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Research Paper

# Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners

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## HIGHLIGHTS

- The paper defines the concept of green infrastructure within the context of climate adaptation.
- Green infrastructure uptake is subject to biophysical and socio-political constraints.
- Interviews with planners indicate tendencies for institutional path dependence.
- We discuss this as an institutional barrier to the green infrastructure adoption.
- We propose a conceptual model that explicitly recognizes such institutional factors.

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## ABSTRACT

Urban green infrastructure can help cities adapt to climate change. Spatial planning can play an important role in utilizing green infrastructure for adaptation. Yet climate change risks represent a different sort of challenge for planning institutions. This paper aims to address two issues arising from this challenge. First, it defines the concept of green infrastructure within the context of climate adaptation. Second, it identifies and puts into perspective institutional barriers to adopting green infrastructure for climate adaptation, including path dependence. We begin by arguing that there is growing confusion among planners and policy makers about what constitutes green infrastructure. Definitional ambiguity may contribute to inaction on climate change adaptation, because it muddies existing programs and initiatives that are to do with green-space more broadly, which in turn feeds path dependency. We then report empirical findings about how planners perceive the institutional challenge arising from climate change and the adoption of green infrastructure as an adaptive response. The paper concludes that spatial planners generally recognize multiple rationales associated with green infrastructure. However they are not particularly keen on institutional innovation and there is a tendency for path dependence. We propose a conceptual model that explicitly recognizes such institutional factors. This paper contributes to the literature by showing that agency and institutional dimensions are a limiting factor in advancing the concept of green infrastructure within the context of climate change adaptation.



## 1. Introduction

How to adapt cities to climate change is emerging as one of the greatest challenges that spatial planners will face in the 21st Century (Measham et al., 2011; Perry, 2015). Planning scholars have responded to this challenge by articulating a range of potential responses through both adaptation and mitigation. Adaptation responses include: fortifying coastal zones; devising interventions to bolster food and water security; developing strategies for coastal retreat; and better integrating emergency service responses into planning systems (Davoudi, Crawford, & Mehmood, 2009). Some of these responses are already being implemented by practitioners. Yet adaptation has been slow, mainly because some potential solutions are politically unpalatable (Byrne & Yang, 2009). Other solutions may be expensive, may impact the rights of private property owners, may require major changes to existing planning systems, or may constrain future property development options (Bulkeley, 2013). Green infrastructure however, appears to be relatively quick to implement, is comparatively inexpensive, has broad

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public appeal, and is politically benign (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Byrne & Yang, 2009). Moreover, it could gain rapid acceptance in an age where planning is increasingly attentive to urban infrastructure (Dodson, 2009).

Green infrastructure has broad appeal, largely due to its multiple benefits (Emmanuel & Loconsole, 2015; Gill, Handley, Ennos, & Pauleit, 2007; Jim, 2015; Kambites & Owen, 2006). For example, climate change will likely magnify urban heat island effects and increase flood events for many cities (Field, Barros, Stocker, & Dahe, 2012; Lo, 2013). Such impacts will likely be exacerbated by increases in 'hard' surfaces associated with rapid urbanization (e.g. concrete, stone, tile, asphalt and tarmac) (Field et al., 2012; Gartland, 2011). In cities worldwide, hard surfaces can now comprise as much as 67% of land area, while 'green' areas can fall as low as 16% in some cities (Gartland, 2011). Green infrastructure can contribute to ameliorating these problems by regulating ambient temperatures and reducing storm-water runoff, as well as affording recreational opportunities – among other benefits, recognizing of course that benefits are dependent upon the scale, form and function of urban greening (Pataki, Carreiro, et al., 2011). Although there is considerable scope within various planning systems and institutional structures to advance green infrastructure initiatives, this is yet to be realized on a major scale.

The relatively slow uptake of green infrastructure is perplexing. It begs the question: 'What are the barriers to, and drivers for, adopting green infrastructure for climate adaptation?' Unfortunately, researchers have tended to privilege the biophysical dimensions of green infrastructure over socio-cultural and political-institutional concerns, so we know little about the latter. Byrne and Yang (2009, p. 38) have suggested that four classes of interrelated factors shape the efficacy of green-space as a climate change adaptive response: The biophysical character of the built environment; planning systems; institutional frameworks and governance structures; and the perceptions and values of urban residents. Although they did not undertake empirical research to test these assertions, their conceptual overview is instructive, and is worth briefly revisiting here.

