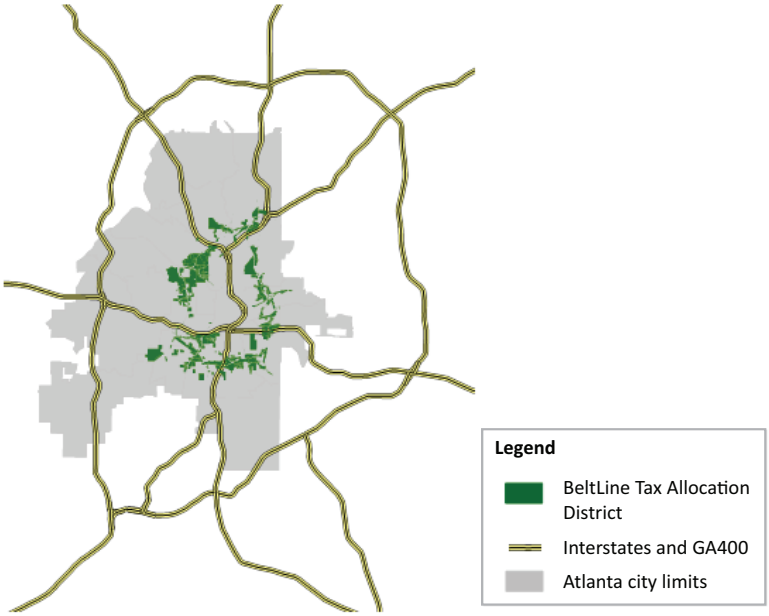

Figure 1. Map of Atlanta BeltLine project.

denser city with more public transit and affordable housing. As a pioneering urban sustainability project in the U.S., the BeltLine offers an ideal case to study whether or not public support and willingness to use of the urban sustainable projects align well with each other. This analysis also sheds light on the effective design and implementation of smart solutions for sustainable cities.

This paper is organized as follows. The next section provides an overview of the Atlanta BeltLine project, including its history and vision. The third section discusses the people and built infrastructure for sustainable cities in the context of the BeltLine project. Then we use survey data to understand how the public perceives and intends to use the BeltLine parks and transit systems. To explain the discrepancy between public support and individual use of the project, ordered logistic regression models are estimated. The analysis confirms the widespread public support while also revealing substantial resistance on the part of residents to change their commute or use of greenspace. The findings show that drivers of public support and prospective use of the BeltLine project differ. We conclude this paper with a discussion of implications for sustainable urban planning.

2. The City of Atlanta and the BeltLine Project

Metropolitan Atlanta is the eighth largest metropolitan area in the U.S, with a population of 5.7 million in 2015 (U.S. Census Bureau, 2016). Atlanta has actively engaged itself in the global paradigm shift towards sustainable cities. One of the city's key efforts is the Atlanta BeltLine project, which promises to transform the city from what is arguably the southeastern United States' poster child for urban sprawl into a smarter, denser, greener, healthier, more mixed use, and more prosperous metropolis (Alex Garvin & Associates, Inc., 2004). City planners and project designers claim "the Atlanta BeltLine will provide the framework for smart growth, enhancing the city's sustainability and economic vitality" (Atlanta BeltLine, 2017a). The magnitude of the BeltLine's promise, if not the reality, is hard to overstate. Press conferences and promotional materials echo the "transformational" rhetoric (Atlanta BeltLine, 2011; Kirkman et al., 2012). The project remains a work-in-progress today, and time will tell how it evolves. Early indications, with seven new parks, over 2,000 affordable workforce housing units, and 11 miles of trails since 2008, are promising (Atlanta BeltLine, 2017b).

The BeltLine concept, first proposed by Ryan Gravel in his 1999 master's thesis at the Georgia Institute of Technology, involves converting a 22-mile ring of largely abandoned rail lines around the Atlanta core into a greenbelt with a light rail loop. Sustainability and transit-oriented development (TOD) are central to the design, planning, and implementation of the project. Table 1 summarizes the BeltLine program elements and how they promote sustainability. In particular, brownfields will be replaced with new trails and greenspace. The BeltLine regional transit and the Atlanta Streetcar system will connect with the existing urban transit systems (Atlanta BeltLine, 2017c). The BeltLine affordable housing element promotes sustainable growth around the Atlanta BeltLine to increase access to mobility, jobs, and quality of life amenities (Atlanta BeltLine, 2013a). The project's goals encompass 1,300 acres of new or expanded parks, connected via 33 miles of continuous trails, and linking the 22-mile transit system to the regional transit network that would also result in over 30,000 new permanent jobs and 5,600 new affordable housing units (Atlanta BeltLine Tax Allocation District Advisory Committee, 2012). The combination of environmentally friendly transportation, economic development, walkability, and

Table 1. Atlanta BeltLine program elements.

Program Elements	Details	Expected beneficiary	How the public would be engaged	How they promote sustainability?		
				Ecological	Social	Economic
Parks	1300 acres of new greenspace; 700 acres of renovated greenspace	All citizens in the metro Atlanta region and visitors	Use park amenities and programs	✓	✓	✓
Trails	33 miles of trails	All citizens in the metro Atlanta region and visitors	Use trails to promote walking, jogging, biking and living along the BeltLine	✓	✓	
Affordable Housing	5,600 affordable housing units	Homebuyers and renter who wish to live in and around the BeltLine, developers and businesses	Take advantage of the various benefits, such as tax exemptions for homeowners, down payment assistance program and owner-occupied rehabilitation funding, etc.		✓	✓
Transit	A streetcar light-rail transit system	All citizens in the metro Atlanta region and visitors	Use MARTA, the new Atlanta Streetcar and other public transit	✓	✓	✓
Economic Development	Revitalizing 45 BeltLine neighborhoods; creating 30,000 permanent jobs and 48,000 one-year construction jobs	All citizens in the metro Atlanta region, property owners, employees and visitors	Spend within the BeltLine TAD; invest in retail, office and other development activities along the BeltLine		✓	✓
Urban Farm	Aluma Farm at Aluma Park and more	Farmers and urban neighborhoods	Purchase locally grown produce	✓	✓	✓

Source: Atlanta BeltLine (2013a).

social equity makes the BeltLine a major effort for urban sustainable development.

Despite the excitement and widespread political support, the BeltLine proposal took the better part of a decade to wend its way through the political process before the first segments opened (see Table 2 for highlights of the timeline). Some initial hiccups occurred, such as a hold-out slowing land acquisition and a Georgia State Supreme Court ruling that led to amending the state constitution to allow the BeltLine to be funding through Tax Increment Financing (TIF) (Sherman v. Atlanta Independent School System et al., 2013). In light of the sticky nature of entrenched interests and of the equilibrium urban form in Atlanta—and the need to amend the state constitution—breaking ground on such a major, transformational project just a decade after a master's thesis was written is a remarkable achievement in its own right.

3. People and Built Infrastructure for Sustainable Cities

In 2014, the Atlanta BeltLine received the EPA's National Award for Smart Growth Achievement. Smart growth refers to strategies to protect health and the environment as well as improve communities' attractiveness, economic strength, and social diversity (Environmental Protection Agency, 2017). The Atlanta BeltLine project is intended to transform the "dominant urban form" characterized by sprawl, automobile dependency, a hollowed

Table 2. BeltLine historical milestones.

1999	Ryan Gravel develops BeltLine idea in his Georgia Tech master's thesis.
2004	Grassroots support grows, *Emerald Necklace* (Garving & Associates, 2004) study commissioned.
2005	Mayor Franklin creates the BeltLine Partnership; BeltLine Redevelopment Plan and the TAD are approved.
2006	Atlanta BeltLine, Inc. created to oversee implementation; more land acquired.
2007	MARTA approves light rail transit on BeltLine. BeltLine Zoning Overlay District adopted. BeltLine acquires 4.5-mile stretch of loop from hold-out developer.
2008	Effort of nonprofits lead to first trail segment opening. First TAD bonds issued.
2010	Construction on trails and parks continue, more trails open.
2011	More parks, trails open. Trails host arts and running events.
2012	Master planning process concludes. Transportation Special Purpose Local Option Sales Tax (TSPLOST) vote fails.
2013	Leadership change at Atlanta BeltLine, Inc. after finance scandal. The City of Atlanta was awarded an $18 million grant from the U.S. Department of Transportation to develop the Atlanta BeltLine.
2014	More trails open and an art exhibit was hosted. A tour bus program was implemented.
2015	More trails and skateparks open, and affordable housing programs were developed. Senate Bill 4 was passed to allow public-private partnerships to fund transportation. The Atlanta Streetcar System Plan was adopted by the City Council.
2016	City of Atlanta voters passed the TSPLOST and MARTA sales taxes, which will finance land purchases and the constructions of transit network of the BeltLine.
2017	Seven of the Atlanta BeltLine parks are open to the public. More than 2,000 affordable workforce housing units were created.

out downtown core, and other ills common to large U.S. cities (Kirkman et al., 2012). This model is widely understood to be unsustainable in the long run, requiring ever-growing inputs of energy and other resources while also fostering social inequity and other ills.

By seeking to catalyze a more structural change towards a sustainable city, the BeltLine aims to not just undo the old pattern, but also institute a new pattern. It promises a new vision that emphasizes cohesive community, urban connectivity, and smart growth. As an integrated approach to land use, transportation, and economic development, the BeltLine will expand unprecedentedly the city's park land, public spaces, regional transit and transportation networks (Atlanta BeltLine, 2017c). Note that this entails not only a change in technical aspects of systems, the arrangements of physical objects and the flows of energy and matter through them. It also entails a change in social forms and norms, and in the values and visions of individuals living within the system. An explicit part of the vision of advocates for the BeltLine is not only a transformation of how people behave, but in fostering a new kind of civility in a distinctly new urban context (Atlanta Development Authority, 2006). As the most ambitious and comprehensive revitalization effort ever undertaken in the City, "you might say that the battle over the BeltLine is a matter of life or death" for Atlanta (Pendergrast, 2017, p. x).

The key challenge here is that the dominant urban form of the last century has been particularly hard to change (Wheeler, 2003), although recent development of information technologies has been shown to affect urban commuting behaviors (Kumar, 1990). Such is the nature of equilibria that they are often stable equilibria, but the dominant urban form of the 20th century may be especially "sticky": efforts toward change may be deflected or pulled back toward the established equilibrium, either through the brute resistance of physical infrastructure, the persistence of values and attitudes shaped by the dominant technical form, or both. As a "sociotechnical ensemble" or an interdependent network of urban systems (transport, land use, governance, industry, etc.) (Bijker, 1995), the dominant urban form in the U.S. is proving to be one that many reformers and visionaries are finding we are "stuck" with (Kirkman et al., 2012).

As noted, the role of private behavior and the values and attitudes from which it springs has received far less attention in the urban planning literature compared to the technical and policy aspects of sustainable cities (see for instance Bulkeley & Betsill (2005) for a detailed policy discussion). Residents of the city not only play a critical role in the governance and management of sustainable urban project (Drazkiewicz, Challies, & Newig, 2015), they are also expected to become active users of the various features of sustainable cities (Nevens, Frantzeskaki, Gorissen, & Loorbach, 2013). For many initiatives for sustainable cities (e.g., energy efficiency [Stieninger, 2013], information technology [Khansari, Mostashari, & Mansouri, 2014]), changing human behavior through urban

planning efforts has proven to be at least as important as technological advancement. This highlights the need to understand how the general public perceives and responds to smarter urban infrastructure, and how perceptions and responses are conditioned by existing systems.

The literature shows mixed evidence on the relationship between technology and behavioral changes. Some conclude a positive role of technology in driving behavior changes. For instance, Durand, Andalib, Dunton, Wolch, & Pentz (2011) find that smart growth features—such as diverse housing types, mixed land use, compact development, and open space—correlate with increased levels of physical activity and walking. Nasri and Zhang (2014) find that TOD areas in Washington, D.C. and Baltimore tend to reduce residents' vehicle miles traveled by around 38% and 21% respectively. Others show the impact of technology on behavior change to be insignificant or even negative. Energy efficiency technology is an often-cited example that might lead to increased energy consumption due to rebound effects (Herring & Roy, 2007). There is also evidence that people who believe technological solutions will solve environmental problems were less likely to engage in pro-environmental behaviors (Gigliotti, 1992).

Of particular interest in the wide array of studies of resident responses to UIS changes is the literature examining utilization of new public transit projects. Proximity to stations matters (Cervero, 1993), but transit ridership depends on other aspects of urban form. Residential and employment densities around transit stations, the degree of mixed land use (Tumlin, Millard-Ball, Zucker, & Siegman, 2003), and small block size (Arrington & Cervero, 2008) matter as well. Rail transit ridership in New York City and Hong Kong is influenced by land use, station characteristics, socio-economic and demographic characteristics, and inter-modal coordination among different public transportation modes (Loo, Chen, & Chan, 2010). Further supporting the multidimensionality of factors influencing transit utilization by residents, Pucher (1988) and Nasri and Zhang (2012) identify a supportive urban development throughout the larger metropolitan area as impacting transit utilization. Transit usage clearly depends on the broader, complex technological system of the city as well as individual characteristics.

To better understand the prospect of urban infrastructure promoting sustainability, this study examines public perception of and willingness to use the Beltline project by analyzing survey responses from urban residents. This independent survey sheds light on how the public sees the city's challenges, how they perceive and intend to use the project, and what factors explain the two stages. The results confirm widespread support for the project, but they also reveal some undercurrents that dim the prospects for sustainable urban transformation. This study has important implications for other smart city initiatives and helps identify the obstacles that exist for cities using major capital investments to promote sustainable behavioral changes.

4. Analysis of Survey Responses: What the BeltLine Means to Atlantans

In this section, we evaluate public perception and behavioral changes that are likely to follow from the BeltLine project. Based on results of background interviews, focus groups, and pilot surveys, we designed and administered an online survey in the summer of 2009. A sample of adults in the Atlanta metropolitan area was drawn randomly from Survey Sampling International's large online panel, with 60% from within the City of Atlanta (see Cavallaro (2012) for more details on the online panel's characteristics). Selected panelists were contacted via an email invitation to an online survey about "housing, green space, and transportation" that took, on average, nine minutes to complete. A total of 946 respondents completed this 37-question survey between 16–29 June 2009 about their attitudes toward the city, their views on the BeltLine, and demographics. When comparing with Atlanta metro-area demographics, the sample appears representative for many variables, such as age, income, car ownership, house tenure, and household size. The sample does appear to have shorter commutes, less tendency to move and higher educational attainment. These differences are likely largely accounted for by our oversampling of City-of-Atlanta residents, and the inclusion of those working part time or working at home in our sample. Kirkman et al. (2012) provide more details on this survey.

Descriptive statistics from survey responses are summarized in Table 3. The results show that Atlantans tend to see the City as a typical American urban form characterized by high automobile dependence and low-density urban sprawl. Over three fourths of people think Atlanta is too automobile dependent, although people do not see Atlanta as particularly lacking greenspace (nearly half respondents agree Atlanta is a very green city). Almost 30% of respondents think that traffic is a problem in Atlanta because of too few alternatives to driving, 21% blame dense population in the city, and 18% think too few, badly designed or poorly maintained roads are the main causes. The public is generally pessimistic about future quality of urban life. Most Atlantans (74%) believe that mobility will worsen over the next five years, and 52% of respondents think Atlanta's quality of life will decline in that same period (while just 14% expect improvements). When faced with a choice between an Atlanta in 2060 that looks like it does today and one with more density, transit, and congestion, respondents favored the New York City version of future three times more often than those preferring the status quo. Although Atlantans hope that the city as a whole evolves substantially, most of them prefer that their neighborhood not change: 64% of respondents indicate that they hoped their neighborhood would stay the same after they moved there.

The transformative potential of the BeltLine proposal seems appealing to the Atlanta public. Results show strong support for both the BeltLine and its goals. About

Table 3. Descriptive statistics from survey responses.

Variable	Mean	Std. Dev.	Min	Max
Atlanta is too auto-dependent (1=disagree strongly; 7=agree strongly)	5.6	1.7	1	7
Atlanta is a very green city (1=disagree strongly; 7=agree strongly)	4.3	1.7	1	7
How will Atlanta's quality of life change in 5 years (−1=worsen, 1=improve)	−0.4	0.7	−1	1
How will mobility in Atlanta change in 5 years (−1=worsen, 1=improve)	−0.7	0.6	−1	1
Prefer a 2060 Atlanta that looks like it does today (=−1) or an Atlanta with higher density and housing costs, and more transit, congestion and parks (=1)	0.4	0.8	−1	1
How familiar are you with the BeltLine? (1=not heard of it; 2=heard of it; 3=know some details; 4=very familiar)	2.2	1.0	1	4
The BeltLine is definitely bad (−2), more bad than good (−1), uncertain (0), more good than bad (1), or definitely good (2)	1.0	1.0	−2	2
Others think the BeltLine is a bad idea (−1), are evenly divided (0), or think the BeltLine is a good idea (1)	0.3	0.7	−1	1
I would use BeltLine parks several times per week (3), per month (2), per year (1), or never (0)	1.0	0.9	0	3
I would use BeltLine transit several times per week (3), per month (2), per year (1), or never (0)	1.0	1.0	0	3
Many other will use BeltLine parks (0=few)	0.9	0.3	0	1
Many other will use BeltLine transits (0=few)	0.8	0.4	0	1
Many other will relocate to the BeltLine (0=few)	0.6	0.5	0	1
BeltLine will fall far short (−2), be smaller (−1), be as large (1), or be larger (2) than planned	0.1	1.5	−2	2
BeltLine will transform Atlanta (0=no, 1=doubtful, 2=maybe, 3=definitely)	2.0	0.8	0	3
When I moved, I hoped my neighborhood would change (−1), stay the same (0), would not change (1)	0.5	0.7	−1	1
Commute mode (1=I drive alone)	0.5	0.5	0	1
Park use frequency (0=never, 1=less than yearly, 2=at least once per year, 3=at least once per month, 4=once per week or more)	2.2	1.2	0	4
Education (years)	15-2	2-3	10	19
Age	49.4	13.8	21	75
Household income (in $, logged)	10.9	0.7	9.6	12.2
Map (shown map=1)	0.5	0.5	0	1
Distance (to BeltLine, in km, logged)	2.4	1.3	−2.9	4.1

three-fourths of respondents indicated that it was a good idea and it would transform Atlanta. Such widespread public approval reflects how the project appeals to a broad array of interests. Mostly, they liked the transit, neighborhood revitalization, and brownfield redevelopment aspects of the project (Figure 2). These BeltLine's promises aligned well with Atlanta's major challenges identified by respondents in the survey. Support for density, workforce housing, or other aspects was weaker. The weaker support for density is unsurprising in that density does not play a statistically significant role in metropolitan-level happiness (Florida, Mellander, & Rentfrow, 2013). However, this contrasts with Atlantans' preference for the high-density version of the future.

