Human-Environmental Interactions in Cities

Human-Environmental Interactions in Cities: Challenges and Opportunities of Urban Land Use Planning and Green Infrastructure

Edited by

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FOREWORD

DAGMAR HAASE, SALMAN QURESHI
AND JÜRGEN BREUSTE

Cities are complex adaptive systems embedded within even more complex and adaptive ecosystems. Cities and their regions are hubs for people, infrastructure and commerce, requiring extensive resources and putting intense pressure on the environment. Urban landscapes are the everyday environment of the majority of the global population, including four out of five Europeans, every second Asian and almost all Latin Americans. The continuous increase in the number and size of cities and the permanent consumption of virgin land into sealed surface pose significant challenges for reducing the rate of biodiversity loss and related ecosystem functionality and ensuring human welfare, which is of major importance in cities. Plants, animals, and microorganisms are the base of all ecosystems and the services they provide. However, urban areas also provide a range of benefits to sustain and improve human livelihood and the quality of life through urban ecosystems.

Generally speaking, locally generated ecosystem services have substantial impacts on the quality of life in urban areas and should, therefore, be more explicitly addressed in conceiving strategies aimed at sustainable development, liveability and resilience in urban milieu. From the Millennium Ecosystem Assessment we know that sixty per cent of the global ecosystem services are degraded or used unsustainably, having adverse effects on human well-being. Because almost no ecosystems remain unimpacted by humans and humans cannot exist without ecosystems, protection and sustainable use of ecosystems are no longer an isolated interest but a key component of global sustainable development, particularly in cities.

Urban biodiversity contributes to multiple ecosystem functions and services that are very important for the well-being of urban residents: reductions in local air pollution, reductions in the urban heat island effect, direct health benefits, such as a lower prevalence of early childhood asthma, reduced mortality, and general health improvements enhanced

public ecological knowledge and awareness of sustainability challenges. Such ecosystem services are generated by a diverse set of urban land uses, including parks, cemeteries, golf courses, watercourses, avenues, gardens and yards, verges, commons, green roofs and facades, sports fields, vacant lots, industrial sites and landfills. Thus, the management of urban ecosystems must be connected to the social-ecological dynamics of developed land. Furthermore, the dependence of cities on surrounding landscape and its biodiversity as well as ongoing interactions between processes occurring in urban, peri-urban and rural contexts are essential for sustaining the production, enhancement and maintenance of ecosystem services and overall urban resilience. To address these challenges of ecosystem degradation and maintenance in cities an interdisciplinary social-ecological system approach is critically important and needed at this time.

INTRODUCTION

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Background

Over the last decade, there has been a surge in research on urbanisation processes, with many scientific studies in the field of urban ecology considering the relationship between these trends and biodiversity and ecosystem services (Konijnendijk et al. 2013). Urbanisation, as a phenomenon describing the relative increase of population in cities and urban areas compared to a relative decrease of the rural population (United Nations 2012), is one of the main driving forces influencing the quality of urban life, the way in which biodiversity is present in the urban environment and, the quality and quantity of ecosystem services.

This has become particularly pertinent since 2008, when the United Nations announced that over half of the world´s population was living in cities. Since that time, numerous studies have focused on the human-

environment interactions in cities. Within this context, the term "urban ecosystem services" became increasingly used in scientific literature. Urban ecosystem services are described as the benefits residents in cities obtain from the ecosystems in cities (Cork 2001; Elmqvist et al. 2013; Millenium Ecosystem Assessment 2005). Studies particularly deal with the specific characteristics of urban green spaces that are beneficial for the urban environment, such as by regulating the urban climate through temperature reductions (Lafortezza et al. 2009; Spronken-Smith and Oke 1998; Yu and Hien 2006) or air purification (Jim and Chen 2008; Strohbach and Haase 2012; Escobedo and Nowak 2009). Interdisciplinary studies combining ecological and social science methods refer to mental and physical improvements of the urban population through cultural services of urban green spaces. That could be the provision of spaces for recreation and social interaction (Kabisch and Haase 2014; Smith, Nelischer and Perkins 1997) or the experiential learning about the natural environment (Irvine et al. 2013; Joh, Nguyen and Boarnet 2011; McMillan 2007). Further, a number of studies showed a measurable, positive psychological health effect when urban residents have contact with nature (Völker and Kistemann 2013), particularly with high levels of biodiversity (Dallimer et al. 2012; Fuller et al. 2007). Such research has demonstrated that successful urban green space planning could contribute to human well-being while promoting biodiversity conservation.