According to Byrne and Yang (2009, p. 38), biophysical factors that potentially delimit the utility of green infrastructure include: The area available for greening, urban morphology, site contamination, engineering and geological issues, vegetation characteristics, and climate. They also highlighted socio-political factors, which include: Governance systems; fiscal constraints; and expectation for public involvement in decision-making. Together these factors describe the social and biophysical feasibility of green infrastructure as a climate adaptation measure. Byrne and Yang (2009) also suggest that these factors interact in multiple, sometimes paradoxical, ways to shape the efficacy of green infrastructure. For example, their conceptual model suggests that species characteristics and urban morphology will combine to determine the maximum scope and scale of ecosystem service benefits that can be derived from a specific green infrastructure intervention. Planning regimes, governance systems and resident's attitudes and perceptions may combine to thwart the deployment of green infrastructure, even when it is viable; conversely they may facilitate the use of green infrastructure, even if ecosystem service benefits are marginal. While insightful, these ideas have yet to be empirically validated.

This paper contributes to an important contemporary spatial planning debate by showing that agency and institutional dimensions are limiting factors to the implementation of green infrastructure through spatial planning activity. Scholarly examination of this issue in literature and debates concerning the role of green infrastructure for climate adaptation is currently lacking. The idea of green infrastructure as a climate adaptation measure warrants a more focused scope and a modified definition in terms of climate *risks* and *systemic complexities*. These unique aspects of climate change differ from common urban issues, such as recreational needs and landscaping, in terms of scale and implications, and challenge some of the current planning practices and existing institutional arrangements.

The key aim of this paper is to begin to test assumptions about the role of biophysical, socio-cultural and institutional factors as potential drivers or barriers in using green infrastructure for climate adaptation, by examining some of these factors within the planning systems of England and Ireland. We begin by defining what we mean by green infrastructure and identifying problems with broad definitions in existing studies. We then discuss empirical research that we conducted, in the form of interviews with seven planners, all of whom have significant experience of planning processes in England and Ireland. From this research, we identify additional potential barriers and drivers to green infrastructure adoption, including path dependence, within the institutional context of planning. We synthesize our findings with those of other studies to produce a revised conceptual framework that can inform future research on this important topic. To advance the debate, we elaborate two important concerns that Byrne and Yang (2009) overlooked, which limit the utility of their conceptual model. First, they did not give sufficient attention to the institutional environment in which decision-making occurs. Second, they overlooked the 'agency' of climate and vegetation as a factor shaping the efficacy of green infrastructure (Pelling, High, Dearing, & Smith, 2008). We offer a revised conceptual framework, which seeks to redress these limitations. We conclude by discussing policy implications and sketch out an agenda to address some of the important knowledge gaps.

## 2. Background

### 2.1. Definition

One of the earliest uses of the term infrastructure, as applied to parks and green-spaces, sought to redefine the public park as an extension of urban infrastructure (Rosenberg, 1996). This use of the term infrastructure sets parks apart from amenity functions, and was intended to invoke an integrated set of large-scale, city-wide public works; functioning as investments and/or assets, and deployed primarily for human benefits–like transport, wastewater, storm-water or energy infrastructure. Green infrastructure has since become an important object of scholarly inquiry.

Green infrastructure typically refers to an interconnected network of multifunctional green-spaces that are strategically planned and managed to provide a range of ecological, social, and economic benefits (Bendict & McMahon, 2006; Kambites & Owen, 2006; Tzoulas et al., 2007; Wright, 2011). Examples of green infrastructure include green roofs, permeable vegetated surfaces, green alleys and streets, urban forests, public parks, community gardens and urban wetlands (Byrne & Yang, 2009; Douglas, 2011; Foster, Lowe, & Winkelman, 2011; Gill et al., 2007; Klemm, Heusinkveld, Lenzholzer, & Van Hove, 2015). Scholars recognize that green infrastructure can potentially improve residents' health and wellbeing, provide food, lower wind speeds, reduce storm-water run-off, modulate ambient temperatures, reduce energy use and sequester carbon, among other 'ecosystem service benefits' (Mell, 2013; Mell, Henneberry, Hehl-Lange, & Keskin, 2013; Roy, Byrne, & Pickering, 2012), although the extent of these benefits remains somewhat contested (Pataki, Carreiro, et al., 2011). Green infrastructure thus holds the potential to cushion cities against many expected climate change impacts (Byrne & Yang, 2009; Brown, Vanos, Kenny, & Lenzholzer, 2015).

However, there are difficulties with how spatial planners and built environment researchers have defined and operationalized the term green infrastructure. For example, the term has tended to