Despite the strong support for the project, probing further raises some issues. Most respondents do not intend to use the BeltLine much for transit or for its parks and trails: only a third of respondents indicated that they expect to use the BeltLine at least several times per month, while two in three respondents would rarely, if ever, use the project's transit or parks (Table 4). In being more likely to support transit than use it, Atlantans may resemble those in other US cities. Atlantans see themselves not using the BeltLine transit more frequently

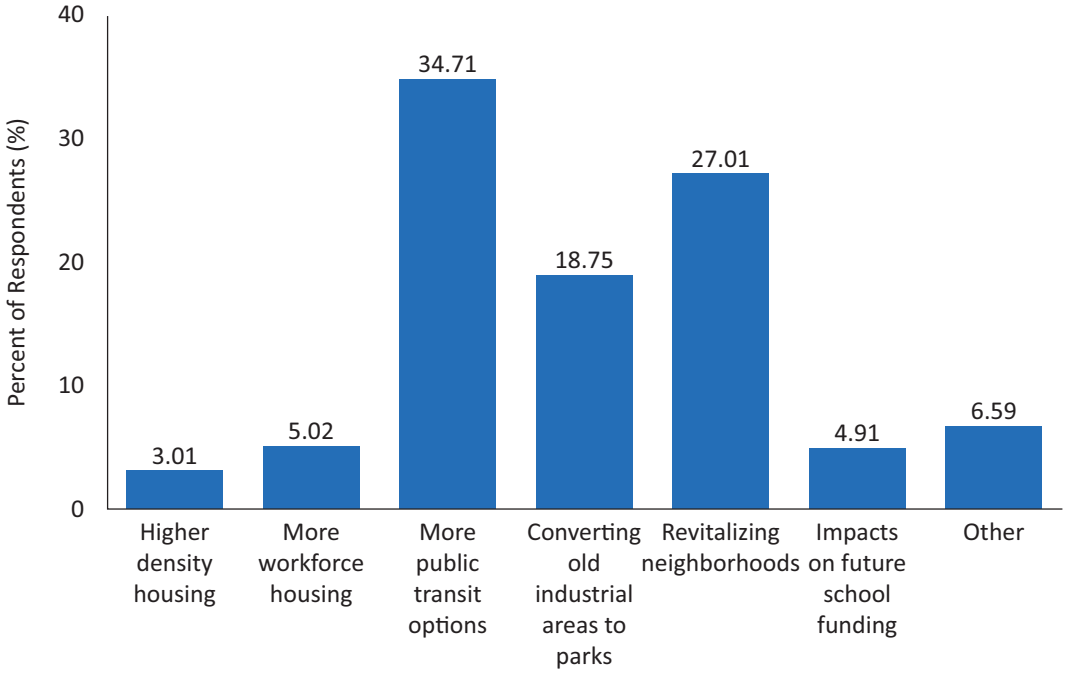

Figure 2. Best part of the BeltLine identified by respondents.

mainly because it won't go where they want (38%) and it is too far out of their way (36%). Uncertainty about the parks' location (30%) and long distance from the parks (36%) keep most respondents from using the BeltLine parks and trails more often. When asked about reasons why others might not use it, respondents recognized that most Atlantans like their community too much to move and like their cars too much to ditch them in favor of transit.

People are optimistic that others will use the parks and transit, but just not them. Among those who had guesses, Atlantans predicting "many others" will ride BeltLine transit or use its parks outnumbered those predicting to "few others" by a 5:1 margin. 50% more respondents expect "many people will move to be closer to the BeltLine" than expect few will. If everyone thinks others will use the BeltLine but just not themselves, then it suggests the project might not catalyze the behavioral change it seeks.

The results of chi-square tests for independence show that prospective use of the BeltLine transit and parks are not independent of public support. BeltLine supporters are more likely to say they will use Beltline transit or parks than skeptics, although the percentages are still low. Just 34.6% and 24.8% of Beltline supporters think that they will use Beltline transit and parks at least several times per month, respectively, compared to 7.7% and 4.8% of BeltLine skeptics[1] (see Table 4). BeltLine sup-

Table 4. Summary of public support and prospective use of the BeltLine (% of survey respondents).

Public Support (How good of an idea is the BeltLine?)		Prospective Use					
		Transit			Park		
		My use		Many others will use	My use		Many others will use
		Every week	Every month		Every week	Every month	
Definitely bad	4.4	0.0	0.0	0.5	0.0	0.0	0.8
More bad than good	6.0	0.0	0.8	1.8	0.1	0.4	1.5
More good than bad	43.7	3.4	6.0	23.8	1.9	5.3	27.3
Definitely good	45.9	11.5	10.1	34.8	2.2	12.8	36.6
Chi-Square (Significance)		53.0 (0.000)	15.4 (0.002)	87.1 (0.000)	24.2 (0.000)	39.6 (0.000)	95.2 (0.000)

[1] BeltLine supporters here are defined as people who think the BeltLine is more good than bad, or it is definitely good. BeltLine skeptics are people who think the BeltLine is definitely bad, or it is more bad than good.

porters are also more optimistic than non-supporters regarding others' use: over 65% of BeltLine supporters and less than 25% of Beltline non-supporters think many others will use the BeltLine.

Further, many respondents think that it will not be completed as planned. Two in five respondents indicated their belief that the BeltLine would be smaller or fall far short of current plans.[2] (the most popular reason given was financial constraints.) Conversely, 18% predicted it would be larger than planned.

It also bears emphasis that information about the project seems to have no sway over Atlantans' attitudes about the project or expectations about future use. In the survey, half of the respondents were randomly selected to view of a map of the project alongside a short text description; the other half merely saw the text. Visualization and geographic details had no influence on responses, which is all the more remarkable considering how unfamiliar most people are with BeltLine details. Fewer than 10% of respondents claimed to be already "very familiar" with the project, 29% said they had not heard of it at all, and 35% had heard of it but did not know details. Regardless, every variable listed in Table 3 shows no difference in means between those seeing the map and those who did not. It had no influence over support, optimism, expected future use, or beliefs about others using it.[3]

5. Understanding Public Support and Willingness to Use

To better understand what explains public support and willingness to use the BeltLine project, a series of ordered logistic regression models are estimated. It can be complicated to sort out all factors that shape and influence public perception and behaviors. In this paper, we follow Kollmuss and Agyeman (2002) and evaluate the impact of demographic factors (education, age, and income), internal (prior knowledge and perception of the city and neighborhood,) and external factors (additional information of the project). We also control for distance, commute time, and current behavioral patterns in our models. Results are presented in Table 5. Model (1) tests who tends to think BeltLine is a good idea. The dependent variable measures public support of BeltLine with four ordinally ranked categories[4] (see variable descriptions in Table 3). Models (2) and (3) test who tends to say they will use BeltLine transit or parks in the future. The ordinal dependent variables measure how often people will use BeltLine transit or parks.

These ordered logit models show some consistent and expected results for support and future use of the BeltLine. The estimated coefficients for distance, optimism about the City's future quality of life, and current park use frequency are significant in all three models. Public support and expectations about future use of BeltLine decline as distance to the BeltLine increases, as people get more pessimistic about Atlanta's quality of life in five years, and as people visit local parks less often. The urban core population appears to support and plan to use the BeltLine because of their easy access to its parks and transit. For people who are optimistic of Atlanta's future quality of life, the BeltLine may help realize their vision through economic revitalization and community development. They are more likely to favor the BeltLine, and obtain direct use value from the project. Park lovers might be particularly attracted to the BeltLine because it proposes to transform the city's park system.

Other factors we expect to influence support and future use, however, offer more mixed results. Demographic variables tend to explain expected personal use of BeltLine, but not support. Coefficients for education and age are negative and significant in Model (2) and (3), while coefficients for household income are insignificant in all models. People who are less educated and younger say that they are more likely to use BeltLine parks or transit in the future, although they are not more likely to think the BeltLine is a good idea. Household income has no influence on either support or future use of the BeltLine. This may suggest the paradoxical impacts this urban greening initiative has on different income classes. On the one hand, lower income communities may benefit from the affordable housing opportunities provided by the BeltLine. On the other hand, BeltLine is expected to boost property values by making the city more liable and attractive, which potentially invites urban gentrification (Zukin et al., 2009).

Whether or not the BeltLine will catalyze behavioral changes highly depends on people's current lifestyles. Respondents are more likely to use BeltLine parks if they already visit local parks more frequently, and they are more likely to use BeltLine transit if they are already less car-dependent in daily commute. The high toll of daily commuting, one of the major challenges in urban development, is often the result of a city's geographic expansion outstripping its ability to get people moving between home and work (Smith 1990). In this survey, however, time spent in daily commutes plays no role in explaining either public support or use of the BeltLine.

Table 5 results also indicate a nuanced role for attitudes in explaining support and future use. Respondents who hoped that their neighborhood would change express an intent to use the BeltLine more but not more support, despite the BeltLine's promise as a catalyst for sustainable urban transformation. Those hoping for neighborhood change tend to embrace behavioral changes to use the BeltLine transit and parks more

[2] Apparently, the "first" public opinion poll of 600 City residents was conducted in 2007—two years after the city council approved the TAD—and an "overwhelming majority believe the project will be completed as envisioned." (Atlanta BeltLine, 2013b). That survey predated the Great Recession.

[3] When asking a respondent why they might not use the BeltLine much, one answer category referred to the inconvenient location of the BeltLine. Respondents who saw the map picked this category with the same frequency as those who did not see the map, regardless of their self-reported familiarity with the project.

[4] Responses indicating "I need more information to decide" were dropped from the dataset.

Table 5. Ordered logit regression results for public support and prospective use of the BeltLine.

		Prospective Use	
Variable	**Public Support**	**Transit**	**Park**
Education	−0.025	−0.065*	−0.066
Age	−0.0013	−0.021***	−0.021***
Household income	−0.062	0.089	0.052
Familiarity	−0.015	0.20**	0.27***
Map	−0.22	0.069	−0.056
Distance	−0.22**	−0.31***	−0.37***
Map*Distance	0.067	0.068	−0.012
Commute time	−0.0027	0.0026	0.0021
Hoped my neighborhood would change	0.035	0.42***	0.26**
Atlanta quality of life improving in 5 years	0.48***	0.21**	0.34***
Commute mode (2)	0.24	−0.59***	−0.27
Park use frequency (3)	0.31***	0.43***	0.72***
N	548	657	654
Log Likelihood	−543.07	−765.86	−688.24

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

(1) Prospective use of BeltLine parks ("How would you use the BeltLine park and trails, supposing the project is completed as planned?"), coded per the answer categories: *I would visit BeltLine parks or trails several times per week* (3), *per month* (2), *per year* (1), or *never* (0).

(2) Commute mode is a binary variable, coded as 1 if the response is *I drive* alone and coded as 0 otherwise.

(3) Park use frequency ("How often do you visit local or city parks?"), coded per the answer categories: *Once per week or more* (4), *at least once per month* (3), *at least once per year* (2), *less than yearly* (1), *never* (0).

frequently. Conversely, those content with their neighborhood as-is intend to use the BeltLine less and are just as likely to support the BeltLine, perhaps because they see its transformation as affecting others' neighborhoods. Again, the BeltLine has broad appeal by offering a chance for others to change.

Geographic information and prior knowledge of the project play different roles here. Familiarity is positive and significant in Model (2) and (3). People are more likely to plan to use BeltLine parks or transit more if they are more familiar with the project. Familiarity, however, does not necessarily enhance public support of the BeltLine. Surprisingly, visualization and geographic details about the project have virtually no impact on attitudes about the project or prospective use—even though most respondents would be hard pressed to describe its proposed location.[5] Public support appears unrelated to familiarity with and information about the project—casting doubt on the political relevance of a well-informed population. And while familiarity does predict greater intent to use the BeltLine, the (randomly assigned) information treatment in survey was insufficient to affect prospective use responses. The coefficients for the map variable and the interaction term between map and distance are all insignificant. Proximity to the BeltLine is associated with more support and intended use, above and beyond self-reported familiarity, but these proximity effects are neither stronger nor weaker when respondents are primed or reminded about the exact location of the BeltLine.

6. Discussion and Conclusions

This study identifies the potential gap between public support and use of sustainable urban project using data from a survey of the general public. We focus on the Atlanta BeltLine project, one of the largest urban greening initiatives in the country involving a mix of sustainable transportation, greenspace, and economic revitalization projects.

Overall, the survey reveals a seeming contradiction between two distinct perspectives each respondent might take: thinking as citizens, as members of the public, and thinking as consumers, engaged in private behavior aimed at maximizing satisfaction (Sagoff, 2007). When asked to think as citizens about what is best for the community, most respondents support adopting some or all BeltLine components. When asked to think about their own behavior, as self-interested individuals, they show little intent to use the infrastructure personally.

[5] Pre-testing of the survey instrument revealed a common misperception that the BeltLine was outside Atlanta's perimeter highway, rather than in the urban core.

The results also show that drivers of public support for the urban infrastructure project and behavioral changes differ in important ways. BeltLine supporters and users tend to live in the urban core, use local parks often, and be optimistic about the city's future quality of life. Education, age, familiarity, and hopes for neighborhood change have no impact on public support, but they do affect individual willingness to use the BeltLine. In addition, sustaining behavioral responses to the BeltLine is strongly correlated with people's current usage of parks and non-automobile transportation options. Those indicating greater expected behavioral changes are those whose current behavior already appears to be more sustainable. Reaching certain skeptics or potential users may be a challenge for planners designing solutions, and the results here indicate which groups to target.

A further wrinkle arises in that many respondents do expect others to adopt the BeltLine, though they themselves do not, while at the same time they suspect others do not favor it, though they themselves do.[6] The implications of this particular finding are best left to another context.

In order to interpret these findings, we need to understand not only how this contradiction arises, but how it is that the contradiction appears so explicitly in responses to the survey. If we are correct in thinking that the tension between public support and private behavior is largely a function of the stickiness of social and technological systems, then how is it that people living within and conditioned by those systems are able to see beyond them enough to grasp and even support the transformative vision of the BeltLine project?

One possible explanation is that the survey questions are hypothetical. When engaged in blue-sky thinking about what might be possible, talk is cheap (Jerolmack & Khan, 2014). Liking the idea of the BeltLine, especially as a direction for the city to go, need not imply that individuals would be willing to sacrifice and change for it, or even that they could imagine the possibility of changing their own private conduct, given the external and internal constraints under which they operate within the dominant urban form.

Put in different terms, there is no opportunity cost for expressing support for the BeltLine project in a hypothetical survey. The project's primary funding mechanisms (i.e., TIF) played into this with a bold promise and little apparent sacrifice. Making real changes entailed in using the BeltLine are not so cheap, however, as it may involve moving to a new residence, changing employment, changing commuting patterns and modes, and other changes that involve not only new costs, but perhaps the sacrifice of costs already sunk in the status quo. In a recent referendum on a sales tax earmarked for Atlanta regional transportation projects, we saw far less support for paying for projects like this (Hart, 2012) than for its abstract vision in the survey. When the lunches are not so free, the jewels in its emerald necklace shine a bit less bright.

Another possible explanation as to why the contradiction would appear so starkly in the survey is a "sustainability for thee" impetus (Kalamas, Cleveland, & Laroche, 2014). Respondents seemed eager to advocate for a systemic remedy, constructing the BeltLine, especially insofar as it transformed others' behavior while leaving their own neighborhood, attitudes, and patterns of living unchanged. Unlike Atlanta's newcomers, the bulk of Atlantans appear well-entrenched—stuck—in their city and their ways. They might welcome the BeltLine as an attempt to dislodge the city and get others to live sustainably, if only so there will be fewer cars on the highway as they drive to work. But they do not envision substantial change on their part. When such perspectives are pervasive, the city may find itself buying smart solutions that attract few users.

This analysis is not without limitations. First of all, the unique nature of the BeltLine project and the online nature of the survey (and its attendant response rate challenges) can limit generalizability of these results. Second, constraints in survey administration lead to a limited set of measures. Variables such as race, occupation and workplace location, and other social factors can be particularly interesting for future research to understand certain populations. Third, far more could be done to examine the role of knowledge about the project in affecting public support and attitudes. Fourth, the survey context limits how deeply we can probe into reasons underlying the divergence between support and prospective use. While the results here illustrate the different factors influencing each, additional research is needed to provide a richer description. Another concern common to surveys like this is social desirability bias. Yet because both support and prospective use may be pro-social choices, the divergence in responses is harder to reconcile with social desirability. Lastly, given the significance of the BeltLine to the region, we sampled the whole metropolitan Atlanta area. Despite oversampling within city limits, the sample may not be representative of the urban core. A narrower conception of the BeltLine might concentrate on certain communities targeted or served by the project rather than a more general public. Private choices and public support among certain groups (e.g., minorities, TAD residents, housing developers) warrant their own focused studies.

The BeltLine experience thus far has several lessons for other sustainable urban projects. First, although the political and popular demands for much of the project are sufficient to permit some progress despite the Great Recession, sustainable transformation of the city may still be far away if the behavior of individuals is still caught up in the patterns, attitudes and values of the dominant urban form. People's lack of interest in using the BeltLine parks and transit signals that advocates for the BeltLine have not yet grappled with this most basic problem.

A promising approach to addressing the problem would be to approach sustainable urban infrastructure

[6] While 73% favored the BeltLine themselves, only 22% believed that others think the BeltLine is a good idea.

planning as an adaptive, participatory process in which technical innovation, policy change, public engagement, and cultural transformation are all in play. Stakeholder engagement—really, engaging the public in a wide-ranging conversation about our shared environment—is a critical part (Morrissey, Iyer-Raniga, McLaughlin, & Mills, 2012). Innovative approaches may be used to effectively engage different groups of citizens in urban planning, design, and implementation.

Empirical studies have shown the potential of internet-based participation tools in alleviating unequal power relation and providing an interactive and networked environment for urban planning decision making. Web-based virtual worlds, such as Facebook and Second Life can provide platforms for online community organizing around planning issues and virtual workshops (Evans-Cowley & Hollander, 2010). In the case of the BeltLine, online surveys can be used to identify different public groups, and understand the reasons that keep them from using the BeltLine. Citywide briefings, email distribution lists, and e-newsletters can be created around issue topics to target specific group of people. Other smart, sustainable urban projects would do well to go beyond building political support for technical projects toward the development of a new, shared vision of the built environment, its meaning, and its value.

Second, the fiction of a free lunch underlines much of the disjoint between the project's ambitions and its present reality. We cannot take for granted that strong political support for smart infrastructure is sufficient if private behavioral/usage decisions are then going to be necessary for the initiative to succeed. For urban planners, the design, adoption and implementation of smart solutions should be guided by the goal of shifting to sustainable behavioral changes or helping residents become "stuck" in more sustainable ways (Kirkman et al., 2012). The interplay between systemic constraints, private choices, and public support suggests that private adoption decisions may not follow until and unless the systems in which they are embedded are already changing. Thus, efforts to bring about smart and sustainable urban infrastructure may face something of a bootstrapping problem.

Third, the project's most politically controversial component—transit—is also the part that represents the greatest long-term commitment to a new and sustainable city. Unsurprisingly, committing Atlanta to a new vision is contentious. Even among supporters, it seems hard to imagine self-sacrifice for its unrealized promise. If they build it, will Atlantans come? Project planners are banking on "yes."

Alternatively cast, however, the better question is: "What do Atlantans want to get stuck with?" Other smart solutions encounter these questions as well. Sticky equilibria in urban forms exist for powerful reasons (and the alternative of an unstable urban form is even harder to imagine than an Atlanta with greater density and transit). Perhaps it is here where the debate should be had, and cultivated, around the question of what we want to get stuck with. When windows of opportunity open, as they seem to have for the BeltLine, the question is no longer idle. Future generations will enjoy and suffer today's answer. If being stuck with something is inevitable, or at least desirable, then acknowledging that helps frame the terms of the discussion and puts the onus on the planning process to objectively cultivate public imaginations about those future states. In this regard, participatory urban planning from early stages may influence how well infrastructure projects ultimately impact sustainable behavioral patterns after project implementation. This can be a fruitful area for future research.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Testing the Use of Crowdsourced Information: Case Study of Bike-Share Infrastructure Planning in Cincinnati, Ohio

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Abstract
Considering the power of web-based tools for crowdsourcing, planning organizations are increasingly using these technologies to gather ideas and preferences from the public. These technologies often generate substantial, unstructured data about public needs. However, our understanding of the use of crowdsourced information in planning is still limited. Focusing on the City of Cincinnati Bike-share planning as a case study, this article explores the challenges and considerations of using crowdsourced information. Employing mixed analysis methods, the article analyzes participant suggestions and examines whether and how those suggestions were incorporated into the bike-share plan. Interpretive analysis of interviews provided insights about suggestions that were used in the final plan. The results highlight organizational opportunities and limitations. A variety of organizational factors affected the utility of crowdsourced information in Cincinnati bike-share plan. These include the capability of the planning organizations to analyze data and facilitate participation, and the perception of planners about the value of crowdsourced information and local knowledge.

Keywords
bike-share; crowdsourcing; information; organization; web-based technology

Issue
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1. Introduction

How do planners and professionals use crowdsourced information in planning? What considerations should they take into account? Considering the importance of local knowledge in planning, and the ability of web-based technologies in crowdsourcing this knowledge, local governments and planning consultants are increasingly using new technologies to gather information from stakeholders (Evans-Cowley, 2010; Schweitzer, 2014). Crowdsourced information can be useful in infrastructure planning, but is not immune to the issues of data quality or organizational capability compared to other data collection methods (Goodchild, 2007). There is a growing discussion on the role of information technology in changing the pace and quality of information sharing and social interaction by citizens (Sanchez & Brenman, 2013). However, our understanding of the usability of the information, crowdsourced through online participation of stakeholders, in planning and planners' perception of its value is still emerging.