Land use demands and conventional patterns of urban development threaten urban green space and biodiversity, however. Studies show that green areas are now on average smaller than they have been previously in most cities worldwide, with fewer overall hectares per capita (Artmann 2013; Breuste, Haase and Elmqvist 2013). This is also shown by an overall increase in soil sealing, which demonstrates the degree to which landscape ecological knowledge is not being translated into practice (Breuste 2010).

To significantly analyse the patterns of human-environmental interactions within the complex city environment, methodological approaches need to be adapted to local conditions. Although studies using generalised approaches and data can provide some guidance to city planning, these do not account for the degree to which local contextual factors define urban ecosystem development and modification, nor the way in which urban populations depend on these ecosystems. Indicator-based urban socio-ecological modelling is one way in which specific local interactions could be analysed and transferred to other spaces. Other methodological innovations include various approaches such as statistical modelling, pattern analysis or GIS-research (Kabisch and Haase 2014).

Further, the combination of qualitative or quantitative research combining, such as focus groups, observation, and interviews with questionnaire surveys and statistical analysis are encouraging for future urban ecosystem research.

Recent studies on monetary (Gómez-Baggethun and Barton 2013) and non-monetary assessment of ecosystem services (Daily et al. 2009) seem to approach promising scientific tools to support urban planning and policy decision making. These tools attempt to demonstrate and link economic, social, and ecological benefits provided by the urban ecosystem. However, the need for further research to provide planning and policy with standardised temporarily and spatially explicit methods and indicators remains. These methods should be practical, applicable, and should allow for a flexible selection process, which is at best consistent, comprehensive, credible, and sensitive to changes in land management (Oudenhovena et al. 2012).

Scope of the Book

The book *Human-Environmental Interactions in Cities – Challenges and Opportunities of Urban Land Use Planning and Green Infrastructure* provides a number of papers of current research in urban ecology and is in direct accordance with the mission of the Society of Urban Ecology (SURE). SURE was established in 2009 to develop knowledge in understanding the structure and function of urban ecosystems, to facilitate international collaboration and to enrich the dialogue between researchers and practitioners. The main aim of the SURE is to contribute to a balanced interaction between humans and their environments in cities and towns worldwide.

The book addresses international research communities concerned with conceptual, scientific, and design approaches to urban land developments and biodiversity. The main focus is on the understanding of human-environment interactions analysed by multi-disciplinary approaches. The book includes papers on new concepts and challenges emerging from pressure caused by urbanisation—that is the need for sustainable green space development from a patch to a city wide scale. In addition, the book shows important human-species interactions in an increasingly urbanised world. Case studies refer to current challenges for biodiversity in urban areas. In particular, anthropogenic influences on the survival or local extinction of species—such as the structure of the built environment, and emission of pollutants—are identified. In all cases, the importance of urban planning on green infrastructure development, biodiversity

conservation and management within the urban ecosystem is highlighted and planning recommendations are given.

To focus on relevant and up-to-date topics, the contributions to this book relate to the following essential main fields of research in urban ecology:

1. Theory of urban ecology
2. Multifunctional green infrastructure
3. Socio-ecological complexity of urban areas
4. Urban biodiversity and municipal governance

These topics were intensively discussed at the 1st Congress of the Society for Urban Ecology (SURE) which was organised by the Landscape Ecology Lab of the Humboldt-University in Berlin, Germany. The congress took place from 25-27 July 2013. About 210 participants representing more than 30 countries enumerated and validated the discipline's growing concerns by showcasing 190 papers of concurrent scientific and social science research from different contexts around the world. The large number of presented papers and the even higher number of submitted proposals—around 300 abstracts for proposed papers and posters—proved the high research relevance of the presented topics.

In conclusion, this book contributes to an increased understanding of how urban ecosystems function, provide goods and services for urban residents, how they change and what allows and limits their performance, and how governance in general can contribute to and use this understanding for a successful urban planning in an ever more human-dominated world. To further understand this complexity, new approaches in urban planning could be linked with research and education to encourage young researchers to deal with emerging topics, innovative methods and newly developed theories. This book presents a first step by combining empirical case studies with new theoretical insights. These insights are analysed through emerging methodological combinations, and are presented by young scientists in early academic careers.

The Nature of the Papers

The eight papers presented in this book include theoretical-conceptual texts but also contributions that use a theoretical background to introduce empirical case studies. The papers refer to a variety of conceptual and geographical scales ranging from regional to local scales. Some studies focus on a specific case study which has been investigated in detail.

Nevertheless, the results can in terms of applied methodological approaches, concrete insights or recommendations to some extend be transferred to and used for other comparable cases.

With regard to their disciplinary origin and scientific background, the papers come from the fields of landscape ecology, urban ecology, biology and human geography. Pilot studies as well as disciplinary papers by PhD students and post-doctoral researchers rooted in landscape ecology are shown. They describe theoretical approaches, research questions and methodological issues related to their scientific work in progress. Further, a general overview of research and literature related to a specific research problem is presented.

Structure and Contents of the Book

This book consists of two parts.

Part 1: Urban land use conflicts and green infrastructure

The first part about urban land use conflicts and green infrastructure includes four papers dealing with the concept of biophilic urbanism and the provision of multifunctional green infrastructure in specific cases. *Omniya el-Baghdadi et al.* introduces *biophilic urbanism* as an urban design concept that focuses on the integration of natural elements as features in urban landscapes. They review some cases where biophilic elements are used in different geographic scales, from urban parks and green streets at the city and neighbourhood levels to as concentrated as green walls and pot plants at the level of buildings. They further highlight emerging gaps in economic knowledge of using biophilic elements in landscape planning. Referencing previous work in the field, she suggests opportunities for engaging decision makers in the business case for biophilic urbanism. The concept of biophilic urbanism was also used by *Angela Reeve et al.* They refer to the specific level of buildings and explores how nature inside buildings (such as pot plants and internal green walls) can increase worker productivity in office buildings. Drawing on insights from existing research in this field and from a summary of a survey within a Perth office building, the paper makes recommendations regarding opportunities for focusing future investigations to enhance understanding of how biophilic urbanism can contribute to increased wellbeing and productivity in office buildings. In a detailed case study *Andrzej Długoński* introduces a method for analysing the morphological structure of the total green infrastructure in the Polish city of Łódz. He

determines the city's green infrastructure properties and identifies the development principles of the city's green infrastructure. Finally, specific development scenarios for Łódz' green infrastructure are developed and assessed. The identified green infrastructure and the scenarios underline the complexity and functional diversity of the cities different green infrastructure types. Finally, *Nadja Kabisch et al.* introduce findings from an EU-BiodivERsA research projected on urban ecosystem services and biodiversity (URBES). The authors show how regulating and cultural ecosystem services are provided by urban green and blue spaces in the cities of Berlin, Germany and Salzburg, Austria. They conclude that the methodological approach combined with the findings from the ecosystem service assessment could be used as important contribution in urban green space and residential land use planning.

Part 2: Human-Species Interactions: Challenges on Biodiversity in Cities

In the second part on human-species interactions, the book shows challenges on biodiversity in an increasingly urbanised world. In a first paper, *Sonja Knapp* presents a review that summarises positive and negative effects of urban gardening on biodiversity. She concludes that urban gardens are not only centres of interactions between people and biodiversity but simultaneously contribute to human well-being and environmental education while management and human preferences can shape species assemblages. In order to highlight the importance of schoolyards as learning environments and the effects of school gardening on the pupil's perception of plants, *Karlheinz Köhler and Dorothee Benkowitz* outline the recent situation of school gardens in Baden-Württemberg, Germany. By presenting some interesting case studies, the authors stress the multitude of opportunities for children to get in touch with nature, while these opportunities are often underestimated in their educational impact. In contrast to papers highlighting benefits urban ecosystems provide for city residents, *Eric Arnold et al.* refer to nuisances and disservices by urban ecosystems. In particular, the authors analyse the release of pollen with allergenic relevance into the ambient air by urban street trees in the city of Boston, U.S. They conclude that allergenic potential should be taken into consideration when planting trees in cities. This section concludes with the work of *Javier Pineda et al.,* who analyse the effects of land uses and air pollution on populations of House Sparrow as a model of urban species. Applying different urban models following a gradient from a small village to a big city in Spain shows, that intensive or

quick modifications in urban areas could increase selective pressure and negatively affect populations of well adapted organisms. Moreover, this paper adds significant novelty through the use of a relatively unique bioindicator for urban ecosystem research.