Planning organizations have long faced the challenge of generating public participation and relevant input (Bryson, Quick, Slotterback, & Crosby, 2013). Without serious mandates for public engagement, planning organizations may not use participatory processes to collect public input (Hoch, 2007) over concerns that the costs of engaging the public may not pay off. Some planning organizations struggle with the costs of conducting public meetings, while others struggle to even attract citizen participation (Afzalan & Evans-Cowley, 2015; Rhoads, 2010). Some organizations are hesitant about the value of citizens' knowledge in responding to complex planning problems where expert-based knowledge is considered

more useful (Corburn, 2005). These challenges influence how planners see the value of crowdsourcing methods.

This article focuses on the City of Cincinnati Bike-share feasibility study as a case study of crowdsourcing. Bike-share planning is complex and involves such challenges as finding public space for bike-share stations (Krykewycz, Puchalsky, Rocks, Bonnette, & Jaskiewicz, 2010), analyzing station capacity and space use (Daddio, 2012), and equity considerations of implementing bike-share systems (Piatkowski, Marshall, & Afzalan, 2016).

In recent years, cities such as Cincinnati have used online crowdsourcing tools to ask potential users about their desired locations for bike-share stations. Drawing on the literature about using online participatory technologies and crowdsourced information in planning, this study employs spatial and content analysis methods to explore the uses of public input. Unstructured interviews with project managers explored how and why the suggestions were incorporated into the final feasibility plan and the limitations of doing so.

2. Online Participatory Technologies

Engaging communities through online technologies is becoming a common practice for planning organizations (Afzalan, Sanchez, & Evans-Cowley, 2017). These technologies include online tools that are specifically designed to augment public engagement (e.g. MySideWalk), social media platforms (e.g. Facebook groups), or public participation GIS applications (e.g. SeeClickFix). These technologies are seen as advancing information sharing (Riggs, 2016; Williamson & Parolin, 2012), collaboration and interaction (Schweitzer & Stephenson, 2016), social learning (Goodspeed, 2013; Goodspeed et al., 2016); transparency (Schweitzer, 2014), and social mobilization (Frick, 2016). These technologies are used to facilitate engagement at different levels of the "ladder of participation" (Arnstein, 1969). Some are used to facilitate deep discourse and dialogue to discuss complex planning issues and some are used to simply collect data about public opinions (Afzalan & Muller, 2014; Brabham, 2009; Dashti et al., 2014). On the other hand, some scholars raise concerns about the social equity, privacy, and transparency concerns of using these technologies (Schweitzer & Afzalan, 2017). For example, issues of digital literacy have generated discussions around the consequences of using online tools for collaborative decision making processes where not all segments of the population can participate equally (Saad-Sulonen, 2012).

The use of computer-aided technologies in decision making and planning has been supported by the growth in popularity of GIS and its applications in augmenting location-based analysis and information sharing (see Mostafavi, Farzinmoghadam, & Hoque, 2014). Integrating GIS and web technologies has allowed planning organizations to implement public participatory processes using web-GIS applications (Karduni et al., 2017; Zhou, Wang, & Li, 2017).

3. Crowdsourcing Information for Planning: Opportunities and Challenges

3.1. Opportunities

This study considers public input as the core component of participatory goals to democratize decision-making (Raymond et al., 2010). With the growth of social media and information technology, planning organizations have more convenient options for crowdsourcing citizens' ideas and learning about their interest (Seltzer & Mahmoudi, 2012; Yli-Pelkonen & Kohl, 2005). Crowdsourcing is a method for outsourcing problem solving and assists with exploiting ideas of a group to help organizations work more efficiently (Brabham, 2009). It can be used to engage the public to share their ideas about a planning problem. While the new advancements in communication technologies have made the implementation of crowdsourcing methods easier for organizations, using crowdsourced information in planning is still challenging (Seltzer & Mahmoudi, 2012).

The popularity and increasing accessibility of the Internet has facilitated crowdsourcing activities. Web 2.0 has the capacity to produce user generated content and harness the collective intelligence of communities (O'Reilly, 2007). Online crowdsourcing methods provide opportunities for exploiting a crowds' wisdom (Brabham, 2009) and overcoming some of the issues of the traditional methods of participation, including lack of participants' diversity and limitations of time and space for engagement (Evans-Cowley & Hollander, 2010). In addition, the integration of Web 2.0 and GIS is important for the geographic context of public input such as through Volunteered Geographic Information (VGI) (Goodchild, 2007). VGI can enhance institutions' decision making by providing qualitative and quantitative locational information (Barton, Plume, & Parolin, 2005). It also contains types of data that have not been discovered in traditional mapping before. Local organizations or governments can use VGI in their planning processes for sharing spatial information, gathering ideas that consider existing or proposed situations, and learning about potential sources of tension (Goodchild, 2007).

3.2. Challenges

Planners differentiate public participation from scientific or expert knowledge as inputs to plan making. Combining these types of data has been traditionally challenging for planning organizations due to different levels of precision and reliability (Corburn, 2005). However, with the new advancements in online crowdsourcing methods, opportunities exist for verifying publicly generated information with expert analysis (Goodchild & Li, 2012).

Planning organizations face several constraints with using local knowledge in general and specifically crowdsourced information, in planning and decision making (Flyvbjerg, 2013). Local knowledge is not always applica-

ble to socio-economic issues at all scales. In addition, citizen generated input is produced through bottom-up approaches without top-down monitoring processes that control the information quality. This type of input is not filtered; therefore, it may not be well organized, accurate, or up to date. (Flanagin & Metzger, 2008). These issues—beside the large quantity of crowdsourced knowledge, issues of information quality, issues of information credibility and vagueness (Roberts, 2017)—make it challenging for organizations to analyze and interpret crowdsourced information. Using this information may also raise concerns regarding issues of privacy or security as well as Internet accessibility and digital literacy for governmental or non-governmental planning organizations (Schweitzer & Afzalan, 2017).

Table 1 summarizes previous research on the opportunities and challenges of crowdsourcing for urban planning applications.

4. The Case Study

This study focuses on the use of crowdsourced information from a web-GIS tool to engage citizens in the City of Cincinnati's bike-share feasibility study. The City's Department of Transportation & Engineering, in collaboration with a private consulting company, collaborated on creating the feasibility study for a bike-share program. The bike-share program is part of The City of Cincinnati's goal in providing a new option for local mobility around town that is affordable, accessible and visible for citizens and tourists (Alta Planning + Design, 2012).

The organizations involved used a web-GIS crowdsourcing tool (Shareabouts[1]) for collecting ideas about desired locations for bike-share stations, mainly in the downtown, Over-the-Rhine, and uptown area. The tool was promoted using posters, flyers, and online advertisements. This open source tool, developed by OpenPlans, was used by various organizations for diverse types of participatory projects. It allowed users to locate points on a map of Cincinnati to suggest new locations or to support existing locations by clicking a support button (see Figure 1). In addition, participants were allowed to describe why they proposed a location or participate in a discussion by supporting or opposing other suggestions (Alta Planning + Design, 2012). The participants were not required to register or provide personal information such as e-mail address. Of those who did provide personal information, 54% were male, 30% were female, and 16% did not specify. An online platform called Gender Checker[2] was used to identify whether a name was female or male. Over the 36 days that the crowdsourcing tool was running, there were 206 engagements, 330 suggested locations and 503 comments. In addition, 1773 times various locations received supports (likes) from the participants.

Table 1. Opportunities and challenges of crowdsourcing information in planning.

Opportunities
New and unexpected information:
• Gathering novel and unexpected information (Brabham, 2009; Roberts, 2017)
• Gathering information from a diverse and large community (Afzalan, Evans-Cowley, & Mirzazad, 2015; Seltzer & Mahmoudi, 2012)
Information gathering and use:
• Engaging people without considerations of time or place for information gathering or engagement (Evans-Cowley & Hollander, 2010; Riggs & Gordon, 2015)
• If public participatory GIS applications are used, the collected spatial data is easily measurable, interoperable, and quantifiable (Zhang & Feick, 2016)
• More cost and time effective information gathering, comparing to traditional participatory methods (Brabham, 2009, Schweitzer, 2014)
Challenges
• *Information evaluation:* The concerns about quality (Scheuer, Haase, & Meyer, 2013), credibility, and vagueness of the collected information (Longueville, Ostlander, & Keskitalo, 2009) can make interpretation of the information challenging. Collected information may not represent the public interest (Seltzer & Mahmoudi, 2012). Information representativeness should be evaluated for equitable planning.
• *Analysis methods and facilitation:* Institutions may not have staff or resource capacity to fully benefit from the collected information (Klosterman, 2013; Townsend, 2013), to facilitate online participation, or analyze data (Saad-Sulonen, 2012).
• *Education and attitude:* The knowledge, attitude, and perception of professionals and planners may influence the usefulness of the collected information in planning and decision making (Minner, 2015; Slotterback, 2011)

[1] http://blog.openplans.org/category/shareabouts
[2] http://genderchecker.com

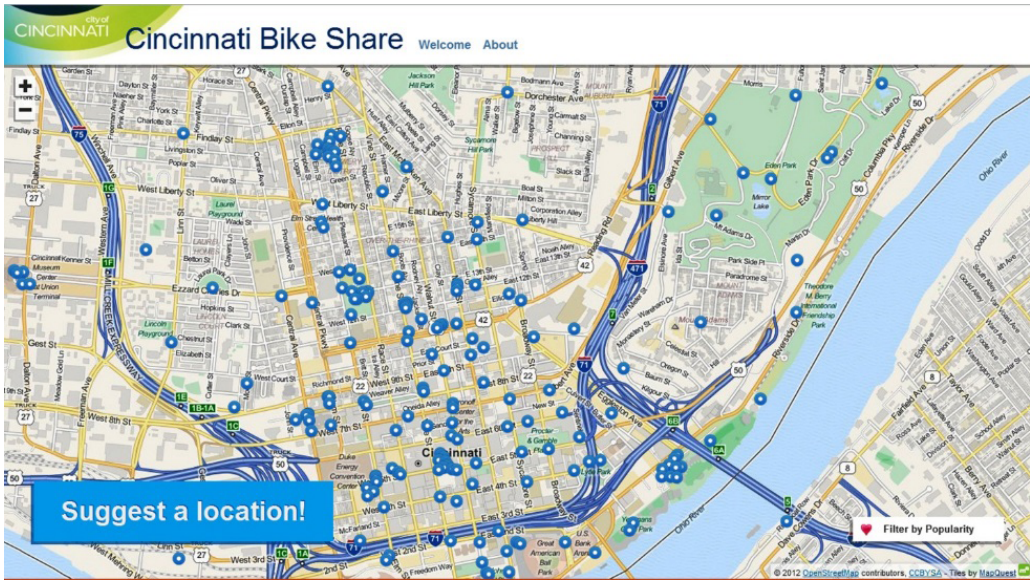

Figure 1. The City of Cincinnati's interactive GIS website interface.

The data collected through the crowdsourcing website was used primarily to identify desired locations for bike-share stations. Among the five main objectives of this plan, the crowdsourcing website informs two of them: (a) Evaluate the preparedness of Cincinnati and identify the most suitable areas for bike sharing and any obstacles that could impact success and (b) Identify an initial service area and size for a potential bike-share system from which to forecast expected demand, costs and revenues (Alta Planning + Design, 2012, p. 1). The project did not include other public participatory processes, relying completely on the online crowdsourcing tool. The crowdsourcing website was their main medium for collecting ideas and interests regarding the location of bike-share stations (Interview with professional 1, July 2014). Eight expert-based meetings with business owners and similar stakeholders were arranged. These meetings focused on exploring desired locations for bike-share stations, based on space need and availability, travel flow, businesses' needs, and community demands (Interview with professional 1, July 2014). These meetings did not involve the public, but instead focused on "expert" opinions about bike-share planning (Interview with professional 2, July 2014). Since the mayor funded the project, the City Council was not responsible to approve the project.

The feasibility plan was created in 2012 and the first phase of the stations were installed in 2014. Among 35 total stations suggested by the feasibility plan, 30 of them are now operational. Nineteen of these stations were located in the downtown area, 11 of them were located in the uptown area, with 60 percent of the suggested locations for bike-share stations in the first phase being implemented. A local non-profit organization was responsible for implementing the plan. One professional argued that various factors influenced the final installation locations of the bike-share stations, clarifying that "there are many demands on sidewalk right-of-way space: contiguous space for pedestrians, ADA requirements, benches, lights, man holes, hydrants, newspaper racks, parking meters, etc.…the final locations were the closest they could get based on these restraints" (Interview with professional 2, June 2015). Figure 2 shows the suitability analysis done as part of the feasibility study.

5. Methodology

This study employed mixed methods for data collection and analysis. Data collection methods included archival research and semi-structured interviews. Archival research was used for two purposes: collecting and digitizing suggested locations and comments, and collecting information regarding the Cincinnati bike-share feasibility plan. The locations suggested online, along with comments, were collected from the crowdsourcing tool manually, since the researchers did not have access to the data collected by the City[3]. The study conducted in-depth semi-structured phone interviews with the two project managers who were involved in using the tool and creating the plan: including a professional from a consulting firm, and another from the City of Cincinnati. Each interview took approximately an hour and explored several open-ended questions, including how and why the crowdsourced information was used in the feasibility study, how the value of the information was perceived, and whether and how the crowdsourced web-GIS tool was helpful. To respect the anonymity of the interviewees, no more information about their backgrounds can be revealed. The interviewees were selected because they were the two main professionals involved in using and implementing the crowdsourcing tool and incorporating the collected information in the feasibility plan.

[3] The City did not respond to the researchers' request to access their gathered data.

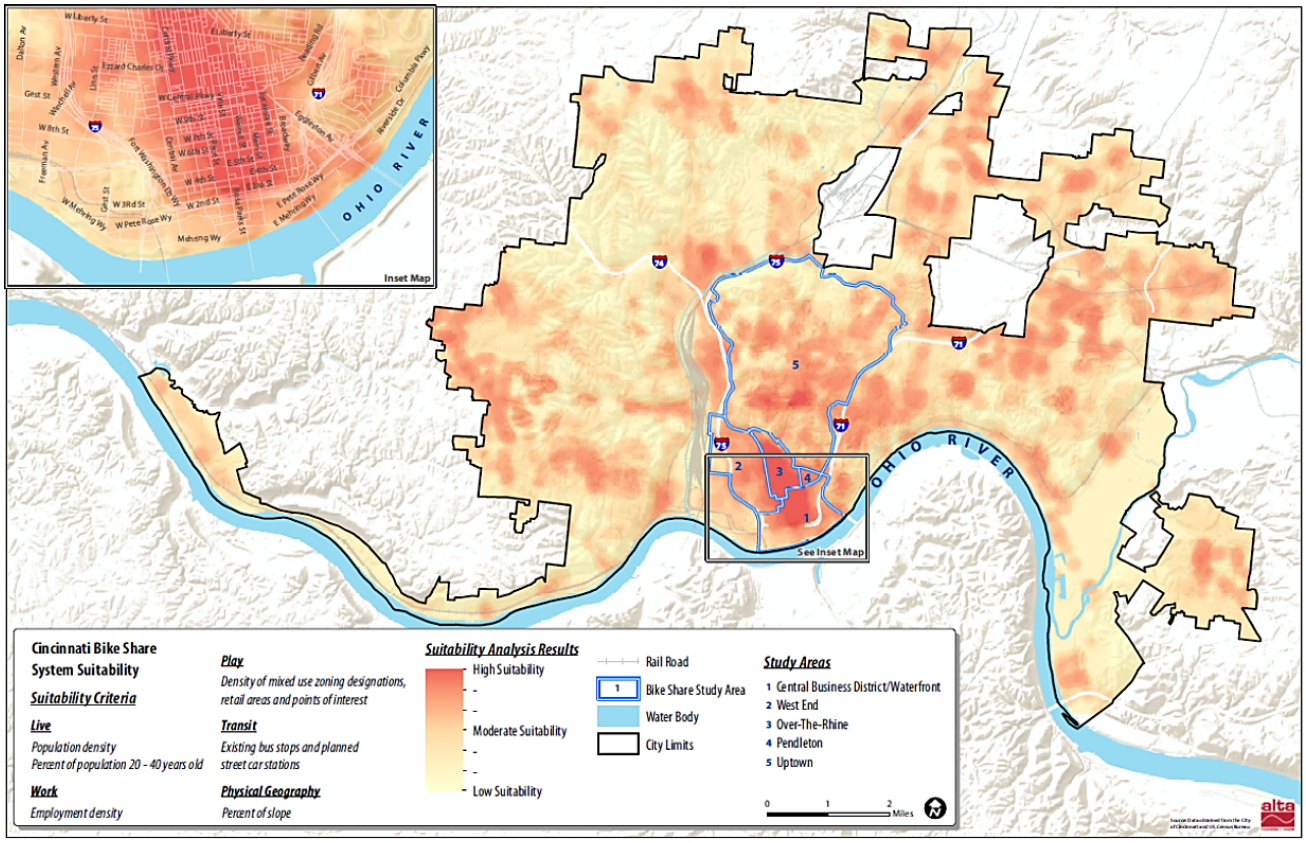

Figure 2. Suitability analysis for Cincinnati Bike-Share Feasibility Study (Alta Planning + Design, 2012, p. 29).

The other professionals involved in this project were not as familiar with the details of using the tool and crowdsourced data.

Data analysis methods included interpretive discourse analysis, spatial analysis, and content analysis. Spatial and content analysis were used to identify citizens' and the plan's suggestions for bike-share stations. They helped with exploring the first question of how the organizations use crowdsourced information, by providing a basis for comparing the crowdsourced information with the plan's suggestions. Qualitative interpretive analysis of the interviews helped with exploring the second question and to determine how the information was incorporated into the plan and how it could be used. The interview results were also used to provide background information about the project.

To explore why participants like or dislike having bike-share stations in the suggested locations, the study analyzed participant comments through a content analysis method. Considering comments as the unit of analysis, the study implemented content analysis to "interpret meaning[s] from the content of text data" (Hsieh & Shannon, 2005, p. 1277) by examining all the 503 comments qualitatively. This study used a content analysis software, NVivo, to find and categorize the repeated themes in the comments. The software computed the number of times each word or term was used and identified emerging themes. This provided a basis for the researchers to identify repeated words, such as "downtown", or "access", or themes such as "downtown access" and qualitatively define themes and sub-themes that explain the participants' reasons for suggesting the stations. The software was then used to review each of the comments and manually code them into an already identified theme (e.g. downtown access) or in new emerging themes or sub-themes that were identified based on the researchers' interpretation of the comments. Since the users' informal communication often used slang and contextual information, qualitative categorization was crucial to ensure the accuracy and comprehensibility of the analysis. The results on the content analysis were not software dependent, as all the comments were reviewed by the researchers.

To identify participants' most desired locations and areas for the placement of bike-share stations, spatial analysis methods were used: to identify clusters of suggested locations we used the Kernel Density tool in ArcGIS software[4]. Kernel Density is a spatial analysis method that creates heat maps by computing the density of each feature in a neighborhood around them. The resulting clusters and heat maps helped researchers visually and qualitatively examine whether the plan's suggested locations for bike-share stations were located within those clusters and overlapped with the online sug-

[4] We used "densities" as the output value in the Kernel Density tool. We accepted the other default factors suggested by Kernel Density tool, as the created heatmap was supposed to be used for a qualitative exploration.

gestions. These clusters can vary in size due to parameters that can be defined by the software, but in this study, the clusters were created only for visualization of the online suggestions and to qualitatively compare those clusters with the actual location of the implemented bike-share stations. All the spatial analysis, including overlaying the clusters of peoples' suggestions and the plan's suggested locations were produced in ArcGIS desktop.

The following criteria informed the case study selection for this research: (a) tool capability: the project uses a web-GIS crowdsourcing tool that allows a large crowd to express their ideas by locating points on a map, creating comments, explaining their intentions, and reasons for their suggestions; (b) plan completion: at the time of the study this was the only plan of its type that was developed and implemented, using a crowdsourcing tool accessible to public, which helped the researchers explore how the information gathered was used in plan creation; and (c) data: the data was geo-tagged, including point and text-based data. This helped the researchers examine how the organization used structured and unstructured crowdsourced data.

6. Analysis Results

This section discusses the results of the content and spatial analysis to explore why and where people like to have bike-share stations.

6.1. Content Analysis

Tables 2 and 3 show the content analysis results and report why people like to have bike-share stations in locations that they have suggested. The tables categorize peoples' reasons for having bike-share stations as themes, sub-themes, and groups. The numbers show percentage of the number of times that a theme, a sub-theme, or a group of comments is repeated. For example, only 1% of the online comments were related to "avoid parking fee", when people were talking about reasons for choosing locations for bike-share stations (See Table 2).

The majority of the participants (83.5 percent) report "accessibility" to particular locations as the main reason for suggesting a location for a bike-share station. This seems like an obvious response since users will want to be close to station locations for convenience as well as those with good access to desired destinations. Each of the themes above were also coded into sub-themes and groups, which are shown in Table 3.

The majority of comments that mentioned "accessibility" as one of the main reasons for suggesting a location for a bike-share station (34%) referred to having access to commercial locations such as restaurants or hotels. In the accessibility theme, downtown accessibility was the second most important reason for suggesting bike-share stations.

6.2. Spatial Analysis

This section builds on the results of spatial analysis to compare online and plan's suggested locations for bike-share stations. The heat map on Figure 3 shows the clusters and density of the suggested locations by people and the plan. Of course, these clusters could have been a bit smaller or larger, depending on the parameters we chose in computing the Kernel Density. However, the final result would not be different, as we were using these clusters for a qualitative comparison. As shown in Figure 3, the number of participant suggestions for bike-share stations are not only high in the downtown or business district area, but also in other neighborhoods up to four miles away from the downtown or business district. The suggested locations in the feasibility study highly overlap with participant suggested locations.

7. Using Crowdsourced Information in the Plan

Based on the Cincinnati Bike-share Feasibility Study and interviews with the project managers, the crowdsourced information was primarily used for identifying suitable locations for bike-share stations but not to explore why and how people are interested in particular locations. The plan's suggested locations for bike-share stations strongly overlap with the suggested locations by citizens. All of the plan's proposed locations are in the areas that were suggested by citizens or very close to their exact location. In addition, the areas suggested by the participants overlap with the heat map that was created as part of the suitability analysis for the Cincinnati Bike-share Feasibility Study (see Figure 2).

The feasibility plan does not directly refer to participant priorities or desired types of activities (e.g. access to parks, businesses, university, etc.). However, it provides a list of high-demand destinations in the study area based the feasibility analysis that includes reviewing participant comments. These included "Washington Park, Fountain Square, Findlay Market, the Purple People Bridge, Ludlow Avenue, Eden Park, Union Terminal, and Gov-

Table 2. Results of the content analysis categorized by themes.

Theme	Accessibility	Replace trips that would otherwise be made on foot	Avoid riding up the hill	To be Green	Negative effects on businesses	Avoid being stuck in traffic	Avoid parking fee
Percentage	83.50%	6.60%	4.10%	2.10%	1.30%	1.30%	1%

Table 3. Results of the content analysis categorized in themes, sub-themes, and groups.

Theme	Sub-Theme	Percentage of each sub-theme	Percentage of each group	Group
Accessibility	Access to Commercial Units	34.10%	8.9%	Access and proximity to businesses (general)
			4.5%	Access to a parking area
			5.2%	Access to a restaurant, cafe or a bar
			3.6%	Access to hospitals
			2%	Access to hotels and meeting centers
			3%	Access to or for a growing business district or new development
			1.3%	Findlay Market
	Downtown Accessibility	16.20%	6.5%	Access to Downtown/Business district
			5.8%	Access within the Downtown/Business district
			1.3%	Access from Downtown/Business district
	Access to College or University	8%	8%	Access to College or University
	Access to Public Services	9.30%	3.7%	Access to a bus stop or a metro station
			2%	Access to bike trails and paths
			2%	Access to Municipality City Hall Court
			2%	Access to cemetery
	Access to Park and Recreation	17.80%	3%	Access to cultural activities and sports
			2.4%	Access to fountain square
			9.5%	Access to parks
	Access to Offices	3%	3%	Access to offices
	Access to Neighborhoods	9.30%	6.3%	Neighborhood and community access (general)
			1.5%	Access to New Port
Replace trips that would otherwise be made on foot			2.6%	Helps people bike instead of walk
			1.5%	To park and walk from here
Riding up the hill			1.3%	Riding up the hill
To be Green			1.3%	Reduce car use
			0.8%	Being Green
Negative effects on businesses			6.7%	Negative effects on businesses
Avoid being stuck in traffic			0.8%	Avoid being stuck in traffic
Avoid parking fee			1.3%	Avoid parking fee

ernment Square, etc. and sites on the University of Cincinnati campus, along McMillan/Calhoun, the Banks, Coffee Emporium, the Cincinnati Zoo, Duke Energy Convention Center, Lytle Park, the Great American Ballpark, and at major employers such as Procter & Gamble and Hewlett Packard" (Cincinnati Bike-share Feasibility Study, Alta Planning and Design, p. 31). This list introduces various types of destinations identified in our study, such as access to the university, downtown, public services, or parks, which also correlate with the participants' suggestions.

On the other hand, some of the suggestions for new stations were dismissed in the feasibility study. A number of these suggested stations were ignored due to lack of adequate open or public space for station implementation. However, the majority of these stations were located in residential neighborhoods outside of this phase of the feasibility study, which is the main reason these suggested locations were not selected (Interview with professional 1, July 2014).

The participant's text-based comments were reviewed without using any particular analytical methods to assess the reasons why participants suggested the locations. However, there was no direct reference to these comments in the plan.

8. Discussion: Using Crowdsourced Information

In this section, we draw upon the literature, the results of the interviews, spatial analysis, and content analysis to discuss how the crowdsourced information was used, and suggest factors that can be considered for its effective use.

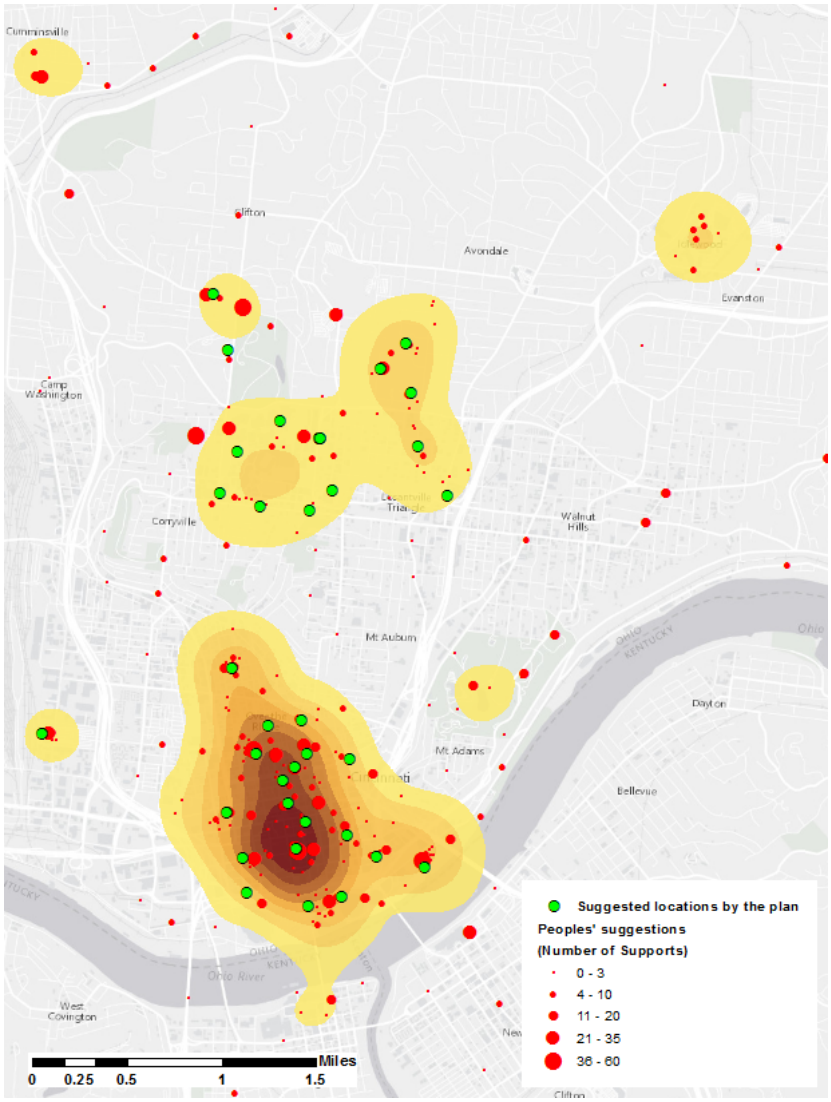

Figure 3. The relationship between suggested locations by participants and the plan.

8.1. New and Unexpected Information

The planners believed that participant-suggested locations in the study area were not different from the locations planners would choose without citizen online participation. Therefore, they did not find the crowdsourced information revealing.

However, the bike-share planning team received some unexpected input that they considered to be valuable. These inputs included considerable interest in having bike-share stations in residential neighborhoods outside of the primary area that was originally defined by the project. Learning about the interest pushed the planning team to more seriously consider this idea in the next phase of the bike-share system expansion (Interview with Professional 1, July 2014).

The planners could have learned more about unexpected information by using the content analysis methods from our analysis. For example, the content analysis could have helped them understand priorities in gaining access to destinations or services. Based on our interviews, the planners did not know whether people were more interested in using bike-share stations to access the University of Cincinnati or parks and recreation areas.

8.2. Information Gathering and Use

The professionals were satisfied with the capability of the crowdsourcing tool in gathering geotagged information from a relatively large crowd, especially since they could easily integrate it with their datasets.

The professionals had different ideas about the value of using the online information. While one professional used the information to learn about participant interests, the other professional used the information mainly to validate the feasibility study process. The second professional argued that the main value of the online comments was to validate the planning process by showing that they have conducted a participatory process:

> The most useful thing was having a map and say here we did public participation…The actual data was not

> used much. The outreach was the most important…It was a great way to reach a large number of people. But, still good that those people feel they are part of the process…nobody wants to be responsible for a fail process. It was helpful for validating [our planning process]. (Interview with Professional 2, July 2014)

In addition, the crowdsourced information was helpful for the planning team to make sure that their ideas were consistent with participant comments and suggestions, especially with a large crowd. As the first professional argued, while the gathered information was not much different from what they already knew, it was still valuable to the planning team to make sure that their plan corresponds with user needs or desires.

The professionals could have enriched the information gathering process by combining the crowdsourcing approach with more traditional participatory methods (e.g. public meetings) to engage the public. In addition, our study shows a need for educating professionals about the value of public engagement and the ethical concerns of dismissing it.

8.3. Information Evaluation

We found that the planners did not evaluate the quality and credibility of the information. For example, several suggested locations belonged to one online participant who expressed her objection regarding the location of more than twenty of the stations suggested by other participants. Our interview with the two project managers indicated that they were not aware of such action since they did not analyze the text-based comments.

Anonymity of the online participants introduced other concerns in the use of the crowdsourced information, especially since the online crowdsourcing tool was used as the main medium for soliciting public input. Although the interviewees preferred to have access to the participants' demographic information, they were satisfied that they had not asked for such information since it may have reduced the number of participants. Although both planners considered the quantity of crowdsourced information to be valuable, there is still a question of representativeness: to what extent this information represents the overall community and the public interest?

8.4. Analysis and Facilitation

In our assessment, the professionals could have used the text-based data more effectively. Their analysis did not consider participant's suggested priorities in detail. For example, the content analysis results showed that having access to the downtown area from other parts of the town is only one of the five most desired suggestions made by the online participants. However, the plan was still focused on the downtown area and uptown accessibility without discussing the accessibility to other parts of the city mentioned by the online participants. Based on the interview results, the planners did not use content analysis methods or tools (e.g. NVivo) for various reasons, such as lack of resources—especially time and staff—lack of experience with analyzing text-based content, and lack of belief in the value of structured analysis of online comments.

This study does not argue that the online comments should be fully incorporated in the plan; instead it reveals that conducting structured methods or tools for analyzing the textual data could show patterns that planners may find useful. For example, using content analysis methods could help the planners identify objections about implementing bike-share stations in particular locations. Based on our case study, conducting the analysis by using only the geo-tagged points may lead to false analysis since some of the geo-tagged points are about rejecting a location for a new station and not supporting it. Furthermore, content analysis could help the planners learn about why people were interested in bike sharing. As our analysis results showed some of the comments revealed interest in the use of bike-share because of their interest in being "green" or walking more.

While both of the project managers had access to the online tool, none of them were involved in facilitating online participation by providing information or responding to questions. Both planners believed that facilitating the online participation was not their priority due to their limited resources.

8.5. Education and Attitude

A planner's knowledge and attitude can influence how crowdsourced information is used. While technical expertise matters in ways in which the information can be analyzed, perception and attitudes towards the use of the information was important too. For example, one of the interviewees believed that citizens' online comments were generally not as useful as the suggestions made by experts due to the citizens' lack of knowledge about the topic. Here is how Professional 2 perceived the value of the online comments:

> Stakeholder [expert-based] meetings were more useful, since people were on the ground...Online feedback had a lot of personal bias…[expert-based] meetings were better…Anytime when you have meeting with people, you get some useless information. But, in your stakeholders meetings they are experts. Stakeholders have more realistic information about where people are travelling…a lot of people [who participated online] were living [somewhere] in the city that was 20 minutes far from downtown. So, you get comments from people that do not know about traffic patterns in downtown.

Appropriate use of crowdsourced information does not only require providing technical education for planners and professionals. We suggest that professionals should

also learn more about the value of using local knowledge in planning and what it adds to expert-based knowledge.

9. Conclusions

Using crowdsourced information in planning processes was related not only to the quality and relevancy of the information, but to other factors such as the organizations' capability of analyzing the information, planner's perceptions of the value of the information, and the planner's attitude towards allocating resources for using the tools and information. This study contributes to the literature on the use of crowdsourcing methods in planning and policy, by discussing various factors that could be considered in using crowdsourced information.

Using qualitative content analysis methods can be resource intensive for planning organizations. It requires time, skilled staff, and financial resources. Planners may consider the type of data they collect by using these technologies before they start using them. Some of the more recent tools provide summary statistics results of the participation or create categories of comments for decision makers. These tools can help planners analyze the comments more quickly and easily.

Considering the role of planners in making plans, it is important to explore how planners and policy makers should be prepared to effectively incorporate new technologies into their projects or plan making processes. It involves educating planners and professionals. Learning about effective uses of crowdsourced information, requires planners' attention to institutional or contextual issues, such as online facilitation, information quality, and technical skills of planners and communities.

Particularly, issues of representativeness and digital literacy should be considered. Although allowing people to participate without registration may help with attracting more participants, it raises concerns. For example, using crowdsourced information that lacks data on the socio-economic background of the participants raises questions about the validity and representativeness of this information.

Professionals' use of crowdsourced information can create ethical concerns about ways in which public participation and knowledge is being used or misused in planning processes. For example, as we saw in this case study, one of the planners used the crowdsourced information mainly to advocate for their interests. While using new participatory technologies can facilitate planning and decision-making by providing valuable information for planners and easier participation for citizens; it can lead to disengagement if they are used instrumentally to legitimize pre-determined elements of a plan.

Due to the focus of this study on a single case, and interview of a small number of professionals, the generalizability of the results should be interpreted cautiously. Different professionals have different skills, perceptions, and attitudes towards using new technologies, data sources, or information in their projects.

The current literature on using crowdsourcing technologies for online engagement has a strong focus on issues of data quality and analysis. It lacks a clear understanding of the effects of organizational behavior on technology and information use in planning processes. With the rapid advancements in the development and adoption of these technologies, planning organizations will have more access to data about citizens' needs and interests. Future studies are needed to explore the use of crowdsourced data in different types of plans and by various types of organizations, focusing on perceptions and attitudes of planners towards using these data.

Conflict of Interests

The authors declare no conflict of interests.

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Article

Sustainable Cities and Healthy Cities: Are They the Same?

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Abstract
There is robust literature examining the wide array of public policies and programs cities pursue in order to try to become more sustainable. Whether the focus of such programs is explicitly on improving the bio-physical environment, climate protection and adaptation, energy efficiency, land use regulation, or any of a number of other targets, such programs often carry with them an expectation that the programs will contribute to improve the health of populations. While there is significant attention to asserting that such a relationship exists, or ought to exist, there have been no efforts to explicitly and empirically link city policies to health outcomes. This paper tackles this issue head-on, investigating the extent to which cities in the US that have the most aggressive sustainability initiatives exhibit better health outcomes than cities with less aggressive sustainability initiatives. Using data from the largest cities in the US, this paper presents evidence concerning the strength of this relationship, discusses the foundations for the relationship, and provides a discussion of the implications for urban planning, sustainability policies and for improving the health of populations.

Keywords
healthy cities; obesity; smart cities; sustainability; sustainability index; sustainable cities

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1. Introduction

An exhaustive amount of research exists on the connection between specific environmental exposures and lifestyle choices (Tremblay et al., 2011; van der Horst et al., 2007) and certain health outcomes. There also exists literature reviewing the implementation of sustainable policies within cities in the United States (Portney, 2013; Portney & Berry, 2010). However, there is a dearth of projects exploring the connection between sustainability policies and population health within major US cities. There is little doubt that a central rationale underlying the sustainability programs and initiatives in cities is rooted in some conception of public health. What we mean by this is that advocates of urban sustainability often offer the argument that by pursuing sustainability policies, cities will improve the health of their populations. The dominant view of sustainability, of course, is related to the quality of the biophysical environment, and cities' policies in pursuit of sustainability promise to improve that environment. But many advocates of urban sustainability go beyond efforts to protect and improve that environment, suggesting that the ultimate purpose is to improve the health and wellbeing of cities' respective populations.

Curiously, while there are many studies of cities' sustainability policies and programs, there are very few efforts to empirically tie these policies to the health of the population. Likewise, public health interventions that have been implemented to improve the health status of certain populations have typically not pursued sustainability programs as possible avenues for improving con-

ditions. In short, we know much more about why some cities are more likely to pursue sustainability policies than we know about what these policies achieve. This project sets to explain the conceptual connections between sustainability policies and programs on one hand and the health of the population on the other. We then examine the empirical patterns of relationship between sustainability and population health across the largest cities in the U.S. Far from being definitive, this paper seeks to begin a conversation about what the health of the population will look like as well as what results seem to be produced when cities adopt and implement sustainability policies. This research specifically examines the prevalence of obesity within urban centers as a public health concern as curbing the rise in obesity has proven to be particularly challenging when utilizing standard public health intervention strategies (Segal, Rayburn, & Martin, 2016, pp. 108–116). Embedded in this is a call for better city-specific measures of health statistics to facilitate future research.

2. Sustainability as a Strategy for Addressing Current Chronic and Degenerative Diseases

The idea that sustainability can be an appropriate vehicle for advancing public health interventions and the health of populations is certainly not new. Although earlier conceptions of this linkage focused mainly on the pursuit of sustainability as a way of reducing exposures to environmental hazards and toxics, more recent conceptions have been somewhat more expansive. The silver lining for many chronic ailments—such as cardiovascular disease, cancer, stroke, and diabetes—is that they are often preventable through nonclinical lifestyle changes (Penedo & Dahn, 2005; Sato, Nagasaki, Nakai, & Fushimi, 2016). However, there are serious conditions, both chronic and acute, that are associated with environmental exposures. Many residence of environmental justice communities, areas in which pollution is ubiquitous, find that they cannot avoid exposures to these pollutants as they are continuously present in the places they live and work (Bryant, 1992; Bullard, 2000; Morello-Frosch, Pastor, & Sadd, 2001). The goal of adopting sustainable policies should explicitly address environmental and public health concerns to create healthier populations.