Concluding remarks

The range of papers presented in this book showcase a variety of disciplinary, methodological and geographical perspectives, reflecting the diversity and complexity of human-environmental interactions in a rapidly urbanising world. The analysis of these interactions and the developments and changes of urban habitats for species aims at the assessment of current challenges of urban ecosystems. Current and future SURE activities will certainly be devoted to these challenges.

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PART ONE

URBAN LAND USE CONFLICTS AND GREEN INFRASTRUCTURE

CHAPTER ONE

ENGAGING DECISION MAKERS IN THE BUSINESS CASE FOR BIOPHILIC URBANISM

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Abstract

The cognitive benefits of biophilia have been studied quite extensively, dating as far back as the 1980s, while studies into economic benefits are still in their infancy. Recent research has attempted to quantify a number of economic returns on biophilic elements; however knowledge in this field is still ad hoc and highly variable. Many studies acknowledge difficulties in discerning information such as certain social and aesthetic benefits. While conceptual understanding of the physiological and psychological effects of exposure to nature is widely recognised and understood, this has not yet been systematically translated into monetary terms. It is clear from the literature that further research is needed to both obtain data on the economics of biophilic urbanism, and to create the business case for biophilic urbanism. With this in mind, this paper will briefly highlight biophilic urbanism referencing previous work in the field. It will then explore a number of emergent gaps in the measurable economic understanding of these elements and suggest opportunities for engaging decision makers in the business case for biophilic urbanism. The

paper concludes with recommendations for moving forward through targeted research and economic analysis.

Introduction

Internationally, the concept of 'biophilic urbanism', a term coined by Professor Tim Beatley to refer to the use of natural elements as design features in urban landscapes, is emerging as a key component in addressing climate change challenges in rapidly growing urban contexts (Beatley 2010). Achieving biophilic urbanism in urban environments is facilitated through the use of 'biophilic elements'; i.e. functional design features (Beatley 2010). These elements can occur at three geographic scales, from as extensive as urban parks and green streets at the city and neighbourhood levels to as concentrated as green walls and pot plants at the level of buildings (SBEnrc 2012). Each of the biophilic elements has a few specific benefits, while a few other benefits are shared by all. Table 1-1 summarises the benefits of a range of biophilic elements, with many shared by all (SBEnrc 2012).

Studies suggest that a wide range of health benefits may arise from daily views of nature (Beauchemin and Hays 1996; Benedetti et al. 2001; Elzayadi 2011; Marcus and Marni 1995). The seminal work of Roger Ulrich in 1984, which found faster rates of recovery in hospital patients with views of nature compared to those without, laid a strong empirical base for this research (Ulrich 1984). More recently, a 2012 report by Terrapin Bright Green discussed how such benefits of nature might affect building occupants, considering in particular employees in the workplace (Terrapin Bright Green 2012). Their report discussed benefits of biophilia in reducing stress, anxiety and absenteeism as well as enhancing productivity and overall employee well-being. These studies, however, still lack economic rigour.

Reviewing this emerging field, it is evident that economic understanding of biophilic elements and their interaction with the built environment remains limited. Within this context, this paper will discuss a number of gaps in economic data. In considering how to articulate the economics of biophilic urbanism, as the current understanding is ineffective, this paper also highlights a gap in understanding what decision makers need in order to make investment decisions regarding the use of biophilic elements. Drawing on existing literature, as well as six case studies developed by the authors and two stakeholder engagement workshops conducted in 2011 for the Sustainable Built Environment National Research Centre (SBEnrc; SBEnrc Stakeholder Workshop 2011), the authors discuss emergent needs

and suggest opportunities of decision makers. The paper concludes with recommendations on areas for future research to enhance understanding of the economics of biophilic urbanism. This investigation has been undertaken in collaboration with SBEnrc, and seeks to compliment and extend the work of Biophilic Urbanism expert Tim Beatley (2010).

Table 1-1. Overview of the elements of Biophilic Urbanism.