The rise in obesity rates within the United States paints a concerning picture for the future health of citizens. While obesity itself is not a health condition, research has shown that obesity is highly correlated to a number of expensive and potentially debilitating diseases, such as type II diabetes and colon cancer, in additional to emotional and social harm (Mokdad et al., 2003; Scott et al., 2008). Many factors have contributed to the rise of obesity in the western world. Lifestyle changes, such as living a sedentary lifestyle and overconsuming calorie dense foods, have become more common and have been shown to be linked to obesity (Manson, Skerrett, Greenland, & VanItallie, 2004). Further, the genetic composition of individuals can increase, or decrease, the risk of obesity (Barness, Opitz, & Gilbert-Barness, 2007). In one cross sectional study using a nationally representative sample, researchers Kirby, Liang, Chen and Wang (2012) found that demographic information, such as race, sex, and employment type, showed a marked difference in obesity rates. Despite a large and growing body of literature no efforts have been successful in stopping this increasing trend on a national, state, or community scale. The failure of standard approaches to health interventions is illustrative for the need to adopt a new approach with sustainability in mind.

The connection between the pursuit of sustainability and achievement of public health goals in American cities has been well documented. Arguing that the connection is finding its way into practice, for example, Jason Corburn (2009) describes how the city of San Francisco has made significant strides in planning for sustainability in a way that readily accommodates public health and healthy living goals. His vision is that decentralized and resident-engaged planning facilitates the goals of achieving a more sustainable and equitable biophysical environment and public health outcomes.

Under the guidelines proposed by Corburn (2009), a more inclusive approach that positively connects the scientific, social, and political institutions will move towards healthier citizens. This includes improving policies, and interventions, with the benefit of local knowledge through community-based organizations and local residents. Therefore, healthy city planning should be viewed as healthy urban planning and readily connect the two into a more holistic approach to improve the health and lives of communities.

3. Sustainable Cities in the U.S.

The concept and practice of sustainable cities has been well researched in the U.S. Over the last 20 years, many cities have created significant sustainability plans, often as a result of their long-term strategic planning processes. By one estimate, by 2015 at least 50 of the largest 55 cities operate under a sustainability plan (Portney, 2013, p. 23). Most such cities engage in making public policies and managing city programs in ways that are consistent with trying to achieve greater sustainability, environmental quality and equity, and energy efficiency. Cities that seem to take the pursuit of sustainability more seriously have been shown to engage in efforts to plan and implement policies on renewable energy and climate protection, public transit, waste reduction, water conservation, protection of environmentally-sensitive land, green building, and dozens of other programs. Many of these cities, particularly in the context of cities' sustainability indicators initiatives, implicitly include efforts to measure a variety of public health outcomes. In many cities, specific programs have been created to affect public health outcomes, from reducing exposures to toxics through asbestos and lead paint remediation, to encour-

aging exercise through bicycle ridership programs, to promoting locally-grown produce through community gardens and farmers markets, and many other programs. We refer to these as implicit health programs because the connection between the programs and public health or nutrition is rarely discussed. There are a few notable exceptions. As noted earlier, Corburn (2009) has documented such efforts in San Francisco. Sustainable cities programs with implicit public health content have been made in a wide array of cities including Seattle, Portland, New York City, Philadelphia, Chicago, Los Angeles, and many others. Indeed, some sustainability plans adopted by cities contain explicit chapters dedicated to achieving targeted public health outcomes.

The idea that when cities pursue sustainability as a matter of public policy they are effectively improving the health of their populations is tantalizing. While there is evidence that sustainability policies do in fact protect and improve the quality of the biophysical environment, neither the policies nor the environmental outcomes have been shown to be related to public health. Despite the logic of the expectation that these should be related, the evidence is lacking. So this analysis examines the simple hypothesis, implied by the logic, that U.S. cities electing to aggressively pursue sustainability policies and programs have healthier populations than cities electing not to pursue sustainability. Specifically, we expect sustainable cities to have smaller numbers of people with chronic health problems.

4. Examining the Largest Cities in the United States

The analysis presented here examines the empirical linkages between city sustainability policies, programs, and outcomes on one hand and public health outcomes on the other. The focus here is on the largest U.S. cities. The 55 largest U.S. cities, for which we have a sustainability policy and one public health outcome measure, collectively have approximately 15 percent of the population of the U.S. These cities and designated subsets provide the basis for assessing the empirical relationships.

4.1. The Dependent Variables: Chronic Health Outcomes

Measuring public health outcomes for cities presents a significant challenge. Very little city-specific data are available. The local data that are available tend to be for counties or for metropolitan areas rather than cities per se. For the purposes of this analysis, we rely on two measures of chronic public health issues. The first of these is the percentage of the adult population with body mass indexes (BMI) higher than 30 in 2013, representing a measure of chronic obesity, in the county where the city resides. The second, also a measure of obesity and related issues, is an independent "Fattest Cities in America" Index created and reported by WalletHub for the largest 100 metropolitan areas (Bernardo, 2017). This index utilized obesity prevalence data collected through the Center for Disease Control and Prevention (2017) Behavioral Risk Factor Surveillance System Survey initiative and The University of Wisconsin Population Health Institute (2017) "County Health Rankings & Roadmap". This index uses several dimensions, including obesity, weight-related health problems, and environmental conditions. We use these "Fattest Cities in America Index" scores for the metropolitan areas containing 54 of the 55 largest U.S. cities (no Index value is reported for Fresno, California). This Index is a composite of some 17 specific indicators derived from a variety of official sources, including the percent of overweight and obese adults, teenagers, and children, projected obesity rates, percent of adults who are physically active, who eat fewer than one serving of fruits and vegetables a day, who have high serum cholesterol, high blood pressure, and heart disease. It also includes three indicators of healthy lifestyles. These indicators are weighted and combined into a single index score for each metropolitan area where the "fattest city" (Jackson, Mississippi) has a score of 84.93 and the least fat city (Seattle-Tacoma-Bellevue, Washington) has a score of 51.93. Among the 54 cities analyzed here, the "fattest" is Memphis, Tennessee (the second fattest city overall) with a score of 82.78, and the leanest is Seattle.

These county and metropolitan area data are but an approximation of the health of the residents of the city, but do provide at least some insight into the health of the people in the respective areas. For the BMI measure, we simply obtained information for the county (or largest county) in which each city exists. Some cities, such as Philadelphia, are coterminous with the county. Many others, such as Jacksonville, Florida, or Boston, Massachusetts, have counties that are only slightly larger than the cities themselves. A small number of cities are split between two or three counties, and for the purposes of this analysis, we used health data for the largest county. A few cities share a county, such as Los Angeles and Long Beach, California, both of which are in Los Angeles County, and Arlington and Fort Worth, Texas, both of which are in Tarrant County. In these cases, both cities are characterized by the same county data. And New York City consists of multiple counties or boroughs, so the BMI data for this city represents an average across all the boroughs. The correlation between these two measures across all 54 cities is .673 (significant at the .000 level), indicating that they are likely measuring a common underlying health condition.

4.2. The Independent Variables: City Sustainability Policies and Results

The estimation of the effects of city sustainability on public health outcomes requires measures of urban sustainability. Here we rely on three independent measures. We employ three measures for the simple reason that this represents a safeguard against the empirical results being an artifact of a single measure, or of a particular group of cities for which any particular measure is avail-

able. First, we rely on the Sustainable Cities Policies Index created by and reported in Portney (2013), computed for the 55 largest U.S. cities based on the policies and programs of cities in 2011. This Index focuses on measuring the amount of public policy effort cities make in the pursuit of sustainability, and does not attempt to measure any outcomes from those policies. It represents a composite additive index of the number of some 38 different specific sustainability-related policies or programs that each city has adopted and implemented. These index values range from 7 in Wichita, Kansas to 35 in Seattle, Washington, Portland, Oregon, and San Francisco, California. In other words, Seattle, Portland, and San Francisco have adopted and implemented 35 of the 38 possible programs and policies, while Wichita has adopted and implemented on 7.

Two additional measures of sustainability are included here despite the fact that these are reported for smaller numbers of cities. These are included in order to provided added evidence that the Sustainable Cities Policies Index measure has some level of validity, and the results that follow are not simply an artifact of this Index. So the second measure of sustainability is the Siemens Green Cities Index (Economist Intelligence Unit, 2011), measuring both environmental quality and city commitment to sustainability programs, for 21 large U.S. cities. This Index, reported for the year 2011, measures a mixture of 30 different environmental quality and sustainability program characteristics. The overall Green City Index values range from 83.8 in San Francisco to 28.4 in Detroit, and provide relative assessments of how well each city performs on some 16 different categories including carbon emissions, energy consumption, land use, building efficiency, transportation efficiency, water quality, waste, air quality, and environmental governance. Higher values represent better environmental performance.

Third, we include the SustainLane Sustainable Cities Score for 2007, measuring characteristics of the natural and built environment, for 49 large U.S. cities. The SustainLane Indexes were computed for large metropolitan areas based on 15 different measures of the quality of the environment and the quality of life in an effort to measure in an objective way how sustainable cities are (Karlenzig, Marquardt, White, Yaseen, & Young, 2007). The resulting index includes air quality, city innovation, commuting to work, energy consumption and conservation, green building, affordable housing, local food and agriculture, traffic congestion, risk of natural disasters, water quality, and other characteristics. Among the fifty cities, Portland, Oregon had the highest sustainability score (85.08), and Columbus, Ohio the lowest (32.5).

Table 1 provides a side-by-side comparison of what the three measures of the key dependent variable, sustainability, take into consideration. These three measures are quite closely correlated, as shown in Table 2. Since the Siemens Index is reported only for 21 of the largest U.S. cities, and the SustainLane Index is reported for only 49 cities, these correlations are based on the smaller number of cities rather than the full group of the 55 largest cities. Analysis of the Sustainable Cities Policies Index, presented later, is based on the full set of the 55 largest cities (54 cities when the "Fattest Cities in America" Index is used as the dependent variable). These high correlations among the three sustainability measures provide strong evidence that they are all measuring the same or a very similar underlying dimension of sustainability, and that there is a high degree of validity to each sustainability measure.

5. Analysis

The expectation that these measures of city sustainability should be related to public health outcomes is examined in Table 2, which reports the bivariate correlations. It is immediately evident that these correlations are extremely high for all three measures of sustainability and both measures of public health. Among the cities studied here, there is a very strong tendency for those with aggressive sustainability programs and efforts to have considerably healthier populations with respect to obesity. Clearly, the results are not dependent on the measure of sustainability. Whether measured by the Sustainable Cities Policies Index for all 55 cities, or just the 21 cities included in the Siemens Green Cities Index, or the Green Cities Index itself, or the SustainLane Index, the patterns represented by the bivariate correlations is the same. Cities that are more aggressive in the pursuit of sustainability demonstrated better outcomes on the two measures. The scattergram in Figure 1 makes the bivariate relationship between the Sustainable Cities Policies Index and the percentage of the adult population with a BMI over 30 very clear. There is little question that among the 55 largest U.S. cities, those that have made policy commitments to the pursuit of sustainability have adult populations with lower obesity rates.

The bivariate analyses provide strong hints that sustainable cities programs may well be linked to public health outcomes. However, this relationship could simply be the result of a set of spurious relationships where both the health outcomes and the sustainability programs are the result of other influences. Before making an inference that sustainability programs contribute to positive public health outcomes, an effort needs to be made to rule out possible basic spurious influences. The analysis here focuses on several specific population characteristics that might play a role. These characteristics are the level of income, here measured as per capita income in 2009, the proportion of the population that is 65 years of age or older, and the percentage of the population that is African American. Each of these characteristics could represent a spurious influence on the obesity outcomes. While many demographic variables have been shown to be associate with increased rates of obesity; race, socioeconomic factors, and age are the primary drives that could be adjusted for within

Table 1. Comparison of three measures of city sustainability.

Sustainable Cities Policies Index Has the city adopted and implemented a policy to:	**Siemens Green Cities Index** At what level is the city's:	**SustainLane Sustainable Cities Score** At what level is the city's:
1. Pursue targeted or cluster green economic development	1. Total CO_2 emissions per dollar of GDP	1. City commuting to work
2. Develop and eco-industrial park	2. Total CO_2 emissions per capita	2. Regional public transit ridership
3. Re-develop at least one brownfield	3. CO_2 emissions strategy	3. Metropolitan street and freeway congestion
4. Develop eco-villages, urban infill housing, or transit oriented housing	4. Total electricity consumption per dollar of GDP	4. Air quality
5. Use zoning to delineate environmentally sensitive growth or protected areas	5. Total electricity consumption per capita	5. Tap water quality
6. Plan land use comprehensively to include environmental issues	6. Commitment to promoting green energy	6. Solid waste diversion
7. Provide tax or fee incentives for environmentally-friendly development	7. Standardized percent of city area devoted to greenspace	7. Land use planning
8. Operate or sponsor intra-city mass transit	8. Population density (number of inhabitants per squarer mile)	8.City innovation
9. Place limits on downtown parking	9. Commitment to improving amount of greenspace	9. Housing affordability
10. Create intra-city HOV car pool lanes	10. Commitment to containing urban sprawl and brownfield redevelopment	10. Natural disaster risk
11. Establish alternatively-fueled city vehicle program (green fleet)	11. Number of LEED-certified green buildings	11. Energy and climate change policy
12. Create a bicycle ridership or bike-sharing program	12. Requirement for energy audits and monitoring	12. Local food and agriculture availability
13. Establish a household solid waste recycling program	13. Commitment to retro-fitting building for energy efficiency	13. Green economy
14. Provide industrial recycling	14. Commuting to work with public transit, walking, or biking	14. Knowledge base and communications
15. Create hazardous waste recycling program	15. Commitment to providing public transit options	15. Green building
16. Operate an air pollution reduction program (e.g. VOC reduction)	16. Average commute-to-work time	
17. Mandate recycled product purchasing by city government	17. Commitment to public transit incentives	
18. Create a superfund (non-brownfield) site remediation program	18. Total water consumption in gallons per person per day	
19. Engage in asbestos abatement	19. Amount of water leakage	
20. Conduct lead paint abatement	20. Commitment to water quality from main water sources	
21. Reduce pesticide use (integrated pest management)	21. Stormwater management plan	
22. Create urban garden/ sustainable food system or agriculture program	22. Amount of solid waste recycled	

Table 1. Comparison of three measures of city sustainability. (Cont.)

Sustainable Cities Policies Index Has the city adopted and implemented a policy to:	**Siemens Green Cities Index** At what level is the city's:	**SustainLane Sustainable Cities Score** At what level is the city's:
23. Mitigate the heat island effect	23. Commitment to waste reduction	
24. Green building program	24. NOx emissions per person per year	
25. Green affordable/low income housing program	25. SO_2 emissions per person per year	
26. Commit to renewable energy by city government (renewable energy portfolio)	26. PM10 emission per person per year	
27. Create an energy conservation program	27. Commitment to air emission reduction	
28. Offer alternative (renewable) energy to consumers	28. Commitment to green action plan	
29. Conserve water	29. Extensiveness of environmental management	
30. Operate a sustainability indicators project in the previous five years	30. Involvement of general public in monitoring environmental performance	
31. Assess progress toward achieving indicators within previous five years		
32. Create an action plan to achieve sustainability indicators		
33. Establish a single city office, agency, or person responsible for implementing sustainability initiatives		
34. Integrate sustainability goals into a citywide comprehensive or general plan		
35. Involve city, county, and metropolitan planning council in sustainability decisions		
36. Explicitly involved mayor/chief executive officer in sustainability decisions		
37. Involve the business community in sustainability decisions		
38. Involve the general public in sustainability planning		

this analysis (Wang & Beydoun, 2007). Geographic regions have been shown to produce disparate rates of obesity, a phenomenon this analysis hopes to further understanding in. Individual-level data, such medical or job history, was outside the ability of this ecological research. Cities with higher incomes, with smaller African American populations, and with larger elderly populations should have better health outcomes—smaller numbers of people with high BMI and better scores on the "Fattest Cities" index. Minority status was included in the analysis as research has shown that lifestyle factors, especially those that promote obesity, may be more likely to impact African Americans compared to their white counterparts (Lin & Kelsey, 2000). Further, health outcomes associated with obesity, such as type 2 diabetes, are more prevalent in the African American community (Signorello et al., 2006). Our expectation is that controlling for these factors, cities that have more aggressive sus-

Table 2. Bivariate correlations between Sustainable Cities measures and Health Outcomes measures.

Sustainable Cities Measures	% of adults with BMI over 30 (2013)	"Fattest Cities in America" Index (2016)
Sustainable Cities Policies Index (2011)	−.452** (n = 55 cities)	−.356** (n = 54 cities)
Siemens Green Cities Index (2011)	−.356** (n = 21 cities)	−.405* (n = 21 cities)
Sustainable Cities Policies Index (2011) for 21 Siemens Cities	−.637** (n = 21 cities)	−.414* (n = 21 cities)
SustainLane Sustainable Cities Index (2007)	−.521* (n = 49 cities)	−.628** (n = 49 cities)

*p < 0.05; **p < 0.01

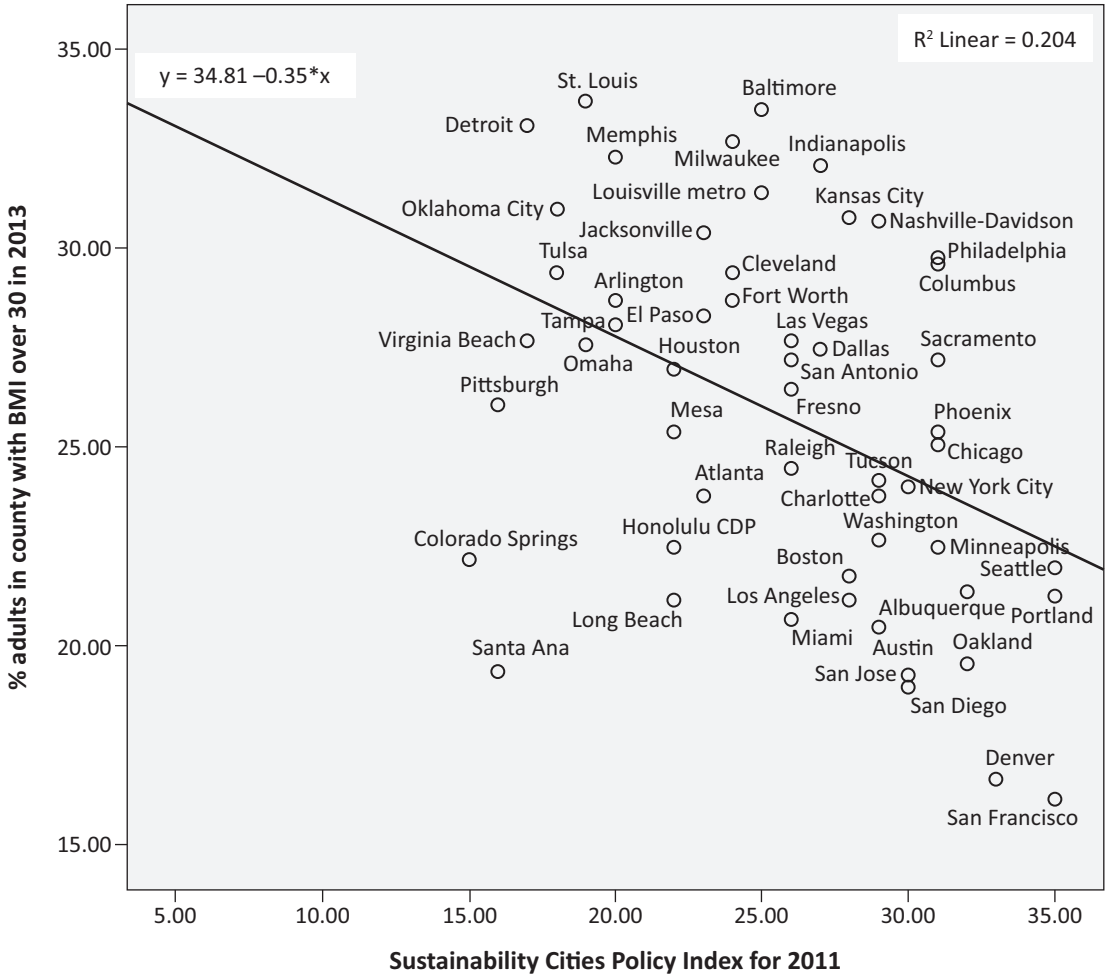

Figure 1. Scattergram showing the relationship between the Sustainable Cities Policies Index and the percent of adults with BMI over 30 for the 55 largest U.S. cities.

tainability policies will continue to present better health outcomes.