	Element	Forms	Specific Benefits	Common Benefits
Building	Indoor Plants	- Pot plants in buildings - Indoor living walls, including pots within a frame (also see Green Walls) - Indoor planted vegetation, such as atriums and large planted installations	- Reduces building occupant illness - Increases building occupant productivity - Improves air quality	Revitalises urban environments
Building	Green Roofs	- 'Intensive': Soil deeper than 200mm and vegetation up to the size of trees - 'Extensive': Soil up to 200mm with ground cover vegetation	- Improves building energy efficiency - Water management - Space efficiency - Food production	Reduces urban heat island effect Improves air quality
Building	Green Walls	- Internal and external green walls - Include: vegetation directly attached to infrastructure (such as ivy), panel systems with substrate (such as preplanted panels with soil), and container or trellis systems.	- Sound insulation - Increases roof/wall lifespan - Vertical urban farming	Improves microclimate Sequesters carbon/ reduces greenhouse gas emissions
Neighbourhood	Green Verges	- Street trees and canopies - Shade planting for buildings - Green streets and alleys that create cool pervious greenways - Rain gardens and bio-swales integrated into stormwater management plan and consisting of pervious channels - Green permeable sidewalks	- Encourages walking, and cycling - Reduces building cooling/ heating energy use - Water management - Food production	Increases biodiversity Improves water cycle management
Neighbourhood	Green Islands	- Urban parks and gardens placed close to transportation routes - Community farms close to homes - Residential backyards - Lawns and gardens (public and private)	- Encourages walking and cycling - Food production - Increases community cohesion	Provides amenity Enhances well-being/ reduces stress
Neighbourhood	Green Corridors	- Green corridors (biodiversity corridors) reaching outside the urban area - Highway crossings and migratory routes - Backyard commons - Vegetated buffer zones along coastal areas	- Links biophilic elements with each other - Encourages walking and cycling	Recreation Reconnects with nature
City	Urban Farming	- Large scale community gardens and urban farms - Urban and peri-urban agriculture	- Food production - Employment and education	Revitalises cities
City	Waterways, and water sensitive urban design features	- Wetlands (natural and constructed) - Ponds and lakes - Rivers and streams - Vegetated swales, drainage corridors, infiltration basins, etc. - Oceans and associated coastal vegetation	- Water management, treatment and storage - Protects downstream water bodies	Increases property value Enhances tourism

Methods

According to Kaplan and Duchon (1988), the use of multiple methods allows for cross-validation, or triangulation, of findings from different sources and data; enhancing the robustness of findings. For this reason, this paper draws from three different qualitative interpretations and analyses—literature review, case studies and workshops. These methods are described in the following paragraphs.

The literature review method was used to provide background context of the available information on biophilic urbanism and economics (*what is so?*). This is due to researcher's assumption that knowledge accumulates and that future research can build on what has been done previously. This sheds light on what the missing gaps in the literature are (*what is missing?*). Once the existing literature and gaps have been identified using this qualitative technique, an integrative literature review followed, which involved drawing on the existing context to distil insights to provide the literature review with an added depth that is informative and relevant. These emerging insights dictated the subsequent method, case study exploration, which aimed to dig deeper into the enquiry (*what is the key question?*). Six case studies (Berlin, Singapore, Chicago, Toronto Brisbane and Portland), were selected based on research conducted by the broader research project for the Sustainable Built Environment national research centre, which identified the successful mainstreaming of biophilic elements within these cities (SBEnrc 2012). A number of economic analysis related questions ensured consistent evaluation of all case studies, providing insights that can inform future use of biophilic elements. The sample for the literature review and case studies included journal articles, books, industry and government reports and online pages.

Semi-structured interviews with two to three participants, identified from the case study exploration based on their involvement in application of biophilic elements in their respective city, were then conducted. Questions or key topic areas from the case study exploration emerged. These were asked or discussed to provide comprehension or validation of findings from the literature review and case studies. The use of semi-structured interviews allowed the interviewer to enquire more deeply into topics of particular interest that emerged during each interview. To enhance the validity of the interview process, the responses given by interviewees were summarised and repeated back to the interviewee to confirm that the information has been interpreted correctly and to allow room for further clarification if necessary.

The paper also draws from two stakeholder workshops for SBEnrc involving over 25 participants in Perth and Brisbane. The workshops were based on the methodology of 'Collective Social Learning', created by Emeritus Professor Valerie Brown, to guide participants through a process to consider first their vision for a biophilic city and the aspects that enable and disable achieving such vision. Following this, a brainstorm was undertaken with each workshop group, to inform the research team's consideration of the various elements of an economic consideration of both direct and in-direct economic benefits and costs of the use of biophilic elements in cities and other urban areas.

Emergent gaps in economic understanding

As the use of biophilic elements begins to gain momentum in some cities, it is evident that some governments and councils have started to recognise the positive potential a biophilic building, neighbourhood or city has to offer. Though, with apparent economic ambiguity and uncertainty of the value of environmental resources (Adamowicz and Beckley 1998; ICEM 2003; Lintott 1996; O'Neil 1997), it remains a hurdle to completely mainstream biophilic urbanism. The case studies have highlighted emergent gaps regarding the economic inquiry of biophilic urbanism and a significant need to further the current level of understanding. The following section will highlight these gaps in knowledge that are essential in strengthening the business case for biophilic urbanism. This includes: the quantification and recognition of indirect benefits, understanding the application of the multiplier effect to biophilic urbanism and identifying and implementing mechanisms to address split incentives.

Indirect benefits

Unquantifiable benefits: Whilst some benefits, such as stormwater management and energy savings, are easily quantified, others are not. Social and aesthetic benefits have been notoriously difficult to translate into monetary terms. Such benefits include education, community connectivity, happiness, improved health and well-being, among others that may not yet be recognised (Terrapin Bright Green 2012). Whilst these benefits' financial returns may not be easily recognised, at times they can be the most significant (Alex Versluis, pers. comm.). This was most evident in a green roof project on a YMCA building in Toronto, Canada, where community involvement instigated a series of ongoing benefits (City of Toronto 2011). Some of the benefits included revitalising an

undeveloped part of downtown Toronto and energising the community to come together and work on a project as well providing a space to conduct yoga and educational workshops. However, whilst these benefits are now apparent in retrospect, it has still not been possible to quantify these in a way that might inform the development of a business case for other building owners similarly considering the installation of a green roof.

Contributing factors: Independent studies from some of the case studies have attempted to quantify economic, social and environmental benefits of biophilic elements but have acknowledged the difficulty in capturing the full suite of benefits (Banting et al. 2005; Chicago Loop Alliance 2011; Skyrise Greenery n.d; Sustainable Technologies 2005). Measurable benefits such as stormwater management and energy savings were generally easily quantifiable, as were some indirect benefits including increased tourism and real estate value (Emily Hauth, Linda Dobson and Matt Burlin, pers. comm.; Hitesh Doshi, pers. comm.). Yet, with regards to these indirect benefits, uncertainty existed in pinpointing the precise portion of the increase that is directly attributable to the biophilic element. This is due to contributing factors such as refurbishments in the case of real estate and advertisement, and weather in the case of tourism that also play a role in increased value.

Multiplier Effect

In the case studies, biophilic elements were initially used to address a particularly prominent challenge(s) facing the city. Once added to a building, neighbourhood or city and when explored further, these biophilic elements appeared to also positively reduce other negative externalities. This suggests that biophilic elements provide positive multiplier effects, however these are as yet only quantified and explored to a limited degree.

For instance, the serious problems of stormwater runoff in Portland and the rising costs of traditional facilities was the first trigger for alternative solutions. Portland city determined that the overall costs of stormwater management could be reduced through the addition of green infrastructure to stormwater management plans (ENTRIX 2010). These green infrastructures, or biophilic elements, are now being retrofitted throughout Portland under the Grey to Green (G2G) initiative, and include green roofs, green urban space and Green Streets (among others). The city of Portland has subsequently explored the broader benefits in terms of health, well-being and liveability. The results indicated positive impacts on physical and mental health, property value and crime rates (among other, ENTRIX 2010). In a similar context, the rising issues of urban heat

island effect in Singapore prompted the need to rethink current urban design. Exploring other benefits that emerged from biophilic elements, it was clear that these elements financially assisted with stormwater management and air pollution reduction. This financial impact of air pollution was quantified in a Singaporean study (Quah and Boon 2003). The study looked at the mortality and morbidity effects of particulate air pollution on residents. By studying the statistical lives that could be saved and the cost of illness incurred, the results showed that the total economic cost of particulate air pollution in Singapore is US$3662 million (or about 4.31% of Singapore's GDP in 1999).[1] This demonstrates that the benefits of urban nature went beyond targeting the initial externality, urban heat island effect.