Tables 3 and 4 provide the results of ordinary least squares regression analyses. Table 3 presents three sets of regression results where the dependent variable is the percentage of people with BMI over 30. Table 4 presents regression results using the Fattest Cities index value as the dependent variable. Explanatory variables account for measures of city sustainability, per capita income, the size of the African American population, and the size of the elderly (65 years and older) population. Each table presents three models where Model 1 uses the Sustainable Cities Policies Index, Model 2 uses the Siemen's Green Cities Index, and Model 3 uses the SustainLane Sustainable Cities index as alternative explanatory variables.

Table 3. OLS regression results showing the effects of sustainability on obesity levels (percent with BMI over 30) in large U.S. cities.

Independent Variables	Model 1		Model 2		Model 3	
	β (SE)	Standardized Beta	β (SE)	Standardized Beta	β (SE)	Standardized Beta
Sustainable Cities Policies Index	**–.172 (.08)**	**–.221****	—	—	—	—
Siemens Green Cities Index	—	—	–.084 (.088)	–.262	—	—
SustainLane Sustainable Cities Index	—	—	—	—	**–.114 (.039)**	**–.318****
Percent African American population	**.106 (.024)**	**.416****	.082 (.045)	.358	.094 (.023)	.378**
Percent Aged 65 or older	.146 (.172)	.079	–.178 (.246)	–.098	.143	.072
Per capita income	**.000 (.000)**	**–.406****	.000 (.000)	–.378	.000 (.000)	–.414**
Constant	34.6** (3.04)	—	35.7** (5.6)	—	36.7** (2.9)	—
Adjusted R^2	.537**		.639**		.616**	
N	55		21		49	

*p < 0.05; **p < 0.001

Table 4. OLS regression results showing the effects of sustainability on obesity levels (Fattest Cities in America Index) in large U.S. cities.

Independent Variables	Model 1		Model 2		Model 3	
	β (SE)	Standardized Beta	β (SE)	Standardized Beta	β (SE)	Standardized Beta
Sustainable Cities Policies Index	–.203 (.168)	–.155	—	—	—	—
Siemens Green Cities Index	—	—	.090 (.192)	.180	—	—
SustainLane Sustainable Cities Index	—	—	—	—	**–.309 (.078)**	**–.484****
Percent African American population	.077 (.051)	.179	.125 (.099)	.352	.070 (.047)	.158
Percent aged 65 or older	–.624 (.363)	–.205	**–1.22 (.538)**	**–.433***	-.277 (.380)	–.079
Per capita income	**–.001 (.000)**	**–.397****	**.000 (.000)**	**–.486***	**.000 (.000)**	**–.292****
Constant	89.1** (6.49)	—	79.1** (12.2)	—	93.6** (6.0)	—
Adjusted R^2	.294**		.290*		.514**	
N	54		21		49	

*p < 0.05; **p < 0.01

These regression results provide additional evidence of the possible connection between city sustainability and the obesity measures by ruling out possible spurious or alternative explanations. OLS regression results are presented here for ease of interpretation.[1] In Table 3, controlling for the demographics, the Sustainable Cities Policies Index and the SustainLane Sustainable Cities Index are both negatively significantly related to the percent of the adult population with a BMI above 30. Cities with more aggressive sustainability programs and policies do indeed seem to be in counties with lower obesity rates. The Siemens' Index coefficient is not statistically significant. In Table 4, the relationships are not nearly as strong. Even so, the SustainLane index is strongly negatively related to the Fattest Cities in American Index, again suggesting that sustainable cities are in metropolitan areas with lower levels of health problems.

6. Conclusions

This project shows that obesity rates are inversely correlated with adoption and implementation of sustainability policies in the largest cities in the United States. The importance of these preliminary findings is underscored by the reality that very few public health interventions have been successful in reducing obesity rates with individuals or at the city, county, state, or national level. While public health efforts have shown success in protecting populations from the historical causes of mortality, such as the implementation of infrastructure systems that address sanitation needs, regulations to improve occupational safety, vaccination campaigns, as well as access to health care and screening programs, we are now faced with new challenges for which our standard model of care is ineffectual in meeting. The prevalence of obesity has risen to 35.6 percent in 2014. Obesity disproportionality affects Hispanic (42.5%), and African American (48.1%) communities (Ogden, Carroll, Fryar, & Flegal, 2015). This trend is correlated with rises in cardiovascular disease, diabetes, and cancer.

Perhaps even more alarming is the increase in youth and adolescent chronic conditions. The World Health Organization (WHO) has declared that childhood obesity is one of the most serious public health issues in the 21st century. WHO researchers in the department of Nutrition for Health and Development have estimated that there are over 43 million obese preschool-aged children globally, a 60 percent increase since 1990 (De Onis, Blössner, & Borghi, 2010). In the United States an estimated 17% of U.S. children and adolescents aged 2–19 years are obese and another 16% are overweight in 2014, compared to only 5 percent obese and 10 percent overweight in 1974 (Fryar, Carroll, & Ogden, 2016). While there was a modest drop in the prevalence of obesity in the United States for adolescents from 2005–2012, in comparison to the prevalence in 2003 (Ogden, Carroll, Kit, & Flegal, 2014), this has unfortunately reversed in more recent years as the prevalence of obesity has increased above the levels seen 2003 (Ogden et al., 2015). There are already an estimated 2.6 million deaths annually associated with obesity, as the current generation ages this number is expected to rise in the coming decades.

The analysis presented here is intended to highlight the potential for city sustainability policies and programs to be used as a vehicle for achieving desirable public health outcomes. We do not wish to argue that the analysis here represents a causal connection. Despite our efforts to measure the city sustainability programs at a time that precedes the public health outcomes measures, there is the possibility that the results here reflect some degree of endogeneity. The clearest limitations of this research revolve around the lack of data at the level of the individual. These results may well be reflective of a more complex set of relationships where healthier communities are more supportive of city sustainability policies and programs. Further, in the absence of most public health outcome data at the city level, as opposed to the county level presented here, constrains the inferences that can be made. Without individual data there were many variables which were unable to be controlled for in the analysis. Lopez (2014) identified that urban sprawl and location of an individual's residence was associated with obesity and should be account for. Further, dietary, lifestyle, and genetic composition, as well as gene-environment interactions were all unaccounted for in this research but have been shown to be determinants of obesity (Hruby et al., 2016). Further, the models only offer a small sample size and may suffer bias due to this. The results explicitly suggest that cities with stronger sustainability efforts are in counties and metropolitan areas with better health outcomes. Because of the fact that some, although not all, cities are in large counties, it is possible that it is better health outcomes in the areas of the counties outside of the city proper influencing this relationship. The results do, however, raise the possibility that city sustainability initiatives hold the promise to be an important vehicle for improving public health, in this case, obesity-related outcomes. We do not interpret the results here as reflecting coincidence. Future research will need to advance this line of inquiry by accounting for specific causal linkages and ruling out alternative explanations, presumably with benefit of more appropriate city-level (rather than county or metropolitan-level) health outcomes data.

Conflict of Interests

The authors declare no conflict of interests.

[1] Tests for multicollinearity and heteroscedasticity indicate assumptions of OLS regression have been satisfied. Results from ordinal regression (not shown but available from the authors) produced nearly identical conclusions, suggesting that the OLS results are not sensitive to possible violations of underlying assumptions.

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Article

A Framework for Multifunctional Green Infrastructure Investment in Camden, NJ

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Abstract
This study demonstrates a decision-support framework for planning Green Infrastructure (GI) systems that maximize urban ecosystem services in Camden, NJ. Seven key ecosystem services are evaluated (urban agriculture expansion, combined sewer overflow reduction, heat island reduction, flooding reduction, capacity building/green jobs expansion, fitness expansion, and stress reduction), to produce a normalized value for each service for each drainage sub-basin within the city. Gaps in ecosystem services are then mapped and utilized to geographically prioritize different kinds of multifunctional GI. Conceptual designs are developed for four site typologies: parks, schools, vacant lots, and brownfield sites. For one demonstration site, additional analysis is presented on urban engagement, life cycle cost reduction, and new sources of funding. What results is an integrated, long-term vision where multifunctional GI systems can be readily customized to meet multiple needs within urban communities. This study provides a portable and replicable framework for leveraging the regulatory requirement to manage stormwater to meet broader urban revitalization goals, all through a decentralized network of green infrastructure assets.

Keywords
ecosystem services; green infrastructure; stormwater management; urban redevelopment

Issue
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1. Introduction

Twenty-first century cities face a wide range of challenges, from climate change and reduced federal infrastructure financing to compliance with environmental regulations. While these issues challenge planners everywhere, they are especially difficult in post-industrial cities already struggling to meet the diverse needs of vulnerable populations while handicapped by eroded tax and infrastructure user bases. In this context, there is a need to maximize the possible community benefits associated with any major infrastructure investment.

Of key interest are multifunctional infrastructure strategies that contribute to economic, environmental, and social bottom lines (Ahern, 2011; Montalto et al., 2012; United States Environmental Protection Agency [US EPA], 2016). This study focuses on the specific opportunity presented by federally mandated stormwater management requirements.

1.1. Regulatory Context

The Federal Water Pollution Control Act of 1972, known as the Clean Water Act, requires communities equipped with combined sewers to develop a Long-Term Control Plan (LTCP) to reduce the frequency and volume of combined sewer overflow (CSO). CSOs occur when urban stormwater entering combined sewers exceeds the system capacity, triggering discharge of untreated combined wastewater and stormwater into local water bodies. There are roughly 750 municipalities nationwide (US EPA, 2004) with combined sewers, including some of the largest cities in the Mid-Atlantic, Midwest, and Northeast regions of the United States. In response to federal policy, urban stormwater managers have, over the past two decades, been investigating a wide range of strategies for controlling CSOs, including the use of in-line or end-of-pipe control strategies such as tanks and tunnels. Such centralized grey infrastructure strategies may be effective at reducing CSO frequencies and volumes but can also be both expensive and difficult to site in urban areas where space is limited and land acquisition costs can be relatively high (Montalto et al., 2007).

Many large cities like Philadelphia and New York are instead increasingly opting to comply with federal CSO control policy using a hybrid, decentralized approach (Mittman & Kloss, 2014). Known generally as Green Infrastructure (GI), this approach seeks to retain, detain, or reuse stormwater at its source. The US EPA (2016) defines GI as "a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits." GI systems may include green roofs, permeable pavements, right-of-way bioswales, constructed wetlands, rain gardens, and a suite of other approaches integrated into the design of streets and parcels.

1.2. Green Infrastructure and Ecosystem Services

To significantly reduce CSOs, GI needs to be applied widely within urban watersheds. Municipal GI programs routinely exceed one billion dollars and involve implementation periods spanning multiple decades. While centralized grey infrastructure solutions take many years to design and construct prior to any realized benefit, the decentralized nature of GI allows it to be implemented at a flexible pace according to municipal capacity, and start producing immediate tangible benefits. The distributed and phased nature of the GI programs creates new opportunities for adaptively re-imagining the design of streets, parks, buildings, and other urban land uses to address multiple sets of goals. In this way, the need to capture stormwater becomes an opportunity for also replenishing water tables, restoring habitats, beautifying streetscapes, creating opportunities for employment and recreation, raising property values, reducing urban temperature, cleaning the air, sequestering greenhouse gases, and enhancing biodiversity (Dunn, 2010; Grant & Gallet, 2010; Schilling & Logan, 2008; US EPA, 2013).

One way of considering these varied benefits is as "ecosystems services," the direct and indirect benefits that humans derive from ecosystems. This term gained widespread use after publication of the Millennium Ecosystem Assessment (MEA, 2005), but only recently has been applied in urban contexts (Miller, 2017). Ecosystem services can be grouped into four general categories: provisioning services (such as food, water, and timber), regulating services (such as regulation of climate, floods, disease), cultural services (such as recreation, aesthetic enjoyment, spiritual fulfillment), and supporting services (such as soil formation, pollination, nutrient cycling). Strategically planned, sited, operated, and maintained, GI systems can provide many different services in each of these categories. By identifying regions within a city in need of certain services, GI planners can infuse local needs and opportunities into decisions regarding what kind of GI to introduce into a community, where specifically to build it, and how it might be designed, operated, and maintained.

1.3. Camden Context

The city of Camden faces many urban redevelopment challenges such as: high rates of poverty, high unemployment, significant recent population loss, and large numbers of abandoned properties and brownfields. At the time of this study, the Camden County Municipal Utilities Authority (CCMUA) was in the process of developing an LTCP for the City of Camden, and was considering incorporation of GI into this plan. Through the collaborative efforts of the Camden SMART (Stormwater Management and Resource Training) Initiative, some conventional GI pilot projects had already been implemented throughout the city, though the approach taken to customize these projects to local community needs had not utilized ecosystem services as a driving principle.

This paper first introduces the GI decision-support tool and how it is used to identify ecosystem service opportunities that can be addressed with multifunctional GI systems. Next, the tool is applied to Camden, yielding maps that identify unique sets of ecosystem service opportunities for each drainage area within the city. Finally, a representative group of sites are identified via the framework, and conceptual designs presented, providing an opportunity to visualize multifunctional GI as well as dive deeper into associated maintenance, programming, and funding issues.

The goal of this paper is to present a decision-support tool that water utilities can use to customize GI siting, de-

sign, operation, and maintenance decisions so as to maximize the potential for the resultant GI systems to provide locally valued ecosystem services, while also managing stormwater. Demonstration of the tool in Camden was appropriate because of the many ecosystem service needs of the city, the opportunity it afforded to provide timely input into CCMUA's ongoing LTCP process, and because of the high level of engagement of local stakeholders in stormwater-related issues.

2. Methodology

The GI decision-support tool is implemented in four phases. During the first phase, a shortlist of ecosystem services is generated, based on literature review and stakeholder consultation. The second phase uses available data to generate "gap scores" for each ecosystem service within each of the city's drainage sub-basins, specifically identifying priority areas associated with each ecosystem service. In the third phase, individual sites are ranked based on stormwater management potential and observed site characteristics. Finally, a small group of demonstration sites are selected for additional conceptual design development as part of phase four. Each of these phases is discussed in more detail below.

2.1. Identification and Prioritization of Ecosystem Services

A literature review was conducted to identify the full range of ecosystem services that could be provided by known GI techniques. Simultaneously, meetings with a diverse set of local stakeholders (government, non-profit, and private stakeholders at the local, state, and federal levels) were held to identify the specific datasets needed to quantify and spatially rank urban ecosystem services needs across the city. The literature review, stakeholder engagement, and subsequent database development culminated in a shortlist of urban ecosystem services deemed appropriate for consideration in the study. These included: urban agriculture expansion, CSO reduction, heat island reduction, flooding reduction, capacity building/green jobs expansion, fitness expansion, and stress reduction.

The ecosystem services that emerged from this process fall into three of the four categories identified by the MEA: provisioning, regulating, and cultural services. Urban agriculture expansion through community gardens is an example of a provisioning service, since these systems can produce food while increasing permeable surface area and reducing runoff. Flooding, CSO, and heat island reduction are examples of regulating services that can be provided by GI, specifically through the ability of vegetated permeable landscapes to provide shade and latent heat transfer, while also collecting and infiltrating stormwater, preventing both surcharges and overflows of the sewer system. Cultural services were more subjectively defined since cultural norms and values are site specific. For the Camden study, three factors that are both linked to human well-being and also related to GI implementation were considered: the availability of outdoor fitness opportunities that could improve physical and mental health, increased access to features that reduce physical stress on individuals, for example tree canopies that produce shading, and access to educational or professional development opportunities.

Note that the selection of ecosystem services that were included in the Camden analysis is not necessarily the same list that would be used in other places, since decisions regarding whether a specific ecosystem *function* actually constitutes a *service* are subject to local values (Bolund & Hunhammar, 1999; Gómez-Baggethun & Barton, 2013). It is conceivable, and indeed probable, that stakeholders in other locales would identify other combinations of ecosystem services to carry forward in the analysis. The unique incorporation of local values and circumstances into the analysis also explains why no supporting services made it into this particular analysis, though supporting services could certainly become important in studies conducted in other places. The key role that local values play in establishing which ecosystem services are utilized in the analysis also underscores the importance of engaging a representative cohort of local stakeholders in the process.

Once the final list of services was developed to guide the overall analysis, a scoring scheme involving factors and weights was developed to compare the ability of each of the city's drainage sub-basins to provide the service. Factors included in the computation of each service score were selected based on the availability of local information in Camden and weighted based on an evaluation of local risk and exposure pathways. Factors that increased either risk or exposure were included and ranked based on best professional judgment. A summary of this evaluation is presented in Table 1.

2.2. Area Level Ecosystem Service Gap Score Algorithms

Algorithms were developed to quantify ecosystem service levels at a neighborhood or "area" scale for drainage sub-basins within the city. Sub-basins are geographic areas that drain to specific CSO outfall locations, and are a common planning unit for stormwater capture. As part of its LTCP planning process, CCMUA must quantify stormwater volumes and water quality impacts (i.e., CSO volume and/or frequency reductions), and modeling activities are typically implemented at the sub-basin level. The median sub-basin size in Camden, approximately .2 km^2, is an ideal area for GI planning, because it is large enough to scale up from individual site-specific GI and monitor cumulative performance, but small enough that measurable outcomes can be observed within a reasonable design and implementation timeline. For planners, this is an important iterative step between demonstration at the site scale and more widespread implementation of a GI program.

Table 1. Phase one evaluation of ecosystem services.

Category	Ecosystem Service (Description)	Ecosystem Service Factor	Factor Weight	Key Data Sets	Notes
Provisioning	Urban Agriculture Expansion (Expansion of gardening and farming opportunities for food production)	Food Desert	0.500	Grocery Store Locations	The 2008 U.S. Farm Bill (Food, Conservation, and Energy Act, 2008) describes a food desert as an area with limited access to affordable and nutritious food, particularly in lower income neighborhoods and communities. In some cases, food production from urban agriculture can play an important role in food security, especially during economic and political crises (Barthel & Isendahl, 2013). For this and other categories, population density is a measurement of exposure.
				Community Garden Locations	
		Population Density	0.500	Population Density	
Regulating	CSO Reduction (Reduction of number and frequency of CSO)	CSO Density	0.500	Average Annual CSO Volume	CCMUA provided annual modeled CSO volumes for each drainage sub-basin within the City. Because CSOs are triggered when stormwater volumes exceed the conveyance capacity of the collection system, impervious area coverage was also evaluated as a contributing factor to CSO reduction. Impermeable surfaces such as roads, roofs, parking lots, and sidewalks that store little water, reduce infiltration of water into the ground and accelerate runoff to ditches and streams (Konrad, 2003).
		Impervious Cover Density	0.250	Impervious Area Coverage	
		Population Density	0.250	Population Density	
	Flooding Reduction (Reduction of localized flooding due to improper surface drainage)	Flood Location Density	0.400	Flooding Locations	CCMUA also provided data on flooding locations and associated traffic reports. In addition to the assessment of impervious coverage, an analysis of average elevations across the City's drainage sub- basins was conducted to approximate flood risk due to low elevations. Exposure was assumed to be greater at higher population densities.
		Mean Elevation	0.200	State of New Jersey Digital Elevation Model	
		Impervious Cover Density	0.200	Impervious Area Coverage	
		Population Density	0.200	Population Density	
	Heat Island Reduction (Reduction of local ground surface temperatures)	Tree Cover Density	0.250	Tree Canopy Cover	The urban heat island effect is the phenomenon whereby urban regions experience warmer temperatures than their rural surroundings (US EPA, 2008). Impervious areas heat up more readily than vegetated pervious ones and are thus a key factor in evaluating the extent of the heat island coverage. Tree canopy coverage obtained from a 2011 study by the U.S. Department of Agriculture was utilized to gain an understanding of existing tree density in Camden. Urban forests ameliorate climate through: shading, evapotranspiration, and airflow modification, which affects the transport and diffusion of energy, water vapor, and pollutants (Nowak & McPherson, 1993). Furthermore, the National Collaborating Centre for Environmental Health (2010) identifies populations vulnerable to heat stress (children under the age of 5, adults over the age of 65) as a focus for heat island reduction.
		Heat-Vulnerable Population Density	0.250	Heat-Vulnerable Population Density (<5, >65)	
		Impervious Cover Density	0.250	Impervious Area Coverage	
		Population Density	0.250	Population Density	

Table 1. Phase one evaluation of ecosystem services. (Cont.)

Category	Ecosystem Service (Description)	Ecosystem Service Factor	Factor Weight	Key Data Sets	Notes
Cultural	Capacity Building and Green Job Expansion (Expansion of education, professional development, and employment opportunities)	Capacity Building Opportunities	0.500	Environmental Community Organization Locations	Exposure to nature and green space provides multiple opportunities for cognitive development, which increases the potential for stewardship of the environment and for a stronger recognition of ecosystem services (Krasny & Tidball, 2009; Tidball & Krasny, 2010). As an example, urban forests and allotment gardens are often used for environmental education purposes (Gröning, 1995; Tyrväinen, Pauleit, Seeland, & de Vries, 2005) and facilitate cognitive coupling to seasons and ecological dynamics in technological and urbanized landscapes. This service addresses the issue of who participates in urban redevelopment, who benefits from the work of GI, and how (Campbell, 2014).
				Public Elementary and Secondary School Locations	
		Median Household Income	0.250	Median Household Income	
		Unemployment Rate	0.250	Unemployment Rate	
	Fitness Opportunity Expansion (Expansion of access to outdoor destinations for fitness)	Outdoor Destination Density	0.500	Public Park Locations	Individuals below retirement age with greater exposure to green space reportedly have lower rates of mortality (Mitchell & Popham, 2007). The body mass index of children has been shown to have an inverse relationship to exposure to green space (Bell, Wilson, & Liu., 2008).
				Community Garden Locations	
		Median Household Income	0.250	Population Density	
		Population Density	0.250	Median Household Income	
	Stress Reduction (Expansion of access to stress reduction features)	Stress Reduction Services Density	0.500	Mental Health Service Centers	When exposed to natural environments, stress levels decrease rapidly, whereas during exposure to urban environments, stress levels remain high or even increase (Ulrich et al., 1991). Another study on recovery of patients in a hospital showed that patients with rooms facing a park had 10% faster recovery and needed 50% less strong pain-relieving medication compared to patients in rooms facing a building wall (Ulrich, 1984).
				Public Park Locations	
				Community Garden Locations	
		Median Household Income	0.167	Median Household Income	
		Unemployment Rate	0.167	Unemployment Rate	
		Population Density	0.167	Population Density	

The algorithms mathematically combine different spatially differentiated variables. A value for each of these variables was developed for each sub-basin area as a normalized value between 0 and 1, where 1 represents the highest priority, and 0 represents the lowest. Informed by the stakeholder engagement process, weights were also assigned based on the anticipated impact of each variable to each service. The summation of the weighted factors equals the service gap score such that:

$$SG_i = (W_1 \times V_1) + (W_2 \times V_2) + \ldots + (W_n \times V_n) \quad (1)$$

$$SGN_i = \frac{SG_i - SG_{\min}}{SG_{\max} - SG_{\min}} \quad (2)$$

with SG_i = raw service gap score, W = weight value, V = variable value and SGN = service gap score normalized.

For example, the service gap score for the ecosystem service of "urban agriculture expansion" considers population density within the sub-basin and its "food desert" density, defined as the relative prevalence of grocery stores and community gardens. Sub-basins with high population density and high food desert density (i.e., fewer grocery stores and community gardens) relative to the city mean were awarded the lowest ecosystem service levels. Areas with the lowest ecosystem service levels had the highest ecosystem service gap score for this service. GI systems conceived for areas with a high urban agriculture gap score would ideally be designed to include food production capacity such as vegetable gardens or orchards.

With the gap scores for each of the seven target ecosystem services within each sub-basin, a composite score was generated. Although various weighting schemes could be used for combining the individual ecosystem service gap scores, including through a participatory stakeholder program, an arithmetic average was used here for demonstration purposes. The composite gap score was utilized to rank the sub-basins in order of highest composite service gap score to the lowest, allowing different drainage sub-basins to be compared to one another using a common metric, and prioritize specific drainage sub-basins for GI implementation. Sub-basins with the highest composite gap-scores were assigned the highest priority in the next phase of work.

2.3. Site Selection and Prioritization

Based on an evaluation of gap scores, land tenure, and field investigation, potential sites for multifunctional GI were identified and prioritized. In terms of tenure, emphasis was placed on public properties (e.g., schools and parks), abandoned sites, and brownfield sites, because of synergies with the interests of CCMUA. A total of 18 schoolyards, parks, vacant lands, and brownfields were identified within the highest priority sub basins. Further refinement of the 18 sites was performed through field investigations conducted by the project team. These field investigations evaluated both the specific ecosystem service opportunities and the "park development impact," a metric used by The Trust for Public Land (TPL, 2004) to assess GI potential in other jurisdictions (see Table 2).

2.4. Ecosystem Service Driven Conceptual Design Process

To visualize potential multifunctional GI, the four top-ranking sites were utilized for further conceptual design development. First, the volume of stormwater generated on directly connected and adjacent impervious surfaces was estimated. Directly connected surfaces are defined as impervious spaces already graded towards the site. Stormwater from adjacent surfaces, by contrast, could theoretically be conveyed to the site using trench drains, pipes, or other hydraulic appurtenances, even if the surfaces themselves were not graded towards the future GI site. Next, the potential site features that could help to address the top three ecosystem service gap scores of the respective sub-basin were identified. Multiple features were incorporated into each site so as to demonstrate the range of options that could be considered in a future participatory process focused on developing final designs.

3. Results and Discussion

3.1. Area Level Ecosystem Service Gap Score Model Results

The composite service gap scores (with equal weighting of the services) are presented in Figure 1 and can be utilized as a general indicator of the portions of the city that could benefit most from multifunctional GI projects. The individual gap scores are presented (with equal interval categories, 0–0.20, 0.21–0.40, 0.41–0.60, 0.61–0.80, and 0.81–1.00) in Figure 2 for the seven individual ecosystem services considered for the Camden study. All of the scores can also be accessed in digital form through TPL's GI Opportunity Mapping GIS Viewer (for access information please contact the authors).

Table 2. A description of the qualitative factors assessed and compared during multifunctional GI site prioritization.

Factor	Description
Potential community impact	Quantified by determining the number of people who live within a 10-minute walk of the site, and reviewing patterns of pedestrian and vehicular circulation.
Potential volume of stormwater managed	Potential volumes of stormwater based on topography, infrastructure, and other factors.
Potential for site improvements	Sites with the greatest need for physical improvement were ranked higher than those that were already in reasonable physical condition.
Potential for 'eyes-on-the-site'	A determination of site visibility, *à la* urbanist Jane Jacobs, which translates to how likely it is to be safe and secure or require additional repair and maintenance.
Qualitative review of social conditions on and around the site	Sites that provided greater opportunities for partnership were favored over those offering fewer partnerships.

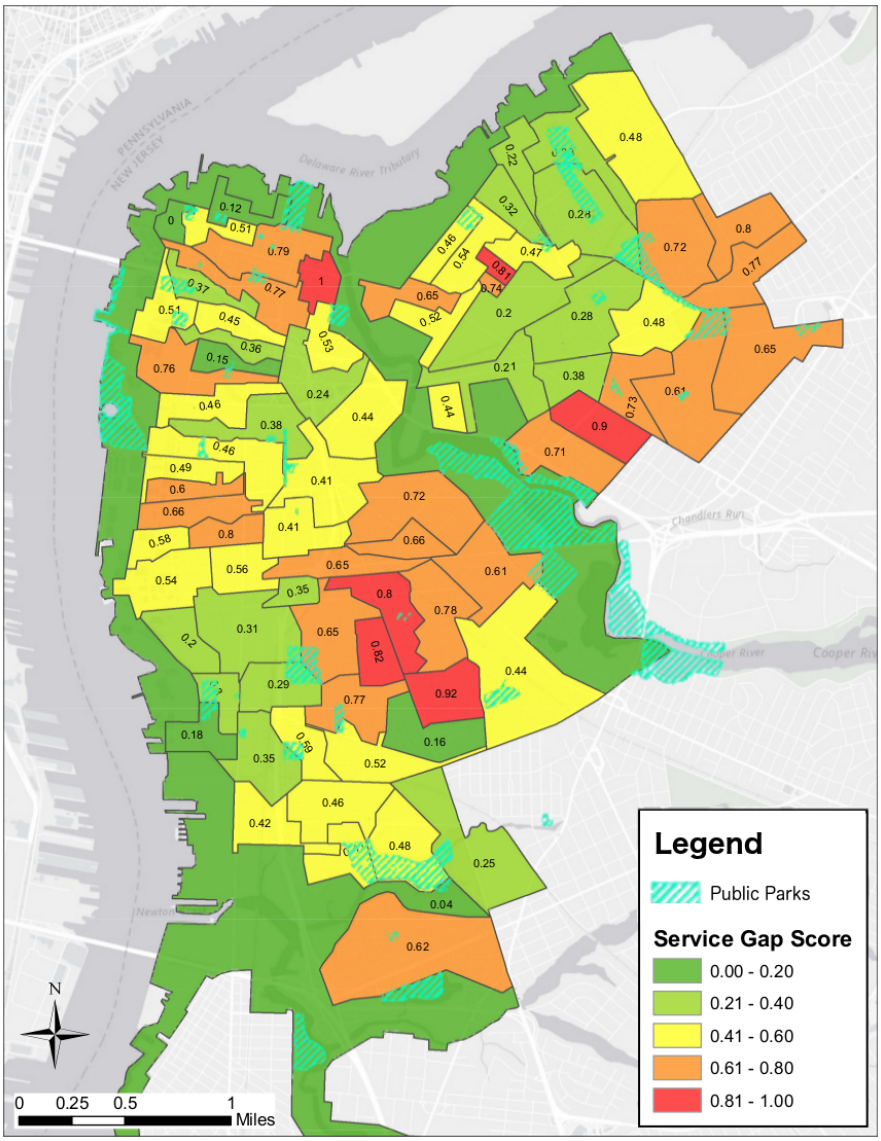


Figure 1. Combined ecosystem service gap score map for the city of Camden, NJ.

Visible differences in individual ecosystem service gap scores across the city's sub-basins suggest that the model algorithms successfully identified gradients in conditions. The ecosystem service gap scores were normalized and thus represent a relative ranking of ecosystem service needs. Lower scoring sub-basins are not necessarily without need, but rather are less in need of a particular service than other portions of the city. By contrast, the highest ranked sub-basins are estimated to benefit most from GI designed to maximize specific services.

Table 3 displays the individual service gap scores for the top 16 ranked sub-basins (20th percentile, combined score). The table shows that the highest ranked services vary for each basin, suggesting an opportunity to customize GI selection, siting, and design decisions to neighborhood conditions. In the conceptual design process, the composite scores were utilized in site selection, while the top three individual gap scores were used to guide development of the key site design features.

3.2. Site Selection and Prioritization Results

Following our evaluation of gap scores and field investigations, a total of 18 sites were selected and prioritized. The strongest candidates in each land tenure type (schoolyard, park, vacant land, and brownfield) were identified for further analysis, and are described below. (For access to the complete site selection and prioritization matrix, please contact the authors).

The highest ranked *park* site was Alberta Woods Park. This site emerged as an exemplary candidate site because of its high visibility and potential ability to manage stormwater from the adjacent right-of-way (ROW) within the boundaries of the park. The park is in a densely populated residential area and is adjacent to a well-traveled vehicular route. In addition, local students at the nearby Francis X McGraw Elementary School can easily access and benefit from the site. The conceptual designs developed for Alberta Woods Park would thus provide a posi-

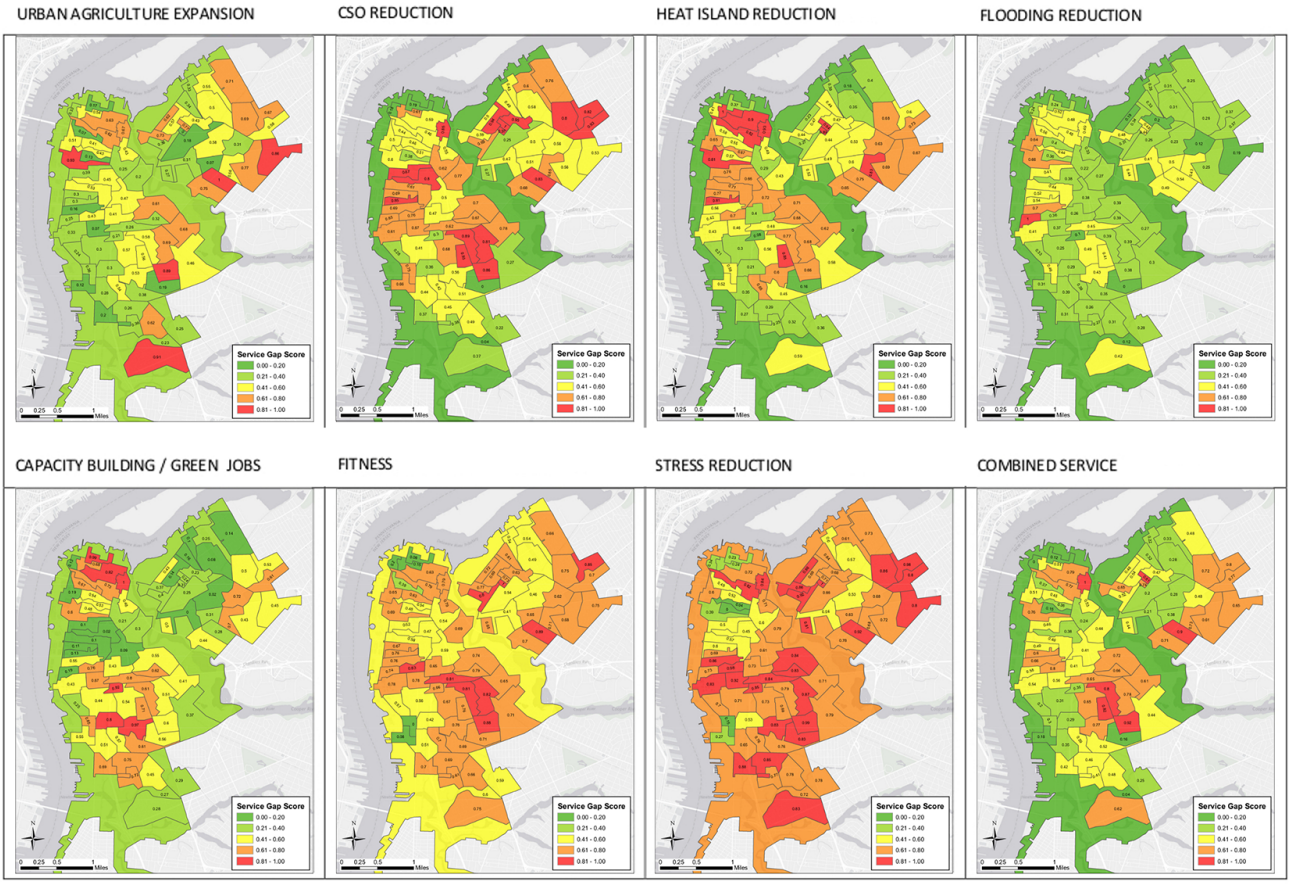


Figure 2. Individual gap score map for each ecosystem service evaluated.

Table 3. Top 20th percentile sub-basins for combined service gap score.

		Service Gap Score							
Sewer Sub-Basin ID	**Catchment Area (km^2)**	**Combined**	**Urban Agriculture**	**CSO Reduction**	**Heat Island**	**Flooding Reduction Reduction**	**Capacity Building / Green Jobs Expansion**	**Fitness Expansion**	**Stress Reduction**
C15	.10	1.00	0.67	0.85	0.93	0.49	1.00	0.79	0.84
C3-8	.21	0.92	0.89	0.86	0.66	0.38	0.60	0.88	0.99
C27-2	.20	0.90	1.00	0.83	0.75	0.54	0.28	0.89	0.92
C3-10	.14	0.82	0.56	0.93	0.85	0.41	0.71	0.76	0.69
C22A-3	.04	0.81	0.77	1.00	0.94	0.48	0.24	0.73	0.71
C3-5	.23	0.80	0.58	0.89	0.77	0.39	0.61	0.81	0.79
C6-2	.11	0.80	0.43	0.76	0.70	0.36	0.76	0.83	0.98
C90-3	.21	0.80	0.67	0.82	0.60	0.37	0.53	0.85	0.98
C13-2	.28	0.79	0.63	0.59	0.90	0.48	0.82	0.63	0.72
C3-6	.28	0.78	0.69	0.81	0.68	0.39	0.51	0.82	0.87
C11-3	.23	0.77	0.62	0.46	0.82	0.48	0.73	0.79	0.82
C90-4	.23	0.77	0.58	0.93	0.73	0.37	0.61	0.70	0.80
C3-9	.23	0.77	0.53	0.56	0.60	0.43	0.97	0.76	0.83
C10-1	.24	0.76	0.93	0.60	0.81	0.66	0.60	0.69	0.39
C22A-2	.02	0.74	0.00	0.97	0.89	0.44	0.31	1.00	1.00
C22-6	.19	0.73	0.56	0.65	0.83	0.43	0.70	0.71	0.68

tive example of stormwater management for direct public benefit within an existing park.

The highest ranked *schoolyard* site was Sumner Elementary School. The site emerged as an exemplary candidate site principally because of its vast impervious surface area, but also because of its potential for increasing recreational opportunities for local students. This school is located within the Whitman Park Choice Neighborhood boundary, making it also potentially eligible for grant funding. The schoolyard currently includes no physical amenities for the children who attend classes. Sumner Elementary was thus selected as an opportunity to demonstrate how stormwater management could be integrated into schoolyard redevelopment.

The highest ranked *vacant* site was a series of interconnected lots located at the intersection of Vine and Willard in North Camden. These lots could be combined to create a new park that would manage both on-site and ROW stormwater. In addition, this site is located in a park-poor area of Camden with a high number of residents who live within a 10-minute walk, and is adjacent to religious institutions. There are no known zoning or other regulatory conditions that restrict the type of redevelopment possible at this site. A complete Environmental Assessment would, however, be recommended prior to start of work on any site. This collection of lots was selected to demonstrate how vacant land could be aggregated and transformed into a multifunctional stormwater park with multiple community benefits.

The *brownfield* site selected for conceptual design development was Camden Labs. While this was not the highest ranked site, the selection and prioritization process revealed this site's great potential to integrate GI systems into an in-process proposal for redevelopment to be undertaken by the Camden Redevelopment Authority and other stakeholders. The site provides a unique opportunity to integrate stormwater management into sustainable housing design, urban homesteading, and a complete sustainable site development.

3.3. Conceptual Design for Four Demonstration Sites

The composite gap scores and site selection matrix directly informed the choice of sites in each of four site typologies: parks, schools, vacant lots, and brownfield sites. Basic design parameters, and a conceptual site plan for multifunctional GI is included for each location in Figures 3–6. The designs present elements that respond to the top ecosystem service gaps identified in this analysis (note inset on each site plan).