Crucial insights emerge in terms of managing these costly externalities through the use of biophilic elements, creating significant economic gains for Portland and Singapore. What these examples highlight is the need to explore the extent of influence of biophilic elements across society; in other words the multiplier effect. This multiplier effect of biophilia is a topic that has not been yet been explicitly discussed in the literature. According to Glaeser, Sacerdore and Scheinkman (2003), the presence of positive impacts creates a 'social multiplier' where summative coefficients exceed that of individual coefficients. Further research into exploring the web of benefits from a biophilic element across society could add significant value to demonstrate the monetary potential. The report by Terrapin Bright Green (2012) has instigated a similar conversation with its exploration of benefits on productivity across five sectors of the economy. Their research explored benefits such as illness, absenteeism, staff retention, job performance, healing rates, classroom learning rates, retail sales and violence statistics. What this report has highlighted is the need to continue to explore the multiplier effect of biophilic urbanism as there could be other unidentified benefits. Identifying the extent to which benefits of biophilic elements reach, coupled with metrics to measure their positive impact, begins to demonstrate the remarkable gains that companies and institutions can capitalise on.

Split Incentives

Whilst identifying the positive multiplier effect could strengthen the business case for biophilic urbanism in cities, the issue of 'split incentives' may make it unfavourable for an investor. This is because the investor in a

[1] The authors of this study note that due to some research limitations, the findings from this study should be treated as indicative rather than conclusive.

biophilic element may not necessarily directly reap the benefits. Hence, this potentially impedes financial returns that reduce the attractiveness for private property owners (SBEnrc Stakeholder Workshop 2011). For instance, a green roof retrofitted by a building owner will not necessarily enjoy the full suite of benefits this provides, as building occupants within proximity enjoy views of this rooftop and incur benefits such as stress relief, and enhanced productivity, among others. Recognising and exploring this limitation could help minimise this barrier by identifying opportunities to link back the benefits to an investor.

Summary of gaps in economic understanding

A summary of the emergent economic gaps discussed above have been captured in Table 1-2. It highlights the need to further explore these gaps in order to strengthen the business case of biophilic urbanism.

Table 1-2. Emergent gaps in economic understanding of biophilic urbanism.

Emergent gaps	Opportunity in addressing gap
Indirect benefits	Opportunity to pinpoint the precise portion of the benefit increase that is directly attributable to the biophilic element. Opportunity to identify and translate social and aesthetic benefits into monetary terms. Such benefits include education, community connectivity, happiness, improved health and well-being, among others that may not yet be recognised.
Multiplier effect	Opportunity to identify the extent of and long-term impact of a biophilic element across society over time. Presentation of a web of interrelated links could add significant value and facilitate visual comprehension.
Split incentive	Opportunity to help minimise the split incentive issue. An investor in a biophilic may not necessarily directly reap the benefits, hence impeding financial returns and reducing the attractiveness for private property owners.

Engaging decision makers

One study distinguishes the difference between stakeholders and decision makers by defining stakeholders as the players involved in the

process where their preferences are captured throughout. Likewise, decision makers are players that are involved in the process but also combine their judgments with the outcomes from the research project to make the final decision (Hajkowicz 2008). The two workshops conducted in Perth and Brisbane in 2011 by the research team from SBEnrc highlighted the need to present a business case for biophilic urbanism in a language that is targeted to suit decision makers. This should be based on decision makers' priorities and terminologies. Hence, in addition to the emergent gaps in economic understanding of biophilic urbanism discussed in the previous section, another prominent shortcoming of the business case is recognising the role of decision makers in biophilic urbanism and their emerging priorities. The following section will explore identified priorities, which includes political priorities, 'what's so' in existing research, 'what can be' by distilling local data and future opportunities that are not yet known. These key interventions highlight the need for further research.

Government incentives

Results from the two stakeholder engagements revealed that financial incentives are a crucial avenue to push the biophilic urbanism agenda forward. This was reiterated in the case study findings. Brisbane government, for instance, has introduced the 'Green Door' mechanism, which will accelerate decisions for development proposals that are identified to be among the most sustainable in Queensland (DLGP 2011). This Green Door "fast track" incentive is designed to encourage sustainable development by expediting applications through the often long and complex development assessment system. As sustainable designs occasionally incur high initial costs, particularly given the lack of economies of scales in the green feature industry, motivation was required to engage community members.

Financial incentives were identified as crucial for property owners. The high initial cost of a biophilic feature as well as the split incentive issue discussed earlier can impede their uptake. Hence, the limited benefits to the building owner for green roofs and green walls may not be sufficient for them to do this on their own accord. Discounted incentive was also found in some of the cities explored. Most North American cities charge property owners separately for stormwater runoff, enabling them to then receive a discount where stormwater was managed onsite, principally through the use of biophilic elements (ENTRIX 2010; Sustainable Technologies 2005). These schemes raise awareness about the costs of

stormwater management, engage property owners and clearly demonstrate the potential of a biophilic element.

These will all require government leadership to drive policies that are adaptive and supportive of biophilic urbanism. In virtually all the case studies explore, there was a political champion that drove the urban greening agenda. This catalysed and encouraged the process.

What's so

The two workshops also highlighted a priority for decision makers to comprehend the current understanding or 'what's so' of biophilic urbanism. Capturing what is already known in the literature or what can be learned from others was expressed as imperative. Learning from others illustrates lessons in terms of successful application as well as highlighting errors that can be avoided. These also outline the benefits experienced from their application. These known benefits include: reducing energy consumption, reducing heat island effects (such as reducing urban heating from concrete and pavements open to solar radiation that will heat buildings and vehicles), enhancing urban biodiversity that may provide greater tourist attraction and greater levels of well-being, improving resilience to natural disasters and extreme weather conditions, improved health and healing outcomes, improving the experience of those visiting and working in urban areas and public buildings, providing learning opportunities in terms of local flora and fauna and responding to pressures related to densification and revitalisation of cities (SBEnrc 2012). Hence an opportunity arises in exploring examples from around the world, conduct feasibility tests to present economic, environmental and social benefits.

What can be

New wealth of opportunities highlighting what is possible with biophilic urbanism was also distinguished as a priority in the SBEnrc workshops. This can be in the form of a local demonstration project with the findings presenting accurate and appropriate data in terms of the environmental, social and economic benefits. A political champion is also important to encourage demonstration projects. This was apparent in Chicago and Portland where costs and benefits of the natural installation were communicated effectively to the public through demonstration projects (Chicago Loop Alliance 2011; ESTRIX 2010). These demonstration

projects were publicly accessible; hence the public could directly appreciate the benefits.

Retrofitting schools with a green roof or green wall was expressed as a beneficial case study as it has the potential to provide dual purposes of being a case study and an educational facility. The results not only shed light on the quantitative benefits, but also on aesthetic and social benefits such as community connectivity, education, enhanced productivity (SBEnrc Stakeholder Workshops 2011). Collecting local data is also significant as aspects such as climate, demographics, infrastructure and government play a pertinent role in biophilic urbanism. Local exploration to capture the successes is important for cities to gain confidence to pursue a project further and to mainstream it wider. As biophilic urbanism is still at its infant stage, data is generally limited and will need to be expanded to have appropriate figures to present to decision makers to make informed decisions and to appropriately apply biophilic elements to cities worldwide.

A summary of the emergent priorities in engaging decision makers have been captured in Table 1-3. It demonstrates the need to further strengthen these gaps.

Table 1-3. Emergent priorities in engaging decision makers

Emergent priorities	Opportunity in addressing gap
Government policies	Opportunity to explore incentives such as green door 'fast tracks' development application processes; financial incentives or discounted incentives
'What's so'?	Opportunity to explore current understanding of biophilia to present economic, environmental and social benefits.
'What can be'?	Opportunity to present new wealth knowledge to shed light on what is possible with biophilic urbanism. Opportunity to present local data to capture the successes to facilitate understanding and confidence in biophilic urbanism.

Conclusion

Appreciating the emergent gaps in quantifying the full suite of benefits that arise from biophilic urbanism and that the conventional model of producing knowledge in relative isolation from other actors in society is ineffective, this paper highlighted these gaps in economic knowledge and suggested opportunities for engaging decision makers. The economic gaps