3.4. Interpreting and Using the Results

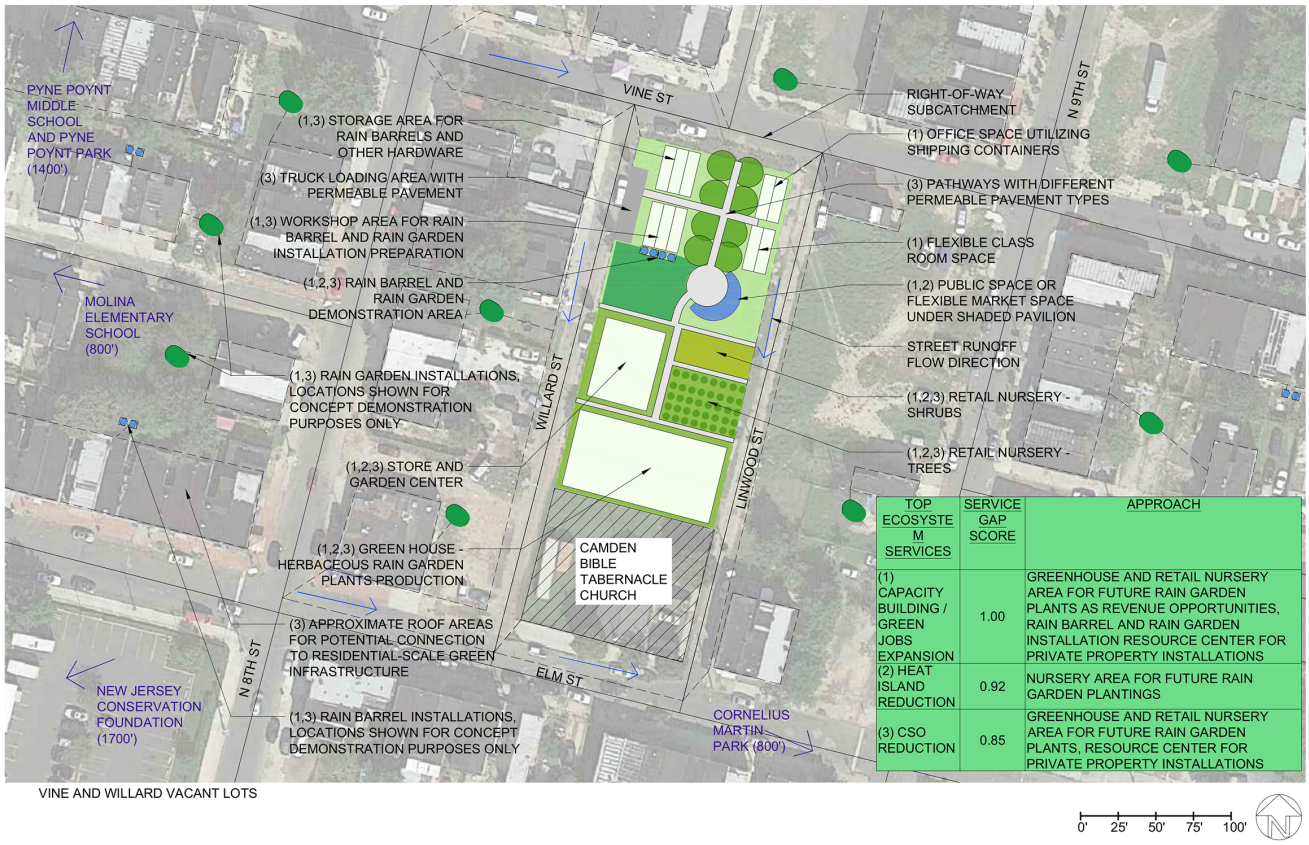
The sites selected and the conceptual designs presented are the results of the ecosystem service gap scores as they are valued in the decision-support framework, assuming equal weighting of constituent services. Thus, they represent only one vision of how these sites could

TOP ECOSYSTEM SERVICES	SERVICE GAP SCORE	APPROACH
(1) URBAN AGRICULTURE EXPANSION	0.77	ORCHARDS FOR FRUIT PRODUCTION AND ABOVE GROUND PLANTERS FOR VEGETABLE PRODUCTION
(2) STRESS REDUCTION	0.72	RECREATION AREAS (CHESS TABLES, BBQS, READING ROOM), SEATING AREAS, PLANTED AREAS
(3) HEAT ISLAND REDUCTION	0.69	EXPANDED VEGETATED RIGHT-OF-WAY AREAS, TREES FOR INCREASED SHADING

Figure 3. Alberta Woods Park concept plan.

TOP ECOSYSTEM SERVICES	SERVICE GAP SCORE	APPROACH
(1) STRESS REDUCTION	0.73	TREES, GARDEN SPACE, BENCHES IN RIGHT-OF-WAY. FLOWER PRODUCTION AND MARKET SPACE IN PARKING LOT.
(2) CSO REDUCTION	0.68	STORMWATER TREE PITS AND BUMPOUTS, TURF FIELD, RAIN GARDENS
(3) FITNESS OPPORTUNITY EXPANSION	0.67	MULTI-PURPOSE TURF FIELD, BASKETBALL COURT, CAROUSEL AND TREADLE WATER PUMPS

Figure 4. Sumner Elementary School concept plan.



TOP ECOSYSTEM SERVICES	SERVICE GAP SCORE	APPROACH
(1) CAPACITY BUILDING / GREEN JOBS EXPANSION	1.00	GREENHOUSE AND RETAIL NURSERY AREA FOR FUTURE RAIN GARDEN PLANTS AS REVENUE OPPORTUNITIES, RAIN BARREL AND RAIN GARDEN INSTALLATION RESOURCE CENTER FOR PRIVATE PROPERTY INSTALLATIONS
(2) HEAT ISLAND REDUCTION	0.92	NURSERY AREA FOR FUTURE RAIN GARDEN PLANTINGS
(3) CSO REDUCTION	0.85	GREENHOUSE AND RETAIL NURSERY AREA FOR FUTURE RAIN GARDEN PLANTS, RESOURCE CENTER FOR PRIVATE PROPERTY INSTALLATIONS

Figure 5. Vine and Willard vacant lots concept plan.

Figure 6. Former Camden Labs stormwater assessment.

be redesigned for multifunctionality. In future analyses, the weighting scheme could be locally tailored through stakeholder engagement. Dialogue about the ecosystem services could be used to elucidate where stakeholders already agree and where additional debate and fact gathering is necessary to build consensus about neighborhood needs. Such a process is important for GI priority setting, but is also more generally valuable in community goal setting.

For example, in a particular jurisdiction, the consultants engaged in the LTCP planning process may be principally focused on the regulatory mandates associated with CSO reduction and/or the public nuisance associated with flooding, and be less aware of other community needs that could potentially be addressed by GI. During a meeting with stakeholders, members of a local senior center could, for example, articulate the difficulty that the elderly feel waiting for buses in the hot sun, and an individual representing the local planning board could inform the group of a new permit issued to open a new supermarket. The resulting deliberation might result in an across-the-board increase in the weight assigned to the heat island service provided by GI, and a localized reduction to the weight given to urban agriculture in the region immediately surrounding the new supermarket. These changes would result in different spatial priorities for GI, and different constituent services guiding their design. In this way, local knowledge and preferences are incorporated directly into the GI planning process, while the deliberation also promotes education, and creates new partnerships between the community and local governmental decision-makers.

The conceptual designs presented emerge from application of the new decision-support tool to Camden, and present customized strategies for utilizing multifunctional GI investments to manage stormwater, while also addressing other community needs, and potentially attracting new interest and funding in GI as an urban policy initiative. To further explore this potential multifunctional role for GI in 21st century cities, additional analysis is presented for the Vine and Willard site.

3.4.1. Vine and Willard Vacant Lots—Urban Engagement Through GI Investment

The Vine and Willard site is an agglomeration of twelve vacant lots at the core of a residential area. The Camden Bible Tabernacle Church sits on the only actively used lot within the block. The collection of lots comprises 2,428 m^2 of pervious grass area, with individual lots owned by the City of Camden as well as some private landlords. While the effort required to synchronize a re-appropriation of these lots for GI may be significant, a concerted effort to do so, for example through the development of a land bank, may be warranted, since similar configurations of vacant or quasi-vacant blocks are common throughout Camden. Analysis of this site is presented as an example of the potential benefits of

attempting to remedy this challenging urban condition with a GI strategy.

The overall vision is to leverage GI investments on the block to create a "neighborhood green infrastructure hub". While actively managing stormwater generated on directly-connected and adjacent impervious surfaces, the Hub would also provide workforce development activities associated with GI installation and maintenance, and retail opportunities associated with sales of rain barrel components, and vegetated "plugs" that could be used in GI installations in Camden, and nearby Philadelphia (Figure 5). In this way, the design concept builds local capacity through green jobs (the sub-basin's top ranked ecosystem service) with a physical GI strategy that that reduces CSOs and the urban heat island effect (the second and third ranked ecosystem services).

Given that most of the existing lots are undeveloped pervious areas (with the exception of a 111 m^2 existing concrete pad), the design would ensure that these spaces remain pervious in perpetuity, while expanding their tributary source area. In addition to these stormwater source areas, the site also presents an opportunity to diffuse knowledge about GI systems into the surrounding residential neighborhood, for example by distributing rain barrels to local households, or disconnecting local downspouts from the sewer systems. The management of rooftop runoff through such measures is known to be relatively cost effective (US EPA, 2013), and can help to expand the impervious area that can be treated by GI beyond the public right-of-way. It could, in this way, provide private property outreach and extension of GI application for CCMUA.

The design includes a retail garden center, nursery and greenhouse, as well as a shaded pavilion for flexible market space and additional retail opportunities (Figure 7). Training facilities are proposed; including workshop areas with demonstration rain garden and rain barrels (which manage stormwater from onsite and ROW areas), and community spaces can be constructed to provide flexible meeting spaces for events or classes. Local community organizations could use the site for workshops, training, and other gatherings, fostering long-term relationships within the neighborhood.

3.4.2. Vine and Willard Vacant Lots—Life Cycle Cost Reduction and New Funding Sources

Obviously, the site would need to be maintained in order to adequately provide the ecosystem services it is designed to provide. It is well established that GI maintenance represents a significant opportunity for urban communities (Water Environment Federation, 2015), by providing new local jobs and environmental education. In Philadelphia, the Community LandCare initiative of the Pennsylvania Horticultural Society works with 18 community organizations, to hire local residents who perform landscape maintenance work on vacant lots in their neighborhood (2017). The GreenHouse program of the Horticultural Society of New York (2017) provides vocational training in horticulture for incarcerated individuals at Rikers Island. Upon their release, graduates of the program may enter a vocational internship program that provides maintenance to gardens, parks, street trees, and green roofs throughout New York City.

Such programs reduce the maintenance burden that decentralized GI creates for public utilities, and could also generate new sources of revenue, further offsetting GI O&M costs. As an example, Table 4 shows a cursory evaluation of the potential revenue that could be generated by paying local adults $15/hr, above a living wage, to grow vegetated plugs (assuming two growing seasons per year, with 269 plugs grown per m^2) at the Vine and Willard Site. The living wage (the hourly wage that an individual must earn to support their family, if

Figure 7. Vine and Willard vacant lots site rendering. Source: ThinkGreen, LLC.

Table 4. Estimated revenue and costs associated with the Vine and Willard site conceptual design.

	Potential Annual Costs (O&M)							
Top Ecosystem Services	**Components**	**Qty**	**Unit Value**	**Annual Revenue**	**Operations and Maintenance Tasks**	**Assumptions**	**Annual Hours**	**Annual Cost ($15/ Hour)**
Green Jobs Capacity Building Expansion (1.00)	Rain garden plant production (364 m^2)	196,125 PLUGS	$0.85/ PLUG	$166,706	Tilling, watering, weeding, harvesting.	8 hrs per session, 5 days a week, 10 months per year	1,600	$24,000
	Demonstration rain garden	205 m^2			Remove trash and sediment. Weeding invasives.	2 hrs per session, twice a month, 8 months per year	32	$480
	Demonstration roof disconnect for rain barrels	3			Remove trash and sediment.	1 hr per session, twice a month, 8 months per year	16	$240
	Retail garden center and retail nursery	483 m^2	Flexible		Retail operations and management	Demand paired to revenue from retail		
	Workshop space	69 m^2						
	Classroom space	46 m^2						
Heat Island Reduction (0.93)	Rain gardens installed on adjacent private parcels	107						
	Trees provided for adjacent rain gardens	107						
CSO Reduction (0.85)	Direct and adjacent ROW	3,098 m^2			Remove trash and sediment from pipes, and connections to GI areas.	2 hrs per session, twice a month, 8 months per year	32	$480
	107 parcel level roof disconnects (20% adoption rate for parcels 500' from site)	6,473 m^2						
			TOTAL	**$166,706**			**1,680**	**$25,200**

they are the sole provider and are working full-time) in Camden is $12.09 (Glasmeier, 2017). Figure 8 shows graphically how this concept would entrain local community members in retrofitting the site so that it can provide the locally needed ecosystem services. Further development of a workforce development program would require a detailed market feasibility study as well as specific scaling to current O&M costs for optimized life cycle cost reduction.

With the recognition that activities such as vacant lot stabilization and workforce development can occur while managing stormwater, multifunctional GI investment on

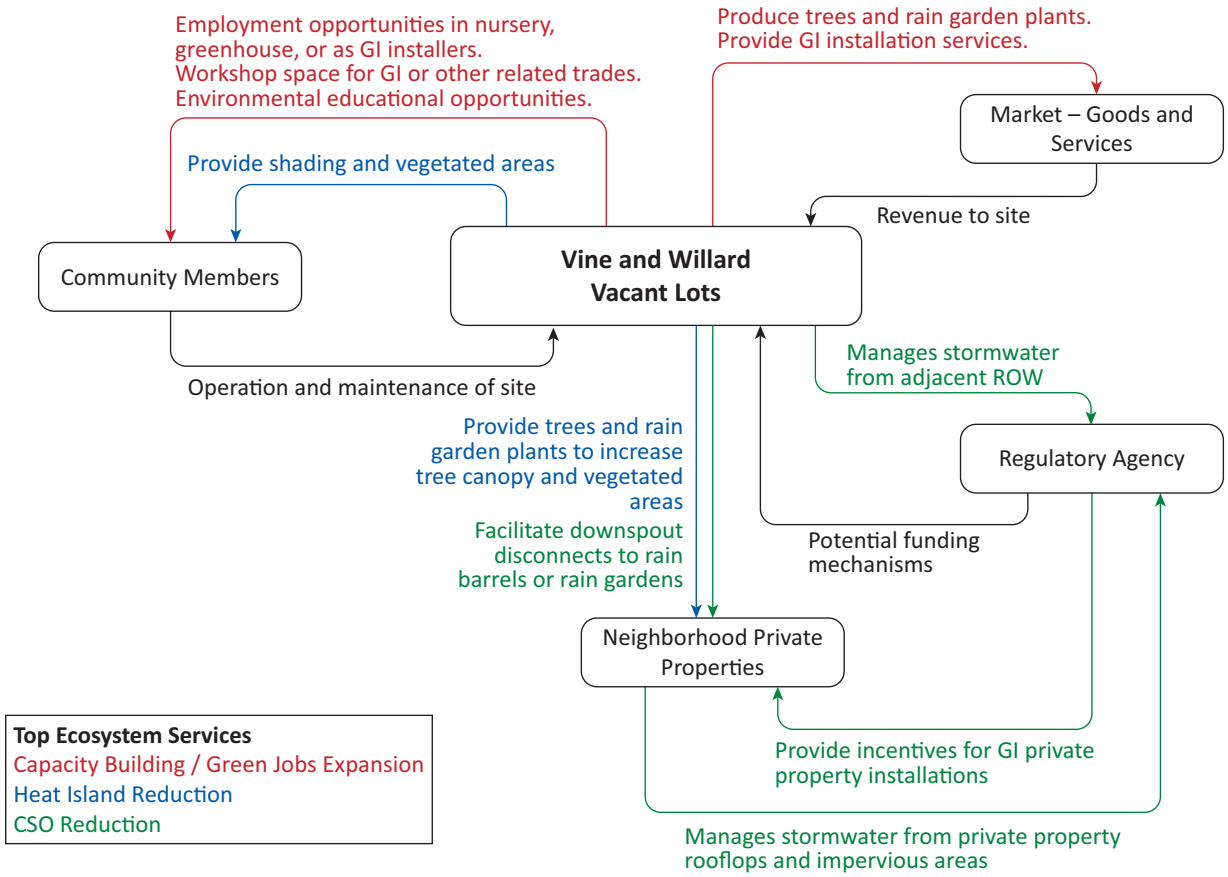


Figure 8. Vine and Willard vacant lots service flow diagram.

a site such as Vine and Willard can be conceived (and financed) as a candidate for many different sources of funding from its inception. In fact, the more multifunctional GI systems become, the greater the number of potential sources of funding for their construction and operation. Currently, CCMUA receives funding for GI development at the federal level through the EPA's Clean Water State Revolving Fund and at the state level through the New Jersey Environmental Infrastructure Trust. The target for these funds is the "Camden City Green and Gray Infrastructure" project, which aims to construct a series of green infrastructure and sewer improvement projects that would manage approximately 30 million gallons of stormwater annually.

However, these same federal and state entities also provide funding for projects that address other environmental and community-oriented goals. EPA's "Urban Waters and Brownfield" program, for example, funds projects that address urban runoff pollution and various brownfield remediation activities. Its "Environmental Education Grants", along with National Oceanographic and Atmospheric Administration's "Environmental Literacy Grants", can also be utilized by educational institutions to promote environmental awareness and stewardship. The National Park Service offers grants to municipalities to expand outdoor park space, like the "Outdoor Recreation Legacy Partnership Program". These open space expansion and protection programs also exist at the local level, such as the "Camden County Open Space, Recreation, Farmland, and Historic Preservation Trust Fund Referendum".

4. Conclusions

The goal of this project was to develop a decision-support framework for planning GI systems that maximize urban ecosystem services. Ecosystem service gaps were evaluated and used to geographically prioritize different kinds of multifunctional GI. Conceptual designs were developed for four site typologies: parks, schools, vacant lots, and brownfield sites. An integrated long-term vision was presented whereby multifunctional GI systems, customized to the needs of different communities, manage stormwater while also creating new opportunities for urban engagement, mobilizing various sources of funding, and contributing to an integrated plan for urban revitalization. Such a strategy would leverage the regulatory requirement to manage stormwater to enable many other community improvements, all through a decentralized network of green infrastructure assets.

As the City of Camden and CCMUA finalize development of their respective LTCPs, a complementary planning effort that, through extensive stakeholder deliberation, seeks to develop GI siting and design configurations specially customized to this city's unique physical, in-

stitutional, demographic, and historic conditions, could help to maximize the full spectrum of benefits achievable through GI in Camden. The better GI systems are tailored to local conditions, and the more ecosystem services they are designed to provide, the more support the program will have from the public, the more funding sources they will become candidates for, and the more spatial and institutional opportunities there will be for integrating different kinds of GI facilities into the city's complex urban landscape. With more widespread spatial application, of course, comes greater stormwater capture, helping municipalities to more efficiently and cost-effectively comply with federally mandated stormwater capture and CSO-abatement goals.

If implemented with broad community participation, the ecosystem services framework presented can help to identify specific geographic opportunities, GI design configurations, and partnership arrangements that can couple flood control, green job growth, heat island mitigation, community engagement, and other ecosystem service targets with stormwater management services. Of course, implementation of this framework at the city scale would require unprecedented levels of interagency coordination, and community outreach and organizing, neither of which are insignificant undertakings. In the long term, the need to green the city for stormwater capture is seen as a vehicle for promoting a broad-ranging discussion about all the ways urban spaces can serve residents of the city, with the LTCP planning process transformed from a plan focused solely on water management to a strategic initiative fostering urban revitalization in Camden, and beyond.

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Conflict of Interests

The authors declare no conflict of interests.

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Sri Rangarajan, PhD PEng DWRE, is an environmental engineer with over 27 years of public/private sector experience. His projects have focused on hydrologic, hydraulic, and water quality evaluations to assist municipalities, regional agencies, and private developers in making informed decisions through sound scientific assessments to meet regulatory requirements in a sustainable and cost-effective manner. He is a co-founder and President of Boomi Environmental, an environmental consulting firm that specializes in resilient urban drainage systems and integrated watershed planning/management.

Eric Rothstein is a Managing Partner and Engineer at eDesign Dynamics, and a hydrologist with twenty years of experience working on a variety of sustainability projects. Mr. Rothstein's career has focused on ecosystem restoration and water resources planning within urban centers. He currently leads the team investigating sustainable water resource planning for multiple projects in New York City. His international work includes water resource and ecosystem planning in Nepal, São Paulo, Brazil, rural Rwanda, and the Aegean coast of Turkey.

Justin Shih worked as a project engineer for eDesign Dynamics from 2013–2016, where he focused on green stormwater infrastructure and habitat restoration. Justin received his BS in Civil Engineering and MS in Environmental Engineering from the University of California Berkeley.

Franco Montalto is a civil engineer with a strong background in both applied and theoretical approaches to solving complex environmental problems. He has a particular interest in the development of ecologically, economically, and socially sensible solutions to urban environmental problems, with a focus on sustainable water resources engineering. He joined Drexel in September 2007 after a two-year research fellowship at The Earth Institute at Columbia University, and adjunct teaching at The Cooper Union for the Advancement of Science and Art in New York City. He also serves as the Director of the North American Hub of the Urban Climate Change Research Network (UCCRN) and is Founder and President of eDesign Dynamics LLC, an environmental consulting firm also based in New York City.